EAN 2014
52nd conference on experimental stress analysis

Advanced Analysis of Acoustic Emission Signals Generated by Cracks during the Hardening of Alkali-activated Slag

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Keywords: Acoustic emission method, duration of acoustic emission signals, amplitude of acoustic emission signals, alkali-activated slag, loss in weight.

Abstract. This paper reports the analysis of acoustic emission signals captured during hardening and drying of specimens of alkali activated slag mortars. Alkali activated slag is a material having a great potential to be used in practice. The main drawback of this material is a high level of autogenous and especially drying shrinkage, which causes a deterioration of the mechanical properties. The aim of this paper is introduce the effect of method and time curing on the microstructure of alkali activated slag mortars. An understanding of microstructure–performance relationships is the key to true understanding of material behaviours. The results obtained in the laboratory are useful to understand the various stages of micro-cracking activity during the hardening process in quasi-brittle materials such as alkali activated slag mortars and extend them for field applications.

Introduction

Acoustic emission is the term for the noise emitted by material and structures when they are subjected to stress. Types of stresses can be mechanical, thermal or chemical [1]. This emission is caused by the rapid release of energy within a material due to events such as crack formation, and the subsequent extension occurring under an applied stress, generating transient elastic waves which can be detected by piezoelectric sensors [2].

Acoustic emission method can monitor changes in materials behavior over a long time and without moving one of its components. This makes the technique quite unique along with the ability to detect crack propagations occurring not only on the surface but also deep inside the material. The acoustic emission method is considered to be a "passive" non-destructive technique, because usually identifies defects while they develop during the test [3].

Fracture in a material takes place with the release of stored strain energy, which is consumed by nucleating new external surfaces (cracks) and emitting elastic waves, which are defined as acoustic emission waves. The elastic waves propagate inside a material and are detected by an acoustic emission sensor. Except for contact less sensors, acoustic emission sensors are directly attached on the surface [4].

Experimental Setup

The initiation of cracks during hardening was monitored by method of acoustic emission (AE). AE signals were taken by measuring equipment DAKEL XEDO with four channels.

The change of weight during the hardening was measured using equipment QuantumX with Z6 bending beam load cell for maximum weight 50 kilograms by HBM.

The mixture for creating three samples 40×40×160 mm was created from 450 g of fine grained granulated blast furnace slag Štramberk 380 (specific surface area 380 m^2/kg), 180 g of sodium silicate (water glass) with modulus 1.6, silica sand with three different grain size 450 g from each grain size and 95 g of water. The specimens were demolding after 24 hours from the mixing. The specimens marked 0/w were measured immediately after demolding. The specimens marked 2/w were placed to water for 48 hours and then were measured.

Results

During experiment an acoustic emission activity was recorded. The guard sensor eliminated mechanical and electrical noise. Acoustic emission system DAKEL with software XEDO has been applied for continuous monitoring of concrete structure loading. Four AE sensors were placed on specimen surface. To evaluate the origin of micro cracks during stress, we focused on the activity of AE, respectively on the most used parameter which is the number of signals overshooting a preset threshold. The diagrams in Fig. 1 and Fig. 2 show the dependence of cumulative counts and loss in weight versus time. A higher number of micro-cracks in the specimen can be inferred from the higher AE activity.

Fig. 3 shows the variation of AE signal duration for each specimen. It is known that the AE signal duration is the time between AE signal start and AE signal end. It was observed that signal duration is longer when the specimens were in the water for 48 hours.

