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OPTIMAL STRUCTURE ESTABLISHMENT OF COMPOSITIONAL MATERIAL FOR MANUFACTURING STRENGTHENED TO BENDING MUD- FLOW PROTECTIVE CONSTRUCTIONS

Abstract. Mudflows generate human and property losses. Natural calamities are not characteristic only for a region or country it is problem of all humanity on the Earth. Mudflows phenomena are widely distributed on the Republic of Kazakhstan territory.

The constructive features of today mudflow-protective constructions in this paper are considered. There had been researches on optimal structure of the compositional material for mudflow-protective constructions. In this study, two main directions are considered in this research work: resource-saving technology and life safety problems investigation.

The purpose of the paper is raw mixture composition development for compositional material obtaining, which together diminish its cost at the strengthening characteristics keeping as well as industrial waste simultaneously utilization.

The basic practically meaningful result is the development of scientific and technological bases of production of new multi-component hydraulic binding materials for compositional material. This technology is ecologically valuable, and it is low-metal-intensive and low-energy-intensive one. The scientific value of research results lie in the new regularities of multi-component system mechanical dispersion based on different grinding principles. It lies also in revealing the new products of mechanically activated multi-component cement hydration in the presence of technogenic waste of the industries (waste of mineral wool production 1.5-2.0; slag of electric-thermal production of phosphorus 2.5-5.0; waste of slate-pipe production 1.2-1.8); as well as the development of compositions of high-strength and technological sorts of cement concretes.

Mathematical modeling of experimental works planning was carried out for compositional material structure determination for mudflow-protective constructions manufacturing with strengthening to bending at which maximal meanings are reached.

Thus, the low-clinkered floured cements developed by us based on industrial technogenic waste that meets the modern requirements. i.e. they improve physical-mechanical characteristics of the material and positively influence on ecological situation and allow decreasing the cost of final product.

Keywords: emergency situations, mudflow, reinforced compositional material, mudflow protective constructions, strength of constructions to bending.

Introduction. Mudflows regularly generate significant human and property losses. Analyzing mudflows is important to assess the risks and to delimit vulnerable areas where mitigation measures are required [1].

Natural emergencies are not specific to a single region or country; this is a problem of all humanity on planet Earth. In this regard, scientists all over the world in the field of life safety and environmental protection are working on prediction, preventive measures, possibilities of reducing the damage to a human and material.

In November 2000 a large landslide of mud and debris was triggered again and it still presents a danger to the relatively new residential houses today. At present, the village is protected against mudflows by a small rockfill dam and by the regulation of the stream bed. In rainy periods removal of mud is necessary maintain safe conditions for the village [2].

Torrential floods are the most frequent natural catastrophic events in Serbia, causing the loss of human lives and huge material damage, both in urban and rural areas. The analysis of the intra-annual distribution of maximal discharges aided in noticing that torrential floods have a seasonal character [3].

Besides of natural calamities as well human activities bad influence on environment and they are needed in new protective measures development.

Nowadays the technologies of emergency situations management in the mountain areas are developed and applied in order to safe conditions of localities organization.

The protective constructions are used more than 30-40 years. They are worn out and partly destroyed. It is necessary to develop ways of their theoretical and experimental researches as well their practical application.

The most complex objective for science in the field of engineering protection of the territories is concluded in how to forecast approaching of danger and what kind of measures to take for risk diminishing of the natural calamities. At the scientific based approach to these problems decision can safe huge material means as well to improve environment and mainly to keep life of people.

The purpose of this work is determination of constructional decision for protection from natural calamities. The maximal index of strengthening is reached at the 7 and 28 days extraction [4-6].

Scientific novelty is concluded in the following:

– experimentally optimal structure of raw mixture for reinforced compositional material obtaining to mudflow protective constructions manufacturing has been determined;

– due to mathematical planning of experiments optimal structure of raw mixture of the compositional material, which strengthening characteristics increasing such as bending and exploitation period duration have been established.

All over the world, where high mountain areas are situated have problems connected with natural calamities. Therefore, protection from mudflows, floods and other natural character emergency situations requires constructions advanced and resources saving with strengthening characteristics.

Material and methods. Nowadays many researchers are interested in out of products of the chemical productions particularly phosphorus slag the yield of which annually is increased.

Authors of this work use the following kinds of material with chemical composition in order to obtain resource-saving and energy economic new material. which answer to all exploitation question.

