SUMMARY

to the dissertation work of **Zhilkibayeva Aliya Mukhametkalievna**
on the topic: **"Investigation of the impact of waste from the Balkhash mining and processing plant on the construction and operational properties of modified concrete"** for the degree of Doctor of Philosophy (PhD) in the specialty 8D07361 – "Production of building materials, products and structures"

The relevance of the work. The use of new technologies and materials made using industrial waste in the construction industry is of high economic and environmental importance. Due to the huge man-made formations in the form of dumps of mining and processing plants, which are the cause of non-returnable losses of natural raw materials, alienation of land from agricultural turnover and pollution of huge territories, scientific and practical interest arises – the possibility of using man-made products, thereby expanding the range of complex mineral additives.

The introduction of active mineral additives into cement makes it possible to obtain concrete with high physical, mechanical and operational characteristics, namely, they increase the density, water resistance, frost, sulfate, alkali resistance and salt resistance of concretes and mortars, while reducing the consumption of clinker cement

The scale of construction of facilities using cement concrete is growing every year, which raises the question of reducing the consumption of clinker cement, due to the high energy intensity of production using active mineral additives. The use of active mineral additives in the form of waste from enrichment has high economic and environmental significance.

The use of waste from the Balkhash Mining and Processing Plant as a complex mineral additive in cement significantly expands the raw material base of the construction industry of the Republic of Kazakhstan and meets modern requirements for ensuring an increase in demand for raw materials and materials, as well as meets the objectives of the program of the Environmental Code of the Republic of Kazakhstan - waste management of the mining industry.

However, the production of complex mineral additives using waste from mining and processing enterprises is hindered due to insufficient knowledge of their properties, their effect on cement hydration processes and the construction and performance characteristics of concretes based on them.

The present work on the development of modified heavy concrete was carried out on the basis of the laboratory of the International Educational Corporation in accordance with scientific and technical programs for the integrated use of man-made waste and within the framework of priority areas – "Deep processing of raw materials

and products" of the State Program for Accelerated Industrial and Innovative Development of the Republic of Kazakhstan.

The purpose of the dissertation is to study the effect of waste from the Balkhash Mining and Processing Plant on the construction and operational properties of modified concrete and the development of compositions of high-strength concretes based on a binder modified by enrichment waste activated with silica.

Research objectives:

- to develop a complex mineral additive based on waste from the Balkhash mining and Processing plant activated with silica and to justify its effectiveness.
- to determine the effective amount of a complex mineral additive in the composition of cement (modified binder).
- to develop optimal compositions of heavy concretes of classes B25 and B35 using a modified binder;
- to investigate the effect of a complex mineral additive in the composition of a modified binder on the basic physical, mechanical, technological and operational properties of concrete.
- to establish the compatibility of the modified binder with superplasticizers of various types.
- to investigate the effect of a complex mineral additive on the hydration processes of cement stone.

Methods of achieving the set goals:

Analysis of the study of domestic and foreign sources, including the study of articles, patents for inventions and utility models, copyright certificates. The study of world experience based on the research of high-strength modified concretes using waste from mining enterprises. Carrying out standard methods of testing the physical and mechanical properties of high-strength concrete in accordance with the requirements of regulatory and technical documentation - ST RK, GOST, CH RK, etc.

To determine the physico-chemical properties of the modified cement stone, research methods were used: thermal, X-ray fluorescence, X-ray phase, as well as methods of IR spectroscopy and electron microscopy.

Scientific novelty of the dissertation:

– the suitability of waste from the Balkhash mining and processing plant has been revealed;

– the composition and effectiveness of a complex mineral additive based on waste from the Balkhash mining and processing plant and silica are determined and justified;

– the effectiveness of the use of a complex mineral additive in cement has been experimentally confirmed;

– the optimal composition of a modified binder with a complex mineral additive has been developed;

– optimal compositions of heavy concrete with the use of modified binder have been developed;

– the effect of a modified binder based on waste from the Balkhash mining and Processing Plant, activated with silica, on the physico-mechanical, technological and operational properties of concrete has been experimentally studied;

– the compatibility of the modified binder with superplasticizers of various types has been studied;

– the effect of a complex mineral additive on the hydration processes of cement stone of heavy concrete has been established, namely, the absorption of lime by Balkhash GOK waste in the initial period (during the first 6 hours), which was equal to 3.0 mg/g, microsilicon – 11.5 mg/g, at more than 6 hours - the rate of absorption of lime by BGOK waste and microsilicon it decreases and amounts to 0.5 mg/g and 5.5 mg/g per hour, respectively. Two stages of the hydration and hardening process of heavy concrete based on modified binder MV-D20 with 1% SP MasterGlenium 305 have been identified: -the first stage is intensive hydration due to the pozzolan reaction and the formation of stable hydrates; the second stage is delayed hydration: from 7 days to one year due to the leveling of destructive processes due to pozzolan reactions.

