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Optimization of precast concrete production technology

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Abstract
Introduction. The article deals with the problems of increasing the efficiency of precast concrete production technology in order to solve the issue of ensuring the required indicators of construction and technical properties of products at existing enterprises of the construction industry with no additional investment costs for their reconstruction and technical re-equipment. The aim of the work of increasing the efficiency of the production of precast reinforced concrete products is to optimize the parameters of the processes of preparing the concrete mixture as well as heat and humidity treatment of manufactured products by means of developing a two-stage method of preparing the concrete mixture and introducing a step-by-step mode into heat and humidity treatment.
Materials and Methods. The article provides a brief description of the substantive aspects of optimizing the parameters of technological operations for the preparation of concrete mixtures as well as heat and moisture treatment of precast reinforced concrete products using the example of the production of PB-type bar bridges. The manufacturing of precast reinforced concrete products using local aggregates with a high content of dusty clay particles, which determines an increase in cement consumption, is accepted as the basic object of the research.
Research Results. The proposed technology for optimizing the production modes of precast reinforced concrete makes it possible to reduce the consumption of cement and superplasticizer additives at the existing enterprises of the construction industry with no additional material and investment costs for reconstruction and technical re-equipment while using local aggregates with a high content of dusty clay particles.
Discussion and Conclusion. The application of the set of measures being developed improves the conditions for defect–free structuring of concrete and makes it possible to reduce the consumption of the most costly components of the concrete mixture, i.e., cement and the chemical additive superplasticizer. Optimization of the precast concrete production technology ensures the directed structuring of concrete and the achievement of standardized product quality indicators. In each specific case of optimizing technological solutions at each specific enterprise, it is a prerequisite to adjust the prescription and technological solutions put forward in the study. An additional effect of the implementation of the technological techniques developed in the study will be an increase in the indicators of the ecological state of the environment and a reduction in the cost of enriching local aggregates.

Keywords: precast concrete technology, preparation of concrete mix, heat and moisture treatment, optimization, quality improvement

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Оригинальное эмпирическое исследование

Оптимизация технологии производства сборного железобетона

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Аннотация
Введение. Статья посвящена проблемам повышения эффективности технологии производства сборного железобетона для решения задачи обеспечения требуемых показателей строительно-технических свойств продукции на действующих предприятиях строительной индустрии без дополнительных инвестиционных затрат на их реконструкцию и техническое перевооружение. Целью работы по повышению эффективности производства сборных железобетонных изделий является оптимизация параметров процессов приготовления бетонной смеси и тепловлажностной обработки изготавливаемой продукции за счет разработки двухстадийного способа приготовления бетонной смеси и внедрения в процесс тепловлажностной обработки ступенчатого режима.
Материалы и методы. В статье кратко излагаются содержательные аспекты оптимизации параметров технологических операций по приготовлению бетонной смеси и тепловлажностной обработки сборных железобетонных изделий на примере производства брусковых перемычек типа ПБ. В качестве базового объекта исследований принято производство сборных железобетонных изделий с использованием местных заполнителей с повышенным содержанием пылевато-глинистых частиц, предопределяющим увеличение расхода цемента.
Результаты исследования. Предложенная технология оптимизации режимов производства сборного железобетона позволяет на действующих предприятиях стройиндустрии без дополнительных материальных и инвестиционных затрат на реконструкцию и техническое перевооружение снизить расход цемента и добавки суперпластификатора при использовании местных заполнителей с повышенным содержанием пылевато-глинистых частиц.
Обсуждение и заключение. Применение комплекса разрабатываемых мероприятий улучшает условия бездефектного структурообразования бетона и обеспечивает возможность снижения расхода наиболее дорогостоящих компонентов бетонной смеси — цемента и химической добавки суперпластификатора. Оптимизация технологии производства сборного железобетона обеспечивает направленное структурообразование бетона и достижение на этой основе нормируемых показателей качества продукции. В каждом конкретном случае оптимизации технологических решений на каждом конкретном предприятии обязательным условием является корректировка предложенных в работе рецептурно-технологических решений. Дополнительным эффектом от внедрения разработанных в настоящих исследованиях технологических приемов будет повышение показателей экологического состояния окружающей среды и снижение затрат на обогащение местных заполнителей.

