

THE EVALUATION OF MECHANICAL AND THERMAL PROPERTIES OF BLENDED CEMENT CONCRETE

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Introduction

Both granulated slag and fly ash are general industrial by-products that have long been used as mineral admixtures to improve durability and produce high strength and high performance concrete. In addition, economic and ecological benefits, such as energy-savings and resource-conservation, can be achieved using blended cement [1,2].

In this paper, a numerical model is proposed to simulate the hydration of concrete containing fly ash and slag. By considering the production of calcium hydroxide in cement hydration and its consumption during the reactions of the mineral admixtures, the reaction of fly ash and slag is separated from that of cement hydration. The developments of properties of concrete incorporating fly ash or slag are determined by the contribution of both cement hydration and the reaction of the mineral admixtures.

Hydration Model

The hydration equation of Portland cement is described in Equation (1), which described the hydration of a single cement particle. The model consists of a single equation composed of four rate determining coefficients, which consider the rates of formation and destruction of an initial impermeable layer, the activated

chemical reaction process and the following diffusion-controlled process.

$$\frac{d\alpha^j}{dt} = \frac{3C_{w\infty}}{(v + w_{ag})r_0^j\rho} \frac{1}{\left(\frac{1}{k_d} - \frac{r_0^j}{D_e}\right) + \frac{r_0^j}{D_e}(1-\alpha^j)^{-\frac{1}{3}} + \frac{1}{k_r}(1-\alpha^j)^{-\frac{2}{3}}} \quad (1)$$

In the equation above, α^j denotes the degree of hydration of cement particles; j refers to an individual cement particle; v is the stoichiometric ratio of the masses of water to cement; w_{ag} is the physically bound water; ρ is the density of cement; r_0^j is the radius of anhydrate cement particles; D_e is the effective diffusion coefficient of water in the hydration product; $C_{w\infty}$ is the concentration of water at the outer region of the gel; k_r is the coefficient of the reaction rate of cement; and k_d is the reaction coefficient in a dormant period.

In the simulation, it is assumed that the reaction of mineral admixtures is divided into three processes: an initial dormant period, a phase-boundary reaction and diffusion processes. The hydration equations for fly ash or slag can be written as follows:

$$\frac{d\alpha_{FS}}{dt} = \frac{m_{CH}(t)}{P} \left[\frac{w_{cap}}{w_0} \right]_{SL}$$

$$\frac{1}{3} \frac{1}{1} = \frac{v_{FS} r_{FS0} \rho_{FS}}{k_{dFS} \left(\frac{1}{D_{eFS}} - \frac{r_{FS0}}{D_{eFS}} \right) + \frac{r_{FS0}}{D_{eFS}} (1 - \alpha_{FS})^{-1} + \frac{1}{k_{rFS}} (1 - \alpha_{FS})^{-2}}$$

The meaning of parameters is available in our former work [3].

Results

By using the proposed model, we evaluate the adiabatic temperature rising and the development of compressive strength of fly ash blended concrete. As shown in Fig.1 and Fig.2, the simulation results generally agree with experimental results.

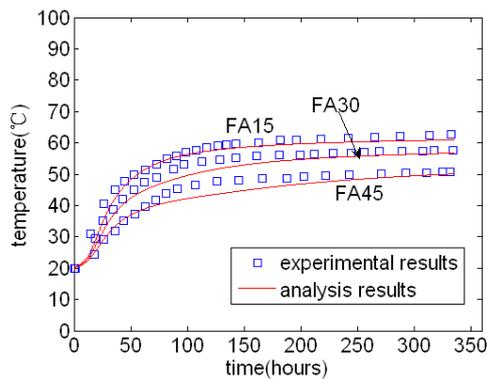


Fig. 1 The evaluation of adiabatic temperature rises of fly ash blended concrete

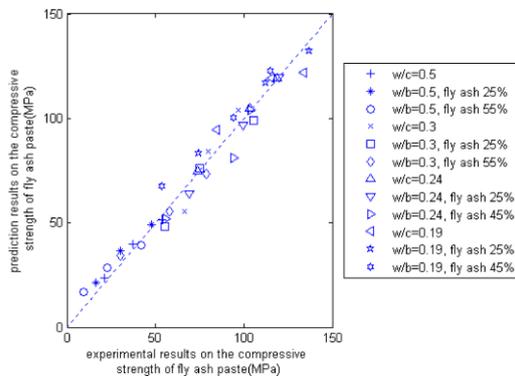


Fig. 2 The evaluation of compressive strength of fly ash blended concrete

Conclusion

In this paper, a kinetic model is proposed to describe the hydration process of concrete containing fly ash or slag. The developments of properties of concrete incorporating fly ash or slag, such as the adiabatic temperature rise, and the compressive strength, are determined by the contribution of both cement hydration and the reaction of the mineral admixtures. The simulation results agree well with the experimental results with different water-to-cement ratios and mineral admixture substitution ratios.

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