THE EFFECT OF CaO-RICH ADMIXTURES ON CONTROLLING DRYING SHRINKAGE OF ALKALI ACTIVATED MATERIALS

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ABSTRACT

One of the main technical challenges regarding alkali-activated materials (AAM) is to overcome their tendency to suffer severe drying shrinkage. In this work, the feasibility of using CaO-based admixtures to mitigate drying shrinkage phenomena was investigated and its effects on fresh pastes and hardened specimens' properties described. The obtained results showed that increasing CaO-rich admixtures dosage up to 3.0 wt% has a beneficial impact on AAMs volumetric stability. Notwithstanding, elevated CaO dosages induced detrimental modifications on pastes workability suggesting a dosage threshold of 2.0 wt%.

INTRODUCTION

In cement industry, the swelling potential CaO-based admixtures has been successfully employed to counteract shrinkage effects. Nonetheless, cement and AAM chemistry are entirely distinct and Ca compounds can affect the polymerization process and products formed. Thence, the present work assessed the feasibility of using CaO-based admixtures to mitigate drying shrinkage phenomena on Fe-rich AAM, while simultaneously investigated their impact on fundamental properties of the fresh pastes and hardened specimens.

METHODS AND MATERIALS

A synthetic glass (PS) mainly composed of SiO_2, CaO, FeO and Al_2O_3 was used as main precursor. Silica fume (SF, Elkem, >95%) and a CaO-rich material (EA , CaO >70%) were used admixtures. Three EA dosages (1, 2 and 3 wt% of solid precursors) were added to a reference paste (EA0, Table 1). An activating solution with 0.74 SiO_2/K_2O molar ratio and 80 wt% H_2O was used. Setting time, length and weight variation were determined as prescribed by EN196-3:2016 and EN12617-4:2002, respectively. Volume and bulk density was determined according EN12390-1 and EN12390-7:2007. Flexural and compressive strength was determined according to EN196-1:2016.

RESULTS

Rising EA was shown to increase solidification rate, suggesting that rising Ca availability enhances the reaction kinetics and accelerates the formation of consolidated structures (Fig. 1). Final setting varied between 90 and 79 min, respectively for EA0 and EA3 (-12 %). These impact is even more significant to the initial setting (-26%). EA2 and EA3 presented shortened but comparable setting nearly hindering samples proper cast.

Table 1: Mix proportions of the reference paste, EA0.

