The American Journal of Engineering and Technology
(ISSN – 2689-0984
Published: April 25, 2021 | **Pages:** 42-53
Doi: https://doi.org/10.37547/tajet/Volume03Issue04-07

IMPACT FACTOR
2021: 5. 705
OCLC - 1121105677

Physicochemical Structure And Properties Of Cement Stones With A Complex Chemical Additive KDj-3CHMB

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ABSTRACT

The technological properties of cement stone modified with a plasticizing complex chemical additive KDj-3CHMB have been studied. The influence of the additive on the basic properties of the cement stone has been investigated. The results of the research are given, indicating the active participation of improving the performance of concrete, as well as the possibility of reducing the amount of cement to 10-15%. The content of the additive KDj-3CHMB in the composition of the cement stone leads to an increase in its density by 7-10% and prismatic strength by 40% in comparison with the control samples. At the same time, the complex chemical additive KDj-3CHMB increases the indicators of mobility and frost resistance of cement stone

KEYWORDS

Complex additive KDj-3CHMB, Portland cement, differential thermal analysis, infrared spectroscopy, X-ray phase analysis, electron microscopy.

INTRODUCTION

The main tasks of modern materials science are the development of methods for the directed formation of a durable structure of composite materials, the production of concretes with specified performance properties with the maximum production technology and saving raw materials. At the same time, the creation of an energy-saving technology of cement compositions based on local raw materials and secondary resources occupies a special place.

VALUE OF THE SYSTEM

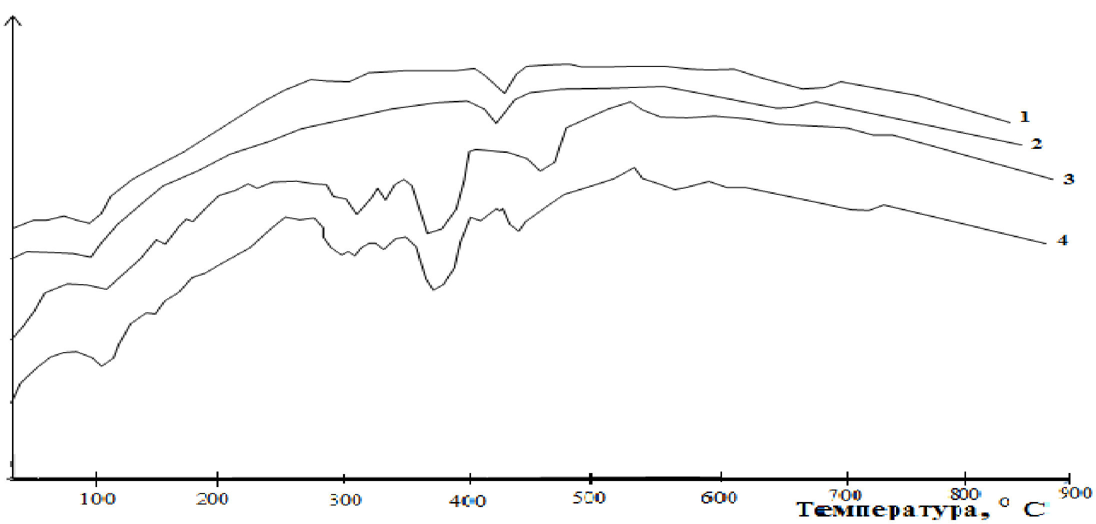
The main tasks of the research are the creation of theoretical foundations for the synthesis of innovative complex chemical additives of a new generation for the manufacture of concretes using high technology .; Investigation of the mechanisms for creating polymer mineral nanostructured complex chemical additives; Research of complex chemical additives - series "Concrete modifier" MB, which increases plasticity, anti-freeze properties and strength in the early stages of hardening; Investigation of micro, nano and macrostructure formation of concretes with polymer mineral nanostructured complex chemical additives.

METHOD

The main directions of improving the operational characteristics of concrete are improving manufacturability, increasing strength and durability. To solve this problem, great attention is paid to blizzards and aerated concrete with new complex additives based on local raw materials. [12].

This article presents the results of a study of cement compositions with a complex chemical additive KDj-3CHMB for physical and mechanical and physicochemical properties and the results of studying the structure formation of cement stone using modern physicochemical methods for studying the process of structure formation of the composition using the method of differential thermal analysis of infrared spectroscopy, X-ray phase analysis, and electron microscopy. [3, 4.5].

