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Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
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STUDY OF THE EFFECTIVENESS OF THE USE OF COMPLEX ADDITIVES MASTER RHEOBUILD 1000 AND MASTER AIR 200

Abstract. The article discusses the results of experimental studies to identify the effect of chemical additives on the properties of concrete on reducing the water demand and workability of the concrete mixture. The task is the need to increase the operational reliability of concrete and reinforced concrete to the quality of structural building materials, including the most common and resource – intensive-cement concrete. Chemical additives, being one of the simplest and most affordable technological methods for improving the properties of concrete, can significantly reduce the level of costs per unit of production, improve the quality and efficiency of a large range of reinforced concrete elements and structures, increase the service life of both reinforced concrete and reinforced concrete, and buildings and structures. The joint work of chemical additives with the mineralogical composition of cement clinker provides an increase in the strength, density, frost resistance and water resistance of concrete. Only those additives that simultaneously have a plasticizing effect (improving the quality of the concrete mixture), the property of significantly accelerating the end of setting, and are inhibitors of steel corrosion in reinforced concrete elements and structures can provide improvement of these properties. Therefore, great attention is paid to the use of chemical additives in concrete technology in the world practice. The resulting concrete mixture has properties that allow it to be transported over long distances, filled with pumping equipment. The purpose of the work is to obtain a plastic, workable concrete mixture, with the preservation of characteristics over time.

Key words: chemical additive, superplasticizer, mobility, concrete structure, concrete strength.

Introduction. The problem of using additives for concrete modification is multifaceted. Currently, there is no unified classification of additives to cements and concretes in the world practice. Different countries have developed their own classification schemes. These schemes are based on the authors [1-3], desire to facilitate the correct choice of additives for concrete or mortars in accordance with their purpose.

The use of additives in concrete should be preceded by testing the properties of concrete mixtures and concretes with them in accordance with the requirements of current standards, regulatory and technical or design and technological documentation 4. In turn, concretes with additives, concrete mixtures, materials used for them, the technology of manufacturing products and structures must meet the requirements of state standards, building codes and other regulatory documents for specific types of products and structures, taking into account their purpose was described 5,6. The expediency of using additives in concrete is determined by the achievement of various technological and economic effects during the operation of products and structures. In terms of quality indicators, additives must meet the requirements of the relevant regulatory and technical documentation for a specific product, and in terms of the effectiveness of the action – the effectiveness criterion according to the requirements of technical document. The effectiveness of additives is determined by comparing the quality indicators of concrete mixes, concrete of the control and main compositions, with the exception of stabilizing, water-retaining additives and additives that increase the protective properties of concrete in relation to steel reinforcement. The last ten to fifteen years have seen the development and increasing use of several types of high-performance concrete, such as high-strength concrete, high-durability concrete, fibre-reinforced concrete, underwater concrete and self-compacting concrete. Most of these contain a combination of admixtures, cement replacement materials etc. and will therefore have very different rheological properties to those of «normal» mixes 7,8

Figure 1 shows the regions of the yield stress/plastic viscosity diagram for four types of concrete. In «normal» concrete, in which the workability is controlled mainly by water content, the yield stress and plastic viscosity will vary together, as already discussed. Flowing concrete, produced by adding superplasticizer to a normal mix (with perhaps a higher fines content to ensure stability), has a yield stress lower than that of normal concrete, and hence a high slump, but a relatively high viscosity for stability. High- strength concrete mixes, which have a high paste content commonly containing microsilica, can be viscous and sticky, making them difficult to handle despite including superplasticizers to produce a high slump/low yield stress.

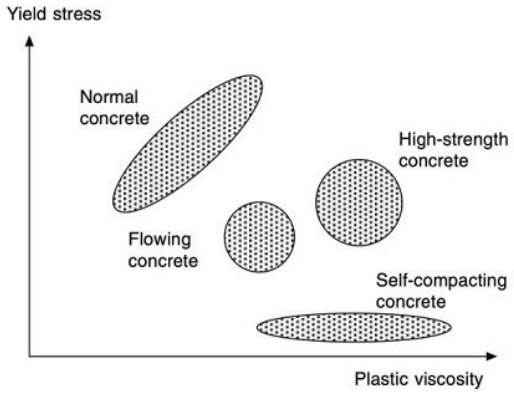

Fig. 1 - Rheology of several types of concrete

Optimization of the composition of heavy concrete based on local raw materials and modifying additives in order to improve the physical and mechanical properties of heavy concrete and products based on them is an urgent task, the solution of which will improve the technical and economic indicators of buildings under construction9.

