

A.N. Chinakulova¹, R.K. Niyazbekova¹, E. Negim²

¹S. Seifullin Kazakh Agro Technical University, Nur-Sultan, Kazakhstan

²Kazakh-British Technical University Almaty, Kazakhstan

(E-mail: ¹aigerim.chinakulova@gmail.com, ¹rimma.n60@mail.ru, ²a.negim@kbtu.kz)

The study of the properties of cement compositions with oil sludge

Abstract. *The production and consumption of cement-based materials in the world is increasing every year. The issue of cost reduction and resource saving for Kazakhstan enterprises for the production of cement and concrete is especially relevant in connection with the adoption of the State Housing Construction Program. This article considers the results of studies of the properties of cement compositions containing oil sludge - waste products of petroleum products. Using it as a raw material is one of the rational ways of its disposal, as this achieves a certain environmental and economic effect. There have been indicated results of the influence of additives on the physic mechanical properties of cement compositions.*

Key words: *cement compositions, oil sludge, normal consistency, setting time, hydration degree.*

DOI: <https://doi.org/10.32523/2616-68-36-2020-133-4-70-75>

Introduction. The State Program “Strategy 2050”, which is aimed at the development of industrial infrastructure and annual Speech of the President of Kazakhstan inspire confidence in the new industrialization of the economy and the creation of domestic industrial trends within the framework of the third industrial revolution [1]. According to the “Nurly Zhol” infrastructural development program, it is planned to build more than 4 thousand km of modern concrete highways, also program “Nurly Zher”, which implements housing project, it is planned to build 1.5 million apartments in 15 years. In Kazakhstan, foreign investment is actively attracted and government orders are increasing. The development and implementation of innovations in the construction industry is constantly being stimulated. Cement consumption volumes almost doubled compared to 2017, the design capacity of all cement plants amounted to more than 12 million tons per year. In this regard, the development of technology, improving the quality of cement, the rational use of raw materials and waste management are of great importance [2]. Almost no cement and concrete production is completed without the use of special chemical additives that give concrete the necessary properties: strength, mobility and setting [3]. Oil sludge is a large-tonnage waste from oil production and refining industries and contains organic substances [4]. Their use in the production of cements and concrete as special additives is probably possible after careful research [5- 8]. Oil sludge is formed during the extraction, processing and transportation of oil and consists of oil products, mechanical impurities (clay, metal oxides, sand) and water [9]. Oil waste poses a great danger to the environment and is primarily subject to processing, although most of the oil sludge is still covered. In this regard, the disposal of oil sludge in order to use them in cement compositions as chemical additives requires further research [10]. To study the effect of oil sludge additives on the properties of cement compositions, the properties of pastes were investigated, the normal density and setting time of the cement paste were determined, and the effect of additives on the physic mechanical properties of cement compositions was studied.

Experimental part. Oil product waste and Portland cement were the main components of the study. The experiments involved sludge dewatering in a vacuum-suction unit with a removable metal funnel. As a filter used technical fabrics. The precipitate obtained after evacuation had a moisture content of 60-65% and was dried to a moisture content of 40% at room temperature, because drying at a temperature above 100°C leads to a change in the organic part of oil sludge. The choice of the optimal

composition of materials was carried out according to the content of free CaO and strength indicator. It was assumed that oil sludge will have a different effect on the hydration hardening of binders adsorbed on the surface of clinker minerals and new formations. The test mixture was prepared with the following amount of materials: M-400D20 Portland cement, sand and water in the ratio of W/C 0.6. The amount of oil sludge that added into the cement-sand mixture were calculated by the dry matter. Cement paste with the addition of oil sludge was thoroughly mixed, after that samples were molded. Samples-beams with a size of 4x4x16 cm on the basis of cement with a content oil sludge in the amount of 1, 2, 3, 4 and 5% of the weight of cement were dried and tested after 2, 7, 28 days. Table I and II show the test results.

