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Complex modified additive for concrete based on industrial waste

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Abstract. The article presents the results of studies of concretes with the use of additives developed based on industrial waste: ash, post-alcoholic bard, and soapstock. The aim of the research was to improve the physical and mechanical characteristics of concrete without increasing its cost. The research was carried out for samples of different ash concentrations and the corresponding percentage of the additive. The material quality was assessed by comparing the results of laboratory tests of the binder and concrete: strength, bending strength, setting time (for the binder); cube strength, water absorption, frost resistance (for concrete). The test results showed the effectiveness of the additive, which can compensate for the losses of physical and mechanical characteristics due to the inclusion of ash into the concrete (to reduce costs). The optimum concentration of the additive is 0.004% by weight of cement, with a cement ash replacement rate of 5%. At these proportions, the investigated parameters, albeit insignificantly, exceed the samples of the traditional composition of concrete without additive, and at a lower concentration of ash, they exceed them to a large extent. The obtained results of the study are of practical value, can be used in construction without reference to the region, as the applied wastes belong to the standard industrial sectors.

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1. Introduction

Today, reinforced concrete structures and products are among the most demanded materials in both civil and industrial construction [1]. Surrounding buildings and structures do not make do without the use of concrete, even in road construction concrete has widespread use [2].

The history of the development of concrete dates back to ancient times, but to this day has active development. Modern technology favors the future prospect of the development of technology for the use and production of concrete in construction [3]. New types of concrete find application in modern practice, such as fiber concretes, self-compacting concretes, carbon concretes, nanoconcretes, and others [4–7].

However, most of the transformation process of concrete as a building material does not involve the development of new materials, but the use of additives to improve its physical and mechanical properties. An additive can be selected, for example, depending on the technological application of concrete or to improve certain concrete properties: setting or hardening rate, an increase of strength, water absorption, frost resistance, etc. [8–10].

This article deals with increasing the strength of concrete through the use of additives. It can be informed that today the construction market has enough specialized additives to improve the strength of concrete [11]. However, this approach to solving the problem will affect the cost of concrete, so the proposed additives are developed from the wastes of industrial production in the region where the research was conducted. In this case, the used waste is not a localized feature of a particular region, but rather an integral part of a particular technological production [12]. Thus, solving the problem of increasing the strength of concrete partially closes the urgent environmental issue of industrial waste disposal [13].

The technical solution to increase the strength of concrete (as well as the accompanying reduction of water absorption and increase in frost resistance) is achieved by using the following components represented by industrial production wastes: post-alcoholic bard (refers to the alcohol production waste), soapstock (refers to the category of fat production waste return), an alkali (caustic soda, NaOH) [14]. In addition to the developed composition, in order to save the binder it was decided to include in the composition of the additive – fly ash [15, 16]. The addition of ash helps to reduce the cost of concrete, as a building product, by reducing the amount of cement [17, 18]. Acceptable addition of ash to the composition of concrete mixture is up to 5 %, while the changes in the characteristics of concrete are minimal, strength losses are insignificant, but they take place. Compensation, and in our case even an increase in strength is due to the use of additives, in particular post-alcohol bard [19]. Post-alcohol bard essentially has plasticizing and hydrophobic properties due to the presence of polymeric components in its composition [20]. Bard has a relatively small plasticizing effect, but sufficient to compact the concrete mixture (by filling the pore structure of ash). The hydrophobizing effect of bard refers to the infrastructural hydrophobization of concrete [21]. The polymer, in the composition of bard, is inherently hydrophobic, that is after curing does not react with water [22]. In the process of mixing, the polymeric component is distributed throughout the entire volume, and during setting, it fills the pore (micropore) structure of the concrete. This leads to a loss of the chemical contact area of water and the inherently hydrophilic concrete, thus increasing the hydrophobicity of the material [23]. Soapstock is a fatty product that forms a convex meniscus when it interacts with water. In contrast to the bard, the non-wettability of soapstock with water contributes to the concrete's volumetric hydrophobicity. However, a positive effect can be achieved only by including caustic soda in the composition of the additive, which brings the soapstock into contact with water. However, once in the concrete mixture, caustic soda reacts chemically with the concrete mixture, restoring the primary hydrophobic properties of soapstock. Thus, the output is concrete with enhanced hydrophobic properties [24, 25].

The aim of the study is to determine the optimal composition of concrete using industrial waste to improve the physical and mechanical characteristics of the material. The optimality of the composition consists in determining such a quantity of components, in which there is no reduction in the strength of the concrete due to the replacement of cement binder by ash. The latter is made in order to reduce the cost of concrete and recycling of industrial waste.

2. Methods

To produce a complex modified additive it is necessary to have a rational ratio of all the components according to their characteristics, taking into account their impact on the qualitative indicators of the heavy concrete. The ratio of the components of the complex modified additive by weight are post-alcohol bard (48 %), soapstock (47 %) and caustic soda (5 %).

The technological process of preparation of the additive is shown schematically in Fig. 1.

