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IMPROVED FINE-GRAINED CONCRETE FOR PAVING SLABS WITH ORGANOMINERAL ADDITIVES

ОРГАНОМИНЕРАЛДЫ ҚОСПАЛАРЫ БАР ТРОТУАР ПЛИТАЛАРЫ ҮШІН ЖАҚСАРТЫЛҒАН МАЙДА ТҮЙІРШІКТІ БЕТОН

УЛУЧШЕННЫЙ МЕЛКОЗЕРНИСТЫЙ БЕТОН ДЛЯ ТРОТУАРНОЙ ПЛИТКИ С ОРГАНОМИНЕРАЛЬНЫМИ ДОБАВКАМИ

Abstract. *Currently, putty concrete is widely used in road construction. But, as can be seen from the experiments, there is a problem of premature destruction of facing concrete exposed to an aggressive environment. In addition, fine-grained concrete is characterized by a higher level of consumption of Portland cement compared to conventional heavy concrete. One of the possible ways to solve these problems is the introduction of a complex organomineral mixture that promotes binding. Crushed concrete was mainly considered as a local building material. Because at present, consumers are abandoning large fillers that require large funds. A large number and of great importance are works on the study of reinforced concrete. To date, approaches to concrete have not changed, and their research continues to develop.*

Keywords: *crushed concrete, organomineral mixture, superplasticizers, modifier MB 10-01, constant factors, dynamic module.*

Аңдатпа. *Қазіргі уақытта майдатүйіршікті бетон жол құрылысында кеңінен қолданылады. Бірақ тәжірибелерде көрстеткендей агресивті ортаға ұшыраған жол төсеніштері майдатүйіршікті бетондардың мерзімінен бұрын бұзылу мәселесі бар. Сонымен қатар, майдатүйіршікті бетон әдеттегі ауыр бетонмен салыстырғанда портландцементті тұтынудың жоғары деңгейімен сипатталады. Бұл мәселелерді шешудің мүмкін бағыттарының бірі байланыстыруға ықпал ететін кешенді органоминералды қоспаны енгізу. Майдатүйіршікті бетон негізінен жергілікті құрылыс материалы ретінде қарастырылатын болды. Себебі қазіргі уақытта тұтынушылар көп қаражатты қажет ететін ірі толтырғыштардан бас тартуда. Майдатүйіршікті бетонды зерттеу жұмыстарының саны көп және маңызы зор. Қазіргі таңға дейін майдатүйіршікті бетонға деген көзқарастар өзгерген жоқ, оларды зерттеу жұмыстары одан әрі қарай даму үстінде.*

Түйін сөздер: *майдатүйіршікті бетон, органоминералды қоспа, суперпластификаторлар, МБ 10-01 модификаторы, тұрақты факторлар, динамикалық модуль.*

Аннотация. *В настоящее время шпаклевочный бетон широко используется в дорожном строительстве. Но, как видно из экспериментов, существует проблема преждевременного разрушения облицовочного бетона, подвергшегося воздействию агресивной среды. Кроме того, мелкозернистый бетон характеризуется более высоким уровнем потребления портландцемента по сравнению с обычным тяжелым бетоном. Одним из возможных направлений решения этих задач является введение комплексной органоминеральной смеси, способствующей связыванию. Дробилкуплетный бетон в основном рассматривался как местный строительный материал. Потому что в настоящее время потребители отказываются от крупных наполнителей, которые требуют больших средств. Большое количество и большое значение имеют работы по изучению железобетона. До настоящего времени подходы к бетону не изменились, и их исследования продолжают развиваться.*

Ключевые слова: *измельченный бетон, органоминеральная смесь, суперпластификаторы, модификатор МБ 10-01, постоянные факторы, динамический модуль.*

Introduction. Before proceeding to the study of crushed concrete, let us dwell on the annotations of the studied works of several scientists who conducted research on this topic:

Currently, fine-grained concretes are found forт the manufacture of reinforced concrete products and the construction of monolithic structures in hydrotechnical construction. The feasibility of their use is primarily determined by the lack of large aggregate in some areas of concrete. The use of local sands or fine waste of crushing rocks instead of the imported large aggregate allows you to achieve significant resource savings. One of the ways to solve this problem is the use of affordable, cheap, often unclaimed local raw materials, to which you can attribute waste crushing rocks.[2]

The interaction between nanoparticles of Styrene-Butyl Acrylate latex and cement particles with various water-cement and superplasticizers-cement ratios during the hydration process has been investigated to achieve the best chemical combination of the materials for enhancing the mechanical properties and workability of the concrete. Analyses and experimental results have shown that the adhesive properties of Styrene Butyl Acrylate (SBA) copolymer latex along with an appropriate percentage of superplasticizers promote the performances of interlayer bonding of concrete. The compressive, splitting, and flexural strengths of specimens have been studied and the formations of the microstructures by the implementation of FESEM, EDX, XRD, FTIR, TEM, and DLS, have been analyzed. The obtained results show the considerable enhancement in the structural behavior of the copolymer-modified concrete in comparison with the control samples by creating cohesive microstructures in the presence of the copolymer. Appropriate water-cement ratio and superplasticizers were selected to study the efficient distribution of the copolymer nanoparticles throughout the cement matrix by the implementation of the FESEM and EDX analyses. The constructed polymer bridges and films between layers of Ca(OH)2 crystals have yielded to the formation of an internal cohesive strong microstructure. Also, XRD and FTIR results indicate that the stability and formation of ettringite have been enhanced by the development of calcium aluminate reaction with SBA copolymer. In the cement pore solution, the chemical interaction between nanoparticles, and Ca2+, the copolymer nanoparticles adsorption on cement paste were applied and the enhanced microstructure of the concrete was obtained.[3]

The incorporation of fly ash in concrete enhanced the durability of portland cement concrete more effectively. Fly ash is incorporated as a mineral admixture because of its advantageous properties like pozzolanic reaction and pore refinement. At the point when fly ash is added in concrete, calcium hydroxide, liberated during cement hydration, reacts with the reactive silica present in fly ash and forms calcium silicate hydrate(C-S-H) gel. This research investigates the influence of fly ash in conjunction with four different superplasticizers (SP) namely Polycarboxylate ether (PCE), Lignosulphonate (LS), Sulphonated Melamine Formaldehyde (SMF) and Sulphonated Naphthalene Formaldehyde (SNF) and on the mechanical and durability properties of concrete. Concrete was made with different levels of class F flyash replacement (0,15, 25, and 35% by mass) of cement, the w/c ratio were maintained constant as 0.37 and the superplasticizer dosage corresponding to saturation dosage. The saturation dosage of superplasticizer is measured by conducting marsh cone and minislump tests. The mechanical and durability properties tested were compressive strength, splitting tensile strength and Sorptivity. PCE based superplasticizers are found to be more effective. Modification in the mechanical by increase in later age strength and durability properties by increase of the concrete was observed with the addition of fly ash and superplasticizer in control mix [5].

In this rapid urbanization age, cement concrete is one of the most popular and demanding building materials. One of the components of concrete is roughly 12вЂ“15% cement. Overall, yearly cement manufacturing contributes around 7% of the world's CO2 emissions. As a result, the concrete industry is a global warming contributor. The goal of this research is to discover a method for mitigating the environmental risks that its production causes. Materials such as Fly Ash (FA), Rice Husk Ash (RHA), Silica Fume (SF), and Ground Granulated Blast Furnace Slag (GGBFS) are examples of supplementary cementitious materials (SCMs). If utilized as a substitute for cement in concrete, these components have the advantage of enhancing the strength of the concrete over time. This study shows the comparative effect of three SCMs i.e. FA, RHA and SF on compressive strength of concrete proportionated by Nominal Mix (NM) and Design Mix (DM) techniques both. In addition to that different ranges of aggregates 20В mmв€'12.5В mm, 9.55В mmв€'4.75В mm were also used to improve the packing density of concrete. During A total of sixty-six 15cmx15cmx15cm cubes were created for the experimental inquiry to measure the strength of cubes for varied curing durations of 14, 28, and 56В days. FA and RHA were utilized individually for partial cement replacement with proportions of 15%, 20%, 25 percent%, 30%, and SF with 10%, 15%, 20%, and the compressive strengths of 14В days, 28В days, and 56В days were computed using the compressive testing machine [6].

