계란껍질 분말을 혼입한 시멘트 페이스트의 수화 특성에 관한 실험적 연구

Experimental Study on the Hydration Characteristics of Eggshell Powder in Cement Slurry

진 옥 곤* 순 양** 이 한 승***
Chen, YuKun Sun, Yang Lee, Han-Seung

Abstract

The eggshell is a type of bio-waste which is considered hazardous to the environment. In this research, the waste eggshell is utilized as a potential filler in cementitious material. This study has measured by zeta potential to analyze the interaction between the surface of the filler and the calcium ion in the solution. Meanwhile, the effect of eggshell powder on cement hydration process has been determined by isothermal calorimeter. The results show that the surface of eggshell powder have a strong adsorption of Ca2+, and addition of the eggshell powder provides a heterogeneous nucleation site for cement, which promotes the growth of hydration products.

키 워 드: 계란껍질, 제타 전위, 수화, 시멘트 페이스트
Keywords : eggshell, zeta potential, hydration, cement paste

1. Introduction

The eggshell is a kind of bio-waste material, and it can be easily obtained from local restaurants or bakers. In the field of building materials, eggshell powder is used to replace part of cement and added into concrete. The workability, strength and durability of concrete containing eggshell powder have been studied extensively, However, as a filler material, there are few studies focusing on hydration of cement containing eggshell powder. Therefore, this research will explore its feasibility as a filler material in cement paste from the perspective of zeta potential and isothermal calorimetry.

2. Materials and Method

The eggshell was collected from Hanyang University cafeteria, and it was washed with distilled water. Meanwhile, the membrane inside the eggshell was separated. The washed eggshell is then dried for 2 days. Finally, it was pulverized in planetary ball mill (FRITSCH PULVERISETTE 6). The speed was set as 500/rpm and this process lasted for 10 minutes. The crude eggshell was converted into fine powders with the average particlesize of 1.8 μm. The zeta potential of eggshell powder was measured in alkaline environment, and its adsorption of Ca^{2+} was also analyzed. The paste of mixture proportions was given in Table 1. The hydration heat rate and cumulative heat of the samples were measured over 72h at 20℃ by using an isothermal calorimeter. Eggshell and cement powder samples were prepared in a glass ampule and mixed with distilled water (w/b 0.50). Subsequently, the sample was sealed and put into a calorimeter for measurement.

* 한양대학교 건축시스템공학과 석사과정
** 한양대학교 스마트시티공학과 박사과정
*** 한양대학교 건축학부 교수, 교신저자(ercleehs@hanyang.ac.kr)

Table 1 paste mixture proportions (wt%)

	Cement(%)	Water(%)	Eggshell powder(%)
0.5ES-0	100	50	0
0.5ES-5	95	50	5
0.5ES-10	90	50	10
0.5ES-15	85	50	15

3. Results and Discussion

The evolution of the zeta potential of eggshell powder in NaOH solution (20mmol/L) is shown in Figure 1. As the concentration of Ca^{2+} increases, the zeta potential increases gradually. This phenomenon indicates that eggshell powder has a strong adsorption of Ca^{2+}. It is because that the adsorption of moderately strong acid-base (donor-acceptor) interaction, and the chemical bonding of Ca^{2+} (nucleus constituents) to the surface of eggshell powder, the extra of Ca^{2+} are adsorbed onto the eggshell powder surface. Therefore, zeta potential is expected to be higher. In Figure 2. It can be seen that the maximum heat flow rate (q¬max) of the reference sample without eggshell powder is equal to 9.00J/g-cement. In comparison, for the samples containing 5%, 10% and 15% eggshell powder, the maximum heat flow rates are 9.48, 9.45 and 10.94 J/g-cement respectively. Thus, the heat flow rate is positively correlated with the content of eggshell powder. In Figure 3, Compared with 0.5ES-0, the growth rate of accumulative heat is 5%,9% and 14% respectively. This means that hydration heat increases due to the filler effect. When eggshell powder is used to replace cement, the water-cement ratio is increased and the dilution effect is enhanced. Meanwhile, the eggshell powder provides a heterogeneous nucleation site for the cement to promote the deposition of hydration products on the eggshell powder.

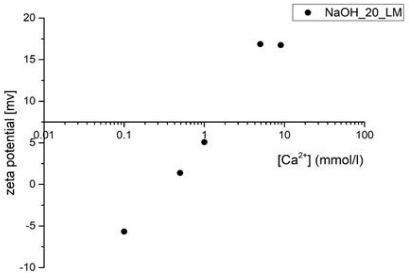

Figure 1 Evolution of the zeta potential

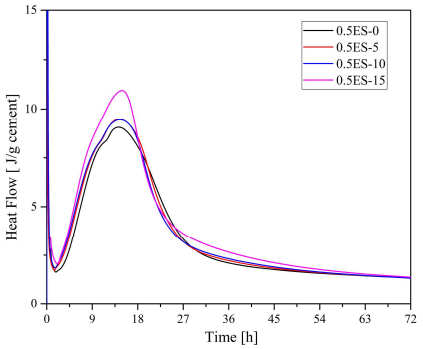

Figure 2. Heat flows rate of paste

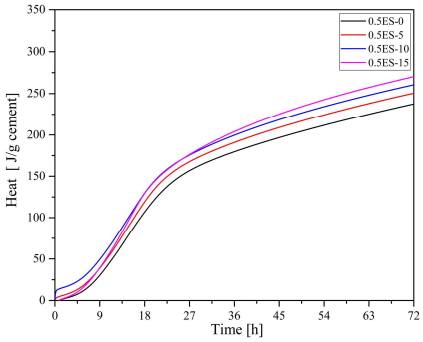

Figure 3. Cumulative Heat of paste

4. Conclusion

In this study, the performance of mixture in the cement paste containing different contents of eggshell powder were measured by zeta potential and isothermal calorimetry technique. The surface of eggshell powder has a high affinity for Ca^{2+}. When eggshell powder is used to replace cement, the dilution effect can be enhanced, and it can provide a heterogeneous nucleation site for cement to promote the formation of hydration products.

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References

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