Portland cement of the following chemical composition, mass. %: SiO_2 – 19.45÷20.2; Al_2O_3 – 4.4 ÷4.9; Fe_2O_3 – 2.9÷4.49; CaO – 60.98÷66.0; MgO – 1.8÷3.18; R_2O – 1.80÷1.90; SO_3 – 1.85÷3.08.

Waste of slate-pipe production. Chemical composition, mass. %: SiO_2 – 20.80; $A1_2O_3$ – 3.85; Fe_2O_3 – 4.15; CaO – 50.0; MgO – 5.35; SO_3 – 1.65.

Waste of mineral wool production represent by themselves fiberglass with an average diameter 0.6 microns and length from 5 to 20 mm with module of acidity equals to 1.4. Chemicalcomposition, mass. %: SiO_2 – 45.8÷46.1; Al_2O_3 – 9.4 ÷9.84; Fe_2O_3 – 1.5÷1.63; CaO – 37.8÷39.1; MgO – 2.2÷2.22; SO_3 – 0.9÷0.93.

The applied slag of electric-thermal of phosphorus production has the following chemical composition, mass. %: SiO_2 – 40.9÷44.21; Al_2O_3 – 1.65÷2.67; Fe_2O_3 – 1.07÷2.6; CaO – 45.0÷45.92; MgO – 1.07÷3.18; SO_3 – 0.3÷0.5.

The binders are received by means of neutralization of ground till specific surface 300-350 kg/m^2 of granulated phosphoric slag with lime (lime-slag binder). cement (cement-slag) and secondary cement dust (dust-slag) magnesium chloride (salt-slag) sodium hydroxide (slag-alkaline). The content of activizators of hardening in the binder is hesitated within 2-12 % from mass of slag.

As reinforced materials are used glass Capron, basalt and steel fiber in the quantity of 2-40% on of binders. For compositional binders receiving of steel fiber segments with diameter 0.5-1.0 mm and 2-20 mm are used.

The significant effect on efficiency of concretes reinforcement with fibers fraction and coarse aggregate content influences. The number of coarse aggregate must be no more than 445-515 m^2/kg and size of its grains do not exceed 10 mm in compositional materials.

The significant influence on comfortable fit of concrete mixture and physical-mechanical characteristics reinforced concretes the diameter and correlation of length to fibers (1/d) diameter. The comfortable fit of concrete mixture with diameter diminishing and 1/d value increasing is lowered.

It is necessary to increase cement quantity for mixture comfortable fit improvement at the given water/cement correlation. For dispersed-reinforced concretes production is more effectively use steel wires with curved ends glued together in bundles. At these conditions clumping of fibers is diminished as well comfortable fit of big amount of mixture, statistic and dynamic properties of concrete is improved [7-10].

Due to the following physical-chemical methods the experimental works are carried out: x-ray phase, analytical, electron-microscopic thanks to electron-solution microscope JSM 63-90 LV, JED-2300 Analysis station Japanease firm JOEL.

It is established optimal composition and technological regime of raw mixture manufacture due to method of mathematical planning of the experiment.

– strength of construction to bend (at the 7 days extraction) kg/cm^2 ;
– strength of construction to bend (at the 28 days extraction) kg/cm^2.

The following factors are varied:

– Portlandcement. %;
– waste of mineral wool production. %;
– slag of electric-thermal of phosphorus production. %;
– waste of slate-pipe production. %.

The ranges of aggregates composition changing are brought in the table 1.

Table 1 – Table samples

Factors	X_1	X_2	X_3	X_4
Lowerlevel (1)	92.4	1.625	3.125	1.65
Upperlevel (+1)	94.8	1.875	4.375	1.50
Shoulder - (= 2) (additionalpoints)	91.20	1.50	2.50	1.20
Shoulder + (additionalpoints)	96.00	2.00	5.00	1.80
Ground level (0) (mid of plan)	93.60	1.75	3.75	1.20
Intervalofvarying (X)	2.40	0.25	1.25	0.30

Tridimensional graphics of strength dependence on bend from different factorsequaled with found optimal values at the 28 and 7 days extraction are shown on the figures from 1 to 8.

