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Research of physical-mechanical and physical-chemical properties of expanded direction concrete with complex polymer - mineral additive of a new generation based on local raw materials

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Abstract. The results of physico-chemical analysis using infrared spectroscopy, X-ray phase analysis and electron microscopy of the microstructure of cement stone and the processes of change: hydration, crystallization, etc. are presented. in cement systems, with the addition of new generation complex chemical additives of the Relaxol KDJ-3 series. It has been established that in cement systems these additives help create new formations that crystallize in a finely dispersed form, clog the pores and capillaries of Portland cement stone, compacting and strengthening its structure. The introduction of the KDJ-3 additive into expanded clay concrete compositions makes it possible to increase its density by 8-10% and strength by 40% compared to the design strength.

1 Introduction

The rapid development of the global construction industry and rising prices for fuel and energy resources lead to the need to create and implement resource-saving and energy-saving technologies in the production of building materials and products. In this regard, the use of new types of environmentally friendly materials in the field of building materials, the effective use of energy-saving technologies, the improvement of new building materials and their existing technologies, thereby improving the physical-mechanical and physical-chemical properties of concrete and concrete mixtures. In this regard, special attention is paid to the creation of compositions of concrete and concrete mixtures, energy-saving technologies for their production with chemical additives based on local raw materials.

Currently, in Uzbekistan and abroad, concretes of almost all compositions are developed and produced with complex chemical additives. However, complex chemical additives created by scientists of the Republic of Uzbekistan are being introduced into concrete technology in very limited quantities. The introduction of complex chemical additives into the composition of concrete mixtures significantly changes their properties;

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complex chemical additives increase mobility, reduce the water requirement of the concrete mixture, which leads to increased strength, accelerates hardening in the first day and at the same time has a positive effect on increasing frost resistance, durability and other operational properties of concrete.

The scientific significance of the research results, the development and use of complex chemical additives is due to the desire to make maximum use of the positive and eliminate the negative properties of individual additives, mainly hardening accelerators and surface-active substances. By correctly combining the types and quantitative ratios of additives, it is possible to specifically regulate the structure and physical and mechanical properties of cement stone and concrete.

Physico-chemical studies of the microstructure of cement compositions with polymer modifying additives. In accordance with the classification of additives according to GOST 30459-2008, superplasticizers (SP) are classified as additives that regulate the properties of concrete mixtures, and occupy first place in the group of plasticizing additives. This is due to the extremely high effect of liquefaction of the concrete mixture without reducing the strength of concrete during all test periods. [1].

The addition of TPP fly ash as an additive or filler when preparing concrete mixtures helps to increase the strength of concrete. Today, effective results are obtained by preparing aerated concrete by adding up to 50% fly ash to the composition of the total dry mixture [2].

SPs appeared in the early 70s as a result of research by Japanese and German scientists. The main idea of creating such additives was to obtain concrete mixtures that could be placed in forms without using mechanical influences, or using them with a sharp decrease in the level of intensity of such influences [3, 4].

2 Materials and methods

Physico-chemical methods of analysis help to study the microstructure of cement stone and change processes, such as hydration, crystallization, etc. in cement systems, with the addition of new generation complex chemical additives of the Relaxol series.

To study the process of structure formation of the cement composition, the method of infrared spectroscopy, X-ray phase analysis and electron microscopy was used.