The scientific novelty of the work is confirmed by the Patent of the Republic of Kazakhstan No. 5430 astringent mixture based on enrichment waste dated 03/05/2021.

Practical significance of the dissertation:

– the optimal composition of a modified binder has been developed using a complex mineral additive consisting of waste from the Balkhash Mining and Processing Plant (BGOK) and silica;

– compositions of effective high-strength heavy concrete based on the resulting modified binder have been developed;

– the basic physical and mechanical properties of class B25 and B35 concretes based on a modified binder have been studied and the physico-chemical processes occurring in the cement system have been investigated;

– it was found that the use of a modified binder based on sulfate-resistant Portland cement CEM I 42.5 CC LLP "Caspian Cement" reduces the relative deformation of concrete in an aggressive environment of class B35 by 12%.

The object of the study is high-strength heavy concrete based on a binder modified with BGOC waste and silica.

The subject of the study: the effect of a complex mineral additive on the heat of hydration of cement and concrete hardening processes; the effect of a modified binder on the rheological properties of a concrete mixture; the study of processes that ensure high strength and sulfate resistance of concrete.

Research methods: the thesis uses modern research methods that meet the requirements of regulatory and technical documentation.

Scientific provisions to be defended:

– study of pozzolan activity to obtain the optimal composition of a complex mineral additive consisting of waste from the enrichment of the Balkhash mining and processing plant and silica;

– investigation of the effect of the obtained complex mineral additive on the technical characteristics of cement;

– investigation of the effect of a modified binder obtained by using a complex mineral additive on the physico-mechanical, technological and operational properties of concrete;

– regularities of the effect of a complex mineral additive on the hydration processes of cement stone.

The validity and reliability of scientific statements, conclusions and recommendations are confirmed by:

– the results of research methods: physico-mechanical, chemical, differential thermal, X-ray and X-ray fluorescence, as well as IR spectroscopy, electron microscopy;

– data on the testing and research of heavy modified concretes of class B25 and B35 based on the developed modified binder MV-D20.

The author's personal contribution to science

It consists in setting the purpose of the work and the main tasks of the study, conducting tests and research; developing the optimal composition of the ratio of waste from the Balkhash mining and processing plant and silica as part of a complex mineral additive; developing the composition of a modified binder using a complex mineral additive and compositions of heavy concretes of classes B25 and B35 based on it; determining construction and operational characteristics heavy concrete of class B25 and B35 based on a modified binder.

Approbation of the work. The main provisions of the work were reported and discussed at international conferences:

– The 5th International scientific and practical conference "Modern Science and Young Scientists" (Penza, 2021);

– an international scientific and practical conference dedicated to the 80th anniversary of Doctor of Technical Sciences, Professor, academician MANEB Tilegenov I.S. and the 20th anniversary of the International scientific journal Bulletin of TarSU "Nature Management and problems of the anthroposphere" on the topic: "Nature management and current problems of ecology and human life safety in the XXI century" (Taraz, 2021).

Publications. The results of the dissertation are published:

1. Patent for utility model No. 5430 "Binder mixture based on enrichment waste" dated 05.03.2020

2. Scientific aspects of management of rheological characteristics of concrete mix // Bulletin of the Osh State University. – 2020. – pp. 7-11.

3. Studies of the hardening process and structure formation of concrete using modified binders // Bulletin of KAZGAS. – 2020. – №4(78). – Pp. 163-167.

4. Technological ways to increase the activity of mineral additives // Collection of articles of the 5th international scientific and practical conference "Modern Science and young scientists" (Penza: Science and Education, 2021. - pp. 36-38).

5. Physico-mechanical properties of heavy concrete with a complex mineral additive // The Scientific Journal of the Modern Education & Research Institute. – 2021. – No.16. – pp. 71-76.

