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PHYSICOMECHANICAL PROPERTIES OF CEMENTS WITH APPLICATION OF BARIUM-CONTAINING SULFATEFERRITE CLINKERS

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Abstract. In the work the results of research the physico-mechanical properties of cements with the use of barium-containing sulfateferrite clinkers and gypsum stone are given. As a result of research of barium-containing sulfateferrite clinkers hydraulic properties it is found out that while concretion they show too fast hardening and low solidity therefore they cannot be used as an independent binder. For the purpose of regulation the hardening terms the influence of the gypsum stone additive was studied. It is found out that its injectioning into the barium-containing sulfateferrite clinker composition has a positive influence on the concretion limit while compression. When adding gypsum stone the dependence of compression strength on gypsum quantity has an extreme character and depends on the mineralogical structure of barium-containing sulfateferrite clinkers.

Keywords: cement, concretion, expansion, clinker, gypsum.

1. Introduction

It is known that the presence of an alitizing phase in the structure of clinker provides the high speed of gaining the cement concretion, the barium oxide improves the protective properties of cement for radiation and the additional sulfation creates the conditions for calcium sulfaferrite formation in the structure of clinker. While hardening the calcium sulfaferrite favours the elimination of shrinkage and expansion [1-7]. The obtained results [8-13] indicate the potential of producing barium-containing sulfateferritete clinkers using such wastes as the wastes of iron ore concentration (IOC) and blast-furnace top dust (BFTD). The mineralogical structure of synthesized clinkers depends mainly on the ferruginous component kind and the correlation of the obtained ones. This fact allowed to obtain clinkers with different correlation of minerals in them that will influence the physico-mechanical and special properties of cements with their usage. Therefore it is a great interest to research the influence of barium-containing sulfateferrite clinkers on the physico-mechanical properties of cements with their usage and to define the range of obtained binders application.

2. Experimental

The gypsum stone of Dekonsky ore deposit and barium-containing sulfoferrite clinkers were used for carrying out the research work (Table 1).

The physico-mechanical tests were carried out on the small samples with the sizes $(1.41x1.41x1.41)\cdot10^{-2}$ m, formed from the grout of normal density.

The linear expansion was tested on the beam-samples with the sizes $(1.41x1.41x52.8)\cdot10^{-2}$ m, after 2, 7 and 28 days of hardening under air-damp conditions.

Table 1

Mineralogical structure of clinkers

Name of clinker		Rated content of minerals, mass %			
	C_3S	C_2S	$C_2FC\bar{S}$	B_2S	B_2F
Alite(IOC)	38.57	-	24.08	34.83	-
Alite(BFTD)	14.20	-	70.96	12.83	-
Belite(IOC)	-	32.42	27.03	38.77	-
Belite(BFTD)	-	10.90	74.32	13.04	-
Ferrite(BFTD)	-	-	37.19	28.30	33.02
Ferrite(IOC)	-	-	11.14	77.48	9.89

Table 2

Physico-mechanical properties of samples while hardening cements on the basis of barium-containing sulfoferrite clinkers

Name of clinker composition	Ultimate compression strength (MPa) after days		Linear expansion of the samples (%) after days					
	7	28	2	5	7	10	15	28
Alite(IOC)	40	56	0.09	0.11	0.12	0.12	0.12	0.12
Alite(BFTD)	12	20	0.30	0.35	0.40	0.42	0.44	0.44
Belite(IOC)	25	30	0.10	0.13	0.14	0.14	0.16	0.21
Belite(BFTD)	9	7	0.42	0.48	0.54	0.54	0.55	0.56
Ferrite(IOC)	34	20	0.03	0.05	0.09	0.15	0.49	1.25
Ferrite(BFTD)	20	22	0.15	0.19	0.22	0.23	0.27	0.37

