그래핀 나노리본 혼입 시멘트 경화체의 고온 노출에 의한 기계강도 변화에 관한 연구

A study on the mechanical strength change of graphene nanoribbons enhanced cement paste at a high-temperature

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Abstract : This work explores the effectiveness of graphene nanoribbons (GNRs) in modifying the fire resistance of cement paste. The GNRs are added to the ordinary Portland cement at 0.10 wt% of the cement, and the sample is heated to target temperatures after curing for 28 days. Subsequently, the variations of compressive strength and pore structure are inquired by compared to the control sample without nano reinforcing and the sample with the same amount of carbon nanotubes (CNTs).

키워드 : 그래핀 나노리본, 시멘트 페이스트, 압축강도, 공극률, 내화성
Keywords : graphene nanoribbons, cement paste, compressive strength, porosity, fire resistance

1. Introduction

Ordinary Portland cement is the most widely used artificial material worldwide, forming cementitious composites with aggregates. Generally, they possess superior mechanical strength and are non-combustible. However, at high environmental temperatures, the cement paste, one of the most critical components of cementitious composites, suffers damage that affects their mechanical properties and durability. Previous studies have shown that adding nanomaterials can effectively modify the microstructure of cement matrix and thus enhance the fire resistance of cementitious composites [1]. Furthermore, GNRs, as a new generation of carbon nanomaterials, due to their unique structure and properties, have attracted much attention. Therefore, this paper investigates the effect of improving the fire resistance of cementitious composites.

2. Experimental procedure

Ordinary Portland cement (OPC, ASTM Type I) was applied to fabricate the paste sample. CNTs (Figure 1(b)) were used as the nano-reinforcing material for the paste sample and the raw material to synthesize the GNRs. GNRs are obtained by oxidative deconvolution of CNTs and their structural morphology is shown in Figure 1(a). GNRs exhibit a typical ribbon structure. In this study, the additive amount of nanomaterials was 0.10 wt% of the cement weight, and the water-cement ratio was 0.3. In addition, to ensure uniform dispersion of the nanomaterials in the cement matrix, the polycarboxylate superplasticizer (SP) was also used with an addition of 0.10 % by weight of the cement. When the samples were fabricated and cured for 28 days, they were heated to different target temperatures (200, 400, 600, and 800 °C). Subsequently, the variation of compressive strength and porosity of the paste samples with temperature was investigated.

3. 실험 결과

3.1 압축강도

The compressive strength results are shown in Figure 2. As shown in Figure 2(a), the paste samples reinforced with nanomaterials

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before heating (after 28 days of curing) have significantly higher compressive strength than the control group, which is attributed to the fact that the nanomaterials promote the hydration of the cement particles and improve the microstructure of the samples. However, GNRs exhibited a more noticeable effect in increasing the compressive strength of the samples. When the sample was heated, the compressive strength tended to increase and decrease. This is due to the high-temperature environment (200 °C) promoting the hydration of unhydrated cement particles, while the decrease in strength above this temperature was because of the decomposition of the hydration products resulting in the deterioration of the cement matrix. However, GNRs are effective in suppressing the deterioration of compressive strength at high temperatures.