Materials and methods. To solve this problem, studies were conducted on the influence of plasticizing additives on the basic properties of concrete mix and heavy concrete based on local raw materials. Binders, Portland cements PC400 D-0, PC 500 D-20 of the «Shymkent Cement» plant were used as starting materials for the experimental part of the study, crushed stone and monofractive sand were used as a filler. The Portland cements of this plant have distinctive mineralogical compositions of clinker and technological characteristics given in tables 2 and 3, respectively. As modified additives, Master Rheobuild 1000, Master Air 200. Technical characteristics are given in Table 1.

Table 1- Technical data of additives

№	Name of the additive	Colour	Consistency	Density	Content of chlorine ions
1	Master Rheobuild 1000	Dark brown	Liquid	1,21-0,02 g/cm^3	<0,01%
2	Master Air 200	Light brown	Liquid	1,02-0,02 g/cm^3	<0,01%

Additives do not change the color of concrete, do not create efflorescence on the concrete surface and are suitable for reinforced and prestressed elements and structures, do not cause corrosion of steel reinforcement in concrete. The recommended dosage of the Master Rheobuild 1000 additive leaves 0.8-1.6 kg, Master Air 200 is 0.03-0.20 kg in the liquid state per 100 kg of cement. The dose depends on the purpose of the concrete mixture, its mobility, the cement content and the desired effect.

Table 2- Mineralogical composition of clinker

Name of components	CaO, %	SiO_2, %	Al_2O_3, %	Fe_2O_3, %	MgO, %	SO_3, %	Other, %	PPP, %	∑, %
«Shymkent Cement» Plant									
Cement Clinker	65,4	21,6	5,15	4,86	1,8	0,27	0,35	-	100
«Shymkent Cement» Plant									
Cement Clinker	65,2	21,5	4,7	3,5	2,6	2,9			100

Table 3- Technological characteristics of the PC

Name of Plants	Bulk density, $\rho_н$, kg/cm^3	Fineness of grinding, %	normal cement density, %
«Shymkent Cement» Plant	1,25	28,5	23,9
«Shymkent Cement» Plant	1,0	7,2	25,5

The workability of a concrete mix is the ability of concrete during concreting to fill a mold, formwork under the influence of its own weight or applied external force (vibration, compaction).

Concrete mix workability is determined by the mobility of the concrete mix (P) or the draft of the cone (OK, S). The mobility of the concrete mixture is determined according to the GOST 10181-2014 method, where the draft of the cone OK (S) is determined, see Standard cones are used for testing the concrete mixture depending on the fraction of coarse aggregate:

- with a fraction of crushed stone, no more than 70 mm - 300×200×100 mm (H ×D × d);
- with a crushed stone fraction of more than 70 mm - 450×300×150 mm (H×D×d).

The determination of the strength of concrete consists in measuring the minimum forces that destroy specially made control concrete samples when they are statically loaded with a constant rate of load increase, and then calculating the stresses under these forces. The obtained samples are exposed to a press device that compresses a concrete cube with increasing force until the control sample is destroyed. Summing up the results of the batch of samples and deducing the average value according to special formulas, the compressive strength of concrete is determined.

The compressive strength of concrete is the most important characteristic regulated by regulatory documents. According to practical studies, 80-85% of the grade strength of concrete acquires on the 28th day after sealing with water. The destructive method of testing concrete is carried out using control samples that are subjected to hardening under the same conditions as the construction or removed directly from the concrete monolith after it reaches the required hardness values. These methods of determining the strength of concrete are considered the most accurate. The obtained samples are exposed to a press device that compresses a concrete cube with increasing force until the control sample is destroyed. Summing up the results of the batch of samples and deducing the average value according to special formulas, the compressive strength of concrete is determined 11.

Results. The effectiveness of the additive was evaluated by increasing the mobility of the mixture and the strength of concrete with the same water-cement ratio of the control and main compositions of the samples in accordance with GOST 10181. The workability (plasticization) of concrete mixtures was determined in accordance with GOST 24211. The peculiarity of the selection of the composition of heavy concretes is the need to obtain at a minimum consumption of the binder, in addition to the required strength, also the smallest volume mass.

In the study of modified heavy concrete, the tests were carried out in accordance with the requirements of GOST 11, 12.

The results of the conducted studies of control samples are shown in Table 4.