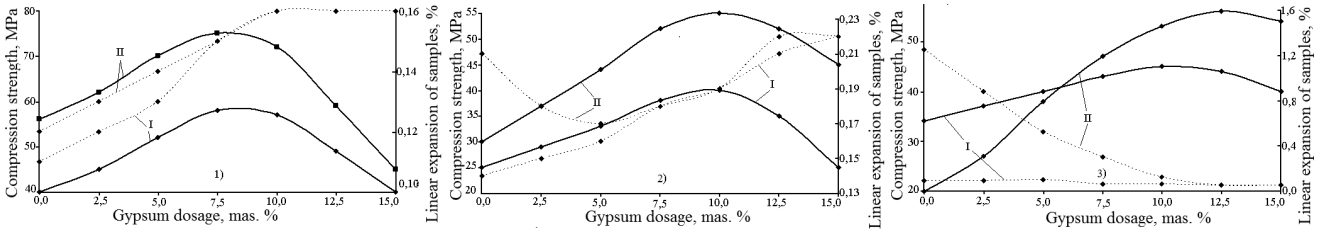

Fig. 1. The dependence of the compression strength (——) and sizes of linear expansion (·····) on the gypsum content while cements hardening with application of clinkers: Alite (BFTD) (1); Belite (BFTD) (2) and Ferrite (BFTD) (3). Age, days: 7 (I) and 28 (II)

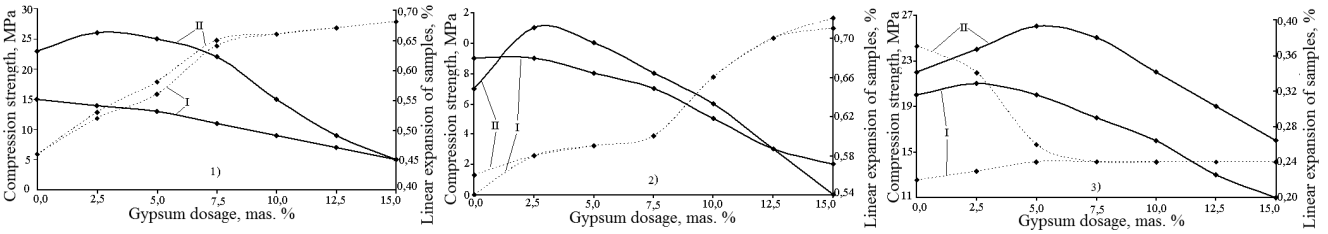

Fig. 2. The dependence of the compression strength (——) and sizes of linear expansion (·····) on the gypsum content while cements hardening with application of clinkers: Alite (IOC) (1); Belite (IOC) (2) and Ferrite (IOC) (3). Age, days: 7 (I) and 28 (II)

Table 3

Material compositions and physico-mechanical properties of samples while barium-containing sulfoferrite cements hardening

Name of cement composition	Gypsum dosage, mas. %	Setting terms		Compression strength (MPa) after days		Linear expansion of samples (%) after days					
		Beginning (hour-min)	End (hour-min)								
				7	28	2	5	7	10	15	28
Alite(IOC)	7.5	1-20	330	58	75	0.13	0.15	0.15	0.15	0.15	0.15
Alite(BFTD)	5.0	1-00	2-50	13	26	0.48	0.53	0.58	0.58	0.58	0.58
Belite(IOC)	10.0	2-10	4-40	40	55	0.13	0.16	0.19	0.19	0.19	0.19
Belite(BFTD)	2.5	1-50	2-30	9	11	0.44	0.5	0.58	0.58	0.58	0.58
Ferrite(IOC)	12.5	2-20	4-00	44	56	0.04	0.05	0.05	0.05	0.05	0.05
Ferrite(BFTD)	5.0	1-10	3-00	20	26	0.15	0.2	0.24	0.25	0.26	0.26

