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# *INDUSTRIAL WASTE UTILIZATION IN THE PRODUCTION OF BUILDING MATERIALS ON ECOSTROINII-PV LLP EXAMPLE*

*The results of the work of EcostroyNII-PV LLP on the processing of technogenic waste of energy and metallurgy of the Republic of Kazakhstan, Pavlodar region are presented. The use of waste in the manufacture of construction products is one of the most effective solutions to environmental problems in the region. The proposed technology for the production of construction products using ash and slag waste provides for innovative compositions of raw materials mixtures and provides an increase in operational characteristics and an increase in labor productivity in construction. The applied technology, in comparison with existing analogues, provides for the use of local waste (ash and slag waste from the burning of Ekibastuz coal, bauxite sludge of the Pavlodar aluminum plant, steelmaking slag). They differ in chemical and granulometric composition, as well as binding properties from other analogues and prototypes. In the production of construction products, a concrete mixture has been introduced and patented, including, %: slag-Portland cement – 14.32–17.00; sand – 18.74–25.52, crushed stone – 46.50-49.71, alumina sludge obtained during processing of Kazakhstan bauxite – 5–7; self-disintegrating slag of steelmaking production – 5–7; ash and slag waste of thermal power plants from burning Ekibastuz coals – 5–7. According to the test results, the average tensile strength of building products (paving slabs, curbstones, hollow bricks) is 3.2 – 3.8 MPa (strength class 2.5).*

*Keywords: construction products; ash waste; energy; metallurgy, bauxite sludge, slag.*

## Introduction

The Republic of Kazakhstan still has huge tonnages of ash and slag waste from thermal power plants and metallurgical waste in old dumps. It is stated that it is necessary to develop a green economy and closed production cycles, which imply a constant cycle of materials during production and consumption, eliminating the formation of waste accumulating in the environment. Waste, unfortunately, continues to accumulate annually. This requires the development of new initiatives to involve them in recycling in order to avoid environmental problems [1].

In the Pavlodar region, the main types of industrial waste are ash and slag waste from thermal power plants from the burning of Ekibastuz coal, waste from metallurgical enterprises from the production of steel, alumina, aluminum and ferroalloys, chemical

industries. A review of studies on the utilization and involvement in the production of Pavlodar region industrial waste showed that much attention is paid to the disposal of particularly harmful waste, as well as the processing of coal mining waste and ferroalloy production [2–6]. It is established that insufficient attention is paid to the issues of waste processing of thermal power plants and waste production of alumina and steel.

Earlier, the EcostroyNII-PV company was established under the World Bank project «Stimulating Productive Innovations» of the ARP-SSG-17/0290F subproject «Innovative technologies for the use of solid technogenic waste from heat power and Metallurgy enterprises of the Pavlodar region in the production of building materials». The main goal of the company was the research, development and commercialization of innovative technology for the production of construction products using local waste from thermal power plants and metallurgy.

Field Study

New compositions of concrete mixtures with improved performance characteristics have been developed using ash and slag waste from thermal power plants and metallurgical enterprises of the Pavlodar region as aggregates and binders. A large number of experiments have been carried out with varying the percentage of all components included in the concrete mixture's composition. The regularities of the influence of various additives on the physic-mechanical characteristics of mixtures are established.

The task of using ash and slag and other industrial waste for the manufacture of construction products was set. To determine effective ways to improve their quality, the effect of modifying additives on the physical, chemical and strength characteristics of products was investigated. Recommendations [7, 8] were used in the preparation of experimental studies. Ash from the burning of Ekibastuz coals of Pavlodar thermal power plants was used in the research. The chemical composition of the ash is shown in Table 1.

Table 1 – Chemical composition of Pavlodar thermal power plant-1fly ash, %

| $SiO_2$ | $Al_2O_3$ | $TiO_2$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $P_2O_5$ | MnO |
|---|---|---|---|---|---|---|---|---|---|
| 60,6 | 28,6 | 1,4 | 5,4 | 2 | 0,5 | 0,5 | 0,2 | 0,7 | 0,1 |

The fly ash used in our technological process (Figure 1) is characterized by a fine granular fraction. According to GOST 25818-91 and 25592-91, the content of CaO calcium oxide in the ash component of the ash-slag mixture and in the fine-grained mixture should be no more than 10 % by weight. The content of magnesium oxide MgO in the ash component of the ash-slag mixture and in the fine-grained mixture should be no more than 5 % by weight. The content of sulfur and sulfuric acid compounds in terms of $SO_3$ in the ash and slag components of the ash–slag mixture should be no more than 3 % by weight, including sulfide sulfur – no more than 1 % by weight. The content of alkaline sodium and potassium oxides in terms of $Na_2O$ in the ash component of the ash and slag mixture and in the fine-grained mixture should be no more than 3 % by weight.

