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The effect of one-part activator on drying shrinkage and mechanical properties of lightweight alkali-activated slag concrete

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ABSTRACT: In order to reduce the negative environmental effects of Portland cement production, lightweight alkali-activated slag concrete can be considered as a new building material in the construction industry. According to the studies conducted by the authors, there is no research about drying shrinkage of one-part lightweight alkali-activated slag concrete. In the present study, the effect of slag content, the dosage of one-part alkali-activator and aggregate combination on the compressive strength and drying shrinkage of lightweight one-part alkali-activated slag concrete were considered. Also, two types of curing methods i.e. water curing and plastic cover curing were selected to investigate the effect of curing conditions on drying shrinkage and compressive strength. To make lightweight concrete, lightweight aggregate (Leca) was used in combination with natural aggregates and two aggregate combinations, one containing lightweight fine aggregate and normal weight coarse aggregate and one other containing both lightweight fine and coarse aggregates, were considered for conducting the experimental tests. A Portland cement mix was also used to make a reference mix of concrete. Compressive strength of the samples was measured at the ages of 7, 28 and 90 days and the drying shrinkage up to the age of 180 days. According to the results, slump and setting time decreased with increasing slag and activator content, while compressive strength and drying shrinkage increased. Examination of the curing condition of lightweight one-part alkali-activated slag concrete showed that drying shrinkage increased and compressive strength decreased with plastic cover curing.

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1- Introduction

The superior properties of concrete, including its ease of casting, ease of access and economical materials and its durability in facing aggressive environmental conditions, have made this building material the most commonly used building material in the world [1]. Lightweight aggregates used to produce lightweight concrete are diverse and exist both naturally and artificially. Lightweight alkali-activated concrete can be used as a new solution to simultaneously reduce the weight of structures, the environmental impact of cement in the construction industry and improve the properties of lightweight concrete. Shrinkage is an important and time-dependent phenomenon in lightweight. Internal curing can be used as a solution to reduce concrete cracking due to shrinkage.

Alkali-activated binder has a low environmental impact and better performance such as high mechanical properties [2, 3], high acid resistance [4, 5], fire [6], freeze and thaw [7] and abrasion resistance [8] than ordinary Portland cement. Among high-calcium alkali-activated materials, slag dedicated the largest share of research to itself [9].

In this research, the effect of slag content on the properties of lightweight one-part alkali-activated slag (LAAS) concrete was studied. LAAS mixture was activated with sodium metasilicate with the weight ratio of 18% and 20% of slag. A Portland cement mix was also used to make a reference mix of concrete. Two curing methods, i.e., water curing and plastic cover curing were applied and workability, setting time, compressive strength and drying shrinkage of the specimens were studied and examined. To investigate the effect of lightweight aggregate content on the properties and drying shrinkage of LAAS concrete, the replacement of fine aggregate and coarse aggregate with LECA as lightweight aggregate was studied.

2- Materials

In this study, the ground granulated blast furnace slag of Sepahan cement factory with a density of 2.780 was used. For activation of the slag, a solid powder of sodium metasilicate.5H2O with a chemical formula () of Silica Gostar product with a mass of 950 g / L and a molar ratio of 1 was used. The binder materials of LAAS included slag and dry part of sodium metasilicate and the Portland cement type I from Sepahan cement factory was the binder material in the lightweight Portland cement concrete (OPC).

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Fig. 1. Curing condition, a) plastic cover curing, b) water curing

3- Methodology

To make lightweight concrete and investigate the effect of the lightweight aggregate in volume replacement on the compressive strength and drying shrinkage, four mixes were designed. In this study, the lightweight aggregates were soaked in water for 24 h before mixing and used as the pre-wetted lightweight aggregate. Two aggregate combinations, one containing lightweight fine (LAF) and normal weight coarse (NAC) aggregates and one other containing both lightweight fine and coarse aggregates, were considered for making the lightweight concrete and conducting the experimental tests. The slump test was carried out according to ASTM C143. The initial and final setting time of the alkali-activated slag paste mixes were determined in accordance with ASTM C191 The compressive strength values were measured according to BS 1881 [10]. The compressive strength test was conducted on cube specimens of size 100×100×100 mm3. The dimensions of the prismatic specimen used to measure the drying shrinkage were 75×75×285 mm3. The specimen strain measurements were implemented by using the DEMEC strain gauge having fixed points on the specimen's both sides with the 8 micro strain accuracy.

4- Conclusion

- The lightweight one-part alkali-activated slag mixes showed lower drying shrinkage in comparison to normal-weight alkali-activated slag mix. The pre-wetted lightweight aggregate decreased the drying shrinkage by internal curing action. However, the drying shrinkage of LAAS concrete was much higher than that of the normal-weight ordinary Portland cement concrete.

- The results showed that the 7-day compressive strength of the LAAS concrete was 87% of its 28-day compressive strength. Moreover, the compressive strength of the LAAS concrete specimens increased more rapidly than OPC concrete specimens at an early age. Examination of the drying shrinkage results also showed that the drying shrinkage of the LAAS concrete was about 1.8 times higher than that of the OPC sample.

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