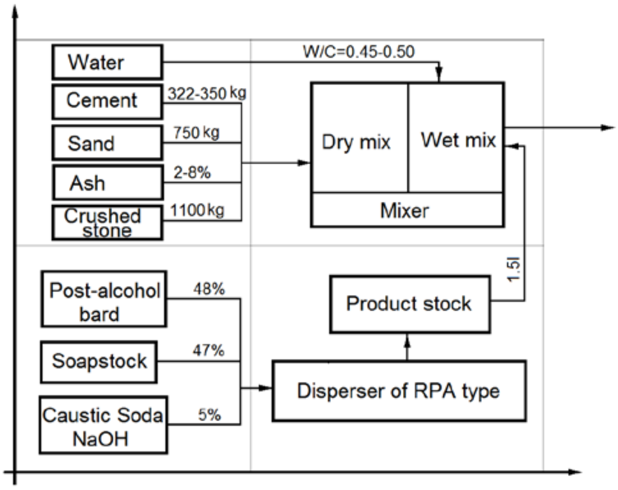


Figure 1. Technological process of additive production.

The combination process should be carried out in the following sequence: caustic soda is combined with soapstick until complete dissolution at a temperature not below 60 °C; next the resulting solution is passed through the rotary pulsation apparatus (RPA dispersant) to accelerate the chemical reaction with soapstick; then the resulting water-soluble emulsion is combined with post-alcohol bard and repeatedly passed through RPA. The resulting emulsion is readily soluble in water, thus providing a set of properties of both hydrophobization and plasticization. The technological process allows for a homogeneous emulsion easily soluble in water without the formation of oil spots, which cannot be achieved with the usual combination of the same components by mechanical agitation without despergation. The whole production process should be carried out at a temperature of not less than 60 °C. The percentage of complex modified additive in concrete mortar varies depending on the percentage of the binder, ranging from 0.5 to 0.8 %.

Determination of the composition of industrial waste to assess their suitability in the cement binder in the production of a complex additive was carried out by chemical analysis. Soapstock has the following composition: fat 38–40 % neutral fat 7–11 %, nonfat components (proteins and carbohydrates) 55–50 % in water, unreacted NaOH and NaCl 0.001-1 %. Post distillery stillage used as an additive has the following composition: crude protein 2.0 %, non-fatty substances 3.0 %, fat 0.5 %, cellulose 0.5 %, the rest is a liquid phase (mostly water with dissolved substances of proteins, cellulose, fats, casein, lignin). Hydrotreatment ashes include: silicon dioxide (SiO_2) – up to 52 %, aluminum oxide (Al_2O_3) – up to 18 %; quicklime (CaO) – up to 13 %, magnesium oxide (MgO) – up to 2 %, iron scale (Fe_2O_3) – up to 7 %, sulfur dioxide (SO_3) – up to 3 %, alkali metals – up to 2 %, ash residue – up to 7 %.

Research on the effect of a complex modified additive on the improvement of physical and mechanical properties of concrete as a building material was carried out in two stages. At the first stage, the performance of the binder with ash was evaluated in comparison with the standard cement binder of the classic technology of concrete production. The first phase aims to evaluate the impact of ash in the composition of the binder on its physical and mechanical properties. The quantitative composition of ash in the composition of the binder is presented in Table 1, the increment of ash component concentration is a multiple of 2 %. In the second phase, the evaluation of concrete as a building material was carried out. The evaluation was also carried out in comparison with the classic technology of production of concrete, standard composition. The purpose of the second stage is to evaluate the effect of the complex modified additive on improving the physical and mechanical properties of concrete. That is, if the component of the first stage contributes to the deterioration of the qualities of the material, the component of the second stage compensates for these losses. Thus, at the output, we get a quality similar to the classical technology of concrete, but with a lower cost, due to the replacement of the components in the composition of the concrete waste industry. Studies are a complex of laboratory tests related to the basic methods of assessing the properties of building materials. Qualitative and quantitative composition of the components of the compared binders and compared samples of concrete are presented in Table 1, where type 1, in both cases, refers to the classical method of production of concrete.

Table 1. Qualitative and quantitative composition of binders and concrete.

Type, number	Cement (PC400 D0), kg	Sand, kg	Ash, kg	Water/Cement	Crushed stone, kg	Additive, l
Step 1 – Examination of the binder						
Type 1	1.00	3.00	0	0.30	–	–
Type 2	0.98	3.00	0.02 (2%)	0.31	–	–
Type 3	0.96	3.00	0.04 (4%)	0.33	–	–
Type 4	0.94	3.00	0.06 (6%)	0.37	–	–
Type 5	0.92	3.00	0.08 (8%)	0.45	–	–
Step 2 – Examination of the concrete						
Type 1	350	750	–	0.45	1100	–
Type 2	343	750	7 (2%)	0.40	1100	1.5
Type 3	336	750	14 (4%)	0.42	1100	1.5
Type 4	329	750	21 (6%)	0.45	1100	1.5
Type 5	322	750	28 (8%)	0.50	1100	1.5

A complex of basic laboratory tests of the binder, Fig. 2A:

- Determination of strength according to Interstate Standard GOST 6139-2003 EN 196-1;
- Determination of the bending strength of Interstate Standard GOST 6139-2003 EN 196-1;
- Determination of the setting time in accordance with Interstate Standard GOST 30744-2001.