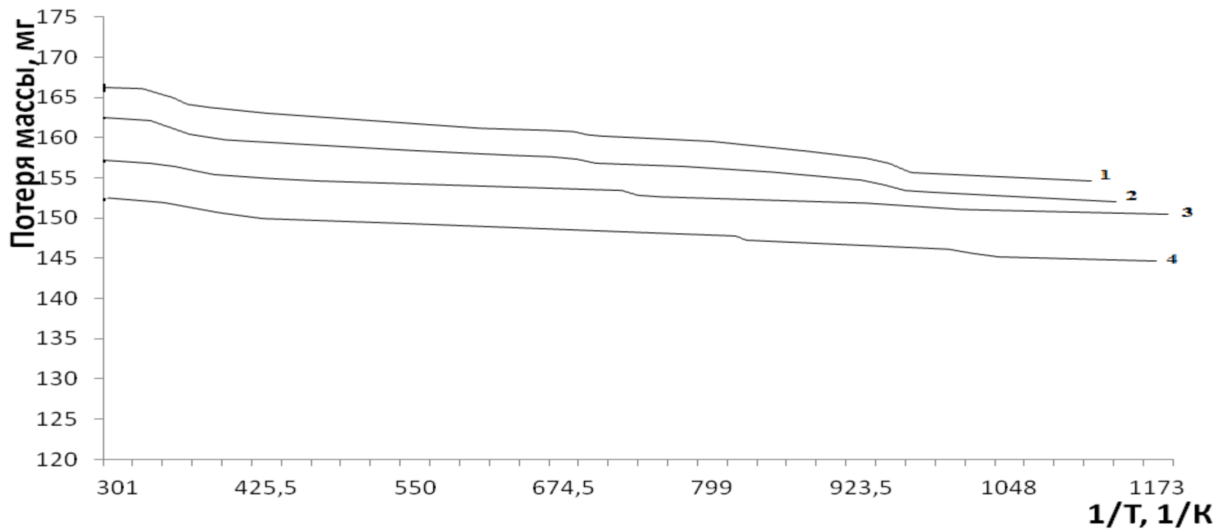
One of the possible reasons for the increase in the strength of cement stone, mortar and concrete with the introduction of KDj-3CHMB should be considered an increase in the volume of hydration products that compact the structure of the cement stone.



1- without additive; 2 - 8% KDj-3CHMB added; 3 - 10% KDj-3CHMB added; 4 - 12% KDj-3CHMB added.

Pictureure 1. Curves of differential thermal analysis of cement stones

In this regard, an assessment was made of the degree of its hydration and the specific surface area of hydrated neoplasms, depending on various amounts of chemical additives.



1- without additive; 2 - 8% KDj-3CHMB added; 3 - 10% KDj-3CHMB added; 4 - 12% KDj-3CHMB added.
Picture. 2 Thermogravimetric analysis of cement stones.

The phase composition of hydrated neoplasms of cement stone made from a test of normal density on the cement of the Akhangaran plant grade PC400 D20 containing KDj-3CHMB was studied by DTA, XRF, electron microscopy, and infrared spectroscopy.

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

Picture. 2 shows thermograms of cement stone hydrated for 28 days with KDj-3CHMB. The endothermic effect at 130-180 °C is observed in all samples. This effect is partly due to the desorption of water from the capillaries of the calcareous silica gel. The endothermic effect at 195-200 °C reflects the dehydration of adsorbed water.

Table 1. Differential Thermal Analysis Results

Temperature the interval of endo and Exo effects, K	Heating duration, min	The number of volatile substances %	Weight loss rate, %/ min	General weight loss %
Cement stone without additive				
393-436	8.325	3	0.36	25
638-678	31.275	10	0.32	
773-813	45	12	0.267	
1003-1063	72.225	21	0.291	
8 % added KDj-3ChMB				
383-433	8.775	3.35	0.382	16.778
656-691	32.85	7.4	0.225	
771-813	45.225	9.1	0.201	

