Application of Local Wheat Straw for Building Material and Products with Gypsum Binders

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ABSTRACT

Dependencies describing the effect of crushed local wheat straw additives of different composition and specific surface area on the main physical-technical properties of construction gypsum have been defined. The effectiveness of adding crushed local wheat straw to construction gypsum increases with a decrease in the content of undrained clay from 14.1% to 9.5%. Gypsum-straw binder compositions have been developed, in which from 20 to 30% of construction gypsum is replaced by agricultural production waste, i.e., crushed wheat straw, without a significant decrease in physical and technical indicators.

Keywords: Local crushed wheat straw, construction gypsum, wheat straw gypsum mixture, steric restriction effect, undrained straw gypsum mixture.

Introduction

Solution of the problem of ensuring "sustainable development" from the point of view of energy resource saving and ecology is related to expanding the production of construction materials based on and using agricultural waste, as well as by-products of various industries [1]. In particular, reducing the consumption of natural raw materials for the production of binders by including fillers with agriculture nature in their composition is one of the promising directions [2]. Local wheat straw is one of the large tonnage wastes of agricultural production, the volume of which is 200-250 thousand tons annually in Bukhara region.

The purpose of research is to study the effect of local wheat straw of different chemical composition and crushing fineness on the properties of construction gypsum.

Methods and materials

In research work, construction gypsum G5AII produced by "Bukhorogips" JSC according to GOST 125-79 was used.

The composition of the original construction gypsum was supplemented with additives of pre-crushed local wheat straw of 20, 30, 40 and 60 mm length and 2.2, 3.2, 3.5, 4.2 mm diameter selected from wheat-growing enterprises for the production of wheat straw: in this case, "Chillaki" variety wheat (BS-1 sample) from the Bukhara agrocluster and Bobur variety wheat (BS-2 sample) of the same enterprise; Wheat of Turkestan variety (BS-3 sample) obtained from "Ziyo Baqo zamini" farm, Vobkent district, Bukhara region; "Andijan-2" wheat variety (BS-4 sample) obtained from "Nemat Bobo" farm, Kogon district, Bukhara region.

Gypsum binders were tested according to GOST 125-79, samples of gypsum straw mixture were tested for strength after 28 days by drying under constant weight. The

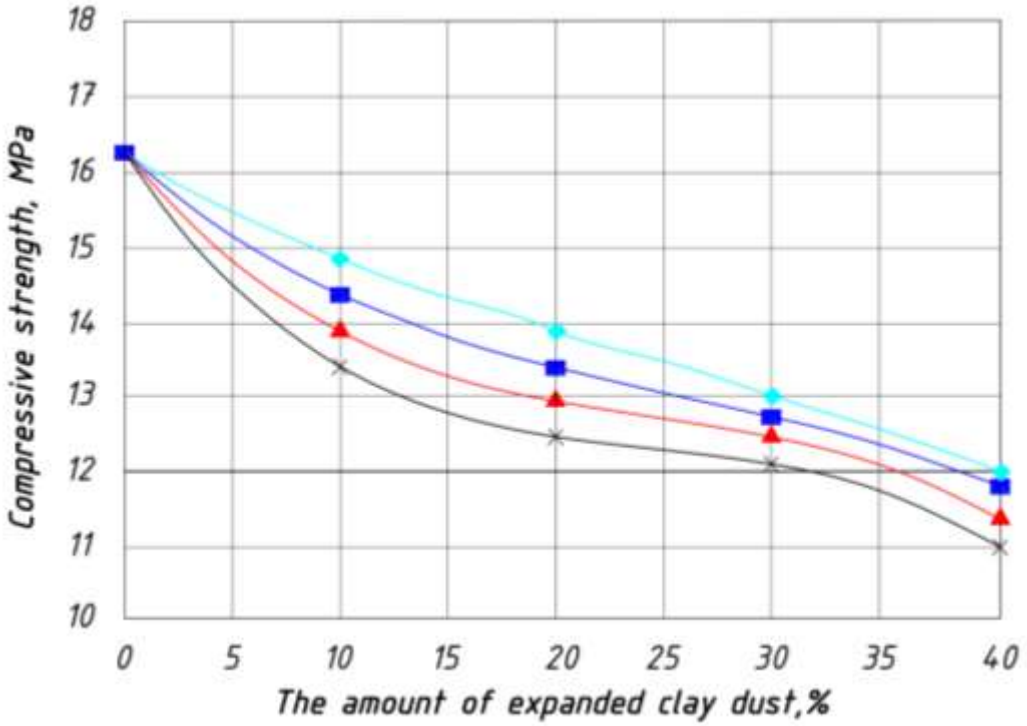
determination of the softening factor was carried out according to the specifications.

Research results and their discussion

Research has shown that selected samples of local wheat straw differ in density and size. The results of research show that local wheat straw is a waste of agricultural products, which contains a certain amount of cellulose and different levels of lignin and pentosans. The composition of local wheat straw samples conducted by the expansion method according to GOST 8735-88 has been determined, which is in BS-1, BS-2, BS-3, and BS-4 samples was 9.5, 11.3; 12.5 and 14.1% respectively.