Table 4- Control composition of heavy concrete

№	Type of binder	Brand of concrete	The amount of the additive	Mobility of the concrete mixture	The draft of the cone, cm,	The composition of concrete on 1 м^3, кг			
						C	M	A	S
1	«Shymkent Cement» LLP	350	-	P1	2-3	420	195	1100	600
2	«Shymkent Cement» LLP	350	-	P	2-4	420	195	1100	600

For further testing of heavy concrete with modifying additives, a binder of «Shymkent Cement» LLP, PC M400 D0 was used. Plasticizing additive «Master Rheobuild 1000» and air-entrapping additives «Master Air 200» were used for modification BASF companies. The studies were carried out at the dosage of additives: 0,5%, 0,7%, 0,9% and 1,3%.

The results of the study of the workability of concrete mixes for two types of cement are shown in Table 5.

Table 5- The effect of the additive on the main characteristics of the concrete mixture

№	Name of additives	Dosage quantity	The draft of the cone, cm	Mark for workability
1	Without additives	-	2,5	P1
2	Master Rheobuild 1000	0,5	9	P2
3	Master Rheobuild 1000	0,7	12	P3
4	Master Rheobuild 1000	0,9	16	P4
5	Master Rheobuild 1000	1,3	13	P3
6	Master Air 200	0,08	6	P2
7	Master Air 200	0,09	7	P2
8	Master Air 200	0,1	9	P2
9	Master Air 200	0,2	12	P3
10	Master Air 200	0,3	10	P3

When additives are introduced into the concrete mixture, a significant increase in its mobility is observed. The best indicators were obtained at a dosage of 0.9% by weight of cement. At this dosage, the mobility of concrete increases by 6.4 times with the addition of Master Rheobuild 1000 and by 4.8 times with the addition of Master Air 200. This effect helps to reduce the I / C ratio when obtaining an equally mobile concrete mixture. The study of the effect of additives on reducing the water demand of concrete mixes is shown in Table 6.

Table 6- The effect of additives on the water-cement ratio

№ Compo-sition	Cement	Sand	W WWater	Crushed stone of fractions, mm		WW/C	The content of additives,% by weig		Sample weight	Strength	
				5-10	10-20		Master Rheobuild 1000	Master Air200		7 days	28 days
1	420	600	95	420	780	0,46	-	-	2,49	186	429
2	420	600	84	420	780	0,44	0,5	-	2,435	198	419
3	420	600	76,4	420	780	0,42	0,7	-	2,436	360	552
4	420	600	68	420	780	0,40	0,9	-	2,456	306	554
5	420	600	80	420	780	0,40	1,3	-	2,45	452	419
6	420	600	89	420	780	0,45	-	0,08	2,43	324	443
7	420	600	84,5	420	780	0,44	-	0,09	2,5	316	438
8	420	600	80,6	420	780	0,43	-	0,1	2,445	326	483
9	420	600	84,8	420	780	0,44	-	0,2	2,335	284	238
10	420	600	89	420	780	0,45	-	0,3	2,240	188	332

Discussion. It was reported by author 13 that, the examined superplasticizer (SP) type, air-entraining admixture (AEA), viscosity modifying admixture (VMA) and anti-foaming admixtures (AFA) significantly affect the properties of fresh and hardened self-compacting concrete. Better insights on the working mechanism of these admixtures are provided based on the advancement of modern techniques in microstructure analysis 14. In the tested concretes with a constant basic composition, along with the increase in SP compressive strength in NAEC increased by 13-14%.

As can be seen from the table, the I / C ratio with the addition of Master Rheobuild 1000 decreases by 13.0% and with the addition of Master Air 200 by 4.4%. With a further increase in the dosage, the rate of increase decreases and the reduction in water demand becomes constant. As already noted, the increase in the mobility of the cement dough, and therefore the possibility of reducing water consumption, comes from the dosage of additives corresponding to the formation of an adsorption layer on the surface of cement particles. A further increase in the dosage increases the concentration of the additive in the solution, but does not affect its adsorption and rheological characteristics of the cement dough.

Conclusion. The study showed that the introduction of additives into the concrete mixture shows a significant increase in its strength. The best indicators were obtained at a dosage of 1.3% and 0.1% by weight of cement. With the introduction of additives, not only the grade of concrete increases, but also the intensity of the increase in the strength of concrete significantly accelerates, therefore, additives accelerate the hydration processes and ensure the compaction of the cement stone structure in the early stages of its formation.

