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Variability of sorptivity in the concrete element according to the method of compacting

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Abstract

Sorptivity is one of the parameters which describe the durability performance of concrete. Its value depends not only on the composition of concrete mixture (including among others w/c ratio) but also on the curing procedure. The presented study attempts to determine the impact of the compacting procedure on the value of concrete sorptivity and its distribution along the height of the element.

Sorptivity tests of two concretes were made. Each concrete was manufactured in two coarse aggregate variants: with natural aggregate and with mixture of natural and recycled concrete aggregate (RCA). Tests were performed on the specimens obtained by slicing cores drilled from 260 mm high concrete blocks. Concrete in the blocks was compacted by three methods and the sorptivity was measured at different distances from the block upper surface. The results of the tests were compared with the results obtained on the 150 mm cube specimens cured in different conditions.

The results showed a clear (approximately linear) decrease of sorptivity values with distance from the upper surface of the element. The influence of the compaction method on the values of sorptivity and it distribution along the height of concrete element is also clearly visible.

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Keywords: Concrete, sorptivity, durability.

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1. Introduction

Sorptivity of concrete is one of its main properties associated with durability of reinforced concrete structures [1, 2, 3]. Sorptivity is a measure of the capacity of concrete to absorb water under capillary forces. It is being tested by many methods and often considered as a constant value for a given concrete, thus its material feature. Measurements of sorptivity S are carried out by mass method or volumetric method in which concrete specimens are dried to the constant mass [4, 5]. In order to determine concrete sorptivity S by the mass method, the mass M(t) of water which penetrated into specimen under the capillary forces through the surface area F at time t, should be measured. Water penetrates through one of specimen's whole surface plane (e.g. bottom surface of cubic specimen) and the movement of penetration is unidirectional. The relation is approximately linear:

$$M(t) = F \cdot S \cdot t^{0.5}. \quad (1)$$

Volumetric method is based on measuring the volume of water which penetrates the concrete at given time under the capillary forces through the surface equal to cross-section of glass cylinders with scaled pipettes through which water flows. In the initial stage of measurement, the water movement in concrete is similar to unidirectional flow and later turns into multidirectional flow. Relation between the volume of water which penetrates concrete and sorptivity is non-linear. Some researchers points out that concrete sorptivity in the structure is different than the one tested with specimens being cured in a laboratory in the water or in other conditions [6, 7, 8]. Concrete evaluation method developed by M. Alexander on the basis of its sorptivity among others distinguishes the following values:

- potentially possible to reach by material (in conditions of perfect performance and curing),
- possible to reach in actual conditions for performance and curing,
- sorptivity of concrete in the structure.

Measurement of concrete sorptivity in the structure can be conducted with the volumetric method by its natural relative humidity. However, bringing the result of measurement to concrete sorptivity in dry state, which is recognized as a material feature, encounters difficulties due to problems with determining concrete's humidity and water absorption in the structure [9, 8]. The easiest way to solve the problem is to drill core specimens of concrete in the structure and to examine their sorptivity after drying with mass method [8]. However, it requires core specimens drilled out of the element thus it is a destructive test which is not always possible to execute. Sorptivity is also used to determine the effectiveness of the concrete curing [10, 11, 12] and the impact of the concrete curing method is being described in the articles [13, 14]. It is known that the concrete consolidation method, especially when improperly performed which cause overvibration, results in differences in material's structure in the top and bottom part of the element. As a result of over-vibration, the aggregate moves downward, and the water and air move upward, causing porosity increment of the element's upper part. In the tests which were described in the article, an attempt has been made to assess the impact of concrete consolidation method on the sorptivity, measured by mass method, at different distances from the upper surface of the element.

2. Materials and Research

2.1. Materials

The materials used in the research consist of Portland siliceous fly ash cement CEM II/B-V 32.5 produced by Cementownia Ożarów, natural aggregate composed of fractions 0-2 mm and 0-16 mm, RCA 0-16 mm derived from crushed laboratory specimens in age of at least 180 days remaining after test for compressive strength and tensile strength by splitting. The strength of crushed concrete ranged from 35 to 50 MPa. Four concrete series had been tested. Their composition is given in Table 1. In the R1 and R2 series, 50% by volume of coarse aggregate have been replaced by RCA aggregate. Sand point for N1 and R1 series was equal to 40%, whereas N2 and R2 series had sand point equal to 50%. The water/cement ratio was equal 0.5 for N1 and R1 series and 0.75 for N2 and R2 series. The plasticizer FK 88 produced by MC-Bauchemie was used in N1 and R1 series. Tap water was applied. Concrete was made in a laboratory mixer with working capacity of 150 dm^3. Concrete elements in the form of blocks with