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Comparison of Two Methods for Determination of Volume Changes of Cement Based Composites

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Abstract: Paper deals with the comparison of two different methods which are commonly used for determination of volume changes of cement based composites. Performed experimental work was focused on the study of high-performance concrete (HPC) applicable in rehabilitation and renovation of current concrete structures where volume changes of relatively thin layer of reparation material is a crucial parameter to ensure its functionallity. Non-contact laser methodology of measurement was compared with traditional contact testing realized in the steel drain as well as accompanying mechanical testing.

Keywords: Volume Changes; Cement Based Composites; Drain; Shrinkage; High-Performance Concrete.

1 Introduction

Investigation of volume changes of cement based composites, especially of high-performance concrete (HPC), has become into the focus of number research works [1–3]. It is caused by the massive application of efficient admixtures and mineral additives to reach required mechanical and durability properties. Volume changes of concrete are the natural part of concrete technology because of surplus of mixing water and hydration processes of Portland cement. Crack formation and overall decreasing of durability properties rank to the essential negative impacts of studied problem [4].

Present paper deals with the experimental study focused on the methodology of testing volume changes of HPC. Extensive part of general volume changes of HPC is caused by the autogenous shrinkage thanks to the very low water/cement ratio. Autogenous shrinkage of hydrating cement means changes in the close system which are drawn by the processes of hydration of Portland cement and formation of new minerals of decreased molar volume. Commonly used composition of HPC with high amount of reactive additives like silica fume, fly ash, blast furnace slag, etc. [5,6] is conducive to highlight the total exhibition of this type of volume changes what led to the intensive research of autogenous shrinkage of HPC.

2 Experimental

Studied HPC was developed in the laboratories of Experimental Centre and was prepared as precast dry mixture in Stachema company, Fig. 1. Used mixture was developed as material for applicable for rehabilitation of concrete structures. High mechanical and durability properties are required for present type of materials [7,8]. Besides fine silica aggregates was used Portland cement, relatively high dose of silica fume and efficient plasticizer on the base of polycarboxylates. Such formulated mixture ensure suitable primarily resistance to environmental attack [1,9].

Repair mixture are applied on the relative old concrete structure with finished hydration processes [10] that is why are volume changes crucial problem. Extensive shrinkage could causes reduced cohesiveness and generally decreased effectivity of realized rehabilitation.

Fig. 1: Documentation of industrial production of studied mixture.

Two different methods were used for determination of volume changes of high-performance concrete mixture. The first methodology is organized as a non-contact measurement by using laser sensor which allows data recording including the initial phases of hydration. Tested sample is inserted into the waved molding of vertical orientation. Upper surface is equipped by the reflex plate which is necessary to signal transfer. Instrumentation of introduced method is than put into the climatic chamber of constant condition – 80 % RH and 20 °C.

Second applied method was performed as a traditional field measurement in the drain where the longitudinal changes of prismatic specimen are recorded by the couple of sensors placed on the forefronts of the sample. Essential problem of this commonly used method is horizontal pressure of the fresh mixture on the movable part of instrumentation. It means essential delay of measurement in the laboratory praxis.

Bulk density of studied composites was investigated on the base of the actual weight and accurate dimensions of specimens. All tests of mechanical properties were carried out according to the standard CSN EN 196-1 [11] on prismatic specimens 40 × 40 × 160 mm^3. Flexural strength f$_{tm}$ measurement was organized as a three point test with supports distance of 100 mm and was calculated by help of the maximum reached force. For this testing was used universal loading machine MTS 100 allowing to control experiment by the deformation speed which was set up to 0.2 mm/min. The compressive strength (f$_{cm}$) test was performed on two fragments left after flexural test. The area under compressive load (40 × 40 mm^2) has been demarcated by the loading device.

3 Results and Discussion

Graphical comparison of used methods for shrinkage determination is shown in Fig. 2 where is well documented the course of measurement. Both methods were suitable sensitive to record the volume grow due to culmination of hydration heat. General shapes of records of both performed methods are very similar but they are vertically moved. Fundamental difference is given by postpone of the contact method where the initial transformation cannot be recorded. However, extensive setting in the vertical mold of studied mixture was automatically included into the total shrinkage. That is why it is very important always to introduce applied methodology of testing. Determination of volume changes is often for the praxis only marginal issue, but further production of HPC mixtures will lead to establish basic criteria for volume changes limiting due to their long-term durability impact.