6. Technological ways to improve the construction and operational properties of heavy concrete // Materials of the International scientific and practical conference dedicated to the 80th anniversary of Doctor of Technical Sciences, Professor, academician MANEB Tilegenov I.S. and the 20th anniversary of the International scientific journal Bulletin of TarSU "Nature management and problems of the anthroposphere" on the topic: "Nature management and current problems of ecology and safety human vital activity in the XXI century" (Taraz: Dulaty University, 2021. – Vol. 2. – pp. 34-37).

7. The effect of a complex mineral supplement on the hydration of alite. – ALITinform: Cem. Concrete // Dry Mixtures. – 2021. – №3(64). – P. 84-92.

8. Structural characteristics and performance of concrete with a composite modifiying additive // Architectura and Engeneering. - 2022. – Vol. 7, No. 2. – pp. 86-95.

9. The effect of complex additives on the heat of cement hydration and concrete hardening processes // Journal of the Balkan Tribological Association. – 2022. – Vol. 28, No.6. – P. 897-912.

10. Study of the properties of a modified binder obtained on the basis of enrichment waste from a mining and processing plant // Vestnik KazGASA. – 2024. – No. 2 (92). - (in the press).

11. Construction and operational properties of concrete with a modified binder // Vestnik KazGASA. – 2024. – No. 2 (92). - (in the press).

11 scientific papers have been published on the topic of the dissertation, including: 2 articles in publications indexed by Scopus and Web of Science databases; 3 article in journals from the list of publications of the Committee for Quality Assurance in Science and Education; 2 articles in collections of International scientific and practical conferences; 2 in other international publications articles, in other publications of the Republic of Kazakhstan – 1 article, and 1 patent for a utility model was obtained (Appendix A).

The structure and scope of the dissertation. The dissertation is presented on 137 pages of typewritten text, consists of an introduction, 5 sections and main conclusions, contains 37 tables, 28 figures, a list of used sources from 208 titles and 1 appendix.

In the introduction of the dissertation, the relevance of research is substantiated, goals and objectives are formulated, and the object of research is formulated. Research methods and scientific novelty are also considered.

In the first chapter, "The state of the research issue", theoretical and practical studies by domestic and foreign scientists on the production of modified concrete by adding waste from various industries are considered.

Conclusions on the first chapter:

The targeted selection of organic and mineral components of additives makes it possible to regulate the hardening processes and properties of binding systems. The vulnerable point of concrete remains pores capable of further crushing, microdefects in the contact zone of the "cement stone filler". These disadvantages negatively affect the strength, frost resistance, permeability, mass transfer processes and durability of the material as a whole. The solution to this problem is the creation and application of multicomponent organomineral modifiers, which, in addition to prolonged action, synergistic effects of ingredients, can actively influence the formation of a qualitative structure of cement stone at macro and micro levels, providing high strength, density, permeability, frost resistance, corrosion resistance and other performance characteristics of concrete.

In the second chapter, "Raw materials and research methods". This section describes all the raw materials used to produce modified heavy concrete. Raw materials are examined on the basis of the laboratory of "MOK" LLP for compliance with regulatory documents in force on the territory of the Republic of Kazakhstan and methods for studying the resulting modified concrete using Balkhash GOK waste and silica are described.

Conclusions on the second chapter:

The raw materials used comply with the regulatory documents in force on the territory of the Republic of Kazakhstan, as well as research methods and all devices used to study physico-mechanical and physico-chemical processes have documents of compliance.

In the third chapter, "Development of concrete compositions of classes B25 and B35 based on a modified binder", data are provided on the development of the nominal composition of a complex mineral additive using waste from the Balkhash GOK activated with silica, optimal ratios of a modified binder based on sulfate-resistant Portland cement using a complex mineral additive, as well as compositions of heavy concretes based on the resulting modified binder and studies of the rheological characteristics of the concrete mixture.

Conclusions on the third chapter:

To select the optimal ratio of silica and Balkhash GOK enrichment waste as part of a complex mineral additive, their pozzolan activity was determined. The optimal composition of a complex mineral additive has been selected: 60% Balkhash GOK enrichment waste + 40% silica. The optimal dosage of a complex mineral additive in cement is 20%. At the same time, the content of silica in the composition of the concrete mixture B35 is 32-38 kg/m3. The introduction of complex additives significantly affects the processes of structure formation of cement paste.