3. Results and Discussion

The research of physico-mechanical properties of cements with application of barium-containing sulfoferrite clinkers showed that the concretion and linear expansion generally depend on the mineralogical structure of the clinker. The results of cement physico-mechanical tests on the basis of barium-containing sulfoferrite clinkers of various mineralogical structures are given in Table 2.The analysis of the obtained results shows that the linear expansion of samples continuously increases in all cases with the increase of calcium sulfoferrite content in the clinker. The changes of the linear sizes and weakening of concretion observed for belite and ferrite clinkers after 7 days of hardening do not depend on the calcium sulfoferrite content in the clinker and are caused by formation and carbonization of $Ba(OH)_2$ which is precipitated during double-barium silicate hydrolysis [14, 15]. In all cases the expansion for the samples on the basis of alite clinkers is stabilized by 7 days of hardening and $Ba(OH)_2$ carbonization is not able to cause expansion and weakening of cement stone strength in connection with its quite strong structure formation. The cements based on clinkers with high content of ferruterous phases (B_2F and $C_2FC\bar{S}$) – compositions with the application of ferrite and ferrite clinkers – are characterized by high values of linear expansion and low compression strength after seven days which is not restored by 28 days of hardening.

Synthesized clinker tests as binders also showed their practically instantaneous setting (the beginning of 1–3 min, the end of 7–12 min). Therefore the influence of the gypsum stone addition on the obtained cements properties was explored for the purpose of regulation the setting terms. As a result, the gypsum stone injection favours the prolongation of setting terms, increases the value of linear expansion after 7 days of hardening and eliminate the volumetric deformations connected with $BaOH)_2$ carbonization in the later terms of hardening. The dependence of the compression strength while pressing on the injected gypsum stone quantity for the obtained cements is shown in Figs. 1 and 2 and properties of the most rational compositions of cements from the point of view of compression strength, linear expansion and setting terms are given in Table 3.

As a result of researches, the dependence of compression strength on the injected gypsum quantity has an extreme character. The compression strength extreme is within the limits of gypsum quantity of 2.5–12.5 mas % and depends on minerals ratio in clinkers.

The gypsum injection favours the considerable increase of strength and eliminates the later expansion caused by $Ba(OH)_2$ carbonization for the cements with the application of clinkers Alite (BFTD), Belite (BFTD), Ferrite (BFTD) (Fig. 1). At the same time with the increased sulfoferrite content (clinkers Alite (IOC), Belite (IOC), Ferrite (IOC)) the gypsum injection reduces the strength owing to the considerable 7-days expansion (Fig. 2).

4. Conclusions

The results show that the cements on the basis of clinkers Alite (BFTD), Belite (BFTD) and Ferrite (BFTD) are characterized by a high compressive strength and moderate expansion that gives an opportunity to apply them as independent binders.

The cement hardening with the application of Alite (IOC), Belite (IOC) and Ferrite (IOC) clinkers in contrast to the cements with the application of clinkers Alite (BFTD), Belite (BFTD) and Ferrite (BFTD) is accompanied by the considerable linear expansion and as a consequence by poor compressive strength.

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ФІЗИКО-МЕХАНІЧНІ ВЛАСТИВОСТІ ЦЕМЕНТІВ З ВИКОРИСТАННЯМ БАРІЄВМІСНИХ СУЛЬФОФЕРИТНИХ КЛІНКЕРІВ

Анотація. *Наведені результати дослідження фізико-механічних властивостей цементів з використанням барієвмісних сульфоферитних клінкерів і гіпсового каміння. Встановлено, що при твердінні вони показують занадто швидке тужавіння та невисоку міцність, тому не можуть бути використані як самостійні в'яжучі матеріали. З метою регулювання строків тужавіння вивчено вплив добавки гіпсового каміння. Встановлено, що його введення до складу барієвмісного сульфоферитного клінкеру збільшує терміни тужавіння та позитивно впливає на межу міцності при стисненні. При додаванні гіпсового каміння залежність міцності на стисненні від його кількості носить екстремальний характер і залежить від мінералогічного складу барієвмісного сульфоферитного клінкеру.*

Ключові слова: *цемент, твердіння, розширення, клінкер, гіпс.*