F.A. Finger – Institut für Baustoffkunde

Bauhaus – Universität Weimar

ibausil

18. Internationale Baustofftagung

12. – 15. September 2012

Weimar

Bundesrepublik Deutschland

TAGUNGSBERICHT – BAND 1

Grabovchak, V

High Corrosion Resistant Ash Alkali Activated Cements

Abstract

This paper covers the results of development of corrosion resistant ash alkali [illegible] cements based on regulation of phase composition of the hydration products [illegible] changing the alkali content, content of calcium- containing cement [illegible] resulting in the increase strength and density of the cement stone. The results [illegible] suggested to conclude that the cement compositions with predominance in the [illegible] products of weakly soluble low basic hydrosilicates of calcium, hydro[illegible] minerals similar to natural hydroaluminates exhibited the highest corrosion [illegible] The results of comparison suggested to draw a conclusion that the alkali [illegible] cements Types ЛЦЕМ III-400 and ЛЦЕМ V-400, according to National [illegible] Standard DSTU B V.2.7 had high corrosion resistance compared to that of [illegible] allowing to recommend the developed cements for the concretes intended [illegible] aggressive environments, inclusive of sodium and magnesium sulphates and [illegible]

1 Introduction

With the increase in volumes of construction a first-priority issue is how [illegible] their durability Durability of concrete structures is dependent upon service [illegible] and, among many other factors, by characteristics of the cement used for [illegible] concrete. Of special interest is durability of corrosion resistant concretes [illegible] intended use. Until now there is no unified solution for the concrete mix [illegible] would meet all needs with regard to corrosion resistant concretes.

The most important characteristics which determine corrosion resistance [illegible] concretes are: type of cement and its mineralogical composition, [illegible] hydration products, water to cement ratio (W/C), type of admixtures and [illegible] aggregates, pore structure, etc. In the corrosion resistant concrete mix [illegible] following factors should be taken into account: service conditions and [illegible] exposure conditions.

The alkali activated cements based on granulated blast-furnace slags and [illegible] have been developed by a scientific school headed by Professor V.D.Gl[illegible] the cements that can be successfully used for making corrosion resistant [illegible] The alkali activated cement concretes have high strength properties (4[illegible] higher), frost resistance (1000 cycles), water penetration (W10-W50), high [illegible] resistance in different mineral and organic environments [4, 5].

Further research work allowed to develop fly ash alkali activated cements [illegible] fly ash content reached 90% [6-9]. These fly ash alkali activated cements [illegible] important alternative to portland cements containing fly ash in a quantity [illegible] 30%, since in their physical-mechanical properties are similar to the portland [illegible] the fly ash alkali activated cement stone is characterized by the higher weather [illegible]ce, frost- and corrosion resistance.

[illegible] material and methods of examination

[illegible]position of the concrete without admixtures was constant in all experiments. [illegible]cium fly ash class F (under ASTM C 618), ground to a specific surface of 800 [illegible] Blaine, sodium carbonate and sodium metasilicate penthahydrate as alkaline [illegible] were used as basic raw materials. Ordinary portland cement (OPC) Type I [illegible]commercial product with a specific surface of 380 m^2/kg) and blast-furnace slag [illegible] surface 450 m^2/kg) were taken as additional cement constituents. Chemical [illegible]on of raw materials is shown in Table 1.

[illegible] 1

[illegible] composition of raw materials

[illegible]rial	SiO_2, %	Al_2O_3, %	Fe_2O_3, %	CaO, %	MgO, %	SO_3, %	Na_2O, %	K_2O, %	LOI, %
[illegible]	51.08	24.8	13.67	3.12	1.83	0.08	0.60	1.90	1.50
[illegible]	23.4	5.17	4.12	64.13	0.88	0.55	0.41	0.33	0.20
[illegible]	40.0	5.91	0.32	46.9	5.87	1.62			

[illegible] alkali activated cements under study, they were: alkali activated pozzolanic [illegible]ЕМ III and alkali activated composite cement ЛЦЕМ V[13] were prepared [illegible] of the preliminary separately ground fly ash and slag, OPC, and alkaline [illegible] and plasticizer in a ball mill. The slag portland cement M400 (ШПЦ III/A), [illegible] to Ukrainian classification [14] was taken as reference. The composition of [illegible] alkali activated cements under study is given in Table 2.

