STUDY OF LINEAR DEFORMATION CHANGES IN HEAVY CONCRETE BASED ON MODIFIED PORTLAND CEMENT

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Abstract: *The investigation results revealed how modified standard Portland cement of grade 42.5 (M400) with 10% of the expanding additive changes the linear deformation characteristics of heavy concrete. Heavy concrete of class B 22.5 (M300) with a different water-cement ratio (slump 3 cm and 5 cm) was selected as the object of study, from which cubic specimens of side 10 cm were prepared. The impact of modified cement on concrete linear deformations is determined at the ages of 1, 3 and 28 days under normal setting conditions, and changes in the sizes of the same specimens are checked for three months under air-drying conditions. The study confirmed that the most effective impact of modified cement, as in the case of construction mortars, is also observed in 3-7 days of curing. It was found that the effect of modified cement is increased with the increase in the water-cement ratio, and a relatively low percentage of expansion through the low water-cement ratio is explained by the certain rigidity of the concrete internal structure.*

Keywords: *modified Portland cement, expanding additive, heavy concrete, water-cement ratio, linear deformations.*

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Introduction

Ordinary Portland cement has many favorable properties. In certain cases, depending on the importance of the designed structures, buildings, and operating conditions, their use becomes impractical as shrinkage is observed during curing processes. As a result, it becomes imperative to use new types of binders. In particular, to ensure the structure's joint leakproofness and to decrease the water permeability of the hydraulic structures, it is crucial to use non-shrinkable, expanding concrete. For concrete production, special types of cement have been developed in different countries, which, unlike ordinary Portland cement reinforcement, do not exhibit shrinkage but, in contrast, expand and contribute to the production of non-shrinkable expanding construction mortars and concrete. The paper is about the effect of a special expanding admixture previously developed based on local raw materials, on the linear dimensions of heavy concrete.

Materials and Methods

The object of the study is a heavy concrete class 22.5 (M300) made of different water-cement ratios with a slump of 3cm and 5cm. Specimens were stored under humid conditions for up to 28 days, after which they were stored in air-drying conditions for up to 3 months. The impact of modified cement on the change in linear dimensions of heavy concrete specimens is determined by an indicator with an accuracy of 0.001mm. The study data are presented in Tables 1 and 2.

Table 1. Concrete linear dimension changes with a slump of 3 cm

Linear dimension change,%				
Concrete setting time				
1 day	*3 days*	*7 days*	*28 days*	*3 months*
0.11	0.22	0.35	0.30	0.29
0.11	0.19	0.37	0.32	0.32
0.12	0.20	0.36	0.31	0.31
Average				
0.11	0.20	0.36	0.31	0.31

Table 2. Concrete linear dimension changes with a slump of 5 cm

Linear dimension change,%				
Concrete setting time				
1 day	*3 days*	*7 days*	*28 days*	*3 months*
0.11	0.22	0.40	0.36	0.34
0.10	0.25	0.40	0.32	0.36
0.12	0.22	0.45	0.40	0.36
Average				
0.11	0.22	0.42	0.36	0.35

Main Part

Through examining the work of I.V. Kravchenko, T.V. Kuznetsova, B.E. Yudovich, T.G. Gabadadze, and other scientists, it has been determined that lime and sulfate-containing components are the expanding materials during special-type cement production [1–9]. We have determined that the most practical and affordable method to produce special cement is the synthesis of specific expanding additives and the chemical activation of Portland cement by this additive. This conclusion is based on the authors' studies and considers the possibilities of the raw material base of the Republic of Armenia. We have studied the natural minerals and various industrial wastes of the republic. We concluded that the carbonate-containing additive could be the smoke released from the flue gases removed from the furnaces of the Ararat cement plant. The sulfate-containing component is the gypsum of Tokmahgol or Parakar mines. The raw material calculations confirmed that, it would be better to use the Parakar gypsum as a sulfate-containing component, as the use of the latter increases the content of 3(CA) $CaSO_4$, the main mineral that promotes the expansion of the synthesized additive. For the synthesis of additives based on the abovementioned components, raw materials of different percentages were prepared and kiln roasted at temperatures of 900–1100 °C. Physical-chemical studies of the produced sintered material confirm that the highest quantity of the expanding mixture is observed at a weight ratio of 40:60 cement powder-gypsum, which was introduced in various amounts into the 42.5 grade cement of the Ararat cement plant. The effect of the additives' introduction of different quantities into this composition, which expanded the cement-construction mortar, has been tested. It has been shown that a higher expansion is observed with the addition of 10% additive [10,11].

Based on the aforementioned characteristics, it was investigated how modified cement in the same quantity affected changes in the linear deformations of heavy concrete.

Discussion of Results

The data study in the tables reveals that the higher water-to-cement ratio in the concrete mix enables the concrete to expand proportionally more than it would with a lower water-to-cement ratio. This phenomenon can be explained that concrete has a more rigid internal structure under a low water-to-cement ratio.

Conclusion

Analyzing the data of heavy concrete sample linear change under different ages, which are modified with the developed additives, the expansion phenomenon depends not only on the additive quantities but also on the water-cement ratio of the concrete mix. Concrete expansion has been shown most effective when using modified cement between the ages of 3 and 7 days after setting. Besides, increasing the value of the water-cement ratio of the concrete mix contributes to a relative increase in the percentage of concrete expansion. We have established that during the later set-up period, i.e., up to 3 months in ventilated conditions, the specimens practically do not change their linear dimensions.

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