Table 2 – Plan and treatment results of the experiments for determining the optimal composition of composite materials, which gives the maximum value Y_1 – the strength of the structure in bending (with exposure time of 7 days) kg/cm^2

№ test	Internalvarieties				Yield		Inaccuracy (error)		Coefficient of mathematical model (1) in real scale	
	X_1	X_2	X_3	X_4	$Y_{experiment}$	$Y_{calculated}$	absolute	relative %		
1	2	3	4	5	6	7	8	9	10	11
1	94.80	1.63	3.13	1.35	147.400	147.5238	-0.1238	-0.0840	№	meaning
2	92.40	1.63	3.13	1.35	147.000	146.9924	0.0076	0.0052	1	473.0706
3	94.80	1.88	3.13	1.35	146.900	146.8954	0.0046	0.0031	2	3.8260
4	92.40	1.88	3.13	1.35	146.500	146.5562	-0.0562	-0.0384	3	-320.9542
5	94.80	1.63	4.38	1.35	146.600	146.7070	-0.1070	-0.0730	4	-159.0778
6	92.40	1.63	4.38	1.35	145.700	145.7068	-0.0068	-0.0046	5	-276.7881

Продолжение таблицы 2

1	2	3	4	5	6	7	8	9	10	11
7	94.80	1.88	4.38	1.35	148.500	148.5355	-0.0355	-0.0239	6	-0.0401
8	92.40	1.88	4.38	1.35	148.000	148.0259	-0.0259	-0.0175	7	23.5433
9	94.80	1.63	3.13	1.65	148.200	148.2034	-0.0034	-0.0023	8	0.9723
10	92.40	1.63	3.13	1.65	147.700	147.7437	-0.0437	-0.0296	9	-1.4522
11	94.80	1.88	3.13	1.65	147.800	147.8753	-0.0753	-0.0509	10	0.9252
12	92.40	1.88	3.13	1.65	147.850	147.7738	0.0762	0.0515	11	0.8049
13	94.80	1.63	4.38	1.65	147.500	147.5268	-0.0268	-0.0181	12	1.4044
14	92.40	1.63	4.38	1.65	147.000	147.0306	-0.0306	-0.0208	13	45.5884
15	94.80	1.88	4.38	1.65	147.000	147.0356	-0.0356	-0.0242	14	91.4725
16	92.40	1.88	4.38	1.65	147.300	147.2625	0.0375	0.0254	15	45.9248
17	96.00	1.75	3.75	1.50	147.000	146.8542	0.1458	0.0992	16	-0.2948
18	91.20	1.75	3.75	1.50	146.000	146.0346	-0.0346	-0.0237		
19	93.60	1.50	3.75	1.50	148.000	147.8949	0.1051	0.0710		
20	93.60	2.00	3.75	1.50	148.400	148.3982	0.0018	0.0012		
21	93.60	1.75	2.50	1.50	148.500	148.4494	0.0506	0.0340		
22	93.60	1.75	5.00	1.50	148.000	147.9393	0.0607	0.0410		
23	93.60	1.75	3.75	1.20	146.200	146.0841	0.1159	0.0793		
24	93.60	1.75	3.75	1.80	147.000	147.0047	-0.0047	-0.0032		
25	93.60	1.75	3.75	1.50	146.700	146.6751	0.0249	0.0170		
26	93.60	1.75	3.75	1.50	146.500	146.6751	-0.1751	-0.1195		
27	93.60	1.75	3.75	1.50	146.900	146.6751	0.2249	0.1531		
28	93.60	1.75	3.75	1.50	146.490	146.6751	-0.1851	-0.1264		
29	93.60	1.75	3.75	1.50	146.880	146.6751	0.2049	0.1395		
30	93.60	1.75	3.75	1.50	146.560	146.6751	-0.1151	-0.0785		
31	93.60	1.75	3.75	1.50	146.700	146.6751	0.0249	0.0170		
Summaryerror =							-0.22656	-0.0012		
Averagemeaningoferror =							-0.01133	-0.0001		
Meaning of criteria of $R_{quadratum}$ =							**0.9837**			

Table 3 – Plan and treatment results of the experiments for determining the optimal composition of composite materials,

which gives the maximum value Y_2 – the strength of the structure in bending (with exposure time of 28 days) kg/cm^2