	Mix proportions (wt%)		
	PS	SF	Solution
EA0	72.1	4.1	23.8

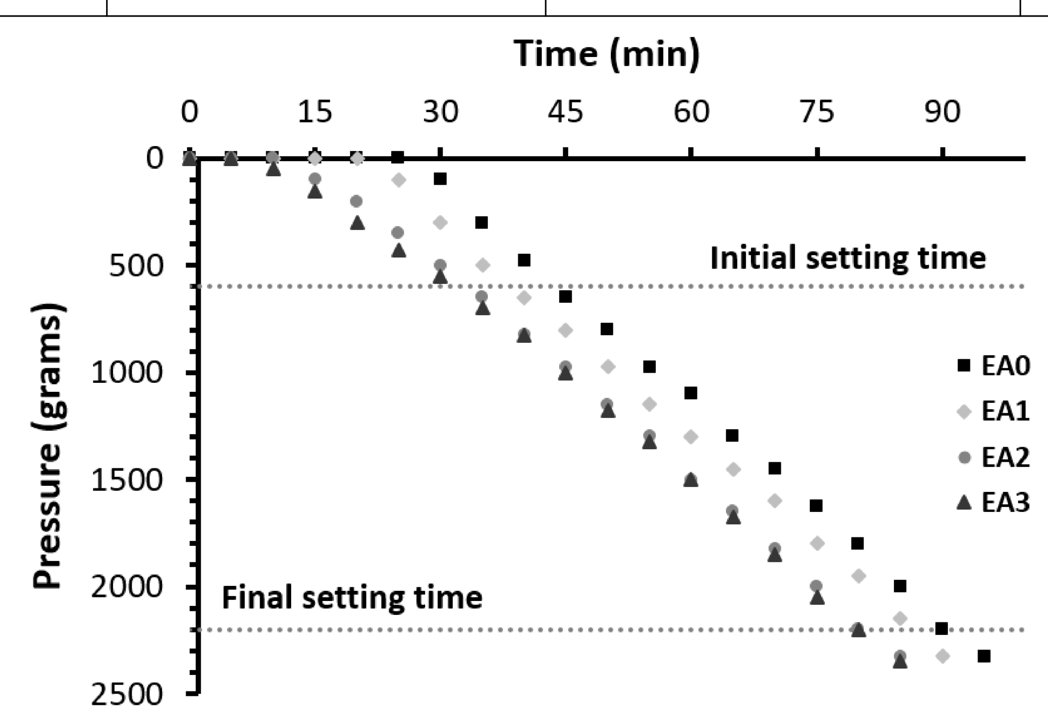
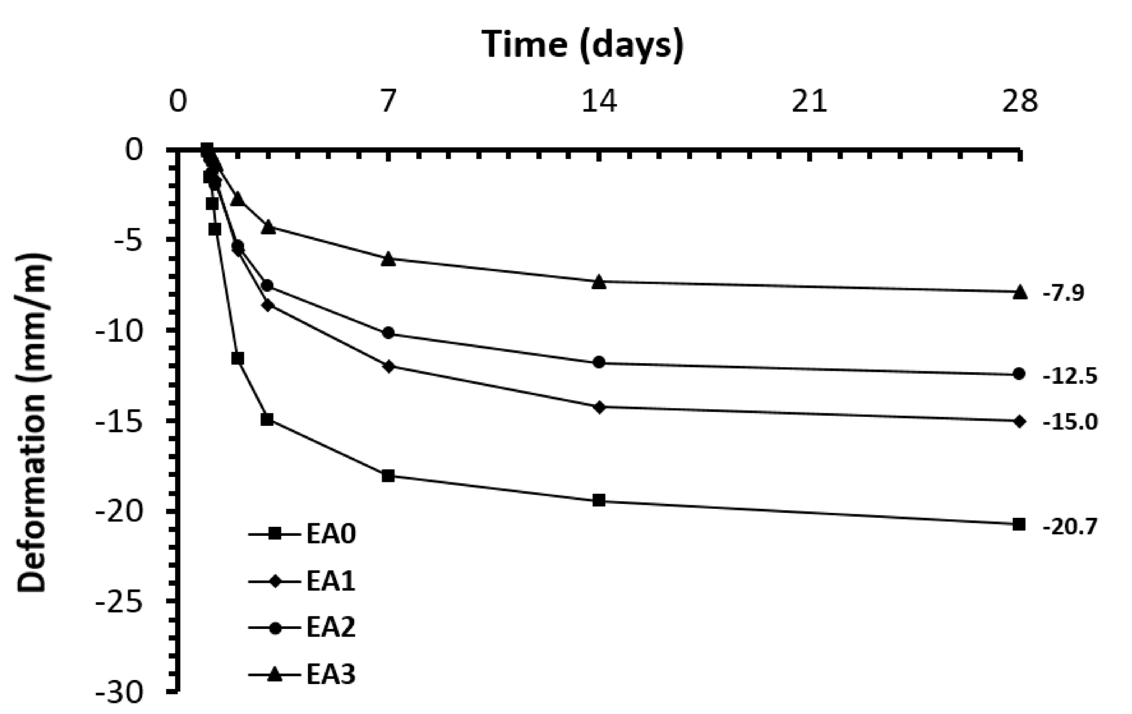


Figure 1: Pastes setting time as function of EA content.



	Mass variation (wt%)
EA0	-3.7±0.4
EA1	-3.5±0.2
EA2	-3. 2±0.1
EA3	-2.7±0.1

Figure 2: Drying shrinkage and mass variation as function of EA content.

All samples loss mass and shrunk continually during the testing period (Fig. 2). Still, the rate in the initial 7 days was considerably more pronounced. EA0 presents the highest linear length reduction, while risen EA content improves volumetric stability (up to 62.1%) and decreases mass loss (up to 25%).

Table 2: AAM mechanical properties after 28 days of curing.

	EA0	EA1	EA2	EA3
Flex. strength (MPa)	7.1±0.7	7.0±0.0	5.1±0.8	4.6±0.5
Comp. Strength (MPa)	100.5±8.5	111.5±0.2	116.0±0.1	96.1±6.6

EA2 achieved the highest compressive strength while EA0 presented the best flexural performance (Table 2). With the exception of EA3, compressive strength increased as the EA content rose, while the flexural strength exhibited the opposite trend. In general, the results indicate that EA addition has a positive impact on compressive strength development while the increase of rigidity of structures lead to the decrease of its flexural strength. Still, all the produced samples presented considerable flexural (> 4 MPa) and compressive strength (> 96 MPa) after 28 days of curing at room temperature.

CONCLUSIONS

- ✓ CaO-rich admixtures can partially mitigate drying shrinkage.
- ✓ Shrinkage reduction was proportional to EA content.
- ✓ High levels considerably hasten pastes' setting times.
- ✓ The produced AAM presented considerable flexural (up to 7 MPa) and compressive strength (up to 116 MPa).
- ✓ A optimal EA dosage between 1.0 and 2.0 wt% was suggest.

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