Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2022, 9(3):50-53**

Review Article

ISSN: 2394-2630
CODEN(USA): JSERBR

A review of research progress and development prospects of alkali-activated materials

Peiqing Li, Bin Yu, Shuaijun Li, Yilin Li

School of Transportation and Vehicle Engineering, Shandong University of Technology, Zibo, Shandong province 255022

Abstract Alkali-activated gelling material is a kind of gelling material that can stimulate the activity of precursors in an alkaline or strong alkali environment, so that it can maintain and develop properties. At present, the two most widely used alkali-activated gelling materials in the world The materials are high-calcium-alkali-activated cementitious material system and low-calcium-alkali-activated cementitious material system, the former is mainly represented by granulated blast furnace slag (GGBFS), and the latter is mainly represented by fly ash (FA). For the precursor to obtain an alkaline environment, an activator needs to be added. Alkali-excited materials do not require calcination in the preparation process, which enables them to save more resources than traditional cement materials, and alkali-excited cementitious materials have the characteristics of fast setting, early strength, and high temperature resistance. These characteristics make it better used in some special occasions, such as its fast setting and early strength characteristics can be well used in engineering repairs, etc., but these characteristics also limit its application in a wider range, so at present The main research direction in the world is how to make the alkali-excited materials have a larger application space. This paper briefly summarizes the research status and application prospects of alkali-excited gelling materials in improving fast setting and early strength.

Keywords alkali activated; slag; fly ash; activator; retarder

1. Overview of alkali-activated Materials

1.1 Background of the Development of Alkali Excited Materials (AAM)

As the most commonly used building material in the construction field, cement will cause a lot of energy consumption and a huge amount of carbon dioxide emissions during the production and calcination process. 7-9% of the carbon dioxide produced, while accounting for 3% of the world's total energy consumption [1, 2], It can be seen that in the environment of increasingly serious environmental problems, it becomes particularly important to reuse environmental protection materials or industrial wastes, especially the use of industrial wastes in the construction industry. Under this premise, researchers are exploring During the process, I gradually focused on industrial wastes such as GGBFS. Such wastes do not need to be calcined at high temperature like cement in terms of utilization and processing. They can be put into use only by natural drying or drying, so it can greatly reduce the amount of waste. Therefore, the development of alkali-activated materials is of great significance to the improvement of human environment and energy conservation.

1.2 alkali-activated materials composition

Alkali-activated materials are composed of precursors and activators, and their properties can be modified by adding additives. Adverse effects, but a considerable number of researchers have found suitable admixtures for alkali-excited materials, which will be described in detail later. The precursors and activators are summarized below:

1.2.1 Precursors

The precursors in the alkali-excited materials mainly provide elements such as silicon, aluminum, and calcium. The hydration reaction of these elements during the coagulation process is accelerated by using an activator, thereby generating ettringite and other substances. The key factors of the mechanical properties of the material after curing for 7d and 28d, John. L. Provis in (Alkali-activated materials) summarized The types of precursors[3]. The available precursors include, but are not limited to, blast furnace slag, fly ash, calcined clay, red mud, steel and copper slag, etc. It can be seen that the choice of alkali-excited materials in the selection of precursors is mostly rich in silicon, aluminum, and calcium. Industrial waste, but for some precursors, the activator that can effectively stimulate its performance has not been found effectively. Exciters with excellent performance such as copper slag and municipal solid waste incineration ash are summarized in Figure 1-1.

Activator / Solid raw materials	MOH	$M_2O·rSiO_2$	M_2CO_3	M_2SO_4	Others
Granulated blast furnace slag	feasible	excellent	appropriate	feasible	-
Fly ash	excellent	excellent	Poor - it is feasible to add cement / clinker	Only cement / clinker can be added	$NaAlO_3$-Appropriate
Natural pozzolanic materials and pozzolans	feasible	excellent	-	Only cement \ / clinker can be added	-
Skeleton aluminosilicate	feasible	feasible	Only cement / clinker can be added	Only cement / clinker can be added	-
Iron slag	-	excellent	-	-	-
Phosphorus residue	-	excellent	-	-	-
Copper slag	-	feasible	-	-	-
Red mud	-	feasible	-	-	-
Bottom ash and municipal solid waste incineration ash	-	feasible	-	-	-

Figure 1.1: Summary of different solid feedstock and activator combinations [3]

1.2.2 Activator

From Figure 1.1, it is easy to see that the current mainstream exciters chosen are mainly compounds that can provide OH^-、SiO_2、CO_3^{2-}、SO_4^{2-}. Among them, the most widely used are mainly $M_2O·rSiO_2$ compounds, the typical representative of this is water glass, in addition to the above compounds, cement or clinker can also be used as an exciter, but the application is relatively narrow.

