석회석 소성 점토 시멘트(LC_3) 페이스트의 고온 내화성능에 관한 연구

Experimental Study About Properties of Limestone-calcined-clay Cement (LC_3) Concrete Under High Temperature

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Abstract

Limestone-calcined clay-Cement (LC3) concrete provides a solution for sustainability, durability, and profitability of concrete industry. This study shows experimental studies of the macro properties (residual compressive strength), the meso properties (mesoscopic images), and micro properties (thermogravimetric (TG) analysis, X-ray powder diffraction (XRD), FTIR spectra, Raman spectra, Mercury intrusion porosimetry, and SEM) of LC3 paste with various mixtures and at high elevated temperatures (20 ℃, 300 ℃, 550 ℃ and 900 ℃). We find (1) Regarding to macro properties, LC3 cementitious materials are at a disadvantage in compressive strength when the temperature is higher than 300 ℃. (2) Regarding to meso properties, when the temperature reached 550 ℃, all samples generated more meso cracks. (3) Regarding to micro properties, first, as the substitution amount increases, its CH content decreases significantly; second, at 900 ℃, for samples with calcined clay, a large amount of gehlenite crystalline phase was found; third, at elevated temperatures (20 ℃, 300 ℃, 550 ℃ and 900 ℃), there is a linear relationship between the residual compressive strength and the cumulative pore volume; fourth, at 900 °C, a large amount of dicalcium silicate was generated , and damage cracks were more pronounced. The experimental results of this study are valuable of material design of fire resistance of LC3 concrete.

키 워 드 : 석회석 소성 점토 시멘트, 내화성능, 압축강도, 수화반응
Keywords : imestone-calcined-clay cement, high temperature, strength, hydration

1. 서 론

Limestone-calcined clay-Cement (LC_3) concrete is new type concrete. Many advantages can be achieved by using LC_3 concrete, such as high late age strength, excellent durability about chloride ingress and alkali silica reaction, and low CO_2 emission. In addition, because limestone and clay are world-wide available, the production of LC_3 concrete is feasible for various countries. In summary, Limestone-calcined clay-Cement (LC_3) concrete provides a solution for sustainability, durability, and profitability of concrete industry.[1)]

Although abundant studies have been done about hydration-mechanical-durability-sustainability aspect, the studies about properties of LC_3 concrete subjected to high elevated temperature is limit. To fill this gap, this study shows experimental studies of the macro properties (residual compressive strength), the meso properties (mesoscopic images), and micro properties of LC_3 paste with various mixtures and at high elevated temperatures.

2. 재료 및 실험방법

The mix proportions are shown in Table 1. The water-to-binder ratio of all formulations is 0.5. Among the ternary mixtures, the weight ratio of calcined clay (CC) and limestone (LS) is 2: 1.

Figure 1 shows the compressive strength of pastes. Obviously, the compressive strength of all samples increased when the temperature increased to 300 ℃, and then decreased as the temperature increased. All samples showed an increase in compressive strength at 300 ℃, possibly caused by the accelerated hydration of unhydrated particles due to increased temperature . So, it is beneficial to improve the macroscopic properties of the materials when exposed to a not too high temperature (not more than 300 °C). After 550 °C, the compressive strength of

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all samples can be observed to decrease sharply, especially A15. This phenomenon may be due to the increase in vapor pressure due to the dense pore structure of the ternary mixture, which makes the structure easier to spall and crack. When the temperature reaches 900 °C, the compressive strength decreases more significantly, especially in the samples with added limestone. This may be due to the decomposition of limestone.

Table 1. Mix composition.

Mix No.	Cement [wt.%]	Calcined clay [wt.%]	Limestone [wt.%]
OPC	100	0	0
LS15	85	0	15
CC30	70	30	0
A15	85	10	5
A30	70	20	10
A45	55	30	15

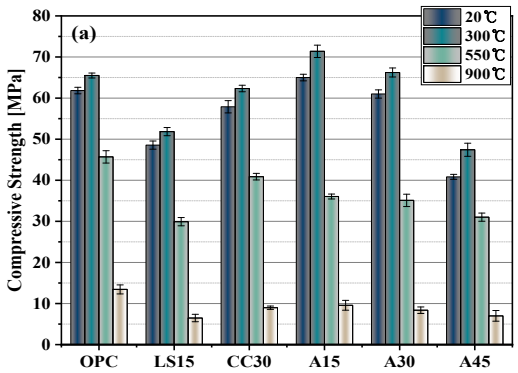

Figure 1. Compressive strength for different temperature

3. 결 론

Macro results shows at 20℃, A15 paste presents highest strength than other mixtures. Regarding compressive strength at normal temperature, A15 is the optimization mixture of LC3 paste. At 300℃, the strength of all the specimens are higher than 20℃. At 500℃, the strength of specimen containing admixtures shows lower strength than plain specimen. At 900 ℃ , as the increasing of replacement ratio of calcined clay and limestone, the reduction of residual strength becomes obvious. LC3 cementitious materials are at a disadvantage in compressive strength when the temperature is higher than 300 ℃.

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