1008-1063	72.45	14.1	0.195	
10 % KDj-3ChMB				
393-443	13.275	4.95	0.373	
478-503	20.25	5.94	0.293	
533-568	26.325	6.93	0.263	
603-668	35.1	7.33	0.208	
668-728	41.85	7.92	0.189	14.85
728-753	46.35	8.91	0.192	
753-803	51.525	9.9	0.192	
843-873	59.4	10.89	0.183	
873-903	63.45	10.95	0.172	
12 % added KDj-3ChMB				
383-418	12.375	1.4	0.113	
451-473	17.55	3.3	0.188	
495-513	22.05	4.35	0.197	
568-594	28.8	5.1	0.177	
594-638	33.975	5.2	0.153	
638-671	38.025	5.4	0.142	
671-723	41.85	5.8	0.138	13
723-751	46.35	5.9	0.127	
751-793	49.95	6.5	0.13	
833-873	60.3	7.2	0.119	
873-895	64.125	7.97	0.124	
1013-1053	80.775	10.87	0.134	

C-S-H (partially crystallized tobermorite-like calcium hydro silicate) also has a low-temperature endothermic effect at 160-165 °C, this mineral can gradually lose water up to 700 °C. Tobermorite gel obtained by hydration of C3S and alite has similar thermal characteristics; the endothermic effect at 140-150 °C is associated with the loss of adsorbed water, another peak at 570 °C reflects the thermal decomposition of Ca (OH) 2 into CaO. The observed endothermic effect at 790 °C is due to the presence of calcium hydrosilicate.

On the derivatograms of samples with KDj-3CHMB at the age of 28 days, a weak endo effect was recorded at ~ 210 °C, which probably corresponds to the dehydration of X-ray amorphous hydrogenite. The exo effect at 840-880 °C indicates the presence of a binder of low-basic calcium hydrosilicates C-S-H (I) in the stone.

In the derivatograms of the compositions with KDj-3CHMB, in addition to the effects characteristic of highly basic hydro silicates of calcium and portlandite, endo effects are recorded at ~ 200 °C and 300 °C, corresponding to the stepwise dehydration of 2CaO A12O3 8H20. A weak echo effect at 840-870 °C, corresponding to the transition of dehydrated low basic HSC, is present after 28 days of hardening. In addition, the observed effects characterizing the presence of an alumina hydrate gel (370 °C and 930 °C).

During DTA, the presence of endo effects at ~ 130, 600, 700, and 760 °C, corresponding to

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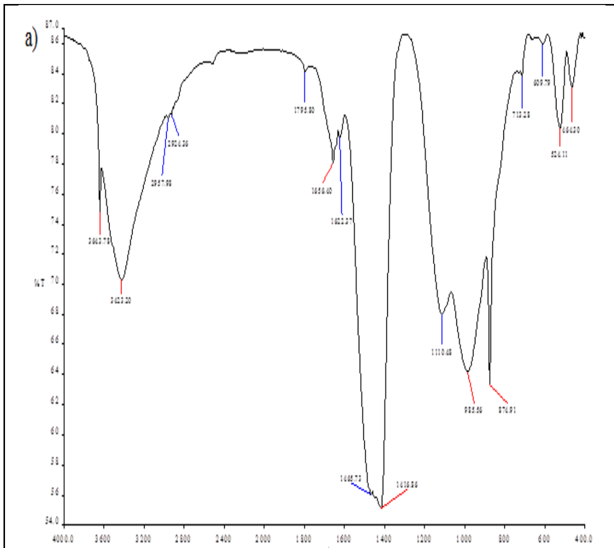
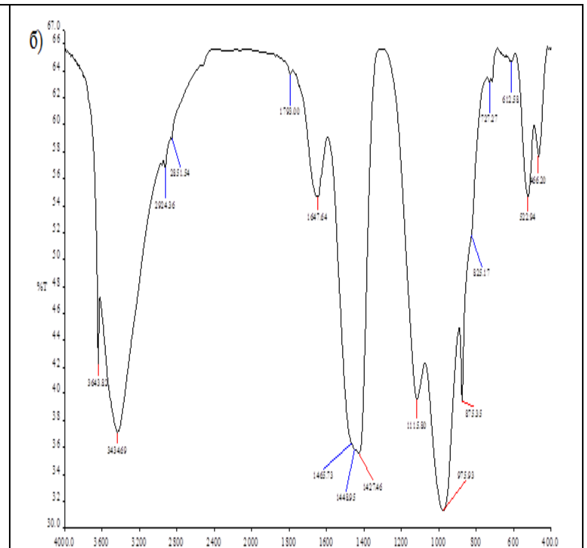
dehydration of calcium hydro silicates, and a weak exo effect at - 880 °C, characterizing the transition of dehydrated low basic HSCs, were noted. The amount of chemically bound water increases in 28 days by 14%, which in this case may indicate an initially higher degree of hydration of clinker minerals.