Concrete of class B 35 based on modified binder MV-20 with superplasticizer "MasterRheobuid 1000 K" is recommended for the manufacture of concrete and reinforced concrete products in factory conditions. The MasterGlenium 305 superplasticizer is recommended for monolithic construction. Optimal compositions of heavy concretes of classes B35 and B25 using a modified binder have been developed. The use of a binder with a 20% complex mineral additive reduces the water consumption of concrete mix B35 and B25 by 18 and 20%, respectively.

The fourth chapter, "The effects of a complex mineral additive on the structure of the cement system and concrete," examines the effects of a complex mineral additive on the hydration processes of cement stone, as well as its effect on the heat of hydration of cement and concrete hardening processes.

Conclusions on the fourth chapter:

It was revealed that the activation of waste from the Balkhash mining and processing plant with silica significantly increases the degree of hydration of C3S stone, which after 3, 7 and 28 days. the normal hardening is, respectively, 52.5; 65.0 and 75.0% compared with the initial sample, in which the degree of hydration is, respectively: 50.5; 60; and 68%, moreover, at the 7-day age of hardening increases the rate of hydration of C3S to 5%, which contributes to an increase in strength in the initial periods of hardening 21%. It was found that an increase in the strength of C3S stone and the degree of hydration with an increase in the hardening period is accompanied by an increase in chemically bound water.

It was found that in heavy concrete of class B35 with the use of modified binder MV-D20 with the addition of 1.0% superplasticizer MasterGlenium 305, the maximum hydration temperature is 79.8 ° C and is reached 26 hours and 30 minutes after pouring; the maximum temperature in the range of 78.1-79.8 ° C lasts for 9 hours. The studied complex additives, by changing the rate of hydration and the time to reach the maximum temperature, determine the periods of formation of cement stone hydrates, which allows us to consider their effects as a factor of directed influence on the processes of structure formation and hardening of heavy concrete.

In the fifth chapter, "Physico-mechanical properties of concrete on modified binder MV-D20", all the physico-mechanical characteristics of heavy concretes of strength classes B25 and B35 based on modified binder are given and the sulfate

resistance of heavy concrete using modified binder using Balkhash GOK waste is determined.

Conclusions on the fifth chapter:

Concrete compositions of class B25 and B35 based on the modified binder MV-D20 have been developed, which gain the required normative strength at the 28-day age of hardening. In the initial hardening periods (7 days), concretes of class B25 and B35, respectively, gain more than 70% of the required standard strength. The water absorption index of concrete of class B 25 based on modified binder MV-D20 with 1.0% superplasticizer MasterGlenium 305 in the range of 3.69-4.46%. The average value of concrete water absorption is 25-4.20%. The water absorption of heavy concrete In 35 with the use of modified binder MV-D20 with 1.0% superplasticizer MasterGlenium 305 is 2.99-3.70%. The average value of the water absorption of concrete B35 using a modified binder MV-D20 with the addition of 1.0% superplasticizer MasterGlenium 305-3.46%. The grade of concrete in 25 corresponds to W10 in terms of water resistance, and in 35 c– W12, while the actual value of concrete resistance to air penetration to concrete of class B 35 with the use of modified binder MV-D20 ranges from – 24.4-26.6 s /cm3.

The established relative deformation of concrete of class B 35 based on CEM I 42.5N CC belongs to group III – sulfate-resistant.

Conclusion

Based on the conducted research, the following main conclusions were made

1. The analysis of literary sources has shown that significant theoretical research and practical experience in the use of finely dispersed active mineral additives have been accumulated in building materials science. The use of finely dispersed active mineral additives in the production of concrete and reinforced concrete allows:

– to reduce the delamination of the concrete mixture during transportation and improve its workability;

– to improve the construction and operational properties of heavy concrete;

– increase compressive strength;

– significantly increase the durability of concrete and reinforced concrete structures. However, the use of waste from mining and processing enterprises of the Republic of Kazakhstan as mineral additives has not been fully investigated.

2. The optimal composition of a complex mineral additive has been selected: 60% Balkhash MPP enrichment waste + 40% silica. It was found that an increase in the amount of silica by more than 40% in the composition of the complex additive will lead to an increase in the water demand of the mixture. The pozzolan activity of a complex additive consisting of 60% of the Balkhash MPP enrichment waste and 40% of microsilicon is 48 mg/g. It was revealed that the introduction of 40% silica into the Balkhash MPP enrichment waste increases the pozzolan activity of the complex additive by 2 times.