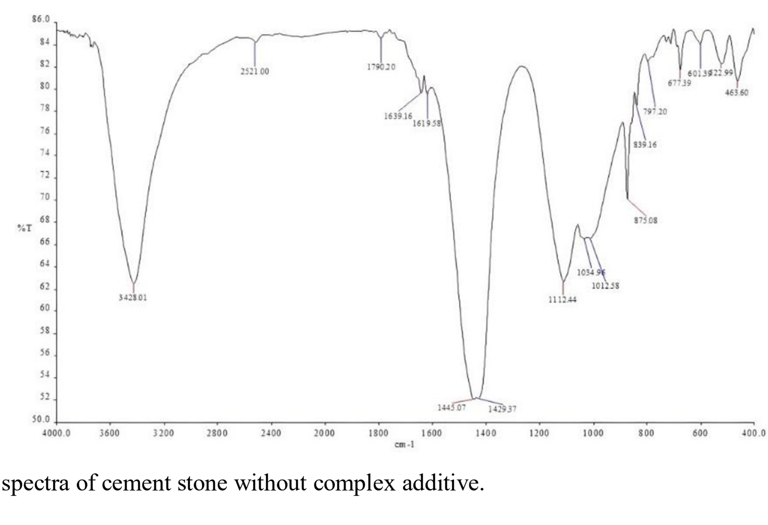

Fig. 1. IR spectra of cement stone without complex additive.

Hydration of binders occurs in the presence of a small amount of water, i.e. under natural conditions, as a result of which a large number of small crystals are formed. It is difficult to provide the binder with the required amount of water using mechanical mixing. This task is performed by a complex additive, improving the wettability of cement particles [5].

When studying the thermogravimetric curves of samples, one can observe a sharp change in mass loss in the first two endo effects in cement stones with the addition of the complex additive KDJ-3, and in cement stone without additives, this change is insignificant.

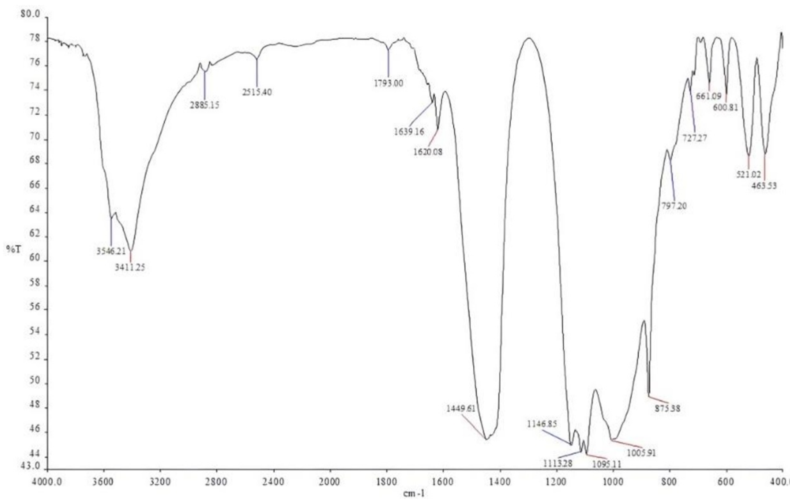

Fig. 2. IR spectra of cement stone with complex additive KDJ-3, in an amount of 1.0% by weight of cement

In the IR spectra of hydrated minerals CA and CA_2, an intense band appears with an absorption maximum at 520 cm^{-1}, which belongs to the stretching vibrations of Al - O bonds in AlO_6 - octahedra. The bands with maxima at 1150, 1020, 970 and 920 cm^{-1} in the IR spectra of hydrated CA and CA_3 are due to bending vibrations of –OH bonds of gibbsite. In the region of stretching vibrations – OH groups, the band at 3400 cm^{-1} belongs to C_3AH_6, and the rest belong to – OH groups of molecular water gibbsite.

Consequently, IR spectroscopy shows a change in the coordination of aluminum atoms during the hydration of calcium aluminates, i.e. transitions from tetrahedral coordination (non-hydrated minerals) to octahedral (hydrate phases) with parallel formation of groups - OH instead. Absorption bands in the regions of 463, 513, 661, 727, 863, 1000, 3546 cm^{-1} indicate the formation of minerals such as calcium hydrosilicate. As can be seen in the figures, when adding the complex additive KDJ-3, one can observe a high intensity of absorption bands characteristic of minerals that provide high strength and durability of cement stones [6; 4-47-s., 7; 10-210-b.].

Figure 3 shows that the spectrograms of cement stone are characterized by the presence of several specific maxima. The presence of a maximum of absorption bands at 900-1000 cm^{-1} characterizes the presence of calcium hydrosulfoaluminate. At the same time, a more distinct rarefaction of the spectrum with a maximum in the region of 1000 cm-1 indicates better crystallization of HSAA in the presence of the complex additive KDJ-3.