TABLE I
PHYSICAL PROPERTIES OF CEMENT COMPOSITION

Sample	Normal consistency, %	Setting time	
		initial, min	final, h/min
Portlandcement	25	90	4.5
+ 1% oil sludge	24.5	95	4.6
+ 2% oil sludge	24	94	4.5
+ 3% oil sludge	24	95	4.6
+ 4% oil sludge	24.5	95	4.7
+ 5% oil sludge	24.5	93	4.6

Results and discussion. The structure formation in cement pastes and hardened samples was studied using known methods [11]. The degree of hydration of minerals was judged by the amount of chemically bound water (DTA), the intensity of the C3S peak, and scanning electron microscopy data. As can be seen from the table, a significant improvement in the strength characteristics of all types of cement is observed with the adding of 2.0-3.0% oil sludge. A study of the structure formation of oil sludge showed that they are dispersed systems with a coagulation structure. As the sedimentation analysis in the water – oil sludge system showed, over time, sediment condenses and a relatively stable complex coagulation structure forms. At the same time, the volume of sediment increases when diluted with water, which indicates the formation of additional intermolecular bonds. In order to study the effect of the organic part of oil sludge on hydration processes, aqueous solutions were studied by electron microscopy. Experiments have shown that associates of macromolecules form in aqueous solutions.

TABLE II
BENDING AND COMPRESSIVE STRENGTH OF CEMENT
COMPOSITION AT DIFFERENT PERIOD OF STORAGE)

Sample	Bending strength, MPa			Compressive strength, MPa		
	2 days	7 days	28 days	2 days	7 days	28 days
Portlandcement	27.6	4.7	6.6	25	38.1	49.8
+ 1% oil sludge	2.78	4.8	6.9	25.3	38.4	49.10
+ 2% oil sludge	2.82	5	7.1	26.8	40.5	52.3
+ 3% oil sludge	2.63	4.84	6.88	25.0	38.1	48.8
+ 4% oil sludge	2.62	4.85	6.87	25.0	38.0	48.9
+ 5% oil sludge	2.56	4.59	6.44	24.7	37.9	48.5

TABLE III
HYDRATION DEGREE OF PORTLANDCEMENT

Sample	Amount of chemically bound water			Hydration degree		
	2 days	7 days	28 days	2 days	7 days	28 days
Portlandcement	10.8	13.8	16.5	59.6	65.4	72.1
+ 2% oil sludge	10.1	14.3	16.7	62.5	67.3	74.4
+ 3% oil sludge	10.2	14.3	17.0	62.7	67.5	73.1

The study of structure-forming processes in such solutions by electrophoresis showed that associates have a certain charge and, therefore, in cement suspensions will affect the adsorption processes. In cement suspensions, hydration hardening of clinker minerals and the structure formation of the organic part in an aqueous suspension proceed in parallel. Due to the presence of functional groups and their high adhesion to clinker minerals and their hydration products, the molecules of resins, asphaltenes, which form the basis of the organic part of oil sludge, are adsorbed on the surface of cement particles, mainly on a polarized layer of water. As a result of the formation of an uneven surface layer and a change in the magnitude of the electrostatic forces, a structure with a different thickness of the adsorption layer is formed. The concentration of ions in the solution changing in this case creates a diffusion flux through the formed organic layer. Studies have shown a different nature of the effect of oil sludge on the hydration properties of cements. The degree of hydration of cement minerals increases with the introduction of oil sludge in the amount of 2-3% by weight of cement. Such a concentration of oil sludge promotes the formation of an adsorption layer, in which simultaneously charged surfaces repel each other, with constant W/C, the physical and mechanical properties of the materials improve, as can be seen from Table III.

Conclusion. One way to increase the depth of oil refining, reduce environmental pollution by products of the oil industry and the rational use of natural resources is to involve in the processing of oil production waste. The use of oil sludge as chemical additives in cement compositions can reduce production costs, reduce the environmental damage caused by oil waste during their disposal and storage at oil depots. The experimental results indicated that a mixture containing oil sludge in an amount of 2-3% by weight of cement is stable and can be used as a chemical additive in cement compositions. The proposed chemical additive based on oil sludge is of practical importance in the use of cement compositions. The results of the experiments showed that the addition of oil sludge to the composition of cement compositions improves its physical and mechanical properties: compressive strength, density, water absorption, which increases the durability of concrete.