3. The optimal dosage of a complex additive with enrichment waste from the Balkhash mining and Processing plant in the cement composition is 20%. At the same time, the content of silica in the composition of the concrete mixture is 35-32-38 kg/m3. It is shown that a further increase in the amount of silica in the composition of concrete can cause large shrinkage stresses. Shrinkage cracks in concrete in contact with the aggregate and in the cement stone itself can reduce frost resistance and serve as foci of concrete corrosion.

4. It has been established that complex additives significantly affect the processes of structure formation of cement paste. The introduction of the superplasticizer "Master Rheobuild 1000 K" accelerates the beginning of setting of the cement dough and shortens the period of structure formation. The beginning of setting of the cement dough occurs after 110 minutes. The period from the beginning to the end of setting is reduced by 40 minutes, compared with cement dough without additives. The MasterGlenium 305 superplasticizer has very little effect on the rate of structure formation in the initial period, because the onset of setting occurs after 150 minutes, but by the end of the setting period, the rate of structure formation significantly decreases. In this case, the period from the beginning to the end of setting is 70 minutes, which is 40 minutes less than cement paste without additives. Therefore, concrete of class B 35 based on modified binder MV-20 with superplasticizer "MasterRheobuid 1000 K" is recommended for the manufacture of concrete and reinforced concrete products in factory conditions. The MasterGlenium 305 superplasticizer is recommended for monolithic construction.

5. The optimal compositions of heavy concrete B35 and B25 using a complex modifying additive are determined as follows:

concrete of class B35, kg/m3: modified binder-420; crushed stone fr. 5-10 mm – 480; crushed stone fr. 10-20 mm -700; sand-650; water-164; Master Air 200-0.336 and MasterGlenium 305 – 4.20;

concrete of class B25, kg/m3: modified binder-380; crushed stone fr. 5-10 mm – 460; crushed stone fr. 10-20 mm -670; sand-690; water-152; Master Air 200-0,304 and MasterGlenium 305 – 2.66.

The density of the concrete mix B35 is 2420-2440 kg/m3; The volume of entrained air is 4.0-4.4%. The mobility of the concrete mixture along the draft of the cone is 16 cm. Under normal hardening conditions, the compressive strength at 1 day of age is 21.5–23.0 MPa; 7-day 28.5-32.0 MPa and 28-day 49.8-50.7 MPa.

The density of the concrete mix B25 is 2410-2430 kg/m3; The volume of entrained air is 3.8-4.5%. The grade of the concrete mix according to the draft of the cone is P4. Under normal hardening conditions, the compressive strength at 7 days of age is 23.5-25.0 MPa and 28-day 34.5-35.3 MPa.

6. It was found that the introduction of a 20% complex modifying additive reduces the water consumption of concrete mix B35 and B25 by 18 and 20%, respectively. With an increase in the amount of the additive by 25%, the decrease in water demand is 15 and 18%, respectively. It was determined that the introduction of MasterGlenium 305 into the composition of the concrete mixture B35 SP in an amount of 1% of the binder weight or 4.20 kg/m3 prolongs the retention of mobility up to 4 h 30 min.

An analysis of strength indicators in the initial periods of concrete hardening in combination with the MasterGlenium 305 superplasticizer showed that with constant I/C on the first day, there is a slight slowdown in compressive strength gain. However, by the third day the lag is leveled, and at the age of 7 days it has an increase in strength.

7. It was revealed that the activation of waste from the Balkhash mining and processing plant with silica significantly increases the degree of hydration of C3S stone, which after 3, 7 and 28 days of normal hardening is, respectively, 52.5; 65.0 and 75.0% compared with the initial sample, in which the degree of hydration is, respectively: 50.5; 60; and 68%.

8. It was found that the complex additive reduces the amount of Ca(OH)2 by 43% at the 28-day age of hardening. With an increase in the curing time of C3S stone with a complex additive up to 360 days, the reduction in the content of portlandite is 60%. Electron microscopic studies have shown that at the initial ages of hardening, hexagonal prismatic crystals of portlandite are found in the pores, indicating a strong initial supersaturation of the liquid phase with Ca2+ ions. Further recrystallization and growth of hexagonal portlandite crystals obey the laws of collective growth and proceed metasomatically.