The realization of the concept of high-quality concrete was possible, first of all, due to the use of superplasticizers. The optimal combination of 1p and 1x modifier mixtures is indicated, and if necessary, their combination with small amounts and other organic and mineral materials allows to control the rheological properties of concrete mixtures and to change the structure of cement stone at the micro level to give concrete high performance strength. MTB is fine-grained concrete [1, 2].

A complex organo-mineral mixture consisting of MB10-01 modifier and ash 8 contributes to the compaction of the structure and the addition of calcium hydroxide to water-insoluble compounds, and at the same time it is assumed that it plays the role of a fiuely dispersed component that actively affects all the main processes of MTB structure formation.[4]

Materials and methods of research (materials and research methods). Laboratory and industrial studies were conducted to confirm the correctness of the developed theoretical rules. M500 grade Portland cement was used as an astringent (with normalized chemical and mineralogical composition) in the research by the following manufacturing plants: "Shymkent Cement" (Shymkent Cement JSC); "Zhambyl Cement" JSC (Zhambyl city); Complex organo-mineral mixture consisting of MB 10-01 modifier and CHP-22 ash (Kyzylorda region, Kyzylorda city).

During the research, standard methods were used mainly in accordance with the existing GOST, as well as specially developed in this work. The selection of optimal compositions of high-quality MTB for road pavements with complex organomineral mixture was carried out by mathematical planning of the experiment according to the B4 type plan based on d-optimap.The compaction coefficient of the concrete mixture, as well as the conditions of preparation and hardening of concrete, are taken as constant factors. Levels and intervals of change of input parameters are given in the table 1.

Table 1. Levels and intervals of change of input variables

Input parameters	Levels of variation			Change interval
	-1	0	+1	
Cement ash viscous loss,кg/m3, X1	400	500	600	100
Water consumption, dm3/m3,X2	170	190	210	20
Cement ash share,%, Xa	0	32	62	32
Mixture consumption MB of cement mass 10-01, %, X4	5	11	16	6

As a result of the processing of experimental data, equations were obtained, the verification of which adequately describes the system. The dependence of the main construction-technical and physico-mechanical properties of fine-grained concrete developed on the basis of the obtained equations on a number of technological parameters was studied. Thus, during the study of the dependence of the workability of the fine-grained concrete mixture on the ash content (Fig.1), it was found that the introduction of ash into the oily concrete mixtures with a high consumption of cement leads to a decrease in the flaking ability. When it is introduced into mixtures with low consumption of cement, there is an optimal amount of ash, when it is introduced, the workability of the mixture is not only preserved, but even slightly improved. X-Blurring of the cone, mm. Y- Amount of ash in cement, % The dependence of the workability of fine-grained concrete mixtures on the ash consumption at different consumption of cement (water consumption 190 dm3/m3, 1 ...7-C =550 respectively 500,450,400, 350, 300, 250 kg/m3. MB 10-01-10% of cement mass).As can be seen (Fig.3.1), the introduction of fly ash into fatty mixtures leads to a decrease in workability and, the greater the cement consumption,the more noticeable the loss of workability with the same percentage of fly ash relative to cement consumption. In a lean mixture, there is an optimal amount of fly ash, with the introduction of whichthe workability of the mixture is not only preserved, but also slightly improved. With the introduction of ash-) of the sco more than this amount, the deterioration of the workability of the mixture is again observed. The optimal amount of fly ash in this case depends on the cement consumption, the greater the cement consumption, the less it is. At a cement consumption of 250 kg/m it is about 65% of the cement consumption, and at a cement consumption 350 kg/m - about 20%. With a decrease in water consumption or the MB 10-01 modifier, an imperceptible decrease in this maximum is observed. The introduction of MB 10-01 improves the workability of the mixture. At the same time, increasing the consumption of 10-01 MB of cement mass from 5 to 15% allows to obtain a mobile mixture equal to the consumption of 10 dm3/m3 of water. The introduction of a complex organomineral mixture into fine-grained concrete has a significant effect on its compressive, bending and splitting strength, and the maximum strength is achieved at a certain consumption of the mixture, but then the strength gradually decreases with further addition of the mixture.