References

1. Strategies and programs of the Republic of Kazakhstan [Electronic resource]. – 2011. - URL: https://www.akorda.kz/en/official_documents/strategies_and_programs (Accessed: 25.05.2020). XVI International Central Asian Conference and Exhibition “Cement Industry and Market”. National Chamber of Entrepreneurs of the Republic of Kazakhstan “Atameken”. Nur-Sultan: New project, 2013.

2. Kudryashova R.A., Samarkina N.V., Sheymukhova Y.V. The use of superplasticizers in heavy and light concrete, "Bulletin of the Ulyanovsk State Technical University", 2016. No. 1. P. 60.
3. Zain A.M., Mahmud H., Shaaban M.G. Petroleum sludge stabilization and solidification: an alternative treatment using ordinary Portland cement and rice husk ash. In: 2nd international conference on Chemical, Biological and Environmental Engineering. - Cairo: 2010. - P. 30-34.
4. Rustamov E. S., Bakhriddinova M. A. Method of processing oil sludge, Young scientist. - 2014. - No. 11. - P. 107-109.
5. Araujo A.S., Coriolano A.C., Banderia R.A., Delgado R.C. Preparation and compressive strength evaluation of concrete containing oil sludge as additive. Mater Sci Forum. – 2018. – P. 148-52.
6. Sadykov Sh., Sarsembin U.K., Alimbekov Zh.S. The use of oil sludge as an additive in brick production. Academy. P. 23-25(2017).
7. Akchurin T.K., Tukhareli V.D., Pushkarskaya O.Yu. The modifying additive for concrete compositions based on oil refinery waste, Procedia Engineering. P. 150(2016).
8. Nagornov S.A., Romantsova S.V., Cherkasova L. A. Study of the composition of oil sludge, Bulletin of Russian universities. [Electronic resource]. Available at: <https://cyberleninka.ru/article/n/issledovanie-sostava-neftyanyh-shlamov> (Accessed: 15.08.2020).
9. Brekhman A.I., Khabibullina E.N., Ilyina O.N., Fomin A.Yu., Trifonov A.A. Prospects for the use of oil sludge in road construction of the Republic of Tatarstan, Sat. scientific works "Modern scientific and technical problems of transport construction." - Kazan: KazGASU, 2007.– P. 161-162.
10. Makridin N.I., Maksimova I.N. The structure and mechanical properties of cement disperse systems: monograph. - Penza: PGUAS, 2013. - P. 340.

А.Н. Чинакулова¹, Р.К. Ниязбекова¹, Е. Негим²

¹С. Сейфуллин атындағы Қазақ агротехникалық университеті, Нұр-Сұлтан, Қазақстан

²Қазақстан-Британ техникалық университеті, Алматы, Қазақстан

Мұнай шламы негізіндегі цементтік қосылыстардың қасиеттерін зерттеу

Аңдатпа. Цемент негізіндегі материалдардың өндірісі және оның қолданылуы әлемде жыл сайын артуда. Тұрғын-үй құрылыс жайындағы мемлекеттік бағдарламалар қабылданғалы бері Қазақстан кәсіпорындары үшін цемент және бетон өндіруде шығындарды азайту және ресурстарды үнемдеу мәселесі маңызды болып тұр. Бұл мақалада мұнай шламы бар цементтің қасиеттерін зерттеу нәтижелері жарияланған. Мұнай шламын шикізат ретінде пайдалану белгілі бір экологиялық-экономикалық нәтижеге қол жеткізетіндіктен, оны пайдаланудың ұтымды тәсілдерінің бірі көрсетілді. Цементтің физико-механикалық қасиетіне қоспанының әсері зерттелді.

Түйін сөздер: цемент қосылыстары, мұнай шламы, қалыпты консистенция, бірігу уақыты, гидратация дәрежесі.

А.Н. Чинакулова¹, Р.К. Ниязбекова¹, Е. Негим²

¹Казахский агротехнический университет имени С.Сейфуллина, Нур-Султан, Казахстан

²Казахстанско-Британский технический университет, Алматы, Казахстан

Исследование свойств цементных композиций с нефтешламами

Аннотация. Производство и потребление материалов на основе цемента в мире увеличиваются с каждым годом. Вопрос снижения себестоимости и ресурсосбережения для предприятий Казахстана по производству цемента, бетонов особенно актуален в связи с принятием Государственной программы по жилищному строительству. В данной статье опубликованы результаты исследований свойств цементных композиций, содержащих нефтешламы – отходы производства нефтепродуктов. Использование его в качестве сырья является одним из рациональных способов утилизации, так как при этом достигается определенный экологический и экономический эффект.