A set of basic laboratory tests of concrete samples, Fig. 2B:

- Determination of cubic strength according to Interstate Standard GOST 10180-2012;
- Determination of water absorption according to Interstate Standard GOST 12730.3-78;
- Determination of frost resistance according to Interstate Standard GOST 10060-2012.

A

B

Figure 2. A set of laboratory tests.

Tests were conducted for standard samples: prismatic specimens (beams), dimension 40×40×160 mm; cubic specimens (cubes), dimension 100×100×100 mm. Each test was performed for 5-8 samples, to evaluate the average performance of the compared types of materials.

3. Results and Discussion

3.1. The results of determining the strength of the binder

The test results of the strength of the binder are shown in Fig. 3. Fig. 3A shows the dependence of the average values of compressive strength by type of sample, Fig. 3B shows the progression of strength reduction from the percentage of ash in the composition of the binder.

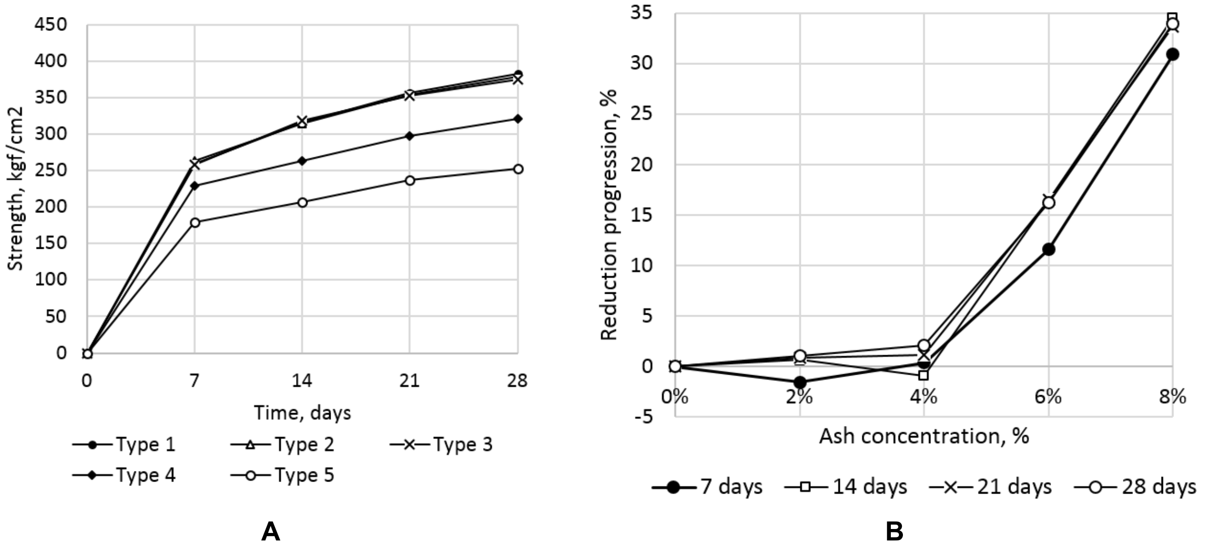


Figure 3. Results of strength tests.

According to the test results, the reduction of strength properties is not linear, despite the proportional replacement of the cement component by ash. Reduction of compressive strength at 2 % substitution with ash was up to 1.0 %, at 4 % substitution it was 1.2–1.7 %, at 6 % substitution it was 11.5–16.4 %, at 8 % substitution it was 30.8–34.5 %. The obtained average values of strength of the eight individual values have good statistical indices: Type 1 – quadratic deviation is 5.77 with an average value of 383 kgf/cm^2 (28 days), coefficient of variation is 2.33 %; Type 2 – deviation – 3.71 with an average value of 379 kgf/cm^2, coefficient of variation – 1.17 %; Type 3 – deviation – 4.07 with an average value of 375 kgf/cm^2, the coefficient of variation – 1.14 %; Type 4 – deviation – 5.81 with an average value of 321 kgf/cm^2, the coefficient of variation – 1.51 %, Type 5 – deviation – 3.14 with an average value of 252 kgf/cm^2, the coefficient of variation – 1.51 %. From the above data we can conclude about the close relationship of individual values within each type of material, as well as a high degree of reliability of the results obtained.

The test results of the strength tests showed a non-linear character of strength reduction by the equivalent replacement of cement by ash, multiple of 2 % by mass. The cause of the progression may be the low density of ash due to its friability, which partially persists even at mixing with additives having plasticizing properties.