Ключевые слова: технология сборного железобетона, приготовление бетонной смеси, тепловлажностная обработка, оптимизация, повышение качества

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Introduction. Reinforced concrete, both prefabricated and monolithic one, is presently the main building material and will remain so in the foreseeable future [1, 2]. The urgency of the problem of increasing the efficiency of precast reinforced concrete production technology at construction industry enterprises is due to the fact that its use enable one to dramatically reduce the time required for the construction, installation and commissioning of building facilities. At the same time, it should be noted that a mandatory condition for manufacturing of reinforced concrete structures is ensuring the proper quality of construction products.

Accelerated strength gain in factory conditions is due to different types of heat treatment of manufactured reinforced concrete products and structures. However, accelerated structuring of concrete of precast products and structures under heat and moisture treatment typically causes a decrease in product quality and durability of buildings and structures being built [3]. It is possible to reduce the negative effects of accelerated concrete hardening due to heat and moisture treatment by gradually increasing the temperature in steaming chambers [4]. This technique enables one to maintain the integrity of the concrete structure and to ensure the normalized quality of reinforced concrete. The negative effects of heat and moisture treatment are particularly intense when local aggregates with a high content of dusty and clay particles (DCPs) are used [5–7].

The above disadvantages of aggregates can be addressed by washing and enriching [8]. However, this not only increases the cost of aggregates, but also requires solving the issue of disposal of flushing water and pulverized waste, as well as allocating additional areas for storing washed aggregates.

As a result of countless studies, highly effective methods of activating aggregates using special equipment have been developed [9–11]. However, high costs for reconstruction and technical re-equipment of the existing construction industry enterprises prevent them from being widely used at the industrial level.

The disadvantages of the local raw material base of aggregates are commonly mitigated by increased consumption of cement, which is the most costly and rather scarce component of the concrete mix [12, 13].

The aim of these studies was to develop methods to increase the efficiency of precast concrete technology at the existing construction industry enterprises without their reconstruction and technical re-equipment, as well as with no excessive cement consumption.

The research was conducted at the operating enterprise of Rostov-on-Don, LLC TD KSM 10, using the example of the production of reinforced concrete bar lintels of the PB type, belonging to the category of prefabricated products of mass use in residential, civil and industrial construction.

Based on the analysis of some previous studies [12–14], the following tasks were identified for achieving this goal:

– development and optimization of technological parameters of two-stage concrete mix preparation;

– development of a stepwise mode of heat and moisture treatment of products;

– assessment of the ecological and economic effectiveness of the studies;

– identification of a promising field of application of the results.

Materials and Methods. The production of precast reinforced concrete lintels of the PB type was employed as the basic option. For products of this type, the concrete compressive strength class B15 was adopted, which, with a standard coefficient of variation of 13%, is 19.2 MPa. The strength of concrete following the heat and moisture treatment is normalized depending on the time of the year:

– in the cold season — R_{HMT} no less than 15,4 MPa (80% of the project strength class);

– in the warm season — R_{HMT} no less than 13,4 MPa (70% of the project strength class).

The grade of the concrete mix for workability for the manufacture of lintels in compliance with the technology in use at the KSM 10 TD LLC plant was adopted to be P2. This is 5–9 cm while assessing the draft mobility of a standard cone concrete mix.

The consumption of materials per 1 cubic meter of the concrete mixture for manufacturing the lintels is shown in Table 1.

Table 1

Consumption of materials

Material type	Measurement unit	Amount
Cement CEM I 42.5	kg/m^3	260
Quartz sand	kg/m^3	750
Crushed stone fraction of 5–20 mm	kg/m^3	1200
Water	l/m^3	190
Superplasticizer additive ST BV2, %	%/kg/m^3	2.0/5.6

Portland cement with no additives was used as a binder, a normally hardening cement I 42.5/NW, which is in compliance with the requirements of GOST 55224-2020 produced at the Eurocement plant of JSC Mordovcement.

Quarry quartz sand with a grain size modulus was used as a fine aggregate. M_{GS} = 1.1.

The major characteristics of sand are

– packed density in dry condition — 1530 kg/m^3;

– the content of pulverized and clay particles — 5.2 %;

– the grain size modulus of the sand — 1.1.

The supplied sand is overall in compliance with the requirements of GOST 8736, according to the size of the sand it is very fine sand.

There are no harmful impurities in the sand, the PH exceeds the limits permitted by GOST (for very small ones — no more than 5%).

