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PREFACE

On the occasion of celebrating the 65-year Anniversary of Vinh University, the 2nd International Conference on Advances in Civil Engineering (ICACE-2024) was organized to connect the faculties of the Department of Civil Engineering research professionals, scholars, and scientists from different institutions both in Vietnam and abroad. ICACE-2024 was organized on December 21st, 2024, at Vinh University, Vietnam. This event was a good opportunity to discuss new research findings in the civil engineering field. We believe that those updated studies will contribute to solving the practical problems. The main topics of the conference included Structural and mechanics engineering, Construction and building materials, Smart and sustainable infrastructure, Geotechnical engineering, Hydraulic, pavement, costal and offshore engineering, and Construction engineering and project management. This proceeding includes the full papers selected from the accepted submissions, which were presented at ICACE-2024.

On behalf of the Organizing Committee, we are sincerely thankful for the contribution of two keynote lectures, which are presented by Dr. Samdani Azad (Yonsei University, Korea) and Prof. Tran The Truyen (University of Transportation and Communication, Vietnam). Additionally, a great appreciation is to all authors who submitted papers and presented at the parallel sessions. We also want to give our sincere thanks to companies and Vinh University for their support. Their contributions made the conference a success.

Assoc. Prof. Tran Ngoc Long

*On behalf of the Organizing Committee of ICACE-2024
Dean of Department of Civil Engineering, Vinh University*

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Research on the possibility of manufacturing high-strength ultra heavy-weight concrete from available material sources in Vietnam

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Abstract. High-strength Ultra heavy-weight concrete (HUC) is a specialized type of concrete with a density exceeding 2700 kg/m³, made from specific aggregates with high density. This concrete is primarily designed for use in structures requiring substantial self-weight, such as protective and stabilizing elements for oil pipelines and offshore oil rig foundations. This study evaluates the feasibility of using magnetite iron ore from the Bac Viet iron mine (Phu Tho, Vietnam), combined with Portland cement, superplasticizer and mineral additives to produce Ultra-heavyweight concrete with the density above 3300 kg/m³, and an average compressive strength of about 70 MPa at 28 days. Additionally, this study indicates the potential to produce high-strength Ultra Heavy-weight concrete products from domestically available materials for use in specialized constructions in Vietnam.

Key words: High-strength Ultra heavy-weight concrete, fly ash, rice husk ash, workability, concrete mixture, density.

1. Introduction

High-strength Ultra heavy-weight concrete (HUC) is a specialized type of concrete with a density exceeding 2700 kg/m³, made from specific aggregates with high density [1, 2]. This concrete is primarily designed for use in structures requiring substantial self-weight, such as protective and stabilizing elements for oil pipelines and offshore oil rig foundations [3, 4].

In addition, with the current explosion of the 4.0 industrial revolution around the world, the problem of electricity shortage has brought many consequences to the economy. In the context of limited development of thermal power due to the problem of reducing carbon emissions, especially coal-fired thermal power, planning the development of power sources will be difficult due to the lack of energy sources with large capacity, stability, and suitable prices. Nuclear power and renewable energy are the world's trends to minimize the impact on climate, environmental pollution, and ensure sustainable development. Many experts believe that to achieve the Net-zero goal by 2050, we must use nuclear power. Nuclear power technology is increasingly advanced, ensuring absolute safety according to strict technical requirements. To build nuclear plants, it is necessary to use high-strength Ultra heavy-weight concrete materials [5].

Research on high-strength Ultra heavy-weight concrete worldwide has been extensively conducted, with notable studies as follows:

The study by Kilincarslan et al. [6] explored the relationship between the barite ore ratio and the physical properties of Ultra heavy-weight concrete, as well as the impact of the cement/water ratio and the proportion of barite ore content. Izaz Ahmad et al. [7] investigated the density of Ultra heavy-weight concrete using barite as fine aggregate, analyzing its influence on the mechanical properties. They determined the proportional relationship between the linear reduction coefficient and the average

volume weight, concluding that barite ore can replace sand without negatively affecting the mechanical properties of Ultra heavy-weight concrete.

The research by K.A. Mahmoud et al. [8] assessed the impact of basalt aggregate size and loading rate on the compressive strength and physical properties of Ultra heavy-weight concrete. Their findings highlighted the relationship between grain size, strength, and volume weight in basalt-based Ultra heavy-weight concrete. Besides, the studies [9, 10] contribute significantly to the understanding of Ultra heavy-weight concrete's properties and its potential applications.