3.2. The results of the determination of the setting time

The results of the setting time tests of the compared samples are shown in Fig. 4. Fig. 4A shows the results of the average and individual values of the beginning and end of the setting (beginning of hardening) according to the type of specimen. Fig. 4B shows the results of the changes in the same times depending on the concentration of the ash component. The results of the mixture setting time do not contradict the results of similar studies, in which the ash was also used [26].

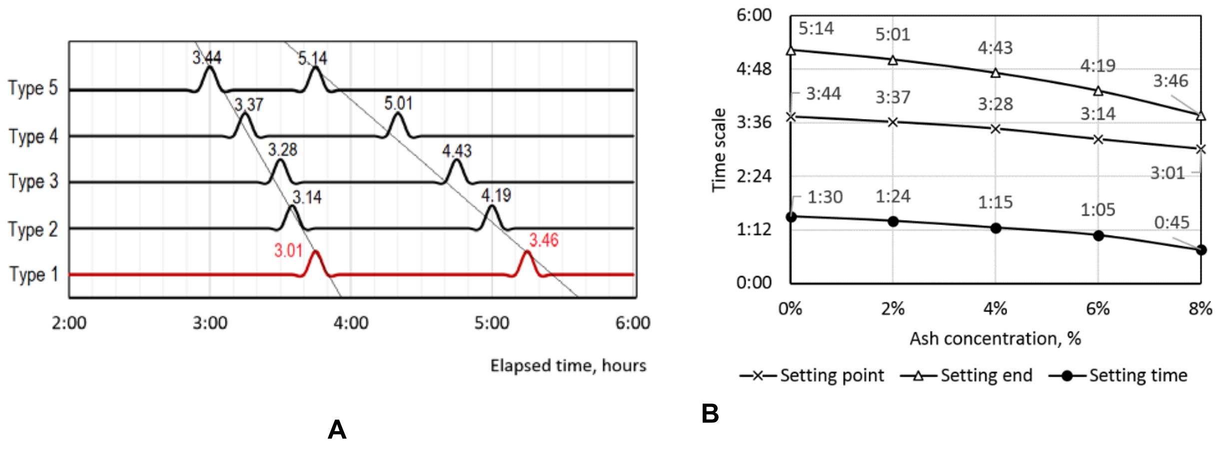


Figure 4. Results of strength tests.

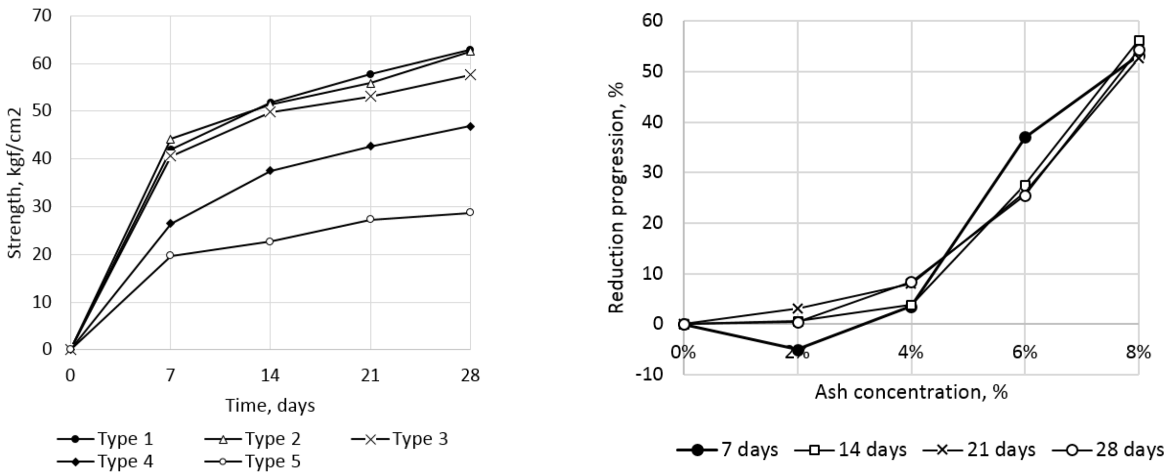
In this case, there is a relatively stable variation at the beginning of the setting time depending on the ash content. The difference of the end-setting times has a greater variation concerning the beginning of setting depending on the type of specimen. This is confirmed by comparing the angles of deviation from the standard cement-sand mortar (without ash) shown in Fig. 4A. In addition, when the concentration of the ash component increases, the setting time decreases due to the absorption capacity of the ash. Compared to the standard cement-sand mortar, the percentage reduction in setting time is as follows: for 2 % replacement of cement with ash – 6.7 % reduction in time, for 4 % – 16.7 %, for 6 % – 27.8 %, for 8 % – 50.0 %. At the same time, there is a nonlinear increase in the percentage reduction in terms according to the linear increase in concentration.