№ test	Internalvarieties				Yield		Inaccuracy (error)	
	X_1	X_2	X_3		$Y_{experiment}$	$Y_{calculated}$	absolute	relative %
1	94.80	1.63	3.13	1.35	150.500	150.5855	-0.0855	-0.0568
2	92.40	1.63	3.13	1.35	151.100	151.3130	-0.2130	-0.1409
3	94.80	1.88	3.13	1.35	153.200	153.2402	-0.0402	-0.0263
4	92.40	1.88	3.13	1.35	153.000	153.2568	-0.2568	-0.1679
5	94.80	1.63	4.38	1.35	150.300	150.2816	0.0184	0.0122
6	92.40	1.63	4.38	1.35	151.000	150.9416	0.0584	0.0387
7	94.80	1.88	4.38	1.35	152.700	152.4960	0.2040	0.1336
8	92.40	1.88	4.38	1.35	152.500	152.5937	-0.0937	-0.0614
9	94.80	1.63	3.13	1.65	153.700	153.5833	0.1167	0.0759
10	92.40	1.63	3.13	1.65	153.400	153.7786	-0.3786	-0.2468
11	94.80	1.88	3.13	1.65	152.500	152.7176	-0.2176	-0.1427
12	92.40	1.88	3.13	1.65	152.300	152.2847	0.0153	0.0101
13	94.80	1.63	4.38	1.65	153.200	153.0906	0.1094	0.0714
14	92.40	1.63	4.38	1.65	153.500	153.4336	0.0664	0.0433
15	94.80	1.88	4.38	1.65	150.700	150.4816	0.2184	0.1449
16	92.40	1.88	4.38	1.65	150.300	150.3778	-0.0778	-0.0518
17	96.00	1.75	3.75	1.50	152.000	152.2313	-0.2313	-0.1522
18	91.20	1.75	3.75	1.50	153.000	152.6296	0.3704	0.2421
19	93.60	1.50	3.75	1.50	153.800	153.7217	0.0783	0.0509
20	93.60	2.00	3.75	1.50	153.800	153.7402	0.0598	0.0389
21	93.60	1.75	2.50	1.50	153.500	153.0439	0.4561	0.2971
22	93.60	1.75	5.00	1.50	151.000	151.3233	-0.3233	-0.2141
23	93.60	1.75	3.75	1.20	149.700	149.5653	0.1347	0.0900
24	93.60	1.75	3.75	1.80	151.000	150.9956	0.0044	0.0029
25	93.60	1.75	3.75	1.50	152.600	152.4847	0.1153	0.0756
26	93.60	1.75	3.75	1.50	152.420	152.4847	-0.0647	-0.0424
27	93.60	1.75	3.75	1.50	152.580	152.4847	0.0953	0.0625
28	93.60	1.75	3.75	1.50	152.300	152.4847	-0.1847	-0.1213
29	93.60	1.75	3.75	1.50	152.400	152.4847	-0.0847	-0.0556
30	93.60	1.75	3.75	1.50	152.600	152.4847	0.1153	0.0756
31	93.60	1.75	3.75	1.50	152.500	152.4847	0.0153	0.0100
Summaryerror =							-0.27902	-0.0044
Averagemeaningoferror =							-0.01395	-0.0002
Meaning of criteria of $R_{quadratum}$ =							**0.9739**	

Coefficient of mathematical model (1) in real scale	
№	meaning
1	529.6355
2	-3.5596
3	-221.3659
4	-59.1221
5	-50.3336
6	-0.0094
7	19.9401
8	-0.1927
9	-24.4914
10	1.8042
11	0.3451
12	1.4871
13	17.3555
14	-3.4337
15	22.1527
16	-0.1466

A **B**

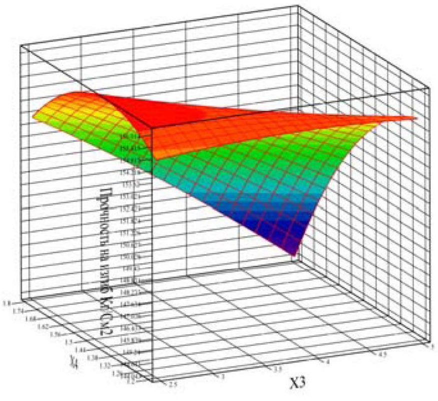


Figure 1 – Tridimensional graphic of strength dependence on bend from X_3 and X_4 at the fixed values X_1 and equaled with found optimal values (at the 28 days extraction)