In Vietnam, notable studies on ultra-heavy concrete include: The research group led by Vu Manh Hung et al. [11], which investigated and successfully produced ultra-heavy concrete using barite ore coarse aggregates, achieving a density of approximately 3200 kg/m³.

Hanoi University of Construction, which developed and proposed an ultra-heavy concrete mix utilizing barite aggregate from Tuyen Quang and But Son cement. Tran Ngoc Tinh et al. [12], who explored the effects of superplasticizers on the strength and structure of ultra-heavy concrete. This research demonstrated the influence of superplasticizers on compressive strength at various curing ages.

Nguyen Manh Kiem et al. [13], who studied the potential of domestic raw materials for producing ultra-heavy concrete suitable for nuclear power plant construction. Their findings focused on barite aggregate concrete but were limited to coarse aggregates with a maximum particle size of 20 mm.

Most recently, in 2021, Duong Ngoc Duc and the research team from the Vietnam Atomic Energy Center for Non-Destructive Evaluation undertook the project: "Research on selecting the composition of ultra-heavy concrete with barite aggregate for shielding Co-60 sources" [5, 14]. This study achieved ultra-heavy concrete with a compressive strength equivalent to at least grade M300, a slump of 8–10 cm, and a bulk density of 3328 kg/m³. However, these studies have not specifically focused on high-strength super-heavy concrete. Most of the research on super-heavy concrete has concentrated on materials such as barite ore, while heavy ores from current iron mines have been scarcely explored as potential materials for such concrete.

Given the above reasons, this study explores the potential of utilizing magnetite iron ore from the Bac Viet mine (Phu Tho, Vietnam) in combination with Portland cement, superplasticizer, and mineral additives to develop ultra-heavyweight concrete. The target is to achieve a concrete density greater than 3300 kg/m³ and an average compressive strength of about 70 MPa at 28 days. This high-performance concrete is aimed at applications in structures that require substantial weight, such as protective and stabilizing elements for oil pipelines and offshore oil rigs and to build nuclear power plants.

2. Materials and Methods

2.1. Materials

a) The binder

Ordinary Portland Cement PC40 (OPC) manufactured at “Nghị Sơn” factory (Viet Nam). The characteristics of this Portland cement and the experimental results obtained for testing its properties are shown in Table 1.

Table 1. Physical and mechanical properties of Portland Cement PC40 “Nghị Sơn”

| Specific weight (g/cm ³) | Fineness | | Time of setting (min) | | Compressive strength (MPa) | | Water requirement (%) |
|--------------------------------------|------------------------------------|---------------------------------------|-----------------------|-------|----------------------------|---------|-----------------------|
| | Retained content on sieve №009 (%) | Specific surface (cm ² /g) | Initial | Final | 2 days | 28 days | |
| 3.15 | 3.8 | 3635 | 140 | 230 | 34.61 | 48.3 | 28.58 |

* Fly Ash (FA) from TPP “Pha Lai” (Vietnam) Class F, blast furnace slag (BFS) S95 Hoa Phat, and Silica Fume SF-90 (SF90) "Vina Pacific" were used as the binder (CKD). Table 2 presents the chemical and physical properties of FA, SF90, BFS, and OPC.

b) Ultra-heavy aggregate (CL)

Both the coarse aggregate (CLL) and fine aggregate (CLN) in this study are iron ore. All the heavy aggregates used in this study were processed from Magnetite iron ore sourced from the Bac Viet iron mine (Phu Tho, Vietnam). The materials consist of the following components:

+ Concentrated iron ore after beneficiation, containing approximately 55% Fe and over 10% Si, with a moisture content of about 10÷15%. The particle size ranges from 0 to 0.14 mm, and the bulk density determined through testing is 2.075 tons/m³ (in Fig. 1).

+ Solid Magnetite iron ore extracted from the Bac Viet iron mine. This material consists of large granular pieces with diameters ranging from 20 to 60 cm (Fig. 2).

