An Integrated System to Predict Early-Age Properties and Durability Performance of Concrete Structures

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ABSTRACT

In this paper, an integrated system is proposed which can evaluate both the early-age properties and durability performance of concrete structures. This integrated system starts with a hydration model which considers both Portland cement hydration and chemical reactions of supplementary cementing materials (SCM). Based on the degree of hydration of cement and mineral admixtures, the amount of reaction products, the early age heat evolution, chemically bound water, porosity, the early age short-term mechanical behaviors, shrinkage and early-age creep are evaluated as a function of curing age and curing conditions. Furthermore, the durability aspect, such as carbonation of blended concrete and chloride attack, are evaluated considering both the material properties and surrounding environments. The prediction results are verified through experimental results.

1. Introduction

In the construction sites, it is important to evaluate the evolution of concrete properties at different ages, such as the temperature history and temperature distribution in mass concrete, the development of compressive strength on various temperature histories, the development of thermal stress, the autogeneous shrinkage and drying shrinkage, the early-age creep behavior, the early age crack, and so on. To build a durable concrete structure, the interaction between concrete and surrounding environment should be considered. The durability relates with both the physical and chemical characteristics of concrete and the surrounding environment conditions. The water permeability, carbonation, chloride ions attack, and other physical and chemical activity have significant influence on the performance of concrete structures. So it is important to evaluate both early-age properties and durability of concrete structures.

In this paper, based on the degree of hydration of cement and mineral admixtures, the chemically bound water and porosity, the hydration heat evolution, the autogeneous shrinkage and

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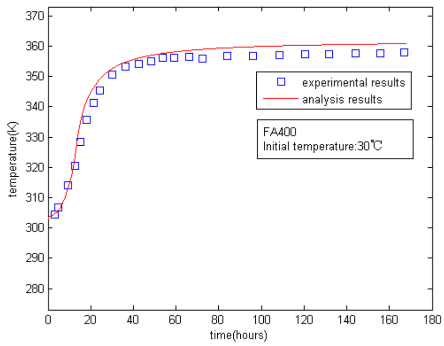
drying shrinkage, the development of compressive strength and elastic modulus, the temperature distribution under a semi-adiabatic condition, and early-age viscoelasticity behavior (basic creep), are predicted. Furthermore, as the durability relates closely with microstructure of concrete and the composition of reaction products, the carbonation of blended concrete and the chloride attack into concrete are evaluated through the hydration model.

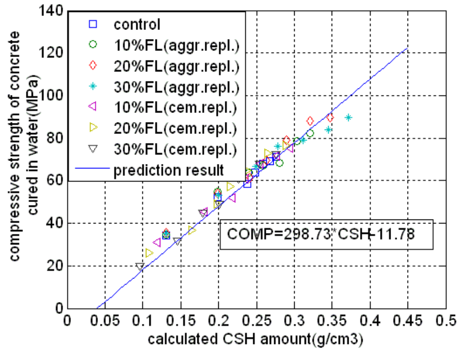
2. Hydration models

In simulation it is assumed that pozzolanic reaction in cement-FL blends includes dormant period, reaction process and diffusion process, which is shown as following equation (1) :

$$\frac{d\alpha_{reacted}}{dt}=\frac{m_{CH}}{P}\frac{3}{v_{FL}r_{FL0}\rho_{FL}}*\frac{1}{(\frac{1}{k_{dFL}}-\frac{r_{FL0}}{D_{eFL}})+\frac{r_{FL0}}{D_{eFL}}(1-\alpha_{reacted})^{\frac{-1}{3}}+\frac{1}{k_{rFL}}(1-\alpha_{reacted})^{\frac{-2}{3}}}$$



(fig. 1) adiabatic temperature rising-fly ash concrete



(fig.2) compressive strength development-fly ash concrete

3. Conclusions

By considering the producing of calcium hydroxide from cement hydration and the consumption of it from the reaction of mineral admixtures, the proposed model seperates the reaction of mineral admixtures from the cement hydration. the development of properties of blended concrete can be evaluated through contributions from reaction of admixtures and cement hydration, respectively.

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