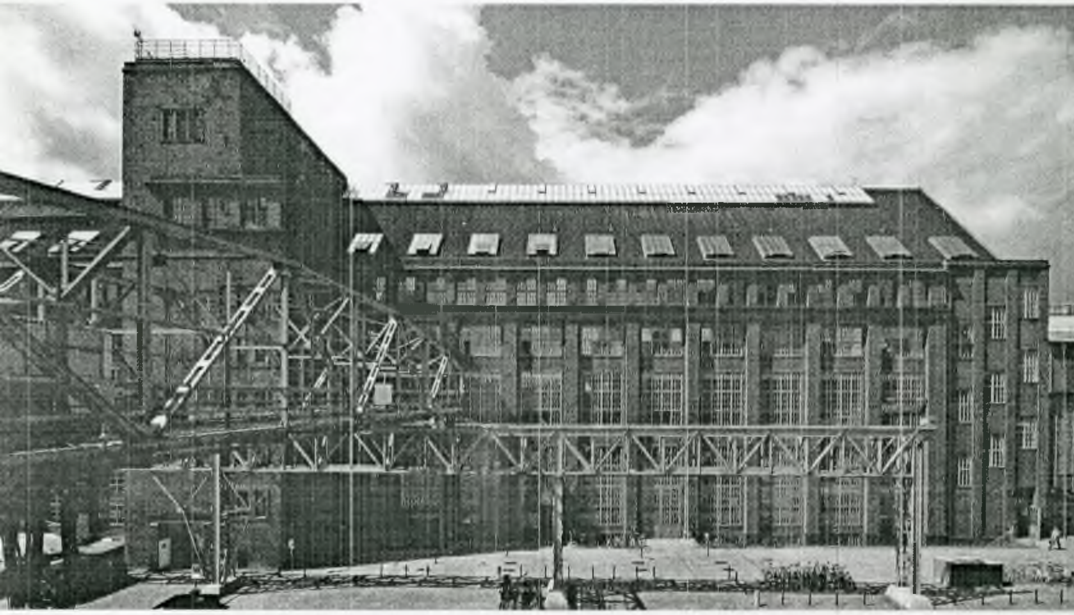
Gesellschaft
Deutscher Chemiker e. V.

GDCh-Monograph Vol. 46

1st International Conference on the Chemistry of Construction Materials

by the GDCh Division of Chemistry of Construction Chemicals
October 7-9 2013
Berl n



Technische
Universität
Berlin

berlin

Edited by
the GDCh-Division of Chemistry of Construction Chemicals

Fly ash based alkali activated cements low heat evolution materials

Kovalchuk O Yu PhD Senior researcher
Grabovchuk V V PhD
SRIBM named after Glukhovskii KNUCA, Kyiv

INTRODUCTION

Hardening of concrete is supported by heat emission due to the cement hydration processes. Rising of temperature leads to stresses because of irregular heating and cooling so as internal layers are cooling slowly When a large thermal stresses are occurred in concrete it is possible to cracks appearance that could decrease strength and durability of concrete. So during thermal balance calculation of concrete hardening special role is given to heat emission /1-2/
To reduce heat emission is possible by introducing to the cement active mineral admixtures, including grinded blast furnace slags and fly ashes. Slag- and fly ash alkali activated cements have low heat emission levels that could be explained by peculiarities of hydration processes of alkali activated cements [2, 3]. Heat emission fly ash based alkali activated cements are studied very poor

RAW MATERIALS AND TEST METHODS

As a raw materials were chosen fly ashes class F according to ASTM C 618, grinded to surface 800m^2/kg· as an alkaline component was used sodium carbonate and sodium metasilicate penthahydrate. As an activator was used OPC type M500 with specific surface 380m^2/kg and granulated blast furnace slag grinded to the surface 450m^2/kg Chemical composition of raw materials is shown in Table 1

Table 1 Chemical composition of raw materials

Material	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	SO_3 %	Na_2O %	K_2O %	mass loses %
Fly ash 1	47.01	17.04	17.12	3.05	1.41	0.06	0.48	1.60	2.47
Fly ash 2	50.94	24.56	13.25	2.86	1.98		0.69	2.69	1.36
Fly ash 3	48.20	19.65	4.50	2.18	1.36	0.11	1.04	2.78	16.02
Fly ash 4	39.99	13.85	12.86	1.40	3.54	0.18	2.30	0.19	21.86
OPC I-500	23.4	5.17	4.12	64.13	0.88	0.55	0.41	0.33	0.20
Slag	40.0	5.91	0.32	46.98	5.87	1.62			

Alkali activated cements were prepared by separated grinding of components and their mixing with alkalis and plasticizer in the mill Objects of investigation – cements, classified according to [4 as alkali activated pozzolanic cement ЛЦЕМ (fly ash content 60%, OPC-40% sodium carbonate – 5% over ash and OPC mass and alkali activated composite cement ЛЦЕМ V (fly ash content 60%, OPC-10% slag 10% sodium carbonate – 4% and sodium metasilicate 6). As analogue was taken slag OPC ШПЦ I/A-400.
Thermal-kinetical properties of cements under investigation were determined on heat emission curves according to [5] that make it possible to study heat emission processes on each stage.