Detailed results of mechanical and basic physical properties determination are introduced in the Tab. 1, graphical illustration of the evolution of flexural and compressive strength is then shown on Fig. 3. It is obvious that coarse of shrinkage well corresponds with the evolution of mechanical properties especially compressive strength.

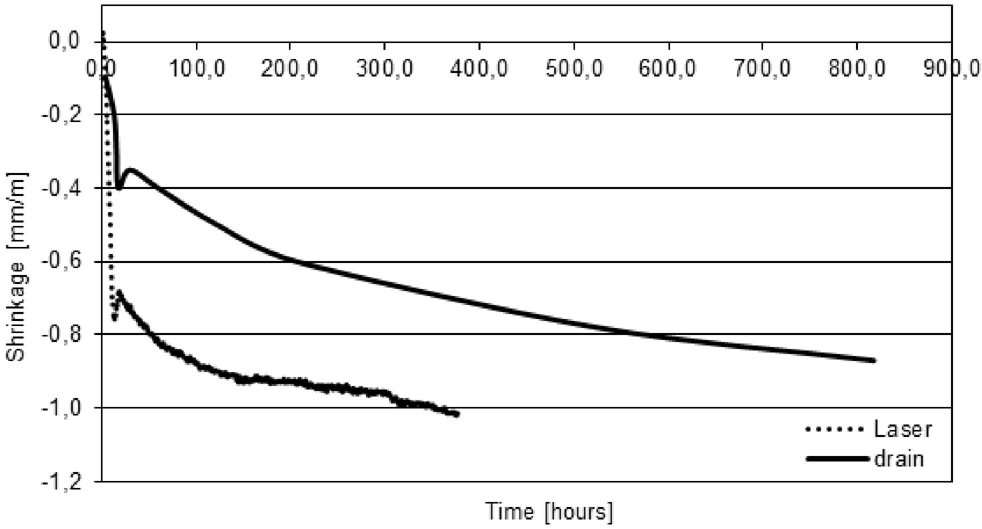

Fig. 2: Comparison of results of both studied methods.

Tab. 1: Basic physical and mechanical properties of studied mixture.

Time [days]	Bulk density [kg/m^3]	f$_{tm}$ [MPa]	f$_{cm}$ [MPa]
1	2340	11	67
3	2340	15	83
7	2400	16	98
28	2400	19	110

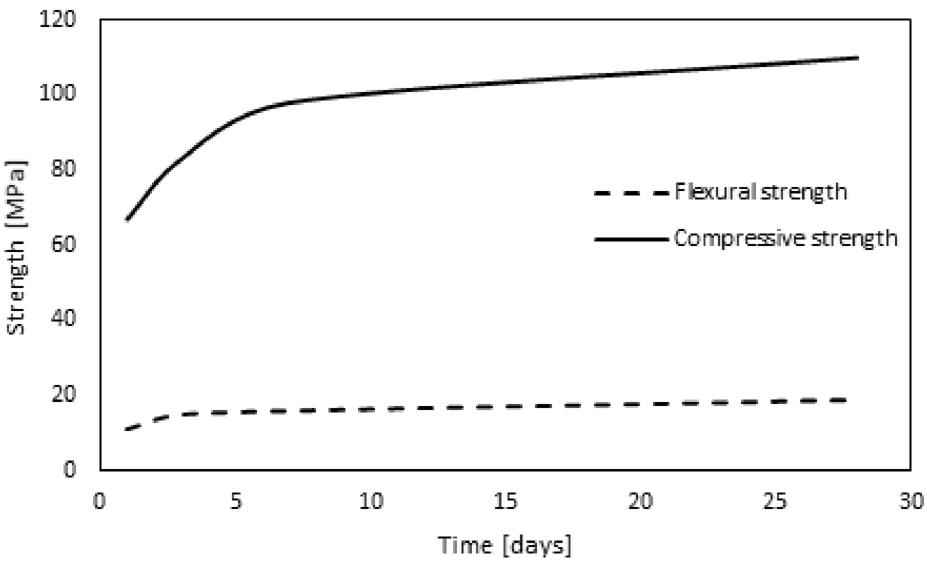

Fig. 3: Evolution of mechanical properties.

4 Conclusion

In performed experimental program were compared two different ways of shrinkage measurement of HPC developed for quick repair of damaged concrete structures. The motivation was to verify commonly used methods for this measurement and to specify interpretation of obtained results. Testing was realized on the semi-commercial HPC developed as a material for rehabilitation. It can be concluded that for accurate determination of total volume changes is necessary to start the measurement procedure immediately as it is possible. Misrepresentation due to initial decay could be up to 35 % what is well documented on the obtained results.

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