The average values are shown in Fig. 4B also confirm the effect of the ash component on the setting time. According to the statistical processing of the data, all individual values of the setting values have a close relationship and high reliability of the results: Type 1 – maximum quadratic deviation (end of setting) is 4.74, coefficient of variation is 2.8 %; Type 2 – quadratic deviation (end of setting) is 7.48, coefficient of variation is 2.3 %; Type 3 – quadratic deviation (beginning of setting) is 4.18, coefficient of variation is 3.2; Type 4 – quadratic deviation (end of setting) is 7.32, coefficient of variation is 5.29; Type 5 – quadratic deviation (end of setting) is 6.21, coefficient of variation is 6.31.

The decrease of the setting time (beginning and end) with the increase of the ash component can be explained by the absorption capacity of the ash. At the same time according to water-binding ratio tests obtained by measuring the flowability of ash-cement-sand mortar, the absorption effect is accompanied during the whole setting period. Consequently, the depletion of water necessary for hydration and workability (mobility) occurs in geometric progression.

3.3. The results of determining the bending strength of the binder

The results of the bending strength tests of the beams are shown in Fig.5. Fig. 5A shows the results of private and average values of bending strengths depending on the type of material, Fig. 5B shows the results of progression of changes in the average values of bending strengths according to the percentage of ash component. The results obtained do not contradict, but, on the contrary, correspond to the results of similar studies of the bending strength of specimens using ash [17, 27].



A **B**

Figure 5. Bend test results.

There is also a non-linear progression of strength change with a uniform increase of ash components in the composition of the binder. The decrease in flexural strength at 2 % substitution with ash is up to 4.9 %, at 4 % substitution it is 3.5–8.4 %, at 6 % substitution it is 25.4–37.1 %, at 8 % substitution it is 52.7–56.2 %. Compared with the strength of the mass, there are a greater relative progression of the reduction of the bending strength (exceeding 1.5 times) quantitative indicators with the increase in the ash component. The obtained average bending strength values also have good statistical indices: Type 1 – quadratic deviation is 2.11 with an average value of 62.9 kgf/cm^2 (28 days), coefficient of variation is 3.35 %; Type 2 – deviation – 1.98 with an average value of 62.6 kgf/cm^2, coefficient of variation – 3.16 %; Type 3 – deviation – 2.05 with an average value of 57.6 kgf/cm^2, coefficient of variation – 3.55 %; Type 4 – deviation – 1.27 with an average value of 46.9 kgf/cm^2, coefficient of variation – 2.71 %; Type 5 – deviation – 1.03 with an average value of 28.7 kgf/cm^2, coefficient of variation – 3.59 % Therefore, we can conclude about the close relationship of individual values within each type of material and the high degree of reliability of the results.

The increase in the progression of the decrease in the bending strength compared to the strength of the grade may be due to an increase in the brittleness of the material, that is, the low resistance to tangential stresses as a result of the increased porosity of the material.

3.4. The results of determining the cube strength of concrete

Fig. 6 shows the results of cube strength tests of concrete specimens using the additive. Fig. 6A shows the results of average strength values as a function of ash concentration, Fig. 6B shows the progress of percent strength reduction by specimen type. The results of the strength test are consistent with similar studies to determine the optimal waste content [17, 27, 28].

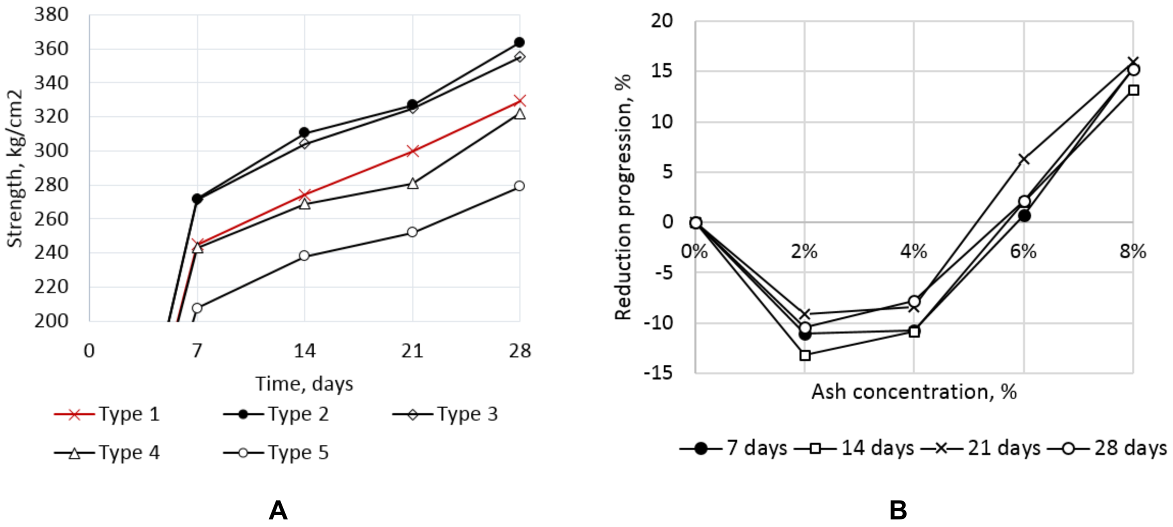


Figure 6. Compressive strength test results.