Thus, the introduction of KDj-3CHMB in small dosages into cement compositions is effective. Initially, the structure of a stone with KDj-3CHMB is composed mainly of calcium hydro silicates of reduced basicity, more resistant to a decrease in the alkalinity of the medium, a low water-cement ratio leads to a decrease in the developed capillary porosity.



a)



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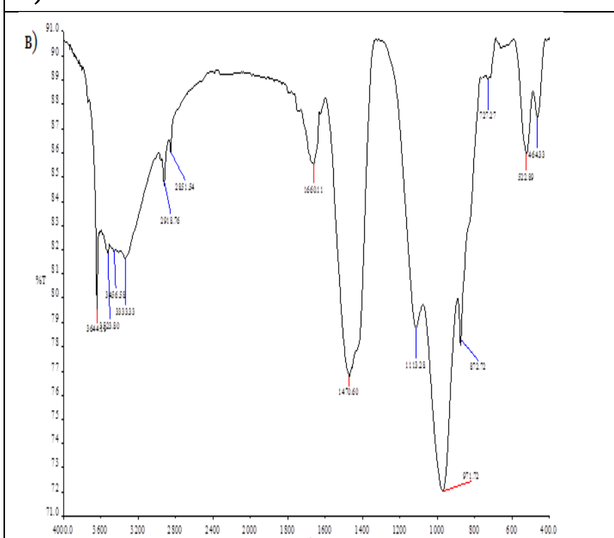

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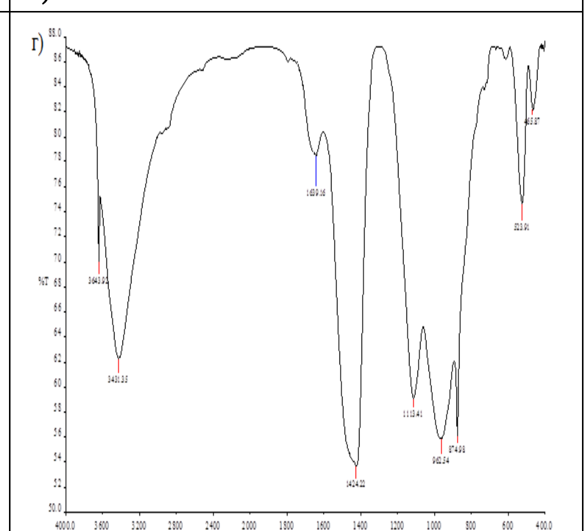

d)

Picture. 3. IR spectra of cement stones: a) control without additives; b) 8% KDj-3CHMB added; c) 10% KDj-3CHMB added; d) 12% KDj-3CHMB added.

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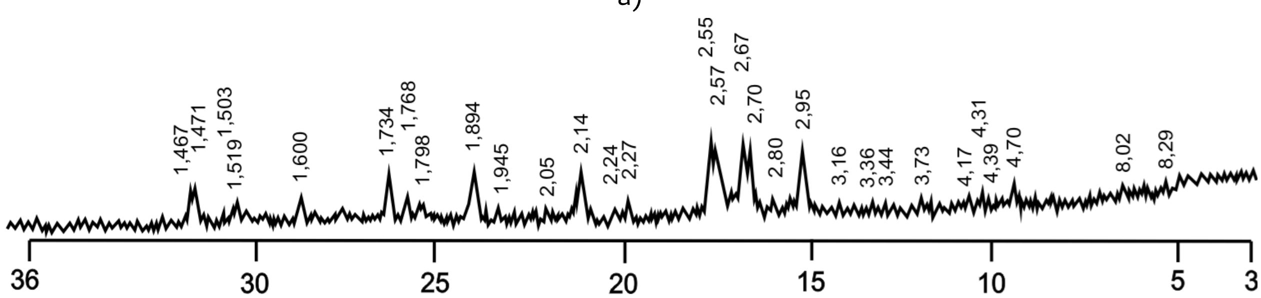
It can be seen from the presented results that the highest absorption of the spectrum is observed at frequencies of 900-1000 cm^{-1}, 1400-1600 cm^{-1}, 3431-3643 cm^{-1}. However, the highest intensity of the spectral lines is characteristic of the compositions with KDj-3CHMB. This phenomenon is confirmed by the degree of cement hydration with the addition of KDj-3CHMB.