The magnetite iron ore extracted from the Bac Viet mine was mechanically processed to obtain particle sizes as follows:

- Finely ground (FG) iron ore powder with a particle size of < 0.14 mm (Fig. 3a);
- Iron ore particles resembling the size distribution of natural sand, with sizes ranging from 0.14 to 1.25 mm (Fig. 3b);
- Iron ore particles resembling the size distribution of natural sand, with sizes ranging from 1.25 to 5.0 mm (Fig. 3c);
- Iron ore particles resembling the size distribution of crushed stone, with sizes ranging from 5.0 to 10.0 mm. This is the composition of coarse heavy aggregate in the concrete (Fig. 3d);

The heavy aggregates used in this study meet the requirements for aggregates for concrete and mortar as specified in TCVN 7570:2006.

Table 2. Chemical compositions and physical properties of FA, SF90, BFS, and OPC

| Properties | | FA | SF90 | BFS | OPC |
|----------------------------------|--------------------------------------|-------|-------|-------|-------|
| Average chemical composition (%) | SiO ₂ | 56.68 | 90.78 | 36.01 | 21.98 |
| | Al ₂ O ₃ | 25.17 | 2.23 | 13.77 | 5.31 |
| | Fe ₂ O ₃ | 7.15 | 2.51 | - | 3.46 |
| | CaO | 1.45 | 0.52 | 41.05 | 62.33 |
| | MgO | 1.57 | - | 7.36 | 2.01 |
| | SO ₃ | - | - | 0.14 | - |
| | Na ₂ O | 2.28 | 0.57 | - | 0.14 |
| | K ₂ O | 3.15 | - | 0.28 | 0.62 |
| Loss on ignition | | 2.55 | 3.39 | 1.39 | 4.15 |
| Physical properties | Specific gravity (g/m ³) | 2.22 | 2.15 | 2.92 | 3.15 |
| | Fineness (cm ² /g) | 5215 | 10160 | 4540 | 3650 |



Fig. 1. Beneficiated iron ore concentrate



Fig. 2. Solid magnetite iron ore from Bac Viet Mine

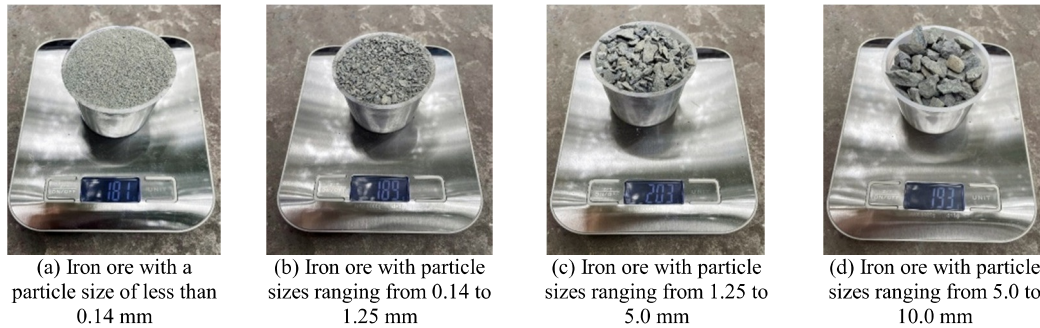


Fig. 3. The composition of heavy aggregates used in this study

The heavy aggregates, after being processed from iron ore, were subjected to particle size distribution according to various sieve sizes, determination of density, bulk density, water absorption, and compressive strength in a cylinder. The experimental results are presented in Table 3.

Table 3. The physical properties of the iron ore from the Bac Viet iron mine

| No | Experimental properties | Heavy aggregate from iron ore with particle diameter: | | | |
|----|---|---|--------------|-------------|-------------|
| | | < 0,14 mm | 0,14-1,25 mm | 1,25-5,0 mm | 5,0-10,0 mm |
| 1 | Density (g/cm ³) | | | 4,492 | |
| 2 | Bulk density (g/cm ³) | 1,508 | 1,575 | 1,692 | 1,608 |
| 3 | Porosity between particles (%) | 66,422 | 64,938 | 62,340 | 64,192 |
| 4 | Water absorption by weight (%) | - | 6,012 | 4,856 | 3,561 |
| 5 | Compression strength in a 75 mm diameter cylinder (%) | - | - | - | 7,3 |

The particle size distribution of fine ultra-heavy aggregate are given in Table 4.