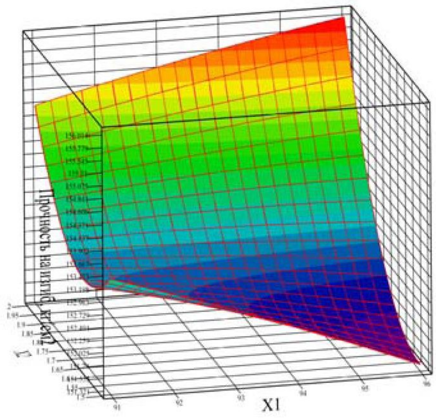


Figure 2 – Tridimensional graphic of strength dependence on bend from X_1 and X_2 at the fixed values X_3 and equaled with found optimal values (at the 28 days extraction)

C

D

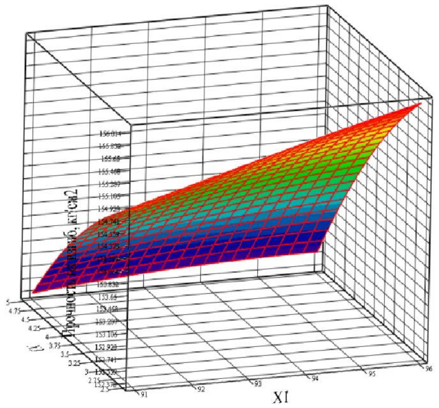


Figure 3 – Tridimensional graphic of strength dependence on bend from X_1 and X_3 at the fixed values X_2 and equaled with found optimal values (at the 28 days extraction)

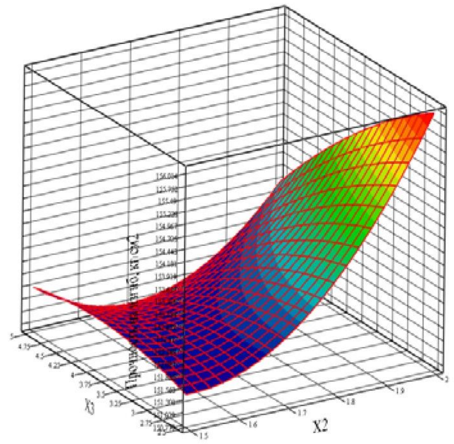


Figure 4 – Tridimensional graphic of strength dependence on bend from X_2 and X_3 at the fixed values X_1 and equaled with found optimal values (at the 28 days extraction)

E

F

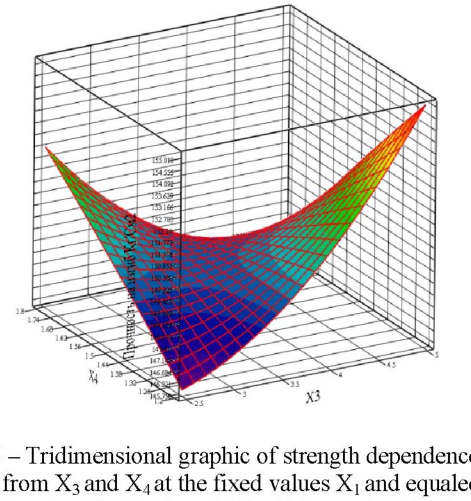


Figure 5 – Tridimensional graphic of strength dependence on bend from X_3 and X_4 at the fixed values X_1 and equaled with found optimal values (at the 7 days extraction)

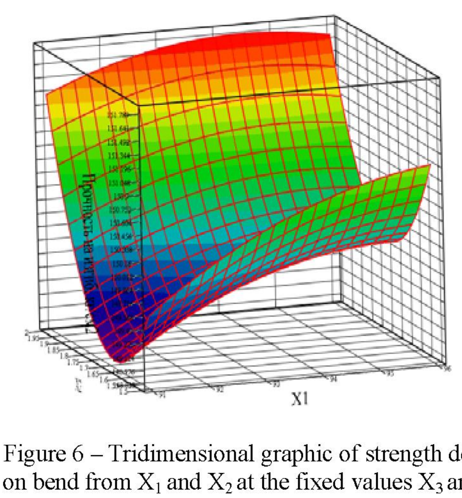
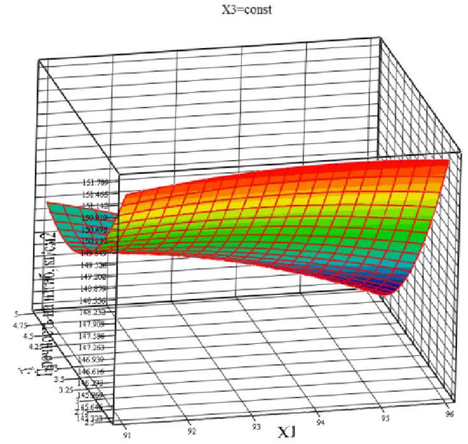
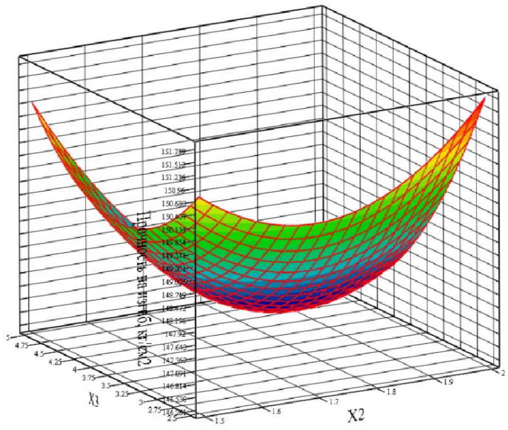