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КЕШЕНДІ ҚОСПАЛАРДЫ ҚОЛДАНУ ТИІМДІЛІГІН ЗЕРТТЕУ MASTER RHEOBUILD 1000 ЖӘНЕ MASTER AIR 200

Аннотация. Мақалада химиялық қоспалардың бетонның қасиеттеріне, атап айтқанда су қажеттілігін және бетон қоспасының ыңғайлылығын төмендетуге әсерін анықтау бойынша жүргізілген эксперименттік зерттеулердің нәтижелері қарастырылады. Міндет олардың бетон мен темірбетонның құрылымдық құрылыс материалдарының сапасына, оның ішінде ең көп таралған және ресурстарды қажет ететін цемент бетонына сенімділігін арттыру қажеттілігі болып табылады. Химиялық қоспалар бетонның қасиеттерін жетілдірудің ең қарапайым және қолжетімді технологиялық әдістерінің бірі бола отырып, өнім бірлігіне шығындар деңгейін едәуір төмендетуге, темірбетон элементтерінің (ТБЭ) және конструкциялардың (ТБК) үлкен номенклатурасының сапасы мен тиімділігін арттыруға, ТБЭ және ТБК, сондай-ақ жалпы ғимараттар мен құрылыстардың қызмет ету мерзімін ұлғайтуға мүмкіндік береді. Химиялық қоспалардың клинкер цементінің минералогиялық құрамымен бірлесіп жұмыс істеуі бетонның беріктігін, тығыздығын, аязға төзімділігін және су өткізбейтіндігін арттырады. Бұл қасиеттердің жақсаруын тек пластификациялық әсері бар қоспалар ғана қамтамасыз ете алады (бетон қоспасының сапасын жақсартады); қасиеті монтаждың соңын едәуір жылдамдатады және темірбетон элементтері мен конструкциялардағы Болаттың коррозиясының ингибиторлары болып табылады. Сондықтан әлемдік тәжірибеде бетон технологиясында химиялық қоспаларды қолдануға көп көңіл бөлінеді. Алынған бетонның жетеуі оны алыс қашықтыққа тасымалдауға, сорғы жабдығының көмегімен құюға мүмкіндік беретін қасиеттерге ие. Жұмыстың мақсаты –уақыт өте келе сипаттамалардың сақталуымен пластикалық, ыңғайлы бетон қоспасын алу.

Түйінді сөздер: химиялық қоспа, суперпластификатор, бетонның қозғалғыштығы, құрылымы, бетонның беріктігі.

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ИССЛЕДОВАНИЕ ЭФФЕКТИВНОСТИ ПРИМЕНЕНИЯ КОМПЛЕКСНЫХ ДОБАВОК MASTERRHEOBUILD 1000 И MASTERAIR 200

Аннотация. В статье рассматриваются результаты проведенных экспериментальных исследований по выявлению влияния химических добавок на свойства бетона, в частности на снижение водопотребности и удобоукладываемости бетонной смеси. Задача является необходимостью повышения их эксплуатационной надежности бетона и железобетона к качеству конструкционных строительных материалов, в том числе и к наиболее распространенному и ресурсоемкому – цементному бетону. Химические добавки, являясь одним из самых простых и доступных технологических приемов совершенствования свойств бетона, позволяют существенно снизить уровень затрат на единицу продукции, повысить качество и эффективность большой номенклатуры железобетонных элементов (ЖБЭ) и конструкций (ЖБК), увеличить срок службы как ЖБЭ и ЖБК, так и зданий и сооружений в целом. Совместная работа химических добавок с минералогическим составом клинкера цемента обеспечивает повышение прочности, плотности, морозостойкости и водонепроницаемости бетонов. Обеспечивать улучшение этих свойств могут лишь те добавки, которые обладают одновременно

пластифицирующим действием (повышающим качество бетонной смеси); свойством значительно ускорять конец схватывания, и являются ингибиторами коррозии стали в железобетонных элементах и конструкциях. Поэтому применению химических добавок в технологии бетона в мировой практике уделяется огромное внимание. Полученная бетонная смесь обладает свойствами, позволяющими осуществлять ее транспортировку на далекие расстояния, заливку при помощи насосного оборудования. Целью работы является получение пластичной, удобоукладываемой бетонной смеси с сохранностью характеристик во времени.

Ключевые слова: химическая добавка, суперпластификатор, подвижность, структура бетона, прочность бетона.

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