Sand can be used for preparing concrete mixtures in compliance with the provisions of GOST 26633 if its effectiveness is confirmed by direct tests in concrete.

A large aggregate — local crushed sandstone — is delivered to the enterprise by rail in the form of a fraction of 5–20 mm. The materials are in compliance with the requirements of GOST 26633.

The major characteristics of crushed stone:

– actual density — 2.67 g/cm^3;

– packed density — 1.46 t/m^3;

– emptiness — 45.3 %;

– water absorption — 1.2 %.

The content of pulverized and clay particles is 0.40%; of grains of weak rocks — 0.3%; of grains of the lamellar and needle shape — 10.73%; no clay in lumps. The content of amorphous SiO_2 species is 17.6 mmol/l; the content of sulfides and sulfates in terms of SO_3 is 0.07%; the content of halides in terms of chlorine ion Cl is 0.02%. The grade of crushed stone 1000 in terms of strength (crushing capacity in a cylinder) enables one to prepare concretes of class B10; B15; B20; B22.5; B27.5. The grade of crushed stone in terms of frost resistance is F200, abrasion resistance is I-1. The content of natural radionuclides Aeff in the filler is 115 ± 15 Bq/kg.

In order to produce concrete mixtures at the existing enterprise of LLC TD KSM 10, a complex chemical additive is used — superplasticizer ST BV2 with the effect of accelerating hardening. The supplier of the additive is LLC Concrete Construction Solutions, St. Petersburg. In compliance with the recommendations of the additive manufacturer, its major application area is for reinforced concrete and concrete structures hardening under heat treatment conditions. The additive does not reduce the protective properties of concrete in relation to steel reinforcement. The additive is delivered by road in the form of a liquid from a transparent yellow to a light brown color of a 30% concentration. Superplasticizer ST BV2 is introduced into concrete and mortar mixtures in the form of a working solution in the amount of 0.1–1.2% of the cement weight in terms of dry matter.

Water (clean tap water) is supplied to the enterprise from the city's water supply network. The water used for mixing concrete and mortar mixtures does not contain harmful impurities interfering with the normal setting and hardening of cement and is in compliance with the requirements of GOST 23732.

In order to obtain data comparable to the literature, as well as to the basic production one, standard methods of testing materials and concrete samples were employed.

Technologies for improving the methods of preparing concrete mixtures, including those based on low-quality aggregates, have been thoroughly investigated by scholars at home and overseas [14–16]. The key reason why the results of these studies have not been widely communicated is the need for extra costs for technical re-equipment of the existing construction industry enterprises.

On top of that, the suggested methods are typically characterized by an increase in the duration of homogenization of a mixture and a decrease in the productivity of concrete mixers and concrete mixing plants.

Once a two-stage method of preparing concrete mixtures was developed without any of these disadvantages with Ye.A. Shlyakhova's direct involvement. It was about pretreatment of aggregates with a high content of polluting dusty clay particles in the concrete mixer with a part of the mixing water adding a surfactant from the production of pentaerythritol from the Rubezhansky Chemical plant. As there was the issue of import substitution to deal with, one of the objectives of these studies was to look into the possibility of replacing pentaerythritol waste with available surfactant additives, mostly the ST BV2 superplasticizer used in basic production.

In order to obtain comparative data, the concrete mixtures being investigated were prepared by means of the traditional one-stage mixing method and the two-stage method being developed. The molded compared samples, beams measuring 40 × 40 × 160 mm after a two-hour pre-exposure, were subjected to heat and humidity treatment with an isothermal exposure temperature of 80 °C in compliance with the basic production regime.

For samples with optimal item-by-item consumption of the investigated components of the concrete mixture, a stepwise schedule of heat and moisture treatment was developed, providing for an intermediate period of concrete exposure. The two-stage schedule of heat and moisture treatment was made up of a few stages lasting for as long as it is shown in Table 2.

