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Mini Review

Technological Monitoring for Hardening and Strengthening of Cement-concrete Compositions

Stackelberg DI*, Vilge BI and Boiko SV

Concretec Ltd, Israel

***Corresponding author:** Stackelberg DI, Concretec Ltd, Israel

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Introduction

The properties of Cement-Concrete Compositions (CCC) are in constant change during a hardening process. At initial stages of hardening, the CCC structure is characterized by viscous-plastic properties, while in final hardened structure, an artificial stone, elastic properties dominate. Technological parameters determined by those properties (W/C-ratio, slump, setting times, strength, etc.) mostly are incompatible with each other. This significantly complicates practical implementation of technological monitoring of CCC hardening and strengthening.

In the recent decades, the electrical resistivity method has been successfully employed for solving these problems. The method's use was started with a pioneering work by Schimizu [1] who studied the Portland cement setting by measuring its electrical conductivity. This method is used in modern concrete science for the determination of the W/C-ratio [2] and the water content in concrete [3], research of early stages of cement pastes and mortars' hardening [4-7], determination of the setting time of cement pastes and concretes [8-12], research and evaluation of various structural properties of concretes, including their permeability characteristics [13-17], studies of the strengthening patterns [18-21]. Various measuring sensors were used in these studies, from the Tester type double electrode sensors [7,11] to complex contactless [4,20] and multi-electrode systems [22].

The absolute majority of the cited works refer to laboratory tests. Any successful use of the electrical resistivity method at construction sites [22], precast plants etc. is rather an exception. For the purpose of an efficient study of the CCC properties and in-situ technological monitoring of their various properties, the Israeli company Concrete Ltd. has developed uniform principles of monitoring the hardening and strengthening of cement-concrete compositions, as well as a measurement system for the implementation of such principles [23-25]. The physical base of the method is a continuous evaluation of the porous solution's state in a hardening CCC in accordance with the results of direct measurements of specific electrical resistivity.

The Concrete Ltd. technology features the following distinct possibilities:

A. Versatility of the developed software (the set of registration, processing and interpretation programs) and hardware (measurement equipment, the main elements of which are 8-channel Data Logger and container type measuring sensor), i.e. the possibility of their practical application in either laboratories [26] or at building sites and plants of construction materials and elements [28,29] without readjustment and resetting.

B. Technological monitoring of concrete properties at all stages of construction: starting from a mixture preparation until reaching the concrete final strength; among others the determination of optimal time the for formwork removing [27], transferring of prestressed reinforcement' efforts to concrete, etc.

C. Implementations of laboratory studies and technological monitoring of hardening and strengthening for the entire range of CCC: cement pastes and cement-sand solutions [27], concrete of various types: ordinary OPC concrete [26], shotcrete [27], aerated concrete [28].

The Concrete Ltd. technology has been successfully applied in a number of projects:

a. Construction of the Tel Aviv - Jerusalem railway tunnel-for monitoring the early hardening of shotcrete in arch elements.

b. Plant manufacture of massive concrete elements of a breakwater-for the hardening monitoring.

c. "Považská cementáreň" cement plant (Slovakia)-for monitoring the characteristics' stability of the Portland cement clinker.

d. El Gad (Russia) construction materials plant-for monitoring the rising and pre-autoclave strengthening of aerated concrete.

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