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Preparation of construction materials based on Metal-containing waste

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Abstract

The main purpose of the work is the preparation of concrete compositions using metal processing waste. In accordance with the established goal, the following research tasks have been defined: preparation of concrete compositions based on metal-containing waste generated during welding as a result of electrode welding, to investigate the properties of the received concrete.

Keywords: Metal containing waste, composite materials, metal processing slag, concrete, additives

Introduction

Man-made raw materials are various production wastes that can be used as mineral raw materials in construction and production of building materials. Man-made raw materials are formed in mining, metallurgy, fuel and energy and chemical industries. Man-made raw materials constitute a large reserve of the country's mineral-raw material base.

The level of use of man-made raw materials in a significant amount is low. The construction industry can be a major consumer of industrial waste. Production of construction materials is the most material and energy-intensive field of human activity. In this regard, since minimum labor is required, natural resources that are ready for maximum use are used.

Man-made wastes such as microsilica and granulated blast furnace slag can be used as highly active mineral admixtures for concrete. The use of ultra-dispersed ferroalloy waste and crystalline silica as an active microfiller for concrete is one of the most effective ways to solve important problems of the construction industry. Allows solving problems such as energy saving and creation of energy-saving technologies for production of modified concrete based on man-made waste.

Industrial waste or industrial by-products are sources of secondary materials. Many wastes are close to natural raw materials in their composition and properties. Industrial waste meets more than 30% of the demand for construction materials, reduces the cost of use by about 20-40% compared to the production of construction materials from natural raw materials, allows the creation of modern construction materials with high technical and economic indicators, and reduces environmental pollution [1].

Construction of the 21st century requires new high-performance building materials, among which high-quality concrete and concrete products occupy an important place [2].

The last decades of the 20th century witnessed important achievements in the theory and practice of concrete technology. New technological methods affecting the structure, properties and technology of concrete with chemical modifiers, active mineral components, composite binders have been created and are widespread. The use of multi-component concretes is increasing at all stages of technology, which allows more effective control of the formation of structures and obtaining materials for various purposes with certain properties. For the successful application of concrete, in-depth knowledge of its structure and properties, development of effective methods for the preparation of concrete, products and structures, the use of new additives and other components that improve the structure and properties of the material, concrete, minimum price, high quality and a product with specified operational properties and optimization of compositions and technologies that allow the production of structures is required [3-4].

The use of effective admixtures or chemical modifiers as developed has gained the greatest popularity as a technique to control concrete technology and obtain environmentally friendly and efficient reinforced concrete products with certain properties. It is known that more than 1,000 types of chemical modifiers of various constructions are used in world construction practice to improve the properties of construction mixtures, including concrete. Important results have been achieved in adjusting the structural properties of concrete by using mineral, finely dispersed fillers. Conventionally, these mineral additives can be divided into two groups: cement diluting fillers (earth slag, ash, etc.), whose particles are much smaller than cement grains and are located in the spaces between them, increasing the density of hardened cement stone, which reduce the activity of cement and compare with cement grains in terms of particle size ultradisperse fillers that can be made. Recently, microsilicate is widely used in the composition of multifunctional complex additives. As a result, modern concrete is significantly different from classic concrete, which consists of cement, filler and water. Modern concretes are multi-component, containing cement, aggregates and water, as well as modifiers, fine mineral fillers and composite binders. The composition of concrete has changed significantly and the requirements for design and preparation technology methods have increased. [5]

As mineral additives (MA) for concrete, natural and artificial substances are used in dispersed form, which are insoluble in water and characterized by a particle size of less than 0.16 mm. Despite the different effectiveness, mineral additives have a similar quality chemical composition (silicon, aluminum, iron oxides, etc.). The differences are in their mineralogical composition, the ratio of components and the degree of dispersion, which determines the dominant mechanism of action in cement systems.The activity of mineral additives, that is, the ability to bind calcium hydroxide in the presence of water at normal temperature, is determined by the content of substances in a chemically active form. The nature and intensity of the interaction of the mineral additive with metal-containing waste depends on the amount of chemically active substances in its composition. [6]

The type and quality of the materials used have an impact on the physical-mechanical and operational properties of concrete. Experimental research laboratories necessary for concrete production have been conducted. Materials used in the study: Portland cement M400 ("Norm OJSC"), gravel, metallurgical slag from a metal processing plant. Sodium silicate solution and polyvinyl acetate solution are used as additives. Metalworking slags are produced by melting the metals of the parts and the electrode during electric power welding at the point of contact between the electrode and the parts to be joined and in the production of strong welding. The protective coating of the metal electrode creates a large amount of slag and gas during welding, which ensures stable burning of the arc and protects the molten metal from oxidation. According to the standard EN ISO 14174:2019 of the slag, the combined use of welding wire and welding dust is listed in the final plan of equipment tests:

Table 1: Chemical composition of metalworking slags

C	**Si**	**Mn**	**P**	**S**	**Cr**
0.09	0.08	1.10	0.005	0.006	0.03
Ni	Mo	Cu	V	Ti	Nb
0.025	0.006	0.06	0.005	0.003	0.006

The metal-containing waste we use has a gray, porous structure. This waste is taken in two forms: large and solid and in powder form.