Table 4. The particle size distribution of sand

| Sieve (hole size), mm | 5 | 2.5 | 1.25 | 0.63 | 0.315 | 0.14 |
|----------------------------|---|-----|------|-------|-------|-------|
| Residues on test sieves, % | 0 | 0 | 0.83 | 14.23 | 73.2 | 6.28 |
| Full balance, % | 0 | 0 | 0.83 | 15.06 | 88.26 | 94.54 |

c) Superplasticizer and Ordinary clean tap water

- In this study, superplasticizers SR 5000F «SilkRoad» (SR5000) were used to improve the performance of concrete mixtures with density of 1.15 g/m³ at a temperature of 25 ± 5°C. The amount of SR5000 is 1,5% by the mass of Portland cement and the decrease of water content of the concrete mixture is about 30%.

- Ordinary clean tap water (W) was used for both mixing concrete and curing of test specimens. The mixing water complies with the TCVN 4506:2012 standard.

2.2. Methods

2.2.1. Research Methods

- Calculation preliminary compositions method of concrete mixture is applied in accordance with ACI 211.4R-93.

- The work ability of concrete mixture is determined by the slump of cone standard with dimensions of 100x200x300 mm.

- The average density of concrete was determined on cube-shaped specimens with dimensions of 100x100x100 mm, in accordance with TCVN 3115:2022.

- The compressive strength of HUC was conducted to evaluate the compressive strength development of the tested HUC-specimens for different time periods. This test was performed on

100×100×100 mm cubic these specimens at 28 days of curing age using a 500T computer-controlled compression tester machine "Controls Advantest 9" with a constant loading rate of 1000 N/s in order to keep the loading rate to a minimum rate in the processing test of concrete patterns. The compressive strength test was performed in accordance with TCVN 3118:2022 (Vietnam standard).

2.2.2. Requirements for High-Strength Ultra-Heavy Concrete

The mix proportions of high-strength ultra-heavy concrete were designed in this study with the following characteristics:

- Workability: A slump flow of 20–25 cm, suitable for pumped concrete applications in high-rise building construction.
- Density: A volumetric weight of approximately 3,300 kg/m³ or higher.
- Compressive Strength: A required compressive strength ranging from 60 to 100 MPa at 28 days.

3. Results and discussion

3.1. Mix Proportions of High-Strength Heavy-Weight Concrete

In this paper, the mix proportion for high-strength ultra-heavy concrete was determined using the absolute volume method, and adjustments were made based on experimental results. The obtained mix proportions are presented in Table 5.

Table 5. Mix Proportions of High-Strength Heavy-Weight Concrete and its Ratios

| Materials Used | Sources of Supply | Symbol | Usage Ratio | Content (kg/m ³) |
|--|---------------------|--------|-------------|------------------------------|
| 1. Composition of Binder (% by the mass of CKD) | | | | |
| Cement Portland PC40 | Nghi Son | OPC | 60% | 600 |
| Silicafume SF-90 | Vina Pacetic | SF90 | 10% | 100 |
| Blast furnace slag | Hoa Phat | BFS | 10% | 100 |
| Fly ash | Pha Lai | FA | 20% | 200 |
| The Binder | X + FA + BFS + SF90 | CKD | 100% | 1000 |
| 2. Composition of Heavy Aggregate (% by the mass of CL) | | | | |
| Finely ground iron ore powder with a particle size of < 0.14 mm | Phu Tho, Vietnam | FG | 10% | 222 |
| Artificial crushed sand from iron ore size 0.14-5.0mm | Phu Tho, Vietnam | CLN | 30% | 666 |
| Coarse heavy aggregate from iron ore with sizes ranging from 5.0-10 mm | Phu Tho, Vietnam | CLL | 60% | 1332 |
| The Heavy Aggregate | FG+CLN+CLL | CL | 100% | 2220 |
| 3. Superplasticizer and Ordinary clean tap water (% by the mass of CKD) | | | | |
| Superplasticizer SR 5000F | SilkRoad | SR5000 | 1,5% | 15 |
| Ordinary clean tap water | Vietnam | W | 25% | 250 |
| 4. Material Proportions Used in this Study | | | | |
| The Water-to-Binder Ratio | $\frac{W}{CKD}$ | - | - | 0,25 |
| The Heavy Aggregate-to-Binder Ratio | $\frac{CL}{CKD}$ | - | - | 2,22 |

3.2. Properties of high-strength ultra-heavy concrete

The laboratory experiments conducted to determine the basic properties of ultra-heavy and high-strength concrete are presented in Tables 6 and 7.