В работе указаны результаты влияния добавок на физико-механические свойства цементных композиций.

Ключевые слова: цементные композиции, нефтешлам, нормальная консистенция, время схватывания, степень гидратации.

Список литературы

1. Стратегии и программы Республики Казахстан [Электрон. ресурс]. – 2011. - URL: https://www.akorda.kz/en/official_documents/strategies_and_programs (дата обращения: 25.05.2020).
2. XVI International Central Asian Conference and Exhibition “Cement Industry and Market”. National Chamber of Entrepreneurs of the Republic of Kazakhstan “Atameken”. Nur-Sultan: New project, 2013.
3. Kudryashova R.A., Samarkina N.V., Sheymukhova Y.V. The use of superplasticizers in heavy and light concrete // “Bulletin of the Ulyanovsk State Technical University”, 2016. No. 1. P. 60.
4. Zain A.M., Mahmud H., Shaaban M.G. Petroleum sludge stabilization and solidification: an alternative treatment using ordinary Portland cement and rice husk ash. In: 2nd international conference on Chemical, Biological and Environmental Engineering. - Cairo: 2010. - P. 30-34.
5. Rustamov E. S., Bakhriddinova M. A. Method of processing oil sludge // Young scientist. - 2014. - No. 11. - P. 107-109.
6. Araujo A.S., Coriolano A.C., Banderia R.A., Delgado R.C. Preparation and compressive strength evaluation of concrete containing oil sludge as additive. Mater Sci Forum. – 2018. – P. 148-52.
7. Sadykov Sh., Sarsembin U.K., Alimbekov Zh.S. The use of oil sludge as an additive in brick production. Academy. P. 23-25(2017).
8. Akchurin T.K., Tukhareli V.D., Pushkarskaya O.Yu. The modifying additive for concrete compositions based on oil refinery waste, Procedia Engineering. P. 150(2016).
9. Nagornov S.A., Romantsova S.V., Cherkasova L. A. Study of the composition of oil sludge // Bulletin of Russian universities. [Electronic resource]. Available at: <https://cyberleninka.ru/article/n/issledovanie-sostava-neftyanyh-shlamov> (Accessed: 15.08.2001).
10. Brekhman A.I., Khabibullina E.N., Ilyina O.N., Fomin A.Yu., Trifonov A.A. Prospects for the use of oil sludge in road construction of the Republic of Tatarstan // Sat. scientific works “Modern scientific and technical problems of transport construction.” - Kazan: KazGASU, 2007.– P. 161-162.
11. Makridin N.I., Maksimova I.N/ The structure and mechanical properties of cement disperse

systems: monograph. - Penza: PGUAS, 2013. - P. 340.

Information about authors:

Chinakulova A.N. – corresponding author, Ph.D. student in Standardization, certification and metrology, S. Seifullin Kazakh Agro Technical University, Nur-Sultan, Kazakhstan.

Niyazbekova R.K. – Doctor of Technical Sciences, Associate Professor of Standardization, certification and metrology Department, S. Seifullin Kazakh Agro Technical University, Nur-Sultan, Kazakhstan.

Negim E. – Doctor of Chemical Sciences, Associate Professor, Kazakh-British Technical University, Almaty, Kazakhstan.

Чинакулова А.Н. – автор для корреспонденции, Стандартизация, сертификация және метрология кафедрасының докторанты, С. Сейфуллин атындағы Қазақ агротехникалық университеті, Нұр-Сұлтан, Қазақстан.

Ниязбекова Р.К. – техника ғылымдарының докторы, Стандартизация, сертификация және метрология кафедрасының доценті, С. Сейфуллин атындағы Қазақ агротехникалық университеті, Нұр-Сұлтан, Қазақстан.

Негим Е. - химия ғылымдарының докторы, қауымд. профессор, Қазақстан-Британ техникалық университеті, Алматы, Қазақстан.