Comparing to the products of low-temperature heating of gypsum rocks, clay mixtures are chemically inert [3-5]. However, it is known that any mineral additives affect the structure of the hardening joint stone [2, 6-9]. According to these, it is appropriate to divide mineral supplements into physically active and physical-chemically active ones. The first is the structure and properties of binding gypsum without chemical interaction with it and participates in the formation of by-products with binding properties; the latter enters into a chemical interaction with the products of binding hydration to form products with binding properties.

The results of research of the effect of local wheat straw additives of different mineral content on the compressive strength of construction gypsum at 250 m^2/kg and 800 m^2/kg specific surface are shown in Fig. 1 and 2.



(r strength limit at compression, MPa // local wheat straw, %

Fig. 1. Dependence on the strength of construction gypsum stone according to the content of additives of local wheat straw with different mineral content, with a specific length of 20, 30, 40 and 60 mm and diameter of 2.2, 3.2, 3.5 and 4.2 mm: ♦ – BS-1; ■ – BS-2; ▲ – BS-3; **x** - BS-4 strength limit at compression, MPa // local wheat straw, %

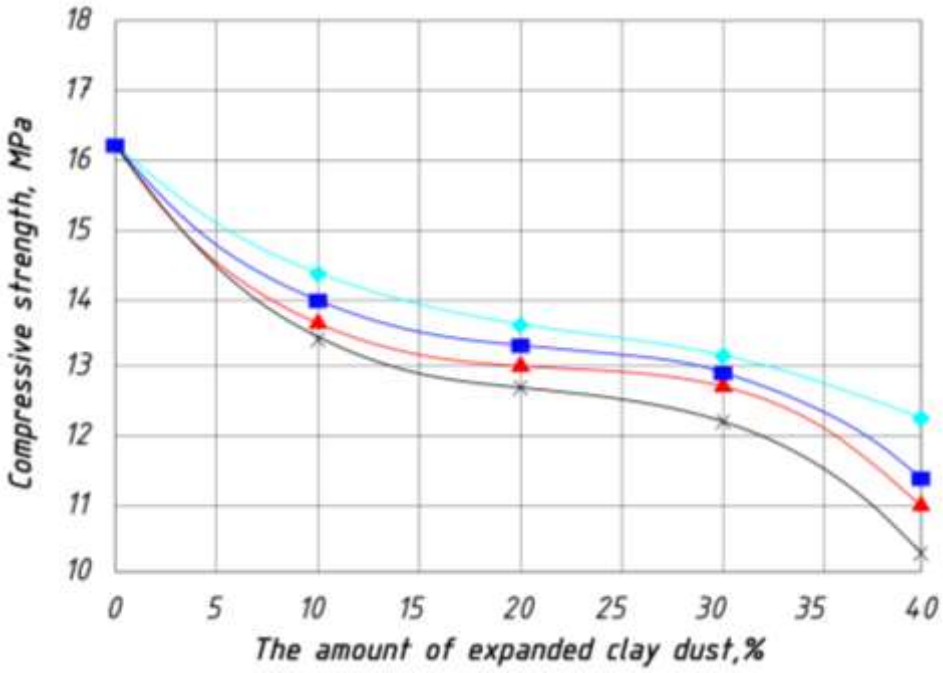


Fig. 2. Dependence on the strength of construction gypsum stone

According to the content of additives of local wheat straw with different mineral content, with a specific length of 20. 30. 40 and 60 mm and diameter of 2.2, 3.2, 3.5 and 4.2 mm: ♦ – BS-1; ■ – BS-2; ▲ – BS-3; **x** - BS-4

Similar laws shown in Fig. 1 and 2 describe the changes in the strength of artificial stone based on construction gypsum, when different amounts of wheat straw with a length of 40 mm are included in its composition.

Thereby, the analysis of the above research data shows that the change in the strength of binder with wheat straw based on construction gypsum is characterized by the amount of wheat straw additives of different mineral content and dispersion. With the addition of up to 10%, the strength of building stone decreases by 9.4-15.8%. Increasing the content of added additives to 20-30% leads to a decrease in the dynamics of strength reduction. Increasing the content of added additives to 40-50% causes a significant decrease in the strength of the gypsum sample by 35% or more.

The dynamics of changes in the strength of samples depending on the amount of local wheat straw additives with gypsum from 10% to 20-30% are explained.

When a certain amount of filler is present, gypsum is characterized by the formation of a framework along with binder particles. A similar mechanism of the effect of inert fillers on the properties of gypsum based on different binders is described in works of V.I. Solomatova and L.I in Dvorkin. [8].

The steric effect of the addition of wheat straw, reflected in the dynamics of the strength change, is occurred by the decrease in the content of the binder from 30 to 20% with the increase in the level of crushing in a certain length from 20 to 60 mm. Comparison of the dependences on the effect of wheat straw additives of different composition shows that the increase in the content of the non-dehydrated gypsum straw mixture in the additives leads to a greater decrease in the strength of the gypsum straw sample.