The absorption maximum at 1400-1600 cm-1, as well as a wide spectrum band in the region of 3300-3500 cm^{-1}, indicates the presence of submicron crystals of hydro silicates of the tobermorite group, the content of which in the samples with KDj-3CHMB is higher than in the composition without additives. The good resolution of the spectrum in these regions indicates a higher degree of crystallization of the above-mentioned hydro silicates of calcium in the presence of g KDj-3CHMB.

A specific feature of KDj-3CHMB is the fact that in the presence of KDj-3CHMB, a smaller crystalline structure of normal hardening cement stone is formed.

a)



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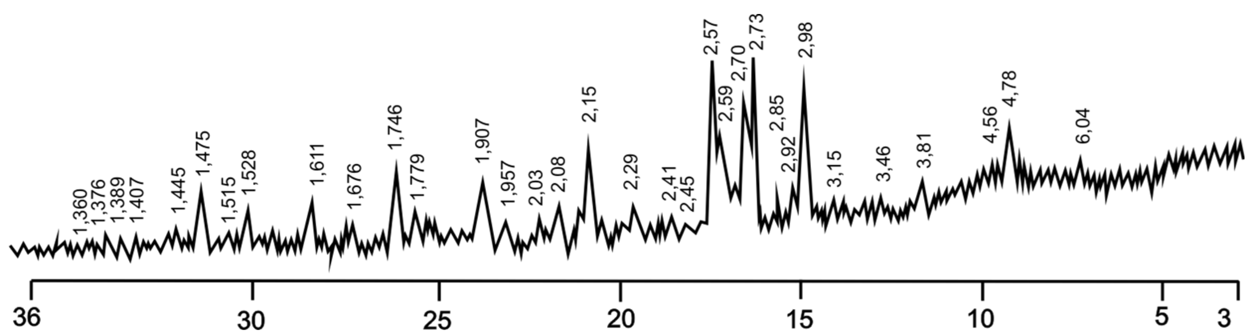

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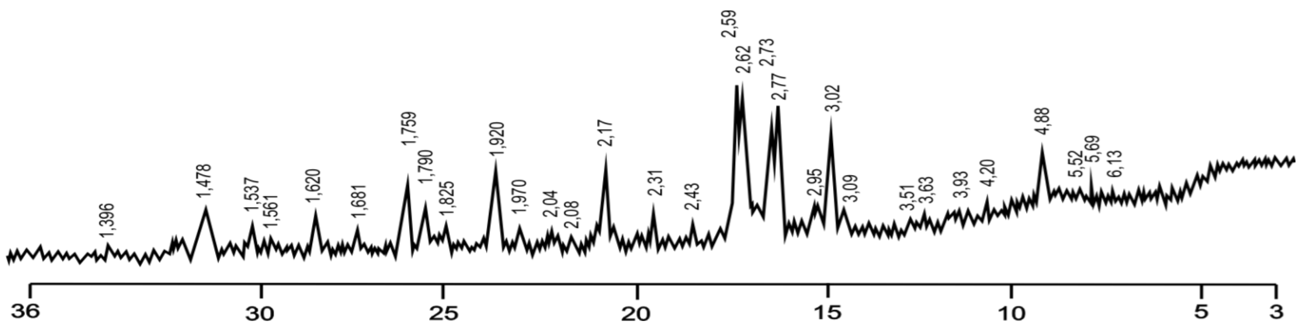
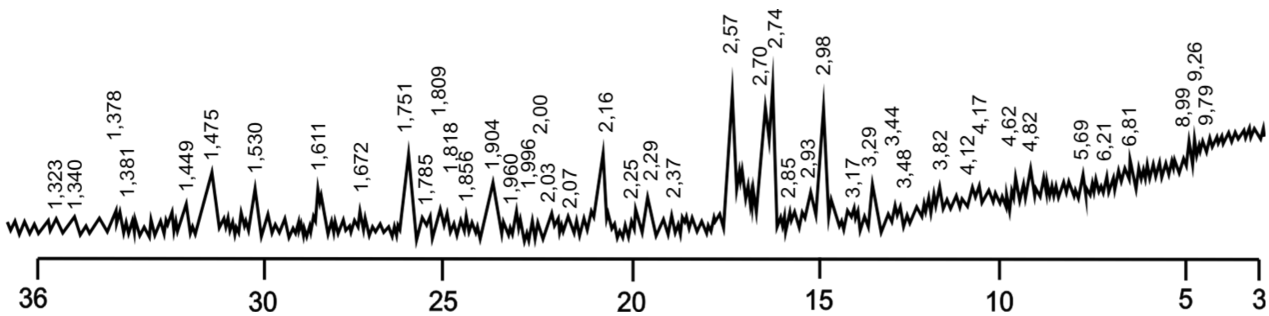


g)



a) control without additives; b) 8% KDj-3CHMB added; c) 10% KDj-3CHMB added; d) 12% KDj-3CHMB added.