Non-linear progression of percentage change of strength in comparison with the samples of type 1 (classical technology) is: at 2 % substitution of ash – 9.1÷13.2 %, at 4 % substitution – 7.8–10.9 %, at 6 % substitution –0.7–6.3 %, at 8 % substitution – 13.2–15.9 %. That is the most approximate, but not satisfactory (since all the values below the samples of type 1) have shown the results of type 4 (which corresponds to 6 % of ash concentration). The obtained values of compressive strength of the concrete also have good statistical indices: Type 1 – quadratic deviation is 2.11 with an average value of 62.9 kgf/cm^2 (28 days), coefficient of variation is 3.35 %; Type 2 – deviation – 1.98 with an average value of 62.6 kgf/cm^2, coefficient of variation – 3.16 %; Type 3 – deviation – 2.05 with an average value of 57.6 kgf/cm^2, coefficient of variation – 3.55 %; Type 4 – deviation – 1.27 with an average value of 46.9 kgf/cm^2, coefficient of variation – 2.71%; Type 5 – deviation – 1.03 with an average value of 28.7 kgf/cm^2, coefficient of variation – 3.59 % Therefore, we can conclude about the close relationship of individual values within each type of material and the high degree of reliability of the results.

3.5. The results of determination of frost resistance

Fig. 7 shows the results for frost resistance of concrete specimens. Fig. 7A shows the results of private and average strength values depending on ash concentration after cyclic freezing of specimens (150 cycles), Fig. 6B shows the progress of percentage reduction of strength by specimen type.

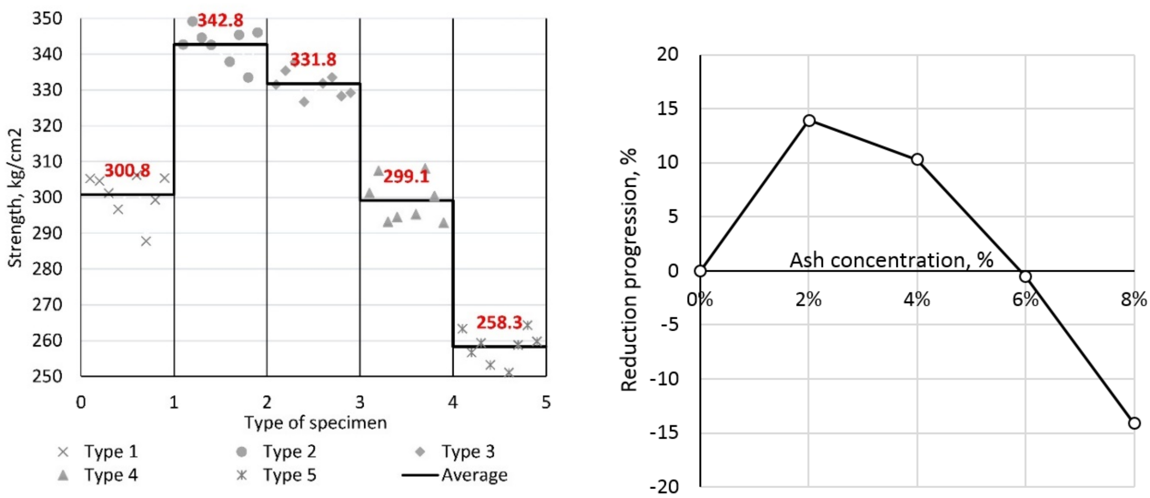


Figure 7. Results of frost resistance tests.

In this case, the non-linear progression of percentage change in strength after freezing is as follows relative to type 1 sample (also after freezing): at 2 % substitution with ash up to 13.94 %, at 4 % substitution up to 10.29 %, at 6 % substitution up to 0.56 %, at 8 % substitution up to 14.12 %. According to the results of statistical processing of data, the obtained values have a close connection and a high degree of reliability, in all cases, the coefficient of variation of individual values does not exceed 9 % (according to the requirements of GOST 100060-2012): Type 1 – quadratic deviation is 6.25 with an average value of 301 kgs/cm^2 (28 days), coefficient of variation is 2.07 %; Type 2 – deviation – 4.96 with an average value of 343 kgs/cm^2, coefficient of variation – 1.44%; Type 3 – deviation – 3.72 with an average value of 332 kgf/cm^2, the coefficient of variation – 1.12 %; Type 4 – deviation – 6.15 with an average value of 299 kgf/cm^2, the coefficient of variation – 2.05%, Type 5 – deviation – 4.55 with an average value of 258 kgf/cm^2, the coefficient of variation – 1.76 %.

3.6. The results of water absorption determination

Fig. 8 shows the results of water absorption tests of concrete specimens. Fig. 8A shows the results of the individual parameter values for assessing the water absorption capacity of concrete as a function of ash concentration, Fig. 8B shows the progress of the percentage reduction in water absorption by type of specimen.