Figure 6 – Tridimensional graphic of strength dependence on bend from X_1 and X_2 at the fixed values X_3 and equaled with found optimal values (at the 7 days extraction)

G

H





Results and discussion. The results of optimal composition of raw mixtures searching at which is reached maximal value of strength of the construction on bend are brought in the table 4.

Table 4 – Table sample.The results of investigation

– strength of construction on bend (at the 28 days extraction) kg/cm^2				
96.0	2	2.5	1.44	**156.01**
– strength of construction on bend (at the 7 days extraction) kg/cm^2				
94.42	2	2.5	1.80	**151.79**

There were carried out testing of the compositional material on bend with different quantity of aggregates. The results of samples testing are brought in the table 5.

Table 5 – Table sample. The results of testing

Compo-tion	Appellationofaggregates, mass.%				Strength limit at the bend.	
	portlandcement	waste of mineral wool production	waste of slate-pipe production	slag of electric-thermal production of phosphorrus	7 days	28 days
Pro-totype	93.5	2.0	–	4.5	146	149
1	94.52	1.61	1.27	2.60	148	154.2
2	93.24	1.73	1.43	3.60	149	155
3	92.80	1.80	1.53	3.87	149	155.5

There are carried out experimental researches on choosing of raw mixture allowing increasing strength of mudflow protective constructions [11-14].

It is maintained optimal composition of the considered material with the limit of strength on bend in 7 days - 149 . in 28 days 155.5 .

The results of experimental data are allowed recommend optimal composition for stable mudflow protective constructions on bend having low cost in building industry.

Conclusion. The most difficult aim for science in the field of engineering protection of territories is conclude in how to forecast a danger approaching and what kind of measures to take for natural calamities risk lowering. It is possible to economy huge material facilities and improves ecology as well as keeps life of people.

In the result of periodic influence on stone-mud stream on constructions the micro-cracks are appeared. They have brought to macro-cracks and exploitation period of mudflow protective constructions is reduced. The application of Portland cement, waste of slate-pipe production, slag of electric-thermal production of phosphorus and waste of mineral wool production as reinforced fibers increase strength on bend and micro-cracks appearance is excluded. Consequently exploitation period of mudflow protection is extended.

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КОМПОЗИЦИЯЛЫҚ МАТЕРИАЛДЫ ДАЙЫНДАУ ҮШІН БЕРІКТІККЕ ИІЛГІШ СЕЛДЕН ҚОРҒАУ ҚҰРАМЫН ЖЕТІЛДІРУ

Аннотация. Сел ағындары адам және мүліктік шығындарға әкеледі. Табиғи апаттар аймақ немесе ел үшін ғана емес, бұл Жер бетінде адамзаттың проблемасы. Сел құбылыстары Қазақстан Республикасында кең тараған.

Қазіргі заманғы селден қорғау құрылыстарынның құрылымдық ерекшеліктері қаралды. Селден қорғау құрылыстарынның оңтайлы құрамының композициялық материал бойынша зерттеулер жүргізілді. Осы

жұмыста екі негізгі бағыты қаралады: ресурс үнемдеушітехнологиялар және тіршілік қауіпсіздігі мәселелерінің зерттеулері.

Жұмыстың мақсаты бұл әзірлеу құрамын шикізат қоспасын алу үшін композициялық материал, бұл жиынтығында оның құнын сақтай отырып төмендетеді, беріктілік қасиетін және бір мезгілде өнеркәсіптік қалдықтарды кәдеге жарату болып табылады.