Table 6. Properties of fresh ultra-heavy concrete mixture

| N | Binder | Heavy | Slump immediately after mixing (cm) | Slump of fresh | Fresh concrete |
|------|----------------------|----------------------|-------------------------------------|----------------|-----------------------------|
| CKD | (kg/m ³) | aggregate | | concrete mix | mix density |
| | | (kg/m ³) | | after 30 | immediately after |
| | | | | minutes of | mixing (kg/m ³) |
| 0.25 | 1000 | 2220 | 20.5 | 18.5 | 3430 |

Table 7. Properties of High-Strength Heavy-weight Concrete in Hardened State

| Average compressive strength (R _n) of concrete (MPa/% of 28-day compressive strength value) at: | | | | Bending tensile | Ratio of | Density of concrete |
|---|--------|---------|---------|---|---|---|
| 3 days | 7 days | 14 days | 28 days | strength value (R _n) at 28 days (MPa) | R _u /R _n at 28 days | at 28 days under saturated surface dry condition (kg/m ³) |
| 42.8 | 60.6 | 70.1 | 75.74 | 10.82 | 1/7 | 3402 |
| 56.54% | 80.05% | 92.6% | 100% | | | |

By utilizing Nghi Son PC 40 Portland cement and ultra-heavy aggregates derived from Magnetite iron ore (Phu Tho, Vietnam), it is possible to produce ultra-heavy concrete with volumetric weights of 3430 kg/m³ in the plastic state and 3402 kg/m³ in the hardened state. These values indicate that ultra-heavy concrete is approximately 1.4 to 1.5 times denser than conventional concrete, showcasing its suitability for specialized applications requiring high density.

Although the concrete mix has a very low water-to-cement ratio, its workability is excellent, and the product does not have segregation or layering. The slump immediately after mixing of fresh heavy-weight concrete is 20,5cm. The water-binder ratio is constant and equal to W/CKD=0.25. This is partly explained by the effect of the superplasticizer used, which significantly improves the workability of the concrete mixture. The amount of superplasticizer A388 is 1,5% by the mass of OPC. Slump of fresh concrete mix after 30 minutes of mixing is 18.5cm. This showed that the slump loss of the concrete mixture after 30 minutes of mixing was negligible.

The experimental results indicate that the fresh concrete mix has a density of 3430 kg/m³ immediately after mixing, while the density of the hardened concrete at 28 days under saturated surface dry conditions is 3402 kg/m³. This negligible difference suggests that the heavy-weight concrete experiences minimal water loss during the hardening process, maintaining a volumetric mass value at 28 days that is nearly identical to the fresh mix immediately after mixing.

From the experimental values in Table 5, it can be seen that the average compressive strength at 28 days of High-Strength Heavy-weight concrete using Pha Lai fly ash, Hoa Phat S95 blast furnace slag and Silica fume SF90 all reached about 75.74 MPa. Meanwhile, their average tensile strength when bending only reached about 10.82 MPa and the ratio of R_u/R_n at 28 days of 1/7.

The components of silica fume SF90, fly ash from the Pha Lai thermal power plant, and Blast Furnace Slag from Hoa Phat contain 90.78%, 56.68%, and 36.01% active SiO₂, respectively. These active SiO₂ components react with hydration products such as CaO and Ca(OH)₂ from cement to form secondary Calcium-Silicate-Hydrate (C-S-H) minerals. This process enhances the

gel phase with adhesive properties while refining the gel pore structure of the High-Strength Heavy-weight concrete. As a result, it contributes to a significant increase in the strength of the final product.

Within the limits of the study, it can be seen that the average compressive strength values at the ages of 3 days, 7 days, and 14 days were all achieved above 56.54%; 80.05% and 92.6% compared to the compressive strength of the sample at the age of 28 days. This experimental result is similar to the properties of high-strength cement concrete using conventional fine mineral additives [1, 2, 3, 4].

