K. AKISHEV, K. ARYNGAZIN, A. TULEGULOV, M. BAYZHARIKOVA, ZH. NURTAI

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EVALUATION OF THE EFFICIENCY OF THE TECHNOLOGICAL PROCESS FOR THE PRODUCTION OF BUILDING PRODUCTS WITH FILLERS FROM METALLURGICAL SLAG

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Preliminary Note – Prethodno priopćenje

The article presents studies related to the practical use of metallurgical slags by Limited Liability Partnership (LLP) "Casting", Limited Liability Partnership "Kazakhstan Steel Production-steel" in the production of building products. The process of preparation and experiments to determine the strength of control samples, full-scale tests of building products are shown. The relevance of the study lies in the fact that the technological process of production of building products involves technogenic waste that cannot be used in the process of metal production, which makes it possible to improve the ecological background in the region, as well as promising opportunities for obtaining raw materials used as ingredients of concrete mixtures. The presented practical implementation of the automation of the process of adding fillers (technogenic raw materials) in the preparation of a concrete mix allows increasing the efficiency and productivity of the production of building products. The article will be useful to everyone who conducts research in the field of recycling of industrial waste from metallurgy, as well as commercial use.

Keywords: building materials, metallurgical slag, mixtures, strength, process automation.

INTRODUCTION

The astringent activity of metallurgical slags makes it possible to obtain building materials with physical characteristics that ensure the operational reliability and sanitary safety of objects under construction for various purposes.

Today, also the whole world is working on the problem of decarbonisation (reduction of CO2 emissions into the atmosphere) [1-2].

One of the largest producers of CO2 is the metallurgical industry. It's no secret that the technogenic deposits that Kazakhstan inherited after the collapse of the USSR are growing from year to year.

In Kazakhstan today there is no developed state programme for accounting, movement and, according to the data from [3], annual increase of technogenic deposits by more than 30 million tonnes of technogenic waste. In this regard, a long debate on what to do with such a huge amount of man-made raw materials continues to this day.

Numerous grant-funded projects related to the solution of environmental issues and the use of man-made raw materials remain at the level of writing beautiful reports and publishing articles in journals.

It would not be true to say that nobody reads reports and articles. And many articles are undoubtedly of scientific and practical interest. But the problem is that the results of the research have no practical use. And this, in turn, has no effect on the decline in the volume of man-made deposits, which are increasing every year. Of course, there are positive examples, in particular the Aksu Ferroalloy Plant, which processes almost all the waste from the main production into metallurgical concentrate; for this purpose, a sintering plant was built [4]. In this respect, any research into the practical use of man-made waste, especially in the technological process of manufacturing construction products, would be useful for reducing the volume of man-made deposits and solving environmental problems.

K. Akishev, Zh. Nurtai zhadira_nurtai@mail.ru, A. Tulegulov, Kazakh University of Technology and Business Development, Astana, Kazakhstan.
Aryngazin K, Toraighyrov University, Pavlodar, Kazakhstan.
Bayzharikova M, M. H. Dulati Taraz Regional University , Taraz, Kazakhstan.

OBJECT AND RESEARCH METHODS

Studies related to the determination of the chemical and granulometric composition of metallurgical slags are described in [5].

Figure 1 shows washed metallurgical slag, Casting LLP.

Figure 2 shows metallurgical slag, LLP «Casting» of a larger fraction.

In our study, various particle sizes of metallurgical slags were used, as well as the composition of concrete mixtures for the production of building products, described in [6].

The quality of metallurgical slag due to long-term storage in man-made deposits requires the implementation of procedures associated with grinding or calcination.

Figure 1 Metallurgical slag washed

Figure 2 Metallurgical slag of large fraction

Figure 3 Laboratory mill

Figure 4 Muffle furnace

A laboratory mill (Figure 3) was used to grind the metallurgical slag, and a muffle furnace (Figure 4) was used to calcinate the resulting metallurgical powder.

The milled metallurgical slag of Figure 5 (particle size 0,026mm) was calcined in a muffle furnace at a temperature of 900 °C for 20 minutes.

The resulting metallurgical powder was added in a percentage of 10-25 to various formulations, consisting

Figure 5 Ground metallurgical slag

of a river stove, cement (M400), crushed stone (various fractions). From the obtained concrete formulations, prototypes 10 × 10, 15 × 15 (Figure 6) were made, which were steamed in the steaming chamber for 12 hours. The resulting prototypes were placed in a room for consonant hardening [7].

Figure 6 Steaming chamber

The prototypes were subjected to a strength test according to [7] Figure 7.

Table 1 provides the results of testing the strength of concrete mixtures with different percentages of metallurgical powder. As can be seen from Table 1, the percentage of metallurgical powder increases the strength of the prototypes up to 23 %, after this value, the strength of the prototypes does not change the value.

Within the framework of the grant project, using the obtained compositions of concrete mixtures, construction products were made (Figure 8).