[illegible] 2

[illegible]on of the fly ash alkali activated cements under study

[illegible] Type	Composition, % by mass				
	Fly ash	OPC I-500	Slag	Alkaline activator	Plasticizer
[illegible]ЕМ III	66.2	28.4		Na_2CO_3-4.7	0.75
[illegible]ЕМ V	54.2	8.9	26.2	Na_2CO_3-4.7 $Na_2SiO_3 \cdot 5H_2O$-5.3	0.7

[illegible] resistance of the fly ash alkali activated cements under study was determined [illegible] to recommendations given in [10] by measuring strength variations of the [illegible] placed in aggressive environments (10%- and 5%- solutions of sodium [illegible] (Na_2SO_4), 4%- and 2%-solutions of magnesium sulfate ($MgSO_4$), concentrated [illegible]. The specimens were kept for 3 days in normal conditions, then, for 25 days [illegible] of technical grade. The test ages were: 30, 60, 90 and 180 days.

The corrosion resistance was expressed by a coefficient of
calculated as a ratio between a flexural strength of the
months in aggressive environment and flexural strength of the
for 12 months in water. According to above recommendations
considered to be a corrosion resistant if the coefficient of
storage for 12 months is equal or higher than (>)0.8.

3 Results and discussion

At the first stage of the study, main physical-mechanical characteristics
alkali activated cements have been determined (Fig.1). The results of
draw a conclusion that the developed cements fall within the ranges
strength requirements for the alkali activated cements ЛЦЕМ III
strength class M400 (their compressive strength was 38.4- 41.3 MPa).

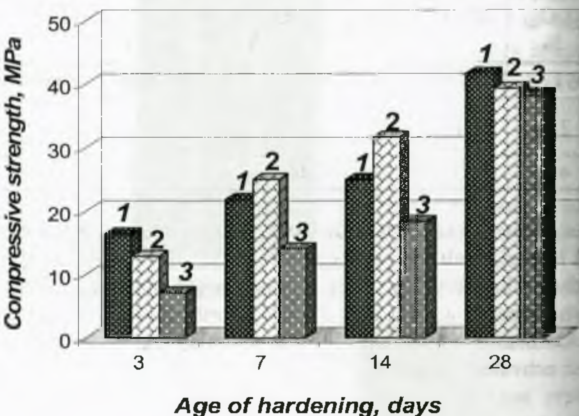

Figure 1
Compressive strength of the cements under study: 1 – ЛЦЕМ III; 2 –
3 – ШПЦ III/A-400.

The results of study of corrosion resistance (Fig.2, a, b, c, d, e, f,)
that all cements under study after long-term storage in aggressive
age of 30 days have increased their strength properties comparing
cement/ This can be attributed to the deepening of the hydration
the age of 2-3 months strength of the majority of the cements under
lowering. So, at the age of 6 months, the cement ШПЦ III/A-400
strength compared to the fly ash alkali activated cements ЛЦЕМ III
Thus, the cement ШПЦ III/A-400 could not be considered as corrosion
(Fig 3)

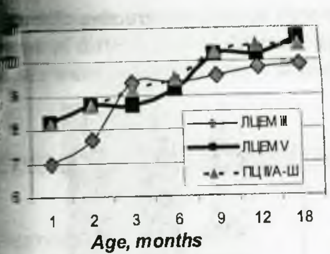

Figure 2a

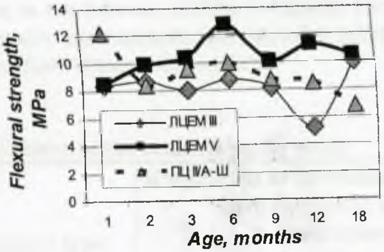

Figure 2b

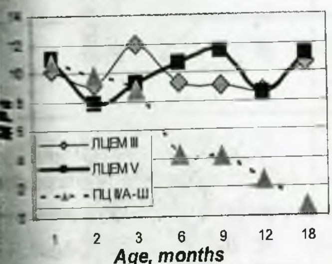

Figure 2c

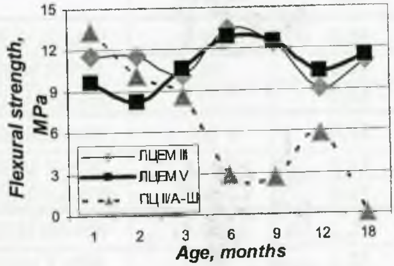

Figure 2d

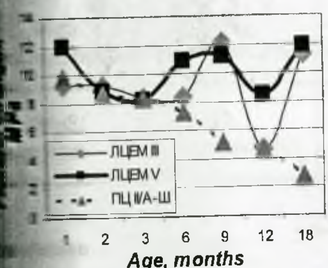

Figure 2e

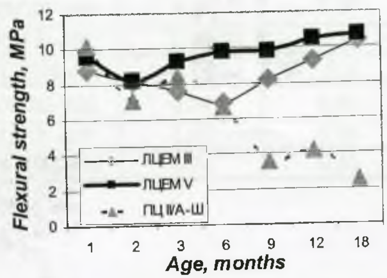

Figure 2f

...l strength of the cement under study vs. age (storage in aggressive ...ment): (a) water of technical grade; (b) sea water; (c) Na_2SO_4 ...ration- 5%); (d) Na_2SO_4 (concentration- 10%); (e) $MgSO_4$ concentration- ...) $MgSO_4$ (concentration- 4%).