Table 2

Main parameters of heat and humidity treatment

Parameters	Designation	Value
Duration of the preliminary exposure (at t = 20–25 ºC), h	τ_{exp}	2
Isothermal heating temperature, ºC	t_{is}	80
Temperature rise rate, ºC/h	v	15–20
Duration of the temperature rise period (1 step of HMT), h	τ^1_p	1
Isothermal heating temperature (1 step of HMT), ºC	t^1_{is}	40
Duration of isothermal heating (1 step of HMT), h	τ^1_{is}	1
Duration of the temperature rise period (2 step of TMT), h	τ^2_p	2
Isothermal heating temperature (2 step of HMT), ºC	t^2_{is}	80
Duration of isothermal heating (2 step of HMT), h	τ^2_{is}	4
duration of cooling after HMT, h	τ_{cool}	2
concrete temperature after cooling, ºC	t_{cool}	40

Research Results. The effectiveness of the suggested two-stage method for preparing the concrete mixtures was experimentally confirmed. The traditional one-step method was employed as a control (basic) method. The research results are shown in Table 3.

Table 3

Results of a comparative assessment of the methods of preparation of concrete mixtures for the concrete lintels

Concrete mixture preparation method	Material consumption, kg/m³ %				Additive dosage, % C kg/m³	HMT mode	Compressive strength, MPa % B15	
	C	S	CS	W			after HMT	after 28 days
Basic	260 100	750 100	1200 100	190 100	0.8 2.0	basic	13.6 71	19.6 102
Two-stage: I step	0	750 100	1200 100	75 40	0.2 0.5	basic	15.2 78	22.8 116
II step	260 100	0	0	115 60	0.6 1.5			
Two-stage: I step	0	750 100	1200 100	70 40	0.2 0.4	stepwise	14.3 73	20.1 105
II step	220 85	0	0	110 60	0.6 1.3			

As can be seen from the data in Table 3, the use of the two-stage method for preparing a concrete mixture enhanced the strength of concrete after HMT by 7% (from 13.6 to 15.2 MPa) and by 14% at the age of 28 days (from 19.6 to 22.8 MPa). This served as the basis for reducing cement consumption by 15% (from 260 to 220 kg/m^3) and the total consumption of superplasticizer additives from 2.0 to 1.7 kg/m^3 without any loss of strength compared to the basic version both after HMT and at the age of 28 days.

Discussion and Conclusion. The essence of the developed two-stage method of preparing a concrete mixture for basic products is that at the first stage of preparing the concrete mixture, the aggregates are mixed with some of the mixing water and the additives ST BV2 in the concrete mixer. At the second stage, cement, the remainder of the mixing water and superplasticizer additives are added to this mixture, then all of the components are finally mixed until there is a homogeneous concrete mixture of the required workability.

As a result of the experimental studies with a quite broad range of mixing water consumption and superplasticizer additives, optimal values of these factors were identified at each stage of the concrete mix preparation: at the first stage, 40% of the total mixing water consumption and 0.2% of the ST BV2 additive (based on anhydrous substance) from the cement mass were introduced; at the second stage of the preparation of the concrete mixture, the remainder of the mixing water and additives was introduced.

The products were manufactured by means of an aggregate-flow production technology using standard technological equipment. The concrete mix was delivered using a factory mixer with a volume of 5 m^3. The height of unloading of the concrete mix was no more than 100 cm in order to avoid its stratification and deterioration of technological properties.

For heat and moisture treatment of the products, a pit steaming chamber was used with heated steam supplied as a coolant from an external boiler room. The full cycle of hardening processes consisted of a stepwise temperature rise with periods of initial and intermediate exposure of the concrete mixture, followed by a period of isothermal exposure of the products at a maximum temperature of 80°C. This technique enabled the neutralization of the unevenness of the temperature field along the cross-section of the product, thus stabilizing the kinetics of chemical reactions and considerably reducing destruction in the material structure. Heat and moisture treatment was performed until 70% of the design strength of the concrete was reached.

In general, the technological flowchart of the two-stage method of preparing the concrete mixture for basic products is shown in Fig. 1.