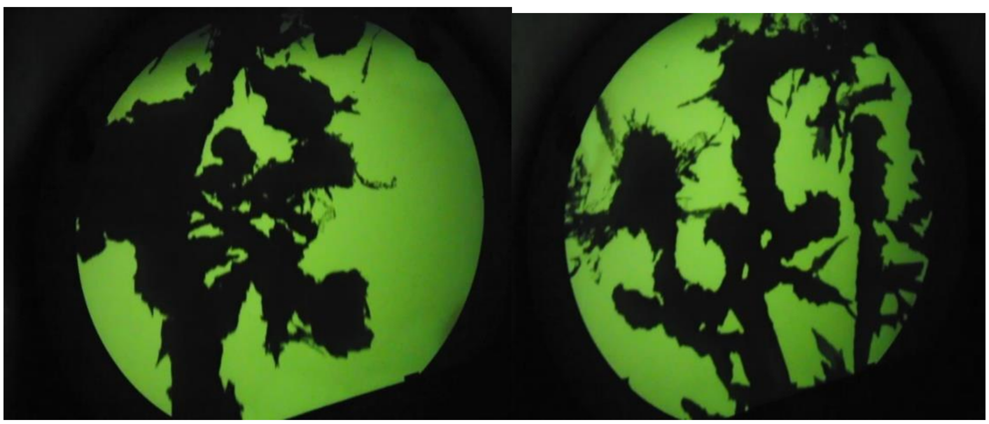
Picture 4. XRF curves of samples of cement stone hardened in natural conditions.

The XRD analysis of binder stone samples showed that KDj-3CHMB does not affect the composition of hydrated phases (Picture. 4). The processing of the XRD results revealed the following: the introduction of KDj-3CHMB with further water hardening of the samples causes the formation of highly basic calcium hydroaluminates in the binder stone, which are found after 28 days of hardening. In addition, the composition of the hydrated phases includes highly basic HSC C-S-H with d/n = 3.09; 2.85; 2.80; 2.00 1.83; 1.56; 1.40 Å; Ca (OH) 2 with d/n = 3.11; 2.63; 1.79; Å, as well as unreacted alite C3S with d / n = 2.74; 2.61; 1.77 Å. At the age of 28 days, the main reflections of low-basic HSCs appear on the X-ray diffraction patterns of the compositions with KDJ-3CHMB. After adding KDJ-3CHMB, the structure of the binder stone at the age of 28 days is mainly represented by C-S-H (II) with d/n = 2.85; 2.80; 2.00; 1.83; 1.56; 1.40 Å; C-S-H (I) with d / n = 2.80; Å; Ca (OH) 2 with d/n = 2.63; 1.79; Å, alite with d/n = 2.74; 2.61; 2.16; 1.77; 1.62 Å, as well as 2CaO · A12O3 · 8H2O with d/n = 2.68; 2.55; 1.75; 1.73; Å

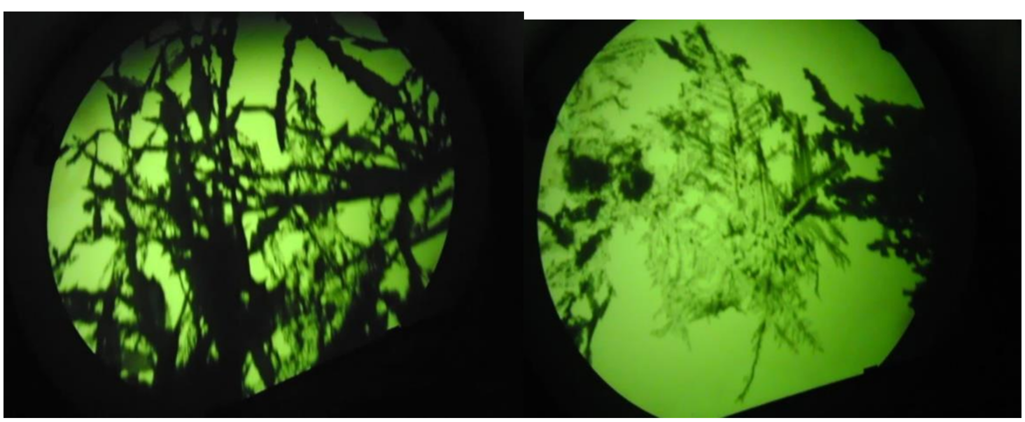
Thus, with the introduction of KDj-3CHMB into cement composites, it will activate the pozzolanic and hydraulic properties of the slag, obtain a significant increase in strength when using additives in optimal amounts, and also activate the hydration processes.