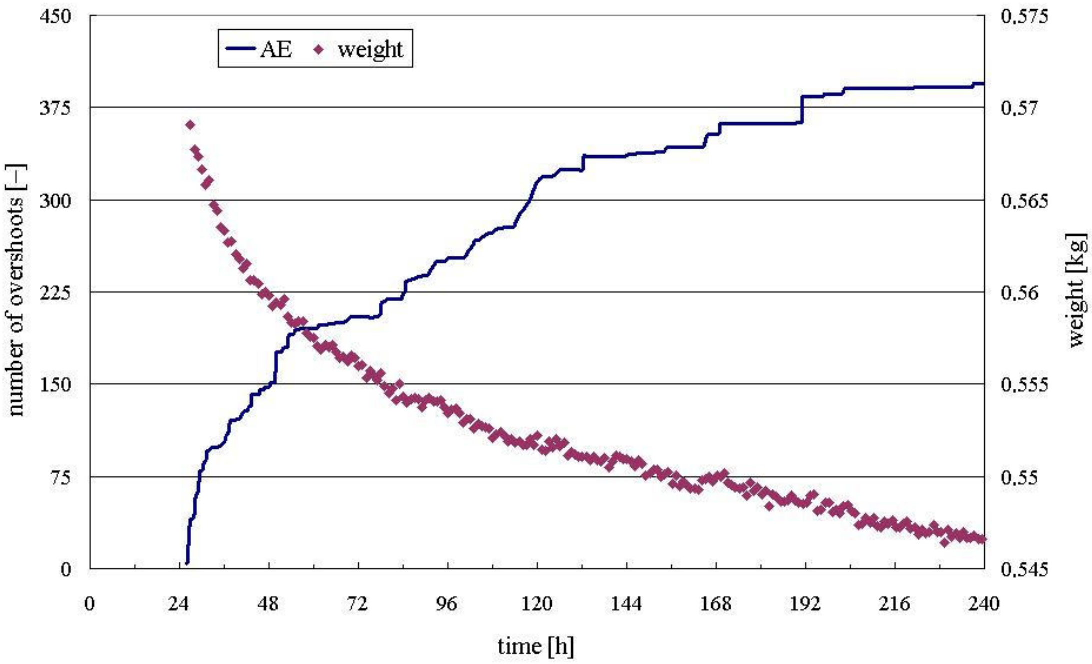

Fig.1. Dependence of cumulative counts and loss in weight versus time for specimen 0/w.

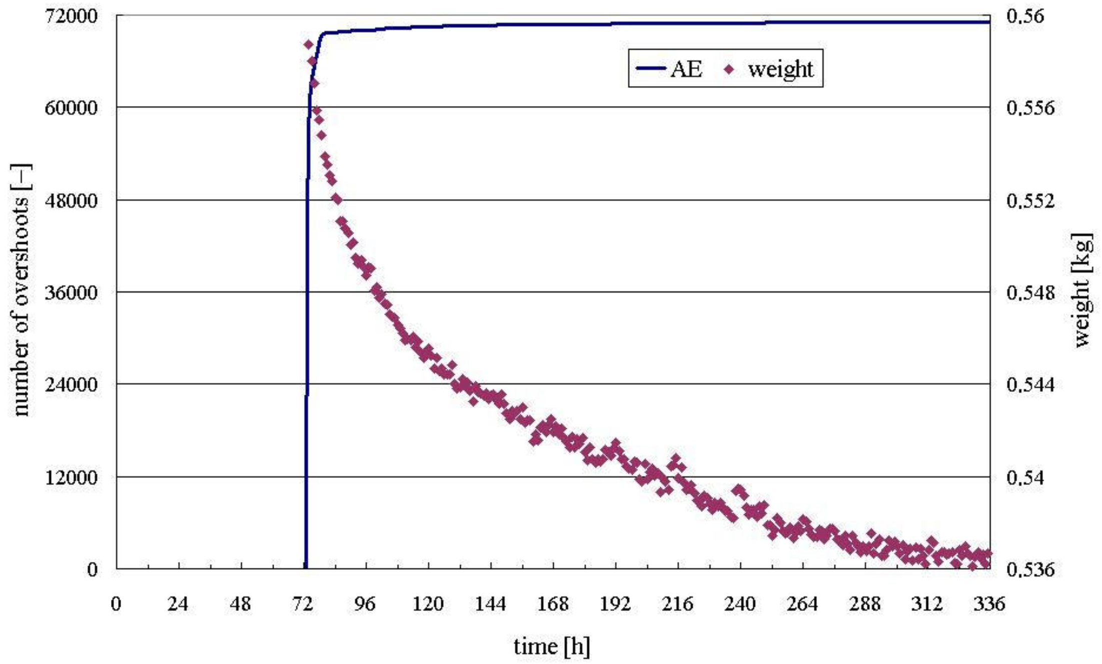

Fig. 2. Dependence of cumulative counts and loss in weight versus time for specimen 2/w.