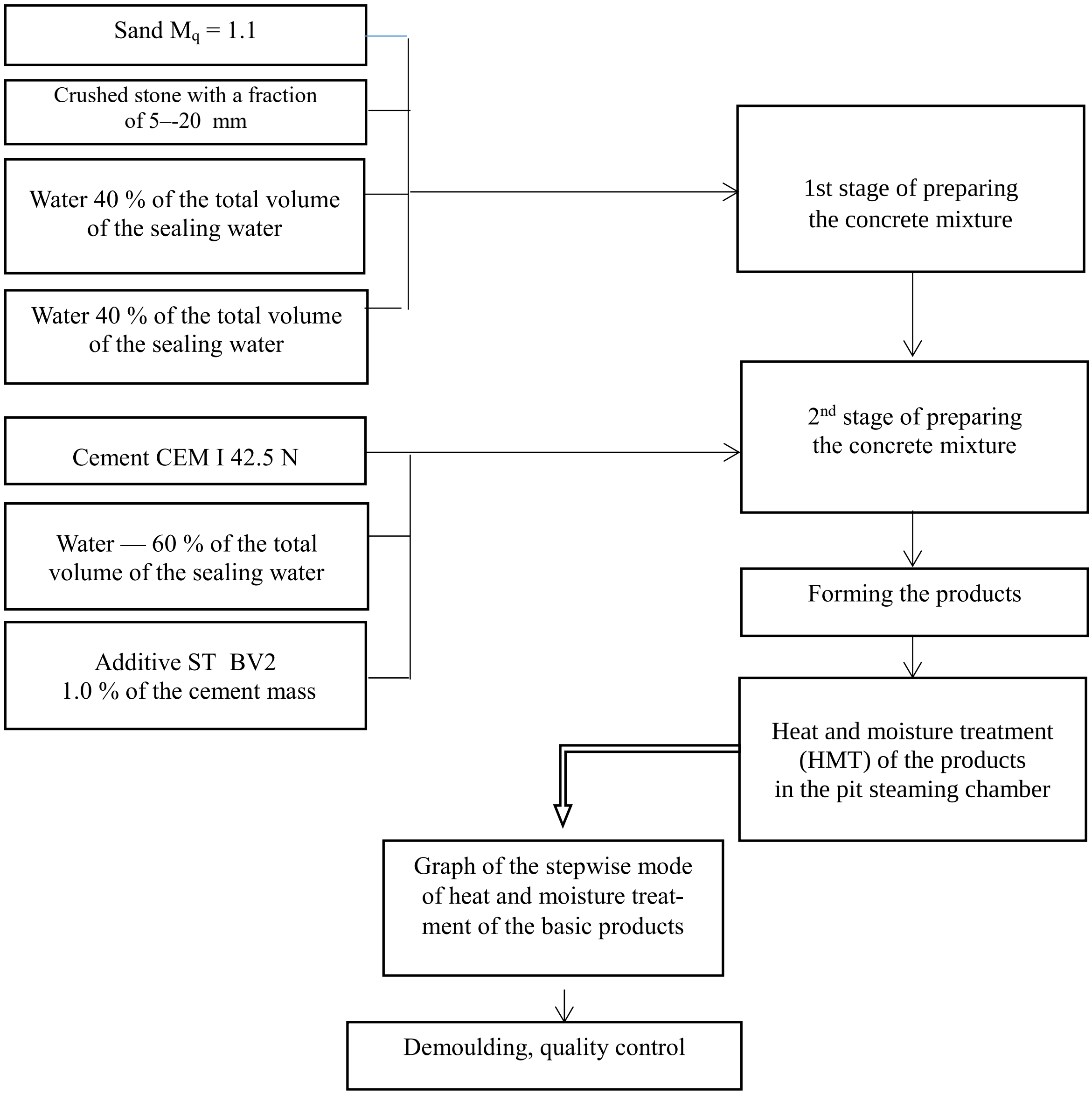

Fig. 1. Block diagram of a two-stage method for preparing the concrete mix for the factory-made reinforced concrete products

The methods developed in compliance with the research aim, which is to increase the efficiency of precast reinforced concrete technology using the example of the production of lintels for covering window and door openings of residential, civil and industrial buildings, enabled us to reduce the cement consumption by 15% and cut down by 0.3 kg/m^3 the superplasticizer consumption at the existing construction industry enterprises with no additional costs for reconstruction and technical re-equipment.

The suggested methods for increasing the efficiency of production technology are readily applicable to most precast reinforced concrete products and structures. At the same time, in each specific case, it is necessary to adjust the formulation and technological solutions accounting for the product requirements, the local raw material base and the specifics of the existing enterprise. Such an adjustment can be made with the forces and the factory laboratory equipment.

Apart from the direct economic effect at the construction industry enterprise, the suggested methods would contribute to improving the ecological state of the environment and reducing the cost of enriching local aggregates and disposing of the waste.

