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Electrical conductivity method to assess static stability of self-consolidating concrete

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ABSTRACT

The objective of this study is to evaluate the applicability of the electrical conductivity method to assess the stability of self-consolidating concrete (SCC) at early age. The method consists in inserting four electrode pairs at different depths of concrete to monitor local change in ionic concentrations with time. Such variations can reflect migration of bleed water along concrete column during the plastic stage. The experimental set-up consisted of a rectangular column measuring 1005 mm in height and 250 × 250 mm in cross section. The variations in ionic concentrations were exploited to derive stability indices with regards to bleeding and homogeneity of concrete. Derived stability indices included bleeding coefficient, segregation coefficient, and homogeneity index.

Various SCC mixtures made with a fixed water-to-cementitious materials ratio (w/cm) of 0.42, different aggregate gradations, and slump-flow values of 650 ± 10 and 700 ± 10 mm were evaluated. Analysis of changes in ionic concentrations along column samples with time provided adequate evaluation of stability of SCC. For example, the increase in the concentration of viscosity-modifying admixture from 1% to 2% was shown to decrease the homogeneity index from 0.36 to 0.27, reflecting better stability. Validation procedure was carried out by correlating stability indices derived from electrical conductivity measurements to physical variations of coarse aggregate concentrations determined on plastic concrete sampled from the tested column elements at the end of electrical conductivity monitoring period. Good correlations between stability indices and aggregate concentrations are established.

1. Introduction

Because of its fluid nature and low yield stress, self-consolidating concrete (SCC) is more susceptible to segregation than conventional concrete. Static segregation is the process in which coarse aggregate separates from the paste and settles down when the concrete is in plastic after casting. The segregation of coarse aggregate can lead to heterogeneous properties of the hardened concrete with direct impact on mechanical, transport properties, and durability. Control of segregation is therefore critical for the material to achieve adequate mechanical properties and structural performance. Stability of fresh concrete is largely dependent on the mixture composition and kinetic of cement hydration at early age. The latter is greatly influenced by the presence of high-range water-reducer (HRWR), viscosity-modifying admixture (VMA), and supplementary cementitious materials (SCMs) [1–6].

Static segregation cannot be easily detected on exposed surfaces of concrete structures unless the mixture exhibits excessive bleeding. On the other hand, in the case of high cohesive concrete mixtures, such as those containing silica fume or VMA, even in the absence of external bleed water, static segregation can still take place [5,7]. This is due to the difficulty of bleed water to travel along bleeding channels in viscous systems. Proper evaluation of the evolution of solution migration at early age can therefore help in developing good understanding of the segregation process in SCC. For example, the evaluation of the migration of internal free water into the system can provide useful information on its heterogeneity. However, there is a lack of tools that can enable the generation of real-time data on the kinetics of bleeding, which is essential to develop fundamental understanding of stability of SCC [6,7].

With the growing use of SCC as a standard material for repair and construction, it is important to adopt accurate and reliable test methods to assess static segregation. Limited number of standard test methods exists to evaluate the stability of SCC. Bleeding is usually measured by collecting excess solution at the upper surface of the concrete as a function of time after placement [8–10]. The observation of the coarse aggregate distribution in a cored sample offers a direct means of determining segregation in the hardened concrete [5]. Segregation and bleeding can also be evaluated by determining the surface settlement (or subsidence) per unit height of concrete [1,2,5,7]. The susceptibility of fresh concrete to segregate can be assessed by observing the material scattering following a given drop over a cone at a certain height, or following some jolting of a given column of concrete [11]. Image analysis along a saw-cut concrete sample is also employed to assess stability [12]. Visual stability rating can be employed to evaluate the stability of SCC. In this method, the SCC cylinder is cut lengthwise, and the cut surface is then used to observe the distribution of coarse aggregates. A Hardened

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