Figure 9 shows the compressive strength of a building product based on metallurgical slag. The strength

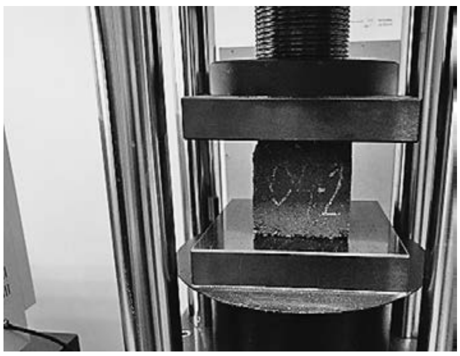

Figure 7 Strength test of the prototype

Table 1 **Percentage value of metallurgical powder and strength**

№	Composition of the concrete mix	
	Metall. Slag/ %	Strength/Mpa
1	5	7
2	10	12
3	20	19
4	23	21
5	25	21

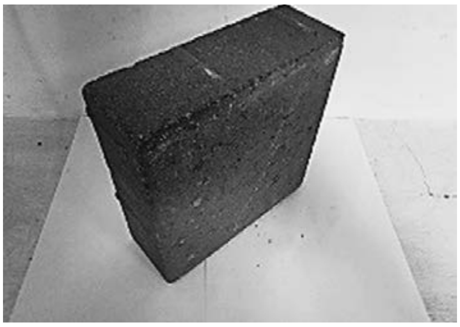

Figure 8 Construction product based on metallurgical slag

Figure 9 Strength of the construction product

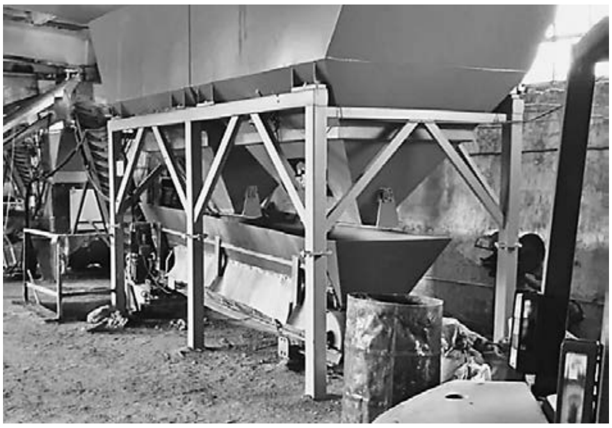

Figure 10 Vertical bins for bulk materials

Figure 11 Refey equipment

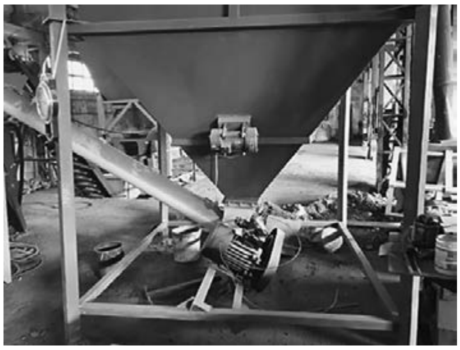

Figure 12 Screw conveyor for metallurgical slag

indicators of a building product produced on industrial equipment practically correspond to the strength of prototypes developed in laboratory conditions, which indicates the prospects and technological feasibility of producing high-quality construction products.

RESEARCH RESULTS AND DISCUSSION

The process of preparing metallurgical slag described above for use in the technological process is quite laborious and energy-intensive. However, taking into account the grinding of metallurgical slag to a size of 0,026 mm, it is possible to obtain construction products of high quality and appropriate strength.

Existing technological lines for the production of building products do not currently have equipment that allows metallurgical slag to be fed directly into a concrete mixer. The high fluidity of metallurgical slag, especially the fine fractions, makes it impossible to use vertical bulk bins (Figure 10).

It is therefore necessary to automate the loading process by using screw conveyors to load the filler from the metallurgical slag directly into the concrete mixer hopper.

In this regard, it is proposed to install an additional screw conveyor as part of the basic equipment manufactured by Refey, Figure 11, for the transport of the filler from metallurgical slag, which not only allows to automate the feeding process and reduce the technological time for performing concrete mix preparation operations.

Figure 12 shows a screw conveyor mounted as part of Refey’s basic equipment.

The conveyor is controlled from a common line control panel.

At present, the grinding of metallurgical slag is carried out by a third party organization, but this year a ball

Figure 13 Tests of a construction product with a filler made of metallurgical slag

mill is to be purchased with a capacity that will ensure that the process equipment can operate without downtime.

Figure 13 shows the moment of strength testing of a construction product.

CONCLUSION

The possibilities and volumes of metallurgical slag in the Pavlodar region allow us to talk about the prospects of replication of the technology for the production of building products with fillers from metallurgical slag presented in the article. Taking into account the rising prices of construction materials, there is a demand for cheap and high-quality construction materials, which is currently not only demanded by the market, but also stabilises the price preferences of potential buyers.

The introduction of automation of the metallurgical slag loading process made it possible to increase the productivity of the construction products production process by 23 %, reduce the number of auxiliary operations and manual labour, and cut production costs by 11 %. The manufactured construction products can be used in low-rise buildings, non-residential commercial buildings, pavements and roads with high traffic intensity.

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Note: Akbota Iskakova is responsible for English language, Almata, Kazakhstan