4. Conclusions

Based on the obtained results of properties of the ultra-heavy concrete, the following conclusions can be drawn:

- By utilizing Nghi Son PC 40 Portland cement, Fly ash Pha Lại, Hoa Phat S95 blast furnace slag and Silica fume SF90 combined with ultra-heavy aggregates derived from Magnetite iron ore (Phu Tho, Vietnam), it is possible to produce ultra-heavy concrete with volumetric weights of 3430 kg/m³ in the plastic state and 3402 kg/m³ in the hardened state. These values indicate that ultra-heavy concrete is approximately 1.4 to 1.5 times denser than conventional concrete, showcasing its suitability for specialized applications requiring high density.
- The average compressive strength at 28 days of High-Strength Heavy-weight concrete all reached about 75.74 MPa. Meanwhile, their average tensile strength when bending only reached about 10.82 MPa and the ratio of R_u/R_n at 28 days of 1/7.
- Within the limits of the study, it can be seen that High-Strength Heavy-weight concrete has a very small water to binder ratio, only 0.25. Therefore, the rate of development of the concrete strength over time has increased faster than traditional cement concrete. The average compressive strength values at the ages of 3 days, 7 days, and 14 days were all achieved above 56.54%; 80.05% and 92.6% compared to the compressive strength of the sample at the age of 28 days.
- This study aims to establish an initial scientific foundation for utilizing locally sourced heavy materials to produce high-strength, ultra-heavy concrete. Such concrete is anticipated to be essential in the future for constructing protective structures and radiation barriers in projects involving radiation equipment or nuclear reactors.

References

- [1] Bazhenov, Y.M.: Technology of concrete. Moscow. Publishing. ASV, 524 p. (2011)
- [2] Joaquim, A.O. Barros, Liberato Ferrara, Enzo Martinelli.: Recent Advances on Green Concrete for Structural Purposes. The Contribution of the EU-FP7 Project EnCoRe. Springer International Publishing AG. Pp. 427-431. (2017)
- [3] Butrim, S.Yu., Gilyazidinova, N.V.: Concrete of high-rise constructions. VIII All-Russian scientific-practical conference of young scientists with international participation "Russia is young". Kuzbass State Technical University named after T.F. Gorbachev. Kemerovo. 19-22 April, pp. 5-13. (2016)
- [4] Huu Duy Pham, Long Ngoc Nguyen.: High-strength and high performance concrete. Construction Publishing. Hanoi. 151 p. (2008)
- [5] Duong Ngoc Duc, Vu Hai Quang.: Calculation and selection of mix design for barite aggregate radiation shielding concrete for Cobalt-60 source shielding. Materials and Construction Journal - Ministry of Construction, số 11.6. pp. 40-48 (2021).
- [6] Kilincarslan, S., Akkurt, I., Basyigit, C.: The effect of barite rate on the some physical and mechanical properties of concrete. Mater. Sci.Eng, A. 42: pp. 83-86. (2006).

- [7] Izaz Ahmad, Khan Shahzada, and Habib Ahmad.: Densification of Concrete using Barite as Fine Aggregate and its Effect on Concrete Mechanical and Radiation Shielding Properties. *Journal of Engineering Research* 7(4): pp. 81-95 (2019).
- [8] Mahmoud, K.A., Tashlykov, O.L., El Wakil, A.F., El Aassy, I.E.: Aggregates grain size and press rate dependence of the shielding parameters for some concretes. *Progress in Nuclear Energy*. 118. pp. 46-53 (2020).
- [9] Akkurt, I., Akyildirim, H., Basyigit, C.: Photon attenuation coefficients of concrete include barite in different rate. *Annals of Nuclear Energy*, 37(7): pp. 910-914. (2010).
- [10] Fugaru, V., Bercea, S., Postolache, C., Manea, S., Moanta, A., Gheorghe, M.: Gamma Ray Shielding Properties of Some Concrete Materials. *APMAS2014*. pp. 21-30. (2014).
- [11] Vu Manh Hung, Pham Quang Dien, Le Quang Hiep, Ha Son, Luu Van Chuc.: Research on the fabrication of X-ray shielding materials, Hanoi, 20. pp. 15-21 (1995).
- [12] Tran Ngoc Tinh.: Research on designing the mix design of ultra-heavy concrete using Tuyen Quang barite ore aggregates and But Son PC40 cement for radiation shielding structures in Vietnam. Ministry of Construction project, pp. 40-46. (2006).
- [13] Nguyen Manh Kiem.: Radiation shielding concrete based on domestic materials, Hanoi, 05. pp. 14-21 (2000).
- [14] Duong Ngoc Duc.: Research on selecting the composition of radiation shielding concrete with barite aggregates for shielding Cobalt-60 sources. Basic-level scientific and technological project, 2020. 60 p. (2020).

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