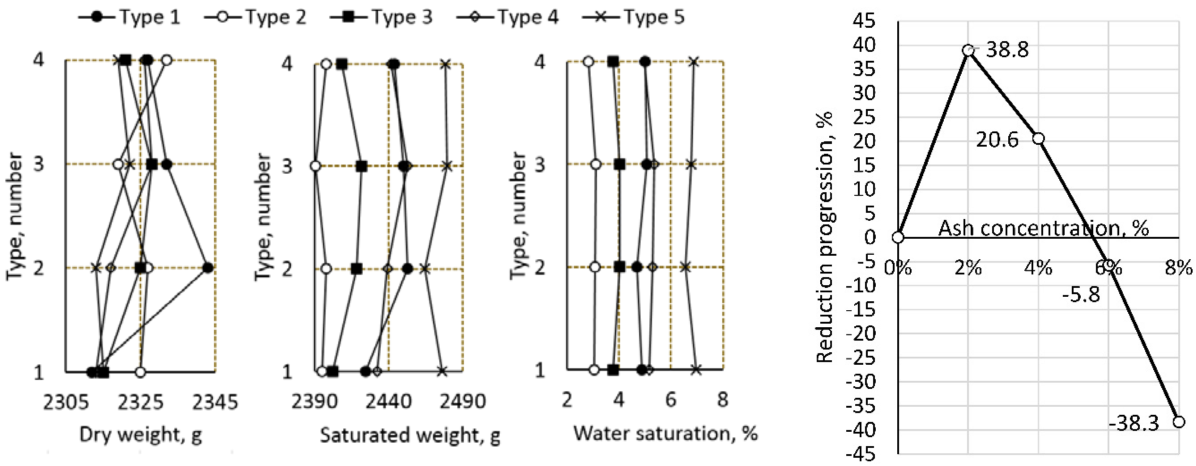


Figure 8. Water absorption test results.

In this case, the non-linear progression of percent change in water absorption capacity is: at 2 % substitution by ash to 38 %, at 4 % substitution to 21 %, at 6 % substitution to 9 %, at 8 % substitution to 41 %. According to the results of statistical processing of the data, the values obtained are also closely related and have a high degree of reliability: Type 1 – quadratic deviation is 0.17, coefficient of variation is 3.42 %; Type 2 – quadratic deviation is 0.12, coefficient of variation is 3.92 %; Type 3 – quadratic deviation is 0.14, coefficient of variation is 3.70 %; Type 4 – quadratic deviation is 0.17, coefficient of variation is 3.20 %, Type 5 – quadratic deviation is 0.18, coefficient of variation is 2.62 %. The close relationship of the coefficients of variation indicates a high degree of validation of the test method and the purity of the experiment. Comparing the results of different types of specimens one can conclude about the effect of the additive on the hydrophobic properties of concrete, and the relatively insignificant difference of weights in the dry state indicates its plasticizing properties (reduction of natural porosity of ash). A significant difference in water absorption capacity of different types is visually traceable by the nature of divergence of the curves of Fig. 8. If in the diagram of dry masses the curves overlapped in places, as a result of random arrangement of the results, in the diagram of water absorption the same curves are distant from each other. Moreover, the curvature and flatness of the water absorption curves indicate the absence or presence of a pattern of influence of the additive on the water absorption capacity of the material. The obtained results of water absorption have a similar relationship to the studies where cement substitution with ash was used [26].

3.7. The evaluation of the optimal composition of the concrete mixture

Fig. 9 shows summary evaluation diagrams, based on which a sample of the optimal composition of the concrete mixture is made. Each of the diagrams represents the dynamics of change of one of the evaluation criteria (previously defined physical-mechanical characteristics of concrete) depending on the type of sample relative to the classical concrete production technology (Type 1). Fig. 9A presents a general comparative diagram of the percentage changes in the physical and mechanical parameters of concrete, Fig. 9B compares the changes in the binder strength and cube strength of concrete, 9C compares the strengths without freezing and after cyclic freezing, 9D compares the strength after cyclic freezing and water absorption capacity.

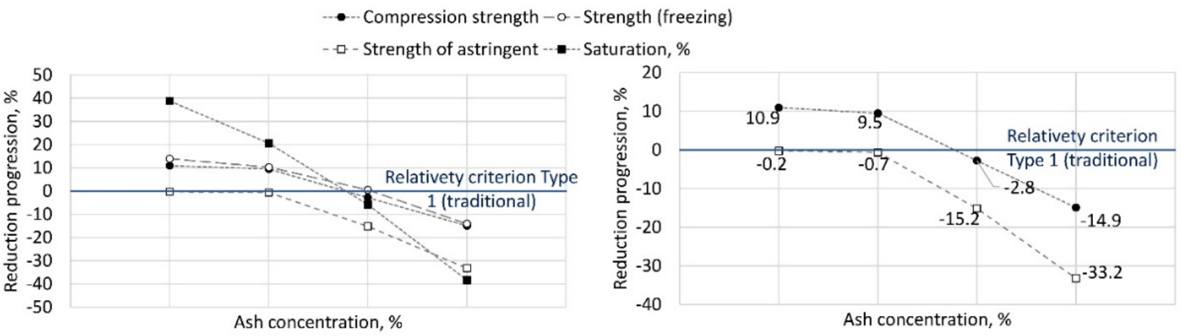


Figure 9. Comparative diagrams of concrete evaluation criteria.