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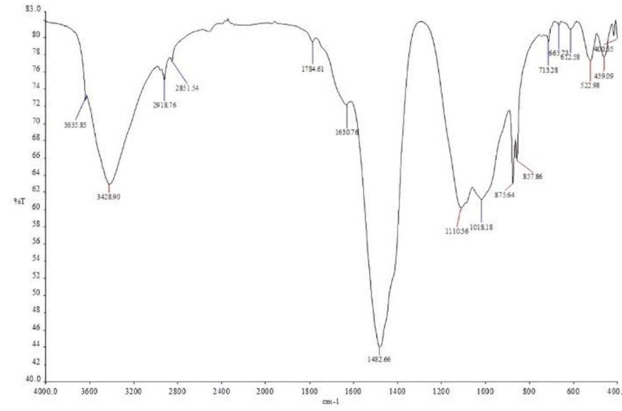
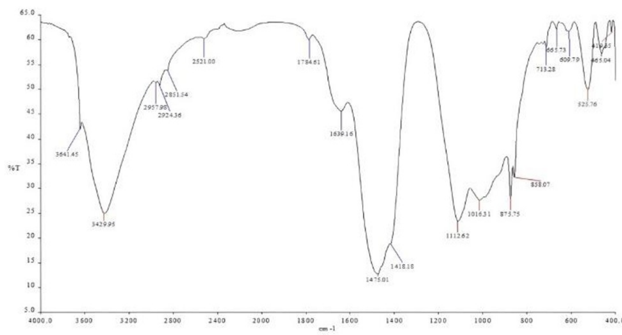
a).



b).



a) control, without additive; b) with the complex additive KDJ-3 in an amount of 1.0% by weight of cement.

Fig. 3. IR spectra of cement stone with complex chemical additive KDJ-3.

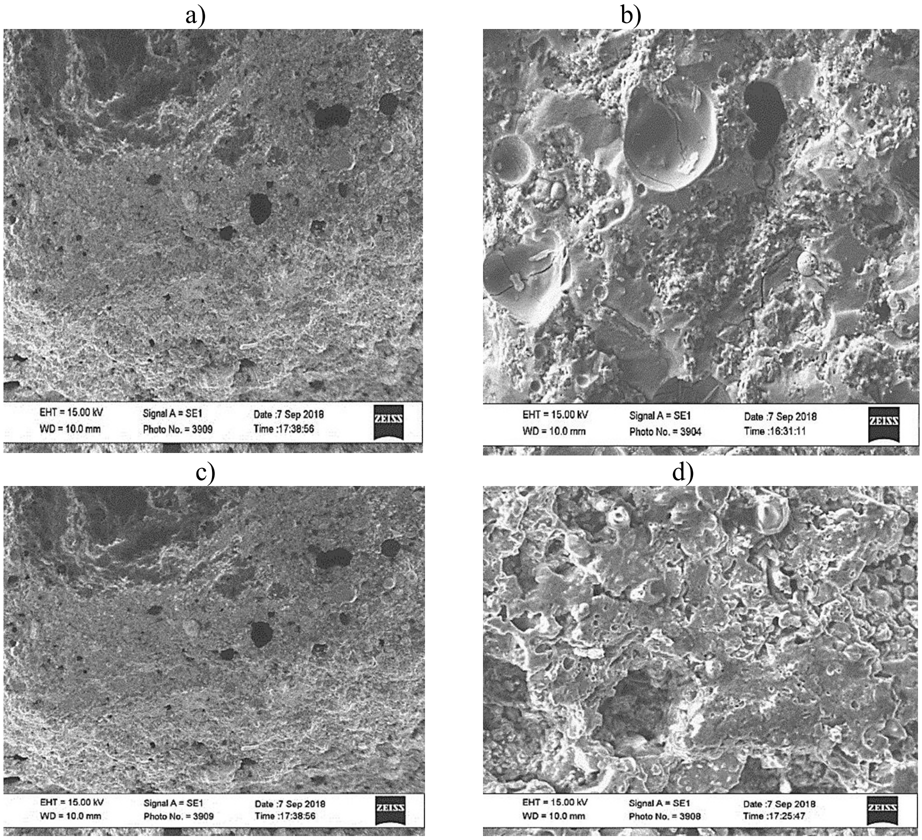
The absorption maximum at 1400-1600 cm^{-1}, as well as a wide spectral band in the region of 3300-3500 cm^{-1}, indicates the presence of submicro-crystals of hydrosilicates of the tobermorite group, the content of which in samples with the complex additive KDJ-3 is greater than in the composition without additives .