Pictureures 5 show the complex structure of the cementitious substance. In the main gel-like mass of neoplasms, needle-shaped crystals of ettringite are observed, filling the free cavities. Ettringite neoplasms are formed in free volumes. On electron micrographs of samples of cement stone with a complex additive, the pores are filled with both gypsum and calcium hydrosulfoaluminate. An increase in the concentration of calcium hydrosulfoaluminate and an increase in the specific surface area of the hydrated phases, both in the general structure of the cement stone and in the defective areas of the spatial skeleton, lead to the strengthening of the material.

a) b)



v) g)



a) control without additives; b) 8% KDj-3CHMB added; c) 10% KDj-3CHMB added; d) 12% KDj-3CHMB added.

Picture. 5. Electron microscopic images of cement stone samples.

The study of binder stone chips at the age of 28 days in an electron scanning microscope showed that during hardening, the structure of slag-containing compositions is blocked, consisting of HSCs of different basicity and degree of crystallization with inclusions of unreacted slag particles and uniformly distributed aggregates of portlandite (Picture. 5)

The structure of the stone without additives is composed of coarse-crystalline formations of highly basic HSC, with well-crystallized inclusions of portlandite, capillary pores are observed.

Cement stone with the addition of KDj-3CHMB has a heterogeneous structure and is represented by both crystalline calcium hydro silicates and sections of C-S-H-gel (Picture. 5 b, c, d,).

Gel-like areas characteristic of a stone are less common, are characterized by a CaO / SiO2 ratio of 2.5-2.8 and have a tendency to crystallize, which indicates an intensification of hydration processes with the addition of KDj-3CHMB.

When using KDj-3CHMB, along with the above-mentioned characteristic neoplasms on the surface of the stone cleavage, gel-like areas of the "mother solution" with a high content of calcium ions appear. It was revealed that in this case, the arrangement of these regions is not of the same character as in the previous cases: they have a smaller size and represent small yields of C-S-H-gel with CaO/SiO_2 ratio = 2.6-2.8, surrounded on all sides by crystalline neoplasms.

Thus, with the introduction of KDj-3CHMB into cement composites, it will activate the pozzolanic and hydraulic properties of the slag, obtain a significant increase in strength when using additives in optimal amounts, and also activate the hydration processes.

EXPERIMENTAL RESULTS

Portland cement of the Kuvasaycement plant, grade PC400 D20, was used for experimental studies. KDj-3CHMB, synthesized at the Tashkent Scientific Research Institute of Chemical Technology of Uzkimyosanoat State Joint Stock Company, was used as a complex chemical additive.