The derived patterns of the effect of soiled wheat straw additives of different specific sizes on the strength of plastered wheat straw have been analyzed

Analysis of construction gypsum allowed determine that the minimum decrease in its strength is observed when the gypsum-straw mixture with expanded gypsum wheat straw has a specific surface of 500 m^2/kg.

The results of research of the effect of the content and specific surface of soiled local wheat straw additives on the normal density and setting time of construction gypsum are shown in Table 1.

Table 1
Effects of content and specific surface area of local wheat straw additives in gypsum on normal density and setting time of construction gypsum.

Additives	Composition of additive %	Length, mm								
		20			40			60		
		Standard density	Hardening time min-s		Standard density	Hardening time min-s		Standard density	Hardening time min-s	
			Begins	Ends		Begins	Ends		Begins	Ends
-	0	53	5-00	8-00	53	5-00	8-00	53	5-00	8-00
BS-1	10	53	5-15	8-20	54	5-30	8-40	55	5-40	8-55
	20	54	5-30	8-50	55	5-50	9-20	56	6-05	9-40
	30	55	6-00	9-50	56	6-20	10-10	57	6-40	10-30
BS-2	10	54	6-20	8-45	55	6-40	8-15	56	7-00	9-10
	20	55	6-35	9-20	57	6-50	9-00	58	7-10	9-30
	30	57	6-50	10-10	58	7-10	10-30	60	7-40	10-00
BS-3	10	55	6-35	9-00	56	7-50	9-20	58	8-10	9-40
	20	56	6-50	9-35	57	8-10	9-50	59	8-35	10-25
	30	58	7-10	10-25	59	8-25	10-40	61	8-50	11-05
BS-4	10	55	6-50	9-15	57	8-10	10-20	59	8-30	10-35
	20	57	7-10	9-50	58	8-40	10-40	60	8-45	11-00
	30	59	7-30	10-40	60	9-00	11-00	62	9-20	11-30

The analysis of the research data presented in Table 1 shows that the normal density and hardening time of construction gypsum increases proportionally to the amount of local wheat straw additives and the content of non-dehydrated clay in the expanded gypsum straw mixture. By adding up to 30% of gypsum wheat straw and changing the amount of non-dehydrated gypsum straw in its composition from 9.5% to 14.1%, the normal density of construction gypsum increases from 53% to 62%, and strengthening increases from 5 minutes to 9 minutes.

It is explained by the fact that the normal density of construction gypsum clay increases with the addition of crushed local wheat straw, and the expanded clay dust with a porous structure increases the water demand of the binder.

The results of research of the effect of the amount and specific surface of crushed expanded clay dust additives on the softening factor of artificial stone based on construction gypsum are shown in Table 2.

Table 2
Effect of the amount and specific surface area of crushed local wheat straw additives on the softening coefficient of gypsum-based construction binder

Type of additive	Amount of additive %	Relative surface coupling coefficient, m^2/kg		
		250	500	800
-	0	0.33	0.33	0.33

BS-1	10	0.34	0.33	0.32
	20	0.33	0.31	0.30
	30	0.31	0.29	0.28
BS-2	10	0.32	0.31	0.29
	20	0.30	0.29	0.27
	30	0.28	0.27	0.26
BS-3	10	0.30	0.29	0.28
	20	0.29	0.28	0.26
	30	0.27	0.26	0.25
BS-4	10	0.29	0.27	0.26
	20	0.27	0.26	0.24
	30	0.25	0.24	0.23

The analysis of the research results presented in Table 2 showed that in the gypsum-wheat straw sample based on construction gypsum with the introduction of crushed up to 30% of local wheat straw additives the softening coefficient decreases from 0.33 to 0.23, the specific surface area increases from 250 to 800 m^2/kg, and the amount of non-dehydrated gypsum in it increases from 9.5 to 14.1%. Varieties of construction gypsum without additives are characterized by the compressive strength of the stone in a dry state of 10 to 18 MPa for 28 days [10].

The results of the above research show that despite the slight decrease in the strength of the construction gypsum-straw sample, local wheat straw crushed with 20-30% additives, the resulting gypsum wheat straw binder can be used together with construction gypsum in the production of various building materials for rooms with humidity up to 60%.

Summary

Thereby, as a result of the study, correlations describing the effect of crushed local wheat straw additives of different composition and specific surface area on the main physical-technical properties of construction gypsum have been obtained. It has been established that the addition of crushed local wheat straw additives of different composition to the composition of construction gypsum with a specific surface area in the range of 250-800 m^2/kg in the amount of 20-30%wt. causes the appearance of the wheat straw effect, the compressive strength based on the gypsum binder from 16.2 MPa to 14.3-11.8 MPa and a slight decrease in the softening coefficient.

The change of softening coefficient from 0.35 to 0.31-0.23 allows using gypsum-based expanded clay binder on a par with construction gypsum without additives. Based on the developed gypsum-local wheat straw binder, dry building mixes, wall stones, other materials and products can be produced, which, along with analogues based on less expensive building gypsum, can be used for application in rooms with a humidity level above 60%.

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