As you can see in the table, the main component of metallic slag is Manganese. You can get acquainted with this waste in the following picture:

Picture 1: Waste in the form of metal-containing dust generated on the weld as a result of electrode welding

Picture 2: A metal-containing hot layer formed on the weld as a result of electrode welding

At the metal pipe manufacturing plant, the layers formed as a result of electrode welding are ground and pulverized in laboratory conditions.

The water to be used for the preparation of the concrete mixture must meet the requirements of GOST 23732-2011. The water used should not contain oil, acid, strong alkalis, organic substances and industrial waste. Drinking quality water or water from a domestic water supply is considered suitable. Water ensures hydration of cement. Any impurities in the water can significantly reduce the strength of the concrete and cause unwanted premature and delayed setting of cement and stains on the surface of the finished product. The water temperature should not be lower than 15ºC, because lower temperatures prolong the hardening time of concrete.

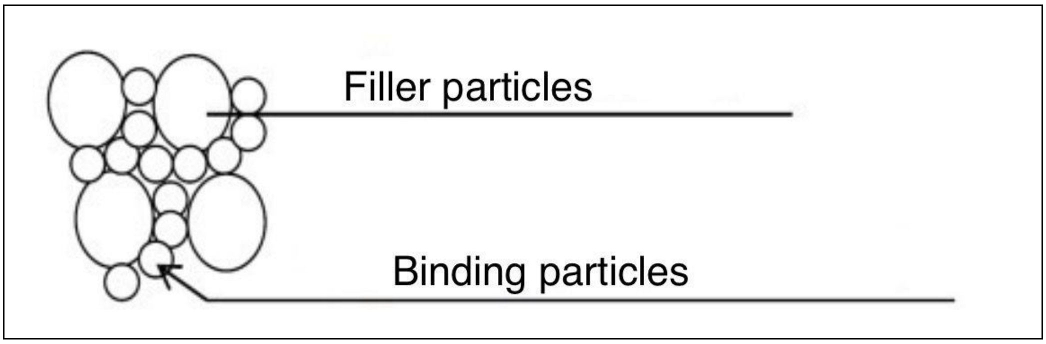
The concrete mixture prepared by mixing concrete components is spread on metal molds. Then compaction is carried out on a vibrating platform. The next step is to store the samples in humid conditions for a day. For more accurate studies, the size and shape of the samples should be strictly controlled. After twenty-four hours, the mold is removed and the samples are removed and stored under normal curing conditions for 7, 14 and 28 days. [7-8]

The composition of concrete mixtures is given in Table 2.

Table 2: The composition of the concrete mixture

Composition	**№ series**				
	1	**2**	**3**	**4**	**5**
Unit	Kg/m^3				
Amount of slag, %	0	30	50	70	100
Cement	617	617	625	617	605
Pebble stone	600	600	598	600	589
Sand	803	560	397	238	-
Slag	-	238	397	560	787
Water	306	306	306	306	300
Water/Cement	0,5	0,5	0,5	0,5	0,5
Average density of concrete, kg/m^3	2326	2321	2323	2321	2381
Spreading , cm	11,0	9,5	8,0	5,5	0

Concrete samples with dimensions of 70x70x70 mm are dried for 7 and 28 days under normal hardening conditions. After 7 and 28 days of curing under normal curing conditions, the specimens were air-dried for two hours and then tested for compressive strength. Some of the samples were immersed in water for 48 hours and tested for compressive strength when the samples were saturated with water.



Picture 2: Scheme of contact of sifted slag granules with concrete

Table 3: Test results for concrete obtained on the basis of metal processing slag

Time	**Highest compressive strength, Mpa**				
	Sand				
	1	**2**	**3**	**4**	**5**
Sieve percentage of slags	0	30	50	70	100
7 days	33,3	35,5	41,2	42,0	48,9
28 days	49,8	48,9	51,0	49,3	48,9
Saturated with water 28 days	45,4	49,8	51,5	51,5	47,2
Size	0,82	0,95	0,92	0,93	0,86
Percentage of strength increase in 28 days compared to 7 days,%	62	68	76	80	78

The strength of the saturated concrete samples two hours after removal from the normal drying chamber was not significantly different from the 28-day tested concrete samples. In these samples, the softening coefficient is higher than 0.8, which indicates that the concretes can be considered waterproof.

At the same time, the use of polyvinyl acetate and sodium silicate solutions in this concrete mixture is also considered. Currently, research is being conducted in this direction.

Results

The results of the article allow expanding the base of raw materials for concrete production using metal-containing waste. We get these results from research. Particles less than 0.15 mm in size make up a significant amount of 20-30% in the slag obtained during metal processing. Due to the presence of such a large amount of fine fraction in the aggregate, the contact area of concrete components increases. As the contact area increases, the adhesion of the sand component increases significantly. In this case, the highly developed surface of fine particles in the form of metal-containing powder formed on the weld as a result of electrode welding allows to intensify the process of cement hydration, which contributes to the dynamics of strength increase. Positive dynamics of strength increase of concrete made using crushed waste, metal-containing slag as fine aggregate and additives such as sodium silicate solution and polyvinyl acetate solution were determined. the strength gain of concrete at the age of 7 days varies between 80-90%.

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