Comparing the percentage progression of strength changes of binder and concrete samples, it can be concluded about the influence of the additive on the improvement of strength characteristics. The dynamics of progression in both cases is identical, the percentage increase in cube strength of concrete from the initial strength of the binder is: for type 1 – 11.1 %, type 2 – 11.2 %, type 3 – 12.4 %, type 4 – 18.3 %, corresponding to a positive correlation coefficient (x_i – ash content with addition, y_i – strength gain) 0.861. Thus, the loss of strength when adding the ash component is compensated by the introduction of a modified additive. Comparing percentage progression of strength change of specimens before and after cyclic freezing, we can conclude about the influence of additive on concrete durability, since strength loss after freezing in percentage ratio is for type 1 – $100\%\left(1-{}^{301}\!/_{329}\right)=8.58\%$, type 2 – $100\%\left(1-{}^{364}\!/_{343}\right)=5.83\%$, type 3 – $100\%\left(1-{}^{332}\!/_{355}\right)=6.54\%$, type 4 – $100\%\left(1-{}^{299}\!/_{322}\right)=7.11\%$, type 5 – $100\%\left(1-{}^{258}\!/_{279}\right)=7.41\%$ At the same time, there is a trend of gradual increase in strength loss depending on the content of the ash component. Theoretically, the results of frost resistance should correlate with the results of water absorption, since the former depends directly on the latter, that is, the loss of strength from the degree of water saturation of the sample. Nevertheless, the percentage progression of water absorption has a sharper character in relation to strength (by frost resistance), the difference is: for type 1 – 24.9 %, type 2 – 10.3 %, type 3 – 5.8 %, type 4 – 24.2 %, which corresponds to a negative correlation coefficient (x_i is ash content with additive, y_i is strength increase) –0.998. Which is directly related to the perceptibility of the absorption effect of ash with the increase of its concentration. Despite the character, the general tendency of the curve propagation indicates the relative influence of the additive on the water absorption capacity of concrete, depending on the ash concentration.

According to the results of comparisons, the optimal composition in all cases will be that composition in which the physical and mechanical characteristics are not inferior to the traditional concrete, in our case, it is the concentration of the ash component between type 3 and 4. The minimum of the three interpolated criteria will be 5.7 %. As the recommended ash concentration (without loss of physical and mechanical properties of concrete) of the concrete composition can be taken a concentration equal, for reliability, to 5 % of the mass of cement, provided the proposed modified additive is used.

4. Conclusion

1. A complex modified additive for improving the strength and reducing the water absorption of concrete has been developed and tested. Full solubility of the additive in water allows it to react effectively with a cement binder without the formation of micropores with reduced water-cement ratio and thereby improve the physical and mechanical, and construction-technical properties of concrete.

2. The complex of laboratory studies was carried out in two stages: the first stage assessed the impact of the ash concentrate on reducing the strength properties; the second stage assessed the impact of the additive on increasing the strength. The results of the research represent the composition of concrete mixture with a rational concentration of ash and additive, without any loss of concrete strength.

3. According to the results of the measurement of the binder, a pattern of decrease in physical and mechanical properties of the binder depending on the concentration of ash from 2 to 8 % by mass of cement was obtained. In all cases, a non-linear progression of the decrease of the compared characteristics was observed despite the proportional replacement of the cement component by ash. The reduction of strength ranged from 1.0 % to 34.5 %, the reduction of setting time from 6.7 % to 50.0 %, the reduction of flexural

strength from 4.9 % to 56.2 %. The above figures indicate a significant impact of the ash component, despite its insignificant percentage in the composition of the binder, on its characteristics.

4. According to the results of measurements of concrete, the dependence of the effect of additive on the increase of its physical and mechanical properties at the same concentration of ash binder was obtained. Nonlinear progression of percentage change in strength is from 0.7 to 15.9 %, change in strength after 150 cycles of freezing is from 0.56 to 14,12 %, change in water absorbency is from 4 to 41 %, depending on the percentage of ash content. The patterns obtained testify to the influence of the additive on the physical and mechanical properties, in particular strength and durability.

5. According to the results of comparisons according to the evaluation criteria (previously determined physical and mechanical characteristics of concrete), the optimal composition of cement-ash binder and complex modified additive was determined. In most cases, the dynamics of progression of changes in characteristics by changing the concentration of ash component has a similar gradual pattern. The optimum composition is the concentration of ash component between type 3 and 4, but satisfying the condition of identical properties of concrete of traditional composition (not lower). In general, the confidence concentration of the ash component replacing the cement binder is 5 %, the modified additive – 0.004 % by mass of cement.

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