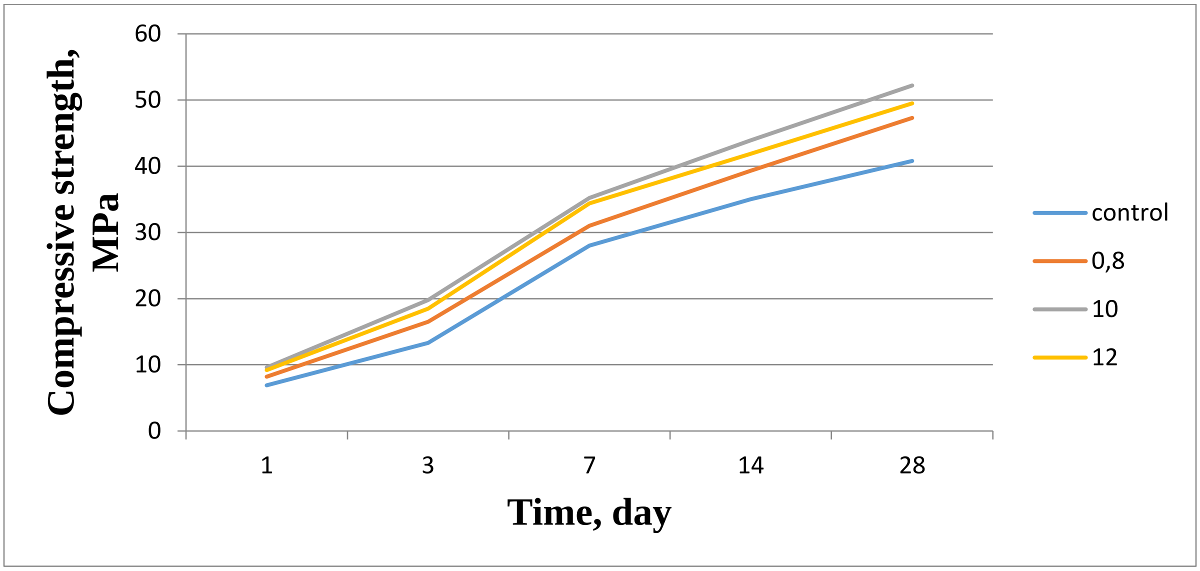
Investigating various compositions of cement stone with the addition of KDj-3CHMB experimentally, with an additive content of 8.10 and 12% of the cement mass, it was found that high-efficiency indicators of the components were observed with an additive content of 10%. The physical and mechanical properties of cement stone with KDj-3CHMB were investigated by making 2 series of the prism of twin samples with dimensions of 4x4x16 cm. The first series of control samples without additive, the second with 10% of the additive KDj-3CHMB. The tests were carried out at 1, 3, 7, 14 and 28 days of hardening. The test results are presented in the table. 1 in Pictureures 5. [6,7]

Table 1. Results of a study of the compressive strength of cement stone with a complex chemical additive KDj-3CHMB

№	Name of sample	Additive content in% by weight of cement	Average density, kg / m3	Compressive strength of cement stone (MPa) at age and its growth (%), days				
				1	3	7	14	28
1	Control	0	1850	6,9 100	13,3 100	28 100	35 100	40,8 100
2	Curing under normal temperature conditions	8	1860	8,2 118	16,5 124	31,2 112	39,3 112	47,3 116
3	Curing under normal temperature conditions	10	1875	9,6 139	19,8 149	35,2 126	43,9 125	52,2 128
4	Curing under normal temperature conditions	12	1890	9,2 133	18,5 139	34,4 122	41,9 120	49,5 121

Research has established that the density of cement stone with the introduction of a complex chemical additive KDj-3CHMB increases by 7-10%. The introduction of 10% KDj-3CHMB additive into the composition of the cement stone increases the strength of the cement stone at all times of hardening [8].

An increase in strength is observed at the age of 1 day. For 39, 3 days. for 49, 7 days. for 26, 14 days for 25 and 28 days. by 28% compared to the design strength of the cement stone (Picture 5).



Picture. 5. Influence of the complex chemical additive KDj-3CHMB on the strength of cement stone in compression

1 - the strength of the cement stone without additives; 2 - the strength of the cement stone with the addition of KDj-3CHMB in the amount of 8.10 and 12% of the cement mass, hardened under normal temperature conditions, respectively.

Thus, by experimentally investigating various compositions of cement stone with the addition of KDj-3CHMB, the content of 8.10 and 12% of the cement mass, it was found that high-efficiency indicators of the components were observed with an additive content of 10%.

CONCLUSION

When complex chemical additives are added in small amounts, minerals are formed in cement compositions, which ensure the strength and durability of concrete products. Crystals of Ca (OH) 2 are clearly observed in the cement stone. The density of these crystals in different micro volumes differs significantly. The results of differential thermal analysis of cement stone with a complex additive indicate that there is also amorphous or weakly crystallized calcium hydroxide.

Experimentally investigated various compositions of concrete with the addition of KDj-3CHMB, the content in an amount of 10% by weight of cement. Research has established that the density of concrete with the introduction of a complex chemical additive KDj-3CHMB increases by 7-10%. The introduction of the additive KDj-3CHMB into concrete compositions increases the strength of concrete at all times of hardening. An increase in strength is observed at the age of 1 day for 39, 3 days. for 49, 7 days. for 26, 14 days for 25 and 28 days. by 28% compared to the design strength of concrete.

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The introduction of the additive KDj-3CHMB into a concrete mixture under equal motion conditions leads to a decrease in water demand by 12-15%, which leads to an increase in the strength characteristics of concrete.

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