The good resolution of the spectrum in these areas indicates a higher degree of crystallization of the calcium hydrosilicates noted above in the presence of a complex additive. A narrow, well-resolved absorption spectrum band with a maximum at 3590-3650 cm^{-1} characterizes the presence of hydroxyl hydrosilicates of the xonotlite group.

Figure 4 shows that on the control sample, hardened under natural conditions, there are diffraction reflections of non-hydrated minerals of Portland cement clinker, namely C_3S - alite (3.034; 2.745; 2.609 Å), C_2S - belite (4.426; 2.745; 2.609; 2. 17 Å), C_3A - tricalcium aluminate (2.694 Å) and hydrate formations $Ca(OH)_2$ - calcium oxide hydrate (3.113; 2.456 Å) and $3CaO{\cdot}A1_2O_3{\cdot}3CaSO_4{\cdot}31H_2O$ - calcium hydrosulfoaluminate (9.69; 5.492; 2.629; 2.456 Å). Interplanar distances are given in parentheses.

The resulting new formations, crystallizing in the presence of a complex additive in a finely dispersed form, clog the pores and capillaries of the Portland cement stone, compacting and strengthening its structure. The phase composition of hydrate new formations of cement stone made from normal density dough using cement from the

Akhangaran plant of the PC400 D20 brand with different contents of a complex additive was studied by electron microscopy. Figure 4.



a) control without additives; b) with the complex additive KDJ-3 in an amount of 0.6% by weight of cement; c) with the complex additive KDJ-3 in an amount of 1.0% by weight of cement; d) with the complex additive KDJ-3 in an amount of 2.0% by weight of cement;

Fig. 4. Electron microscopic images of cement stone samples

Figure 4 shows the complex structure of the cementitious substance. In the main gel-like mass of the neoplasms, needle-shaped ettringite crystals are observed, filling the free cavities. New formations of ettringite are formed in free volumes. In electron micrographs of cement stone samples with the addition of the resulting complex additive KDJ-3, pores are filled with both gypsum and calcium hydrosulfoaluminate. Moreover, when adding a complex additive, the amount of hydrosulfoaluminate becomes predominant. An increase in the concentration of calcium hydrosulfoaluminate and an increase in the specific surface area of hydrate phases, both in the general structure of the cement stone and in defective areas of the spatial skeleton, leads to strengthening of the material. The compaction and strengthening of the structure of Portland cement compositions at the initial stages of hardening is a consequence of the fact that both gypsum and calcium hydrosulfoaluminate, when a complex additive is added, crystallize with an increase in volume.

3 Results and discussion

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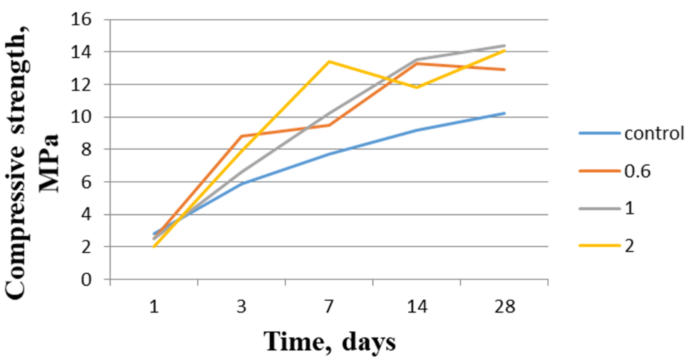
To carry out experimental studies, we used Portland cement from the Akhangarancement plant, grade PTs400 D20, grade of expanded clay concrete M200, and mobility of expanded clay concrete mixture grade P3. KDJ-3 was used as a complex chemical additive, synthesized at the Tashkent Research Institute of Chemical Technology of the State Joint Stock Company "Uzkimyosanoat" [8-11].