References

1. Fotin OV Construction of Precast Reinforced Concrete. *Building Materials*. 2023;4:32–34, (In Russ.) https://doi.org/10.31659/0585-430X-2023-812-4-32-34

2. Davidyuk AN Concrete in Construction - New Challenges and Prospects. *Bulletin of NIC Construction*. 2017;1(12):5–13. (In Russ.) URL: https://elibrary.ru/item.asp?edn=YINMWP&ysclid=m830uuh8d0610542454 (accessed: 14.04.2025).

3. Yelishev KS Formation of the Structure of Heavy Concrete for the Production of Wall Panels. *The Scientific Heritage*. 2021;78-1(78):13–15. (In Russ.) https://doi.org/10.24412/9215-0365-2021-78-1-13-15

4. Zelenkovskaya ZhL, Kovshar SN Purpose and Justification of Traditional Modes of Heat Treatment of Concrete and Reinforced Concrete Products. *Science & Technique*. 2023;22(2):150–157. (In Russ.) https://doi.org/10.21122/2227-1031-2023-22-2-150-157

5. Serebryanaya I, Egorochkina I, Shlyakhova E, Matrosov A Investigation of the Contact Zone Between Cement Stone and Various Types of Aggregates in Concrete. *Networked Control Systems for Connected and Automated Vehicles.* 2022;509:1615–1622. https://doi.org/10.1007/978-3-031-11058-0_164

6. Bazhenov YuM, Murtazaev S-AYu, Bataev DK-S High-strength concretes based on anthropogenic raw materials for earthquake resistant high-rise construction. *Engineering Solid Mechanics.* 2021;9(3):335–346. https://doi.org/10.5267/j.esm.2021.1.004

7. Dzhabarov AS, Belov VV Screening as an Alternative to the Used Aggregates for Concrete. *Building Materials*. 2024;5:28–33. (In Russ.) https://doi.org/10.31659/0585-430X-2024-824-5-28-33

8. Kurbatov VL, Pecheny BG, Kireev VG, Komarova ND Influence of Pollutants in Aggregates on the Properties of Concrete Mixtures and Concretes. *Modern Science-Intensive Technologies*. 2017;9:34–41. (In Russ.) URL: https://top-technologies.ru/ru/article/view?id=36797 (accessed: 14.04.2025).

9. Fediuk R, Mochalov A, Timokhin R Review of methods for activation of binder and concrete mixes. *AIMS Mater. Sci.* 2018;5(5):916–931. https://doi.org/10.3934/matersci.2018.5.916

10. Lotov VA, Sukharev EA, Kutugin VA Preliminary Activation of a Cement-Sand Mixture in Order to Increase the Strength of Concrete. *Izv. vuzov. Chemistry and Chemical Technology*. 2022;65(8):94–101. (In Russ.) https://doi.org/10.6060/ivkkt.20226508.6595

11. Ibragimov R, Fediuk R. Improving the early strength of concrete: Effect of mechanochemical activation of the cementitious suspension and using of various superplasticizers. *Construct. Build. Mater.* 2019;226:839–848. https://doi.org/10.1016/j. conbuildmat.2019.07.313

12. Velichko E, Polkovnikov N, Sadchikova Yu. Efficient concrete increased water resistance modified with mineral and polymeric additives. *E3S Web of Conferences*. 2019;97:02017. https://doi.org/10.1051/e3sconf/20199702017

13. Nesvetaev GV, Lopatina YuYu Design of Macrostructure of Self-Compacting Concrete and its Mortar Component. *Internet Magazine "Naukovedenie"* 2015;7(5). (In Russ.) http://dx.doi.org/10.15862/48TVN515

14. Shlyahova EA *Method of Preparing Concrete Mixture.* Patent RU 2714895 C1 (2020) (In Russ.)

15. Sakanov DK Effective Massive Aggregates for Top Layer of Concrete Pavement. *Problems of Modern Concrete and Reinforced Concrete.* 2016;8:213–224. https://doi.org/10.23746/2016-8-12

16. Kadyrova DSh Strength and Deformative Properties of Concrete Based on Local Raw Materials and Industrial Waste. *Modern Industrial and Civil Construction*. (In Russ.) 2021;17(2):93–101. URL: https://donnasa.ru/publish_house/journals/spgs/2021-2/03_kadyrova_saydullaev.pdf (accessed: 14.04.2025).

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