플라이 애시 미세도를 고려한 플라이 애시 모르타르의 압축 강도 예측

Predicting Compressive Strength of Fly Ash Mortar Considering Fly Ash Fineness

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Abstract

Utilization of upgraded fine fly ash in cement-based materials has been proved by many researchers as an effective method to improve compressive strength of cement based materials at early ages. The addition of fine fly ash has introduced dilution effect, enhanced pozzolanic reaction effect, nucleation effect and physical filling effect into cement-fly ash system. In this study, an integrated reaction model is adpoted to quantify the contributions from cement hydration and pozzolanic reaction to compressive strength. A modified model related to the physical filling effect is utilized to calculate the compressive strength increment considering the gradual dissolution of fly ash particles. Via combination of these two parts, a numerical model has been proposed to predict the compressive strength development of fine fly ash mortar considering fly ash fineness. The reliability of the model is validated through good agreement with the experimental results from previous articles.

키 워 드 : 징크, 강재, 부식, 부착 강도
Keywords : fly ash, cement, hydration, filler effect, compressive strength

1. Introduction

Fly ash, as the industrial by-product from power station, has been widely adopted to substitute part of cement. Utilization of fly ash fly ash will not only greatly improve performances of concrete, but help to save resources but also contributes to the protection of environment and reduction of carbon dioxide emission [1]. It is generally accepted that fineness of fly ash is one of the most important factors to decide its incorporation in concrete. When fly ash with different fineness is blended with cementitious materials, fresh properties, hydration, strength and durability of the cement-based materials will be evidently different. In this paper, a framework is proposed to calculate the compressive strength development of fly ash blended mortar considering filler effect of fly ash.

2. Materials and methods

The framework is divided into two parts, i.e., “reaction of cement-fly ash system part” and “compressive strength evolution part”, as shown in Figure 1, and the latter part is closely related to the former part via the calculated volume of gel and pore. When the cement mineral composition, w/b ratio, curing time, fly ash fineness, and replacement ratio are given, the first part in Figure 1 can be run with the calibrated parameters input, and the reaction process of cement and fly ash system is simulated. In the “compressive strength evolution part”, the corresponding intrinsic compressive strength at each time step t is calculated based on the simulated reaction process in the “reaction of cement-fly ash system part”. The increment of compressive strength caused by physical filling effect is simultaneously calculated, and is added to the intrinsic compressive strength to get the compressive strength for mortar containing fine fly ash.

3. Results and Discussion

Here we use material properties from Choi et al. [2] as input of this framework. The fly ash with three different

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kinds of fineness is obtained by air separation. The water to binder ratio is fixed at 0.4, and four replacement ratios by mass are adopted. The predicted results are compared with the experimental results in Figure 2. As we can see, the error is controlled within 15%, which indicates that the proposed framework can well predict the compressive strength considering fly ash fineness. It should be noted that because fineness is thought to be the main impact factor to the compressive strength, the effect of chemical composition of fly ash is not integrated into this model. In addition, the fly ash is obtained by air separation, the particle shape has to a large extent kept spherical. Sometimes, ultrafine fly ash can also be obtained by mechanical grinding. This kind of method will destroy the fly ash particle shape and break the particle up. Therefore, much modification is still need to be made. Compressive strength of the mortar samples is shown in Figure 1 at different curing conditions and durations.

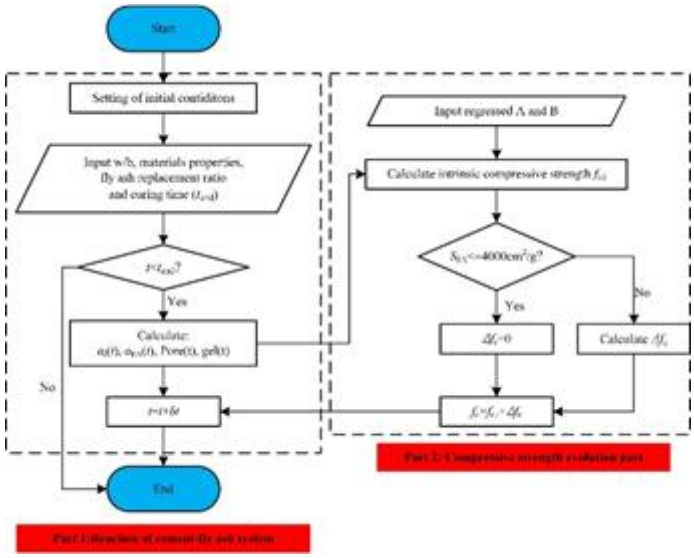

Figure 1. Frame work to calculate compressive strength of fly ash blended mortar considering fly ash fineness

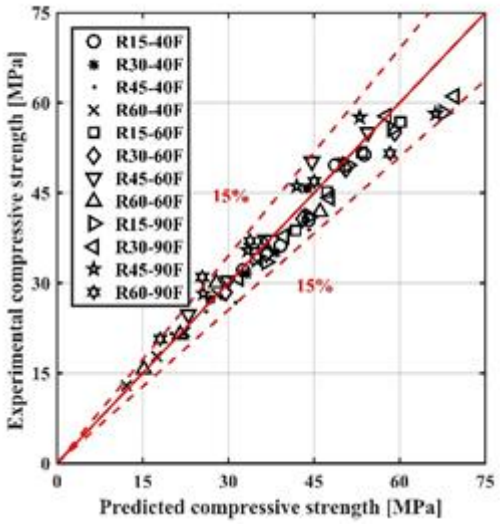

Figure 2. Comparision between the predicted results and experimental results from Choi et al. [2)]

4. Conclusion

This paper proposes a numerical framework to evaluate the compressive strength development of fine fly ash mortar considering fly ash fineness and replacement ratio. This framework is composed of two parts, i.e., "reaction of cement-fly ash system part" and "compressive strength evolution part". Through the combination of these two parts, a series of simulations are carried out to obtain the compressive strength development of fly ash mortar with different fly ash fineness and replacement ratio. The calculation results proved to have a good fit with the corresponding experimental results.

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References

1. Christian Meyer, The greening of the concrete industry, Cement and Concrete Composites, Vol.31, pp.601~605, 2009
2. Se Jin Choi, Sang Soo Lee, Paulo JM Monteiro, Effect of fly ash fineness on temperature rise, setting, and strength development of mortar, Journal of Materials in Civil Engineering, Vol.24, pp.499~505, 2012