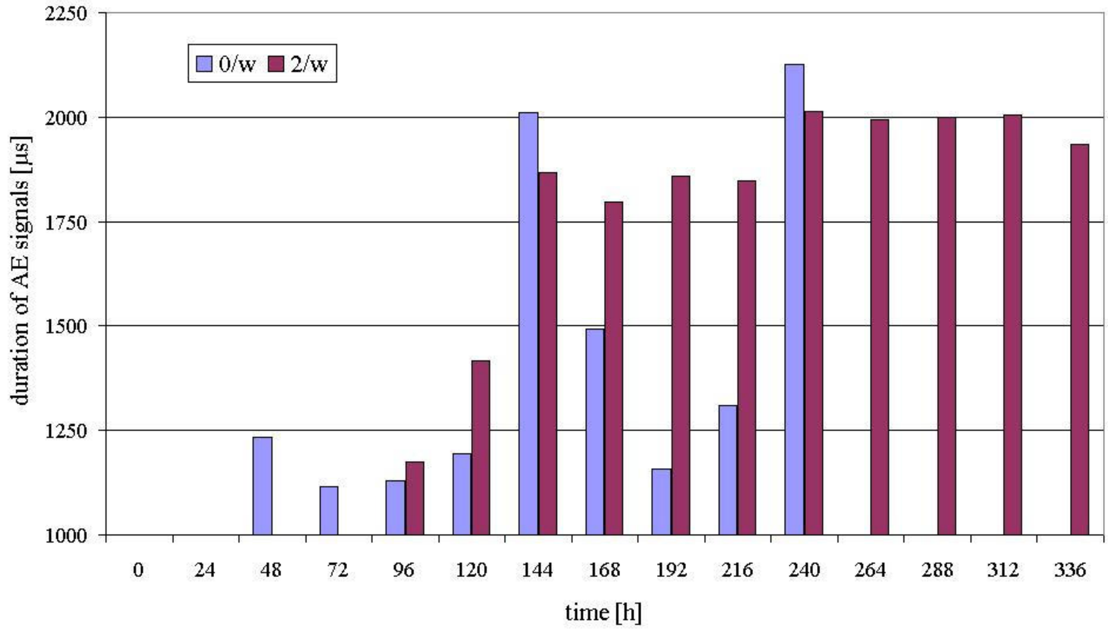

Fig. 3. The comparison of duration of AE signals for both specimens in time intervals after 24 hours.

Fig. 4 shows the resizing of AE signal amplitude for each specimen in time. It is known that the Amplitude is the greatest measured voltage in a waveform and is measured. This is an important parameter in acoustic emission inspection because it determines the detect ability of the signal. Signals with amplitudes below the operator-defined, minimum threshold will not be recorded. It was observed that signal amplitude is high in steady change internal structure.

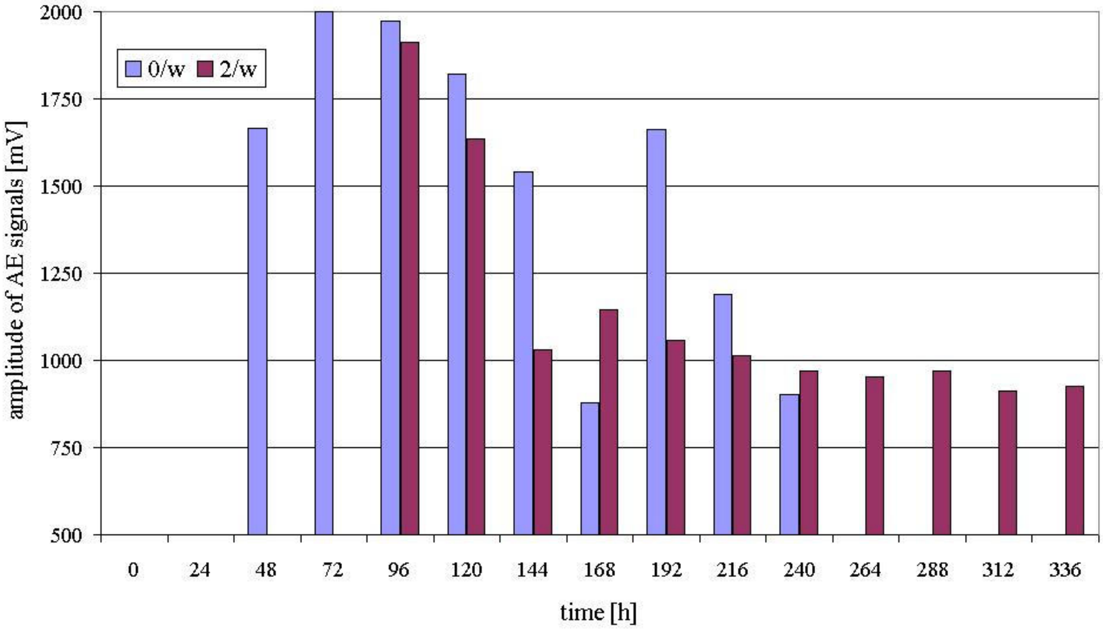

Fig. 4. The comparison of amplitude of AE signals for both specimens in time intervals after 24 hours.

Conclusions

Volume variations of alkali-activated slag (AAS) mortars are connected with autogenous and drying shrinkage. Loss in weight observed during setting and hardening of AAS is a result of drying process. The rate of moisture release is in good accordance with the number of signals detected by AE method. We assume that most of these signals can be attributed to crack formation event; therefore, it can be concluded that the main process resulting in the deterioration of AAS binder is associated with drying shrinkage.

Acknowledgement

This outcome has been achieved with the financial support of specific research program at Brno University of Technology, project No. FAST-S-14-2383.

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