So, when consuming cement, the maximum amount of admixture of 250 kg/m3 is 100%, and 350 and 450 kg/m3 are 50 and 25%, respectively. When the consumption of cement exceeds 500 kg/m, the optimal amount of admixture is up to 15... 20% of the cement mass. The dependence of the dynamic modulus of elasticity on the composition of the mixture is slightly different. At a cement consumption of less than 350 kg/m3, the introduction of a complex organomineral mixture leads to a slight decrease in the dynamic modulus of elasticity. There is a slight increase in the dynamic modulus of elasticity when the consumption of cement exceeds 350 kg/m3. When the water consumption decreases, the tendency of the dynamic modulus of elasticity to decrease during the introduction of the mixture increases.

Conditional ultimate elongation in fine-grained concrete with cement consumption below 500kg/m3 increases and reaches a maximum at a certain amount of admixture depending on the cement consumption. When the cement consumption is 450kg/m3 and below, the increase in the mixture consumption increases the conditional ultimate elongation, and the cement consumption exceeds 450kg/m3, and on the contrary.

In the first case, the optimal amount of the mixture is increased with the increase in water flow, and in the second it is on the contrary. However, there is little change in the conditional maximum elongation of 350...450kg/m3 during cement consumption.

On the basis of these data and taking into account the requirements for road pavement concrete, the optimal composition of fine-grained concrete with high strength was selected for road pavements of various purposes (table. 2) and for composition 3.4, 5 - 8.0 (100).

Table 2. Composition of studied fine-grained concretes for road pavements

№ Content	Cement	Ash	Sand	Water	MB 10-01	С-3, %	СНВ, %	Workability GOST 10181-2000	
								Cone deposit, cm	Hardness, s
1	500	-	1610	242	-	-	0,05	-	21…25
2	330	170	1685	171	-	0,5	0,05	-	41…50
3	650	65	1410	199	65	-	0,05	20…22	-
4	500	75	1570	176	50	-	0,05	2	16…20
5	420	90	1580	128	32	-	0,05	-	61…100

There are 3 compositions of high-strength fine-grained concrete for road surfaces made of different workable concrete mixtures: 3-cast (self-compacting) mixture; 4 and 5 respectively for coating device using medium hard and very hard rail molds and rolling method. Formulations 1 and 2 are controls and are taken as benchmarks for comparison. Additional physico-mechanical and operational studies were conducted on fine-grained concrete compositions which properties are listed in the table. Necessary studies have been carried out for fine-grained concrete.

Strength and deformation characteristics: cube strength (R); prism strength (Rb); tensile strength of concrete (Ka); initial modulus of elasticity (s); moisture loss.

The researches were carried out on cubes with edges of 10 and 15 cm and on samples with prism dimensions 4*4*16 see and see 10*10*40.

Cube strength (R) of concrete was determined in 1, 3, 7, 14 and 28 days. Experimental values of strength and deformation characteristics during short-term loading are given in Table 3.