2. Retarder in the application of alkali-inspired material systems

As the main precursors of AAM, fly ash and slag in the test were found to be a large number of its setting time is too short, especially high calcium precursors such as slag will appear instantaneous condensation or flash condensation phenomenon, its engineering applications have caused a very negative impact, so its setting time control has become an important issue, although the current application of silicate cement admixtures are almost unable to play a role in the alkali-initiated materials Although almost all admixtures currently used in silicate cements do not work in alkali-excited materials or even have negative effects, researchers have found many admixtures that can work.

Sajjad Yousefi Oderji et al [4]. determined the mechanical strength and setting time by adding borax (sodium tetraborate - borax decahydrate), sodium triphosphate, sodium gluconate, tricalcium lignosulfate and sodium triphosphate as admixtures to the mixture of FA and GGBS at different dosing levels. SEM test observed that dense linear structure was observed in the sample with 6% borax admixture, and it is also noteworthy that the setting time was significantly improved after the addition of lignin sulfur tricalcium, but it had a negative effect on the mechanical properties.

Ubolluk Rattanasak et al [5]. in their study by using calcium chloride, calcium sulfate, sodium sulfate and sucrose as retarders in alkali-excited fly ash, found that at the same dosing, sodium sulfate and sucrose had better initial setting time compared to calcium chloride and calcium sulfate, but in the performance of final setting time, sucrose was able to react to a better final setting time of 210-230 min (see Table 2.1).

Table 2.1: Initial and final setting time under different admixture dosing [5]

Admixtures	Dosage / wt%	Initial setting time / min	Final setting time / min
Control	0	60	130
CaCl2	1	26	60
	2	35	45
CaSO4	1	58	115
	2	56	105
Na2SO4	1	82	135
	2	90	130
Sucrose	1	60	210
	2	60	230

JohnBensted et al studied that borates such as disodium octaborate tetrahydrate and sodium pentaborate, which release the most $B(OH)_3$ and $B(OH)_4$ monomers into water, were found to be more effective in retarding coagulation than other borates, and they were also found to be effective in inhibiting calcium hydroxide precipitation through microscopic experiments.

3. Prospects for the development of alkali-inspired materials

In the context of the world's increasingly serious environmental problems, the widespread application of alkali-excited materials is undoubtedly of great significance, especially for alleviating the environmental pressure generated by the accumulation of waste materials in some heavy industrial cities, such as Zibo City, Shandong Province, which produces a large amount of titanium gypsum waste every year due to the production of titanium dioxide, and these wastes have caused great pressure on the local environment. Because these wastes have regional characteristics, i.e., the chemical composition or activity of the same waste generated in different regions may vary greatly, which hinders its widespread application, therefore, it is particularly important to conduct regional research on the application of alkali-excited materials, and the current research in this area is relatively lacking in China, which can be seen that it still has broad development and research prospects.

Reference

[1]. Shi C, Jiménez A F, Palomo A. New cements for the 21st century: The pursuit of an alternative to Portland cement [J]. Cement and Concrete Research, 2011,41(7):750-763.

[2]. Qin L, Gao X, Li Q. Upcycling carbon dioxide to improve mechanical strength of Portland cement[J]. Journal of Cleaner Production, 2018,196:726-738.

[3]. Provis J L. Alkali-activated materials [J]. Cement and Concrete Research, 2018,114:40-48.

[4]. Oderji S Y, Chen B, Shakya C, et al. Influence of superplasticizers and retarders on the workability and strength of one-part alkali-activated fly ash/slag binders cured at room temperature [J]. Construction and Building Materials, 2019, 229:116891.

[5]. Rattanasak U, Pankhet K, Chindaprasirt P. Effect of chemical admixtures on properties of high-calcium fly ash geopolymer [J]. International Journal of Minerals Metallurgy and Materials, 2011,18(03):364-369.

[6]. Bensted J, Callaghan I C, Lepre A. Comparative study of the efficiency of various borate compounds as set-retarders of class G oil well cement [J]. Cement and Concrete Research, 1991,21(4):663-668.