...lculated coefficients of corrosion resistance (Table 2) suggested to draw a ...sion that the developed fly ash alkali activated cements (ЛЦЕМ III-400 and ... V-400) have much better resistance against aggressive environment compared ...PC. So, at the age of 9 months, the coefficient of corrosion resistance of these ... did not lower below 1 and at the age of 12 months the developed composite ... ЛЦЕМ V-400 had good flexural strength (the coefficient of corrosion resistance ... and higher), and the coefficient of corrosion resistance of the developed cement ... III-400 declined below critical level only in sea water and magnesium sulfate with concentration of 4%. This result can be explained by a constructive charact... combined alkaline-sulfate activation of the fly ashes /11/.

Figure 3a

Figure 3b

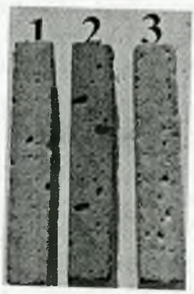

Figure 3c

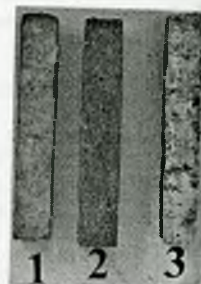

Figure 3d

Figure 3e

Photos of the specimens after 1 year-storage in aggressive enviro... water; (b) 5% Na_2SO_4; (c) 10% Na_2SO_4; (d) 2% $MgSO_4$; (e) 4% $MgSO_4$... 1 – ЛЦЕМ III-400; 2 – ЛЦЕМ V-400; 3 – ШПЦ III/A-400.

Analyzing the coefficients of corrosion resistance (Table 3) suggest... conclusion corrosion resistance of the developed fly ash alkali activated ... study is directly proportional to a quantity of the calcium-co... constituents. Thus, with regard to the calcium-containing cement ...

…on resistance decreases as the follows: ЛЦЕМ V<ЛЦЕМ III< ШПЦ III/А-400. …regard of different aggressive environments, the corrosion resistance decreases as …: sea water < sodium sulfate < magnesium sulfate.

…3

…results of corrosion resistance of the cements under study

Aggressive environment	Cement type	Coefficient of corrosion resistance (Ks) after storage in aggressive environment, days		
		90	180	365
Sea water	*ЛЦЕМ III-400*	0.95	0.84	0.83
	ЛЦЕМ V-400	1.39	0.99	1.22
	ШПЦ III/А-400	1.05	0.85	0.85
Na_2SO_4 (…centration- 5%)	*ЛЦЕМ III-400*	1.0	0.95	0.88
	ЛЦЕМ V-400	1 16	1.13	1.05
	ШПЦ III/А-400	0.45	0.45	0.29
Na_2SO_4 (…ration- 10%)	*ЛЦЕМ III-400*	1.45	1.29	0.93
	ЛЦЕМ V-400	1.40	1.23	1 11
	ШПЦ III/А-400	0.31	0.26	0.09
$MgSO_4$ (…ration- 2%)	*ЛЦЕМ III-400*	0.9	1.27	0.84
	ЛЦЕМ V-400	1.18	1.10	0.91
	ШПЦ III/А-400	0.77	0.5	0.55
$MgSO_4$ (…ation- 4%)	*ЛЦЕМ III-400*	0.74	0.85	0.94
	ЛЦЕМ V-400	1.07	0.96	1.13
	ШПЦ III/А-400	0.71	0.35	0.5

…usion

…s of study suggested to conclude that in corrosion resistance the developed fly … activated cements, they are: alkali activated pozzolanic and alkali activated … exhibit the higher corrosion resistance compared to the slag portland cements … be successfully used in making corrosion resistant concretes for the use in …gressive environments.

…s of study suggested to conclude that the fly ash alkali activated cements … and ЛЦЕМ V-400 exhibit high corrosion resistance (Ks = 1.04...1.39 after 12 … of storage in aggressive environments) and the developed composite cement …-400 has the higher characteristic.