Іс жүзінде негізгі маңызды нәтижесі бұл ғылыми-техникалық негіздерін әзірлеу, өндірістің жаңа көп компонентті гидравликалық тұтқыр материалдар үшін, композициялық материалдар болып табылады. Бұл технология экологиялық бағалы, төмен-металлды және төмен-энергетикалық болып табылады. Ғылыми зерттеу құндылығының нәтижелері жаңа заңдылықтары механикалық дисперсия көпқұрамды жүйе негізделген әртүрлі принциптеріне ұсақтау болып табылады. Ол сондай-ақ анықтау, жаңа өнімдерді механо-белсендірілген көпкомпонентті гидратациялау цемент қатысуымен өндірістік техногендік қалдықтарды (минералды мақтаның өндіріс қалдықтары 1,5-2,0; электротермиялық фосфор өндірісінің шлактары 2,5-5,0; тақтата сөндіру қалдықтары 1,2-1,8); сондай-ақ әзірлеу композиция беріктігі жоғары және технологиялық сорттарының цемент бетондар.

Математикалық модельдеуді жоспарлау жөніндегі эксперименталдық жұмыстарды құрылымын айқындау композициялық материалды дайындау үшін селден қорғау құрылымдарының беріктігін жоғарылату дейін иілу кезінде ең жоғары мәні жетеді.

Осылайша, біздің тарапымыздан әзірленген төмен-клинкерлі цементтер негізінде өнеркәсіптік техногендік қалдықтардың қазіргі заманғы талаптарға сай, яғни, олар физикалық-механикалық сипаттамаларының материалды және оған оң әсеретіп, экологиялық және азайтуға мүмкіндік беріп, өзіндік құны түпкілікті жақсартады.

Түйін сөздер: төтенше жағдайлар, сел, темір-тұтқырлы композициялық материал, селден қорғау құрылыстары, иілуге берік конструкциялар.

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СОЗДАНИЕ ОПТИМАЛЬНОЙ СТРУКТУРЫ КОМПОЗИЦИОННОГО МАТЕРИАЛА ДЛЯ ИЗГОТОВЛЕНИЯ ПРОЧНЫХ НА ИЗГИБ СЕЛЕЖАЩИТНЫХ КОНСТРУКЦИИ

Аннотация. Селевые потоки приводят к людским и имущественным потерям. Стихийные бедствия характерны не только для региона или страны, это проблема всего человечества на Земле. Селевые явления широко распространены на территории Республики Казахстан.

Рассмотрены конструктивные особенности современных селезащитных сооружений. Проведены исследования по оптимальному составу композиционного материала для селезащитных сооружений. В данной работе рассматриваются два основных направления: ресурсосберегающие технологии и исследование проблем безопасности жизнедеятельности.

Целью работы является разработка состава сырьевой смеси для получения композиционного материала, что в совокупности снижает ее стоимость при сохранении упрочняющих свойств и одновременной утилизации промышленных отходов.

Основным практически значимым результатом является разработка научно-технических основ производства новых многокомпонентных гидравлических вяжущих материалов для композиционного материала. Эта технология является экологически ценной, низко-металлоемкой и низкоэнергетической. Научная ценность результатов исследований заключается в новых закономерностях механической дисперсии многокомпонентной системы, основанной на различных принципах измельчения. Она заключается также в выявлении новых продуктов механо-активированного многокомпонентного гидратации цемента в присутствии техногенных отходов производств (отходы производства минеральной ваты 1,5-2,0; шлаки электротермического производства фосфора 2,5-5,0; отходы сланцевого производства 1,2-1,8); а также разработке композиций высокопрочных и технологических сортов цементных бетонов.

Проведено математическое моделирование планирования экспериментальных работ по определению структуры композиционного материала для изготовления селезащитных конструкций с упрочнением до изгиба, при котором достигаются максимальные значения.

Таким образом, разработанные нами малоклинкерные цементы на основе промышленных техногенных отходов отвечают современным требованиям. т.е. они улучшают физико-механические характеристики материала и положительно влияют на экологическую обстановку и позволяют снизить себестоимость конечного продукта.

Ключевые слова: чрезвычайные ситуации, селевой поток, армированный композиционный материал, селезащитные сооружения, прочность конструкций на изгиб.

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