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Comparison of Measurements Methods Intended to Determination of the Shrinkage Development in Polymer Cement Mortars

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Abstract

The paper deals with the experimental determination of the shrinkage progress of the polymer cement (PCC) mortars. The main motivation of performed measurements was to compare the results obtained from two different measurement procedures based on the measurement of the relative length changes and relative mass losses of the test specimens during whole time of ageing. Performed experimental analysis, focused on the determination of the progress of the relative length changes and relative mass losses, showed advantages and disadvantages of investigated measurement procedures. All performed measurements exhibited almost the same total progress of relative mass losses regardless of the used test procedure and size of specimens. The differences in the relative length changes originated from the capabilities, limitations and regulations of particular measurement procedures.

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1. Introduction

Experimental determination of the volume changes of composite materials of different compositions still remains in the focus of researchers, civil engineers as well as concrete producers. Advancement in technology and

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composition of building materials in turn requires advancement in test procedures used for the determination of physical and mechanical parameters of new materials, see e.g. [1,2].

The current approach in the field of material testing is aimed at identifying disruptions in the internal structure of structural elements as early as possible. This facilitates early diagnostics of the problem which allows relevant precautions preventing later decrease in durability of the building structure to be designed. Experience gained from measurements performed in recent years suggests the necessity of assessing the magnitude of shrinkage in two consecutive stages of composite material ageing – in the early stage of setting and hardening and during the long-term of composite materials ageing [3,4,5,6]. The early age measurements are able to identify the volume or length changes as well as initial micro-cracking due to initial solidification, moisture migration and micro-structure formation. The magnitude of these initial deformations, in some cases, can be very significant and can essentially affect the total progress and final value of material shrinkage [7]. Scientific sources provide a number of approaches to determine the value of concrete and mortars shrinkage [8,9,10]. However, these are mostly methods for separate determination of individual components of shrinkage in the early age – such as methods for determining plastic or autogenous shrinkage described e.g. in [4,9,11,12,13,14,15,16] and methods for determining the shrinkage due to drying defined mainly in the national standards of various countries. Contemporary approaches to concrete and mortars shrinkage measurement are based mainly on the determination of relative length changes. In most cases, measurement begins after removing specimens from their moulds, which is typically no sooner than after 24 hours of ageing. In important or complicated load-bearing structures, such as bridges, ceilings, or structures with complex form, shrinkage is measured directly on a structural element using a special type of wire strain gauge designed to be embedded in the concrete. Such gauges are typically tied to the reinforcement cage of the measured element by means of rebar extensions [17,18,19,20,21].

Guidelines reflecting the recent advances in theoretical and experimental research in the field of the creep and shrinkage of cement composites (especially concrete) have been published under RILEM TC-242-MDC (chair Zdeněk P. Bažant) [22].

In recent years, the method of acoustic emission (AE) has also been widely used as a supplemental measurement method for the non-destructive monitoring of the changes in the specimen’s internal structure during static and dynamic loading tests as well as for the monitoring of the behaviour of composite materials during setting and hardening [7,23,24]. The AE method is considered to be a "passive" non-destructive technique because it usually identifies defects as they develop during the test [25] and allows for monitoring of changes in the behaviour of materials over a long period of time and without moving any of its components. This, together with its ability to detect crack propagation occurring not only on the surface but also deep inside the material, makes the technique quite unique.

2. Experimental part

The experimental part was focused on determination of the shrinkage progress of the polymer cement (PCC) mortars. The main motivation of performed measurements was to compare the results obtained from two different measurement procedures based on the measurement of the length changes and mass losses of the test specimens during whole time of PCC mortars ageing.

The first measurement method used for the experiment is procedure described in the ČSN EN 12617-4 [26]. For the purpose of estimation of the influence of different curing conditions on the shrinkage progress, two sets of prismatic test specimens with dimensions of 40 × 40 × 160 mm were manufactured. The first set (Set 1) of specimens was cured according to the standard requirements [26] – after the fresh PCC mortar was placed into the mould, the top surface of the test specimens was protected from drying with PE foil for 24 hours. Than the specimens were demoulded and again coated with PE foil for another 48 hours. After this curing procedure was completed, the coating foil was removed and the test specimens were further exposed to the free drying for the entire time of the measurement. The relative length and mass losses measurement started 24 hours after specimens’ manufacturing. The second set (Set 2) was left in a mould for approx. 70 hours and the top surface was not protected from drying. After demoulding the specimens were left to dry freely during the entire time of their ageing. The relative length and mass losses measurement for Set 2 started approx. 70 hours after specimens’ manufacturing. In

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