Figure 1 – Fly ash of Pavlodar thermal power plant-1

Bauxite sludge of the Pavlodar Aluminum Plant is a by-product of the production of alumina $A_2O_3$ and is included in the formulation of concrete mixtures. The chemical composition of bauxite sludge is given in Table 2.

Table 2 – Chemical composition of Pavlodar aluminum plant bauxite sludge, %.

| $Fe_2O_3$ | $Al_2O_3$ | CaO | $SiO_2$ | TiO | $CO_2$ | $Na_2O$ | MgO |
|---|---|---|---|---|---|---|---|
| 27-33 | 4,0-5,0 | 39-44 | 19-21 | 2,0 | 0,8-1,0 | 0,9-1,5 | 0,3-1,2 |

In appearance, bauxite sludge (Figure 2) is a medium-grained sand of a reddish-brown color with inclusions of easily crumbling lumps of various sizes. The humidity of bauxite sludge samples should be in the range of 20–30 %, the density is 2.6–2.86 g /sm$^3$, the bulk density in the loosened state is from 1.1 to 1.3 g /sm$^3$., the fraction used is 0.05 to 2 mm.

Figure 2 – Bauxite sludge of Pavlodar aluminum plant

**Results and Discussion**

Representative samples of bauxite sludge from the sludge dumps of the Pavlodar Aluminum Plant were selected for the study. Sludge samples were taken in accordance with the requirements of GOST 12071-2014. Statistical processing of the research results was carried out according to the recommendations [9].

Metallurgical slag of the 0–5mm fraction and coarse fractions of 20–30mm were used as fillers. The slag is gray in color, a porous microstructure is observed, the presence of a crystallized vitreous component is noted. Brown inclusions indicate the presence of iron oxide. The chemical composition of the steelmaking slag from Casting LLP is given in Table 3.

Table 3 – Chemical composition of slag steelmaking from Casting LLP, %

| Fe | $SiO_2$ | $Al_2O_3$ | CaO | MgO | MnO | S |
|---|---|---|---|---|---|---|
| 28 – 35,9 | 12,1 – 18,9 | 1,9 -4,8 | 21,1–24,6 | 6,9-20,2 | 5,1 – 8,2 | 0,03–0,04 |

Technogenic raw materials were included in the composition of the concrete mixture as aggregates and binders [10]. For each recipe, 6 samples were made (Figure 3), which were placed in 100x100x100 mm molds according to GOST 25781-81. The samples (without steaming) were stored at room temperature for 28 days, after which strength tests were carried out with them.

Figure 3 – Test samples obtained

As a result of experiments, it was revealed that the ash used as a filler does not affect the decrease in the strength of the concrete mixture. When grinding ash, it can be used as a substitute for clinker. The use of ash up to 15 % of the amount of cement does not affect the reduction of strength indicators and can be used as a filler to replace sand.

The use of bauxite sludge with the addition of lime milk made it possible to increase the strength of concrete samples to the M50 grade, class B3.5 (in the absence of vibration compression). The use of metallurgical slag of the 0–5 fraction as a filler did not affect the strength of the samples due to the absence of vibropressing and steaming chamber, which is why the cement adhesion process was low. Also, tests of the concrete mixture were carried out using metallurgical slag of the 20–30 fraction in forms with a size of 150x150x150 mm according to GOST 25781-81, as a large aggregate instead of crushed stone. More than 30 formulations of concrete mixes have been developed using various fillers, additives and binders.

Based on the tests of samples using ash and slag waste, it was found that there are reserves for saving cement when using ash in the case of preparing industrial samples by vibropressin. Industrial samples of hollow wall stone were manufactured at the Rifey-Udar vibropressing technological line. In the future, the amount of cement was reduced. Tests have shown that the concrete class has become B3.5 (M50), which is enough for the construction of low-rise buildings. According to the same composition, a «Partition stone 390x120x188 mm» was made. The strength of the stones was also B3.5 (M50). Since such strength is not required for the partition material, it is possible to reduce cement consumption.

According to the results of the tests, industrial production was launched. After testing the technology, the composition of the raw material mixture used for the manufacture of building products (paving slabs, curbstones, hollow bricks) was optimized. The mechanical characteristics of the products were preliminarily determined by the destructive method using a hydraulic press PMG 1000MG4 in the amount of 5 % of each batch of products.

The industrial production of hollow bricks began with the period of obtaining the certificate of conformity of the product «Hollow wall stone using ash and slag waste» according to the results of certification in an independent organization JSC «National Center for Expertise and Certification» (Republic of Kazakhstan).

**Conclusions**

On the basis of EcostroyNII-PV LLP, raw mixtures for the production of construction products based on industrial waste of the Pavlodar region of the Republic of Kazakhstan were studied.

A concrete mixture has been introduced and patented in the production of construction products, including, % by weight: slag-Portland cement – 14.32–17.00; sand – 18.74–25.52, crushed stone – 46.50–49.71, alumina sludge obtained during the processing of bauxite – 5–7; self-disintegrating slag of steelmaking production – 5–7; ash and slag waste of thermal power plants from the burning of Ekibastuz coals – 5–7.