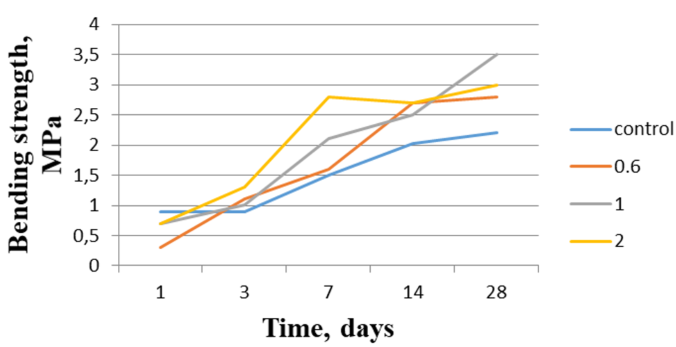
By experimentally studying various compositions of expanded clay concrete with the additive KDJ-3, containing 0.6, 1.0 and 2.0% by weight of cement, it was revealed that high performance indicators of the components were observed with an additive content of 1.0% Physico-mechanical and properties of expanded clay concrete with KDJ-3 was studied by making 3 series of prism samples of twins measuring 4x4x16 cm. The first series was control samples without the additive, the second - with the addition of KDJ-3, content - 1.0%. Test periods are 3, 7, 14 and 28 days after hardening. The test results are presented in Figures 6 and 7.

Research has established that the density of expanded clay concrete with the introduction of the complex chemical additive KDJ-3 increases by 8-10%. The introduction of the KDJ-3 additive into expanded clay concrete compositions increases the strength of expanded clay concrete during all curing periods. An increase in strength is observed at the age of 3 days. by 12%, 7 days. by 31%, 14 days. by 37% and 28 days. by 40% compared to the design strength of expanded clay concrete (Figure 5) [12,13].



1 – strength of expanded clay concrete without additive; 2 – strength of expanded clay concrete with the addition of KDJ-3 in the amount of 0.6%, 1.0% and 2% by weight of cement hardened under normal temperature conditions, respectively.

Fig. 5. Effect of complex chemical additive KDJ-3 on the compressive strength of expanded clay concrete



1 – strength of expanded clay concrete without additive; 2 – strength of expanded clay concrete with the addition of KDJ-3 in the amount of 0.6%, 1.0% and 2% by weight of cement hardened under normal temperature conditions, respectively.

Fig. 6. Effect of complex chemical additive KDJ-3 on the flexural strength of expanded clay concrete

Thus, by experimentally studying various compositions of expanded clay concrete with the additive KDJ-3, containing 0.6, 1.0 and 2.0% by weight of cement, it was revealed that high performance indicators of the components were observed at an additive content of 1.0%.

4 Conclusion

The development and use of multifunctional complex chemical additives is a current direction in the development of modern expanded clay concrete technology for the production of high-quality and durable cement systems. Complex chemical additives KDJ-3 were obtained, which were synthesized based on local raw materials and have a positive effect. It was revealed that the resulting complex additives are supposed to be used in the range of 0.6-1.0 and 2 % by weight of cement.

High mobility, density and strength of cement composites with KDJ-3 have been established. The optimal consumption of KDJ-3 is 1.0-2.0% by weight of the binder. At the same time, water consumption for mixing is reduced by 20-30%, which leads to an increase in strength in the class by 30-40% at 28 days of age. It should be noted that the introduction of KDJ-3 leads to the strength of cement composites at the hardening stage. This leads to simplification of the production of composites. At a flow rate of KDJ-3 of the order of 1.0 and 2.0%, the mobility of the composites is 12 and 15 cm, respectively, while the settlement of the control cone is 3-5 cm

When conducting experimental studies using the complex chemical additive KDJ-3 on the basis of the laboratory “Building Materials” of the FerPI. The high mobility and workability, density and strength of expanded clay concrete have been established.

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