9. It was found that the third stage of hydration (an intensive period of concrete hardening) with the release of a large amount of hydration heat in the first of the manufactured structures from a concrete mixture in 35 using a modified binder MV-D20 with the addition of 1.6% MasterRheobuild 1000 K superplasticizer, this period begins after 4 hours. 30 minutes, while the temperature is 39.2–40.1°C. In the second of the designs, where the modified binder MV-D20 was used with the addition of 1.0% MasterGlenium 305 superplasticizer, the third stage of the hydration process occurs after 5 hours and 30 minutes. At the same time, the concrete temperature is 39.0–40.5 ° C. An increase in the temperature of concrete indicates the beginning of crystallization of calcium hydroxide from the liquid phase. It is shown that in heavy concrete in 35 with the use of modified binder MV-20 with the addition of 1.0% superplasticizer MasterGlenium 305, the maximum hydration temperature is 79.8 ° C and is reached after 26 hours. 30 minutes after pouring; the maximum temperature in the range of 78.1-79.8 ° C continues for 9 hours.

10. The processes of hydration and hardening of heavy concrete In 25 and 35 based on the modified binder MV-D20 with 1% SP MasterGlenium 305 can be divided into two stages:

– the stage of intensive hydration from 5 hours 30 minutes of preparation of the concrete mixture to 7 days of hardening. In this case, the hydration of clinker minerals, the pozzolan activation of the mineral additive and the formation of stable hydrates occur;

– the stage of delayed hydration from 7 days to a year. During this period, the leveling of destructive processes occurs due to pozzolan reactions.

11. The developed concrete compositions of class B25 and B35 based on the modified binder MV-D20 gain the required normative strength at the 28-day age of hardening. In the initial hardening periods (7 days), concretes of class B25 and B35, respectively, gain more than 70% of the required standard strength.

12. The water absorption index of concrete of class B 25 based on modified binder MV-D20 with 1.0% superplasticizer MasterGlenium 305 in the range of 3.69-4.46%. The average value of concrete water absorption is 25-4.20%. The water absorption of heavy concrete In 35 with the use of modified binder MV-D20 with 1.0% superplasticizer MasterGlenium 305 is 2.99-3.70%. The average value of water absorption of concrete B35 with the use of modified binder MV-D20 with the addition of 1.0% superplasticizer MasterGlenium 305 is 3.46%.

13. The actual value of the concrete's resistance to air penetration to concrete of class B 25 using a modified binder MV-D20 with 1.0% MasterGlenium 305 superplasticizer in the range of – 18.4-19.0 c /cm3. The grade of concrete in 25 corresponds to W10 in terms of water resistance. The grade of concrete In 35 with a complex modifying additive in terms of water resistance is W12, while the actual value of the concrete's resistance to air penetration to concrete of class B 35 with the use of a modified binder MV-D20 ranges from – 24.4-26.6 s /cm3.

14. The relative deformation of concrete of class B 35 based on sulfate-resistant Portland cement CEM I 42.5N CC LLP "Caspian Cement" at the 12-month test age is 0.097%. Concrete of class B 35 based on CEM I 42.5N CC belong to group III – sulfate-resistant. It was determined that the relative deformation of concrete of class B25 based on the modified binder MV-D20 with the addition of 1.0% superplasticizer MasterGlenium 305 at 7 and 14 days is exactly zero, and at the 28-day age of hardening is 0.01% and at 12 months of age is 0.095%. Concrete belongs to group III – sulfate-resistant. It was experimentally determined that the relative deformation of concrete of class B 35 based on the modified binder MV-D20 at 7 and 14 days of age is zero, and at 28 days of age of hardening is 0.01% at 12 months of age – 0.085. Heavy concrete In 35 belongs to group III – sulfate-resistant. The use of modified binder MV-D20 to replace the base sulfate-resistant Portland cement CEM I 42.5N CC LLP "Caspian Cement" reduces the relative deformation of concrete of class B 35 by 12%.

15. It has been established that the sulfate resistance of concrete can be increased by introducing into the cement composition waste from the enrichment of the Balkhash Mining and Processing Plant, activated by microsilica. The complex modified additive

is able to bind $Ca(OH)_2$ into insoluble compounds, thereby reducing the degree of leaching of CaO. In addition, the complex modified additive reduces the water absorption and waterproofness of the concrete.