According to the test results, the average tensile strength of building products (paving slabs, curbstones, hollow bricks) is 3.2–3.8 MPa (strength class 2.5).

The use of technogenic waste from heat power and metallurgy in the production of building materials is an effective way to solve environmental problems in industrially developed regions.

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# «ЭКОСТРОЙНИИ-ПВ» ЖШС МЫСАЛЫНДА ҚҰРЫЛЫС МАТЕРИАЛДАРЫН ӨНДІРУДЕ ӨНЕРКӘСІПТІК ҚАЛДЫҚТАРДЫ КӘДЕГЕ ЖАРАТУ

*Өңірдің экологиялық проблемаларын шешудің ең тиімді нұсқаларының бірі ретінде Қазақстан Республикасы Павлодароблысының энергетика және металлургия салаларының техногендік қалдықтарын құрылыс бұйымдарын дайындаудапайдалану жолымен қайта өңдеу жөніндегі «ЭкостройНИИ-ПВ» ЖШС жұмысының нәтижелері ұсынылды. Күл-қожқалдықтарын пайдалана отырып, құрылыс бұйымдарын өндірудің ұсынылатын технологиясы шикізат қоспаларыныңинновациялық құрамдарын көздейді, бұл пайдалану сипаттамаларын арттыруды және құрылыстағы еңбек өнімділігінарттыруды қамтамасыз етеді. Қолданыстағы аналогтармен салыстырғанда қолданылатын технология химиялық жәнегранулометриялық құрамы, сондай-ақ басқа аналогтар мен прототиптерден байланыстырушы қасиеттері бойыншаерекшеленетін жергілікті қалдықтарды (Екібастұз көмірін жағудан шыққан күл-қож қалдықтары, Павлодар алюминийзауытының боксит шламы, болат балқыту қожы) пайдалануды көздейді. Құрылыс бұйымдарының өндірісіне бетон қоспасы енгізілді және патенттелді, оның ішінде жаппай %: шлакопортландцемент – 14,32–17,00; құм – 18,74–25,52, қиыршық тас – 46,50–49,71, Қазақстан Республикасының бокситтерін өңдеу кезінде алынған глинозем өндірісінің шламы – 5–7; болат балқыту өндірісінің өздігінен ыдырайтын қожы – 5–7; жылу электр станцияларының Екібастұз көмірін жағудан қалған күл-қож қалдықтары – 5–7. Сынақ нәтижелері бойынша құрылыс бұйымдарының орташа беріктік шегі (тротуар плиткалары, жиектас, қуыс кірпіш) 3,2–3,8 МПа (беріктік класы 2,5) құрайды.*

*Кілтті сөздер: құрылыс бұйымдары; күл-қож қалдықтары; энергетика; металлургия, боксит шламы, қож.*

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# УТИЛИЗАЦИЯ ПРОМЫШЛЕННЫХ ОТХОДОВ В ПРОИЗВОДСТВЕ СТРОИТЕЛЬНЫХ МАТЕРИАЛОВ НА ПРИМЕРЕ ТОО «ЭКОСТРОЙНИИ-ПВ»

*Представлены результаты работы ТОО «ЭкостройНИИ-ПВ» по переработке техногенных отходов энергетики и металлургии Павлодарской области Республики Казахстан, путем использования их в изготовлении строительных изделий, как один наиболее эффективных вариантов решения экологических проблем региона. Предлагаемая технология производства строительных изделий с использованием золошлаковых отходов предусматривает инновационные составы сырьевых смесей, что обеспечивает повышение эксплуатационных характеристик и увеличение*

*производительности труда в строительстве. Применяемая технология по сравнению с существующими аналогами предусматривает использование местных отходов (золошлаковые отходы от сжигания Экибастузского угля, бокситовый шлам Павлодарского алюминиевого завода, сталеплавильный шлак), которые отличаются по химическому и гранулометрическому составу, а также связующих свойствам от других аналогов и прототипов. В производство строительных изделий внедрена и запатентована бетонная смесь, включающая, %: шлакопортландцемент – 14,32–17,00; песок – 18,74–25,52, щебень – 46,50–49,71, шлам глиноземного производства, полученный при переработке бокситов Республики Казахстан – 5–7; саморассыпающийся шлак сталеплавильного производства – 5–7; золошлаковые отходы тепловых электростанций от сжигания Экибастузских углей – 5–7.*

*По результатам испытаний средний предел прочности строительных изделий (тротуарная плитка, бордюрный камень, пустотелый кирпич) составляет 3,2–3,8 МПа (класс прочности 2,5).*

*Ключевые слова: строительные изделия; золошлаковые отходы; энергетика; металлургия, бокситовый шлам, шлак.*

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