RESULTS AND DISCUSSION

Firstly was studied influence of an activator on heat emission

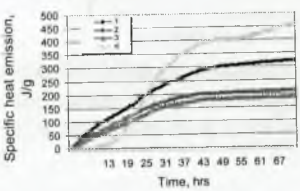


Fig 1 Specific heat emission of cements: 1 – «fly ash – OPC – alkaline component – admixture» 2 – «fly ash – OPC – slag – alkaline component – admixture» 3- «fly ash – slag – alkaline component – admixture» 4 – slag OPC ШПЦ I I/A-400

Analysis of relations $Q = f(\tau)$ (Fig 1)victims about differences in intensity and deepness of hydration at early stages of hardening because of different mineralogical and chemical compositions of cements. Thus, hydration process of slag OPC comparing with alkali activated fly ash based cements is characterized by higher induction period and 1.5 times higher heat of hydration Differences in alkali activated cements compositions determine different heat emission: system «fly ash – slag – alkaline comp. – admixture» is characterized by almost 20 % 100 % lower specific heat emission Q=185 J/g comparing with systems «fly ash – OPC – slag – alkaline comp. – admixture» (Q=202J/g) and «fly ash – OPC – alkaline comp.– admixture» (Q=320 J/g so as hydration processes are depending from type and quantity of Ca-containing components.
According to investigation results (Fig 1 it is set that fly ash based alkali activated cements are characterized by intensive heat emission at early stage of hydration because of chemical reaction of cement

components, which is supporting by destruction of surface layers, causing formation of new phases.

Analysis of influence of heat emission from type of alkaline component was done using system «fly ash – slag – alkaline component – admixture (Fig 2.). The lowest heat emission (202 J/g after 72 hours of hardening) has alkali activated composite cement with 5% of sodium carbonate, for both two other systems there are no huge differences.

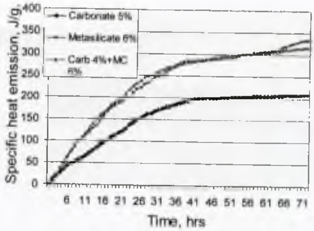


Fig.2. Specific heat emission of alkali activated cement composite cement depending on alkaline component type

Thus, low heat emission is typical for systems with sodium carbonate. In the same time, cements with sodium metasilicates had low heat emission at the first 3 hours.

The next studies were done to determine dependence of heat emission from different quantity of sodium carbonate (3 7 % by mass of cement). Results of tests are shown at Fig 3.

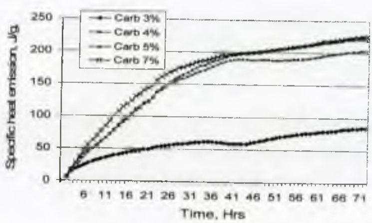


Fig. 3. Specific heat emission of alkali activated cement composite cement depending on alkaline component quantity

The lowest heat emission about 85 J/g) had alkali activated fly ash based cement with 3% of sodium carbonate, increasing of alkalis content from 4 to 7% by mass increased heat emission in 2 times. However physical-mechanical tests shows than with alkaline component content 3% and lower cements alkali activated cements under study had low strength that could be explained by low concentration on alkalis in solution and slow reaction speed.

ntroducing 7% of alkalis increased strength properties up to 41.7 MPa.

Hydration processes also could be influenced by quality of raw ashes and technology of burning So it was tested dependence of heat emission of the cements from fly ash origin. Four fly ashes were chosen for study (Fig. 4). Compressive strength of cements under study at 7 /28 day was: for fly ash 1 – 23.2/38.4 MPa, fly ash 2 – 25.2/42.3 MPa, fly ash 3 – 20.4/27.9 MPa, fly ash 4 – 21 7/31.3 MPa.

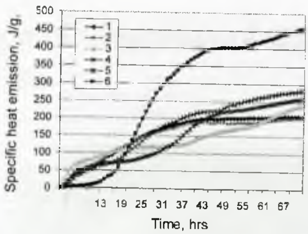


Fig.4. Specific heat emission of alkali activated cement composite cement ЛЦЕМ V-400 depending on fly ash origin. 1 fly ash 1 2 – fly ash 2; 3 – fly ash 3; 4 – fly ash 4, 5 – ЛЦЕМ I-500; 6 – slag OPC ШПЦ I I/A-400.

It could be admitted that lowest heat emission levels are present for ashes with high SiO_2 and Al_2O_3 content (Fig 4 lines 1 2). Also it could be admitted that high unburned carbon content slows heat emission (Fig 4. lines 3, 4), but at 3 days specific heat emission is higher in 2 times comparing to other ones.

CONCLUSIONS

It was shown effectiveness of using of fly ash alkali activated cements for developing concretes with low heat emission properties. Despite the fly ash origin, all the cements had low specific heat emission

BIBLIOGRAPHY

/1/ Mchedlov-Petrosyan O.P Usherov-Marshak A.V., Urzhenko A.M. Heat emission diring hardening of binders and concretes– Moscow, 1984. 224 p.

/2/ Usherov-Marshak A.V Calorimetry of cement and concrete. Chosen papers. Kharkiv 2002 – 183 p.

/3/ Usherov-Marshak A.V Kryvenko P V., Pershina L.A. Correspondence between heat emission kinetic and strength during hardening of binders and concretes– Moscow, 1999, vol. 35, № 2, pp 244-247

/4/ DSTU B V 2.7-181:2009 «Building materials. Alkaline cements. Specifications».

/5/ DSTU B V 2.7-25:2009 «Building materials. Concretes. Method for determination of exothermic heat at hardening. Specifications ».