Table 3. Strength and deformation characteristics of manufactured fine-grained concrete

Content №	Period, day	R10, MPa	R15, MPa	Rb, MPa	R0/R10, MPa	Rbt	Eb*103, MPa	Ɛsr*105, MPa
1	7	24	23	20,3	0,84	2,6	26,75	18,5
	28	43,6	42	39	0,88	4,5	33,46	
2	7	21,4	20,2	19	0,89	3	21,49	15,4
	28	41,3	39	36,5	0,89	4,9	25,57	
3	7	65,7	61,3	58,8	0,88	7,6	35,48	13,5
	28	105,3	102	92,5	0,89	11,3	41,6	
4	7	60	56,3	44,9	0,76	6,8	34,85	11,6
	28	97	89,4	81,6	0,81	9,5	42,90	
5	7	54,7	52,1	46,3	0,83	6,3	38,40	10,9
	28	84,5	81,3	71,6	0,86	8,9	46,00	

Based on the above theoretical positions, the following indicators of strength and deformative properties of the developed fine-grained concrete were considered in the work:

– cubic strength (R);
– prismatic strength (Rь);
– tensile strength of concrete (Rbt);
– initial modulus of elasticity (Eb);
– humidity shrinkage (Ɛsr).

Experimental data show a very rapid increase in the strength of fine-grained concrete developed over time. After 1 day, the cubic strength of fine-grained concrete developed was 20...30%; and 3 and 7 through day-60-75% 28-day strength. Such values of the strength of fine-grained concrete with complex organomineral mixture can be considered as appropriate requirements in the short term; sufficient for high-quality concrete and dismantling of the road structure under construction. By 28 days, the strength of concrete reached 85... 120 MPa, and by 150 days, it exceeded the 28-day strength value by an average of 12%.

The prismatic strength of the concretes made at 7 and 28 days was within 75...90% cubic strength. Thus, the prism strength factor reached 0.8 Cr.

Tensile strength of concrete is determined by the results of bending tests of beams 10*10*40 see table 3 above. The values and characteristics of the shrinkage deformations of the developed concretes are smaller than those of the reference concretes. As you can see, it is given in the table. The absolute values of shrinkage deformations of developed concretes 3 are small (ƐSR=13.5*10-5* and less). Thus, given in the table 3 strength and deformation characteristics allow us to assume that they are developed according to the obtained indicators.

MB may be classified as high quality, but this is not sufficient for use in concrete pavements. Therefore, a large place is given to basic operational research in the work, taking into account the features of their work on road surfaces, the following properties are taken into account: water absorption, permeability, frost resistance, weather resistance, wear resistance. These properties are primarily related to structure, research has focused on examining structure and its effects.

It has been shown that the complex organo-mineral mixture for road surfaces contributes to the formation of crystal hydrate embryos from a saturated solution and changes in their dispersion. Therefore, hydration reactions slow down the growth of Ca(0H)2 crystals, resulting in the formation of long fiber hydrosilicates in the structure of cement paste. This leads to spatial adhesion with highly dispersed hydrated growths.

Water absorption, permeability and wear were determined according to standard methods (State Standard 12730.0-78, State Standard 12730.3-78 and State Standard 13087-81). Frost resistance and weather resistance were determined according to specially developed methods that correspond to the conditions of fine-grained concrete operation on road surfaces.

The results of studies on water absorption and permeability of fine-grained concrete developed for road pavements are presented in the table. 4.

Table 4. Water absorption and permeability of developed fine-grained concrete

Content №	Water absorption, %	Conductivity indicators	
		Air penetration resistance of concrete, mo, s/cm3	Waterproof concrete brand
1	10.9	160.6	W2
2	9.2	189.6	W4
3	2.6	1016	W20
4	2.9	878.9	W18
5	3.6	796.5	W16

They show that the water absorption of the developed fine-grained concrete varies from 2.5 to 3.5, depending on their functional purpose, and the water absorption is 10 or more % compared to the reference. Air and water tightness of the developed fine-grained concrete is 5 and more times higher than the standard fine-grained concrete.

Frost resistance of the developed surface layer was determined. 700...800 cycles for road surfaces and the use of air-permeable mixture is quite a lot. As for weather resistance, the mass loss of the samples after 50 cycles of alternating wetting and deep drying in 10% NaCl solution was 1 to 2%, while MB taken as a reference, this indicator was 4.. .6 %. The wear of the developed fine-grained concrete is within 0.60...0.80 g/cm3, and this indicator is -1.16..L, 19g/cm2 for fine-grained concrete taken as a standard.

Thus, the results of laboratory studies on strength, deformation and service properties allow to confirm that high-quality fine-grained concretes are obtained for road pavements. This is provided by changing the fine-grained concrete structure by introducing a complex organomineral mixture. On the basis of laboratory and industrial research, "Recommendations for the preparation and laying of concrete mixtures" were developed "High-quality fine-grained concrete road pavement coatings with a complex organo-mineral mixture". They describe the requirements for the starting materials. The functional purpose of related laying technology is determined.

The economic efficiency of introducing high-quality fine-grained concrete for paving slabs was determined during the calculation of technical and economic indicators.

Conclusions.

According to economic calculations, the service life of a cement-concrete road surface is considered to be 4 years. The results of the experimental part of the dissertation work demonstrate the advantages of road surfaces made of high-quality fine-grained concrete with an organomineral mixture. For comparative economic calculations, the service life of high-quality granular concrete paving stones for road surfaces with mineral organic additives is considered to be 9 years. Indicators of economic efficiency of compared concretes are presented in Table 5.

Table 5. Technical and economic indicators of road surfaces on various types of fine-grained concrete (per 1m)

R№ s/n	Type of concrete	Indicators						
		Durability, tenge			Tpr, years	n	n-1	Kee tenge/year
		C1	C2	C3				
1	Fine-grained concrete without additives	3647	781,5	26,05	4	2,5	1,5	1044,605
2	High-quality fine-grained concrete	6252	781,5	156,3	9	1,1	0,2	711,165

The estimated cost of installing 1 m2 of cement-concrete roadbed on the basis of a sand-gravel mixture (C1) is currently determined on the basis of the average market price of building materials, products and structures of the city of Kyzylorda.

The cost of 1 m2 of road cement-concrete pavement is determined: the full factory cost of 1 m3 of concrete mix + transportation costs + the cost of laying the concrete mix on the pavement.

Deductions (C3) are determined on the basis of the norms of deductions of fixed assets adopted in the amount of 2.5% of the estimated cost of cement-concrete road surfaces per 1 m2 of current and cement-concrete road surfaces.

To calculate the annual economic effect of using high-quality MZB for road surfaces with an organomineral additive, arranged according to the recommendations of this work, compared with MZB without an organomineral additive, the following initial provisions were adopted. The annual capacity of the plant is about 50,000 m of ready-mixed concrete or 7000 m of road surface. The Tpr of 1 m of road surface from the Ministry of Health without an organomineral additive is 4 years, and the Cee for 1 m is 963.03tenge /year. The TPR of the road surface made of high-quality MZB is 9 years old, and Kee for 1 m 655.63 tenge/year. Under the accepted conditions, the annual economic effect in tenge for a road surface made of high-quality MZB is:

(200,5 - 136,5)*7000 = 2 151,82мың теңге жол төсеніш тақтайшаларына 1 м road surface or (200,5 -136,5)*50000 = 3 million 200 1000 thousand tenge per 1 m3 of concrete.

The calculated economic effect should be considered as indicative, since some initial data require clarification (Tpr., Tpr.op.). But even preliminary calculations allow us to assume a significant economic effect when implementing the results of this work.

1. It is possible to create high-quality fine-grained concrete for road surfaces, it contributes to a decrease in capillary porosity, an increase in density, and strengthens the contact zone between cement and stone by changing its structure with MB 10-01 modifier and a complex organo-mineral mixture consisting of ash.
2. A mathematical model of the dependence of the main structural and technical properties on variable factors was obtained, which allows determining the optimal amount of a complex organomineral mixture.
3. Optimum compositions of high-quality fine-grained concrete for road surfaces with a complex organo-mineral mixture have been developed in relation to the concrete mixture (cast) required by technology, medium hard, very hard).
4. Fine-grained concrete for road surfaces with a complex organo-mineral mixture was developed. The main physical and mechanical properties (compressive and tensile strength during bending, elastic modulus, shrinkage deformation) were studied.
5. The economic efficiency of introducing high-quality fine-grained concrete for road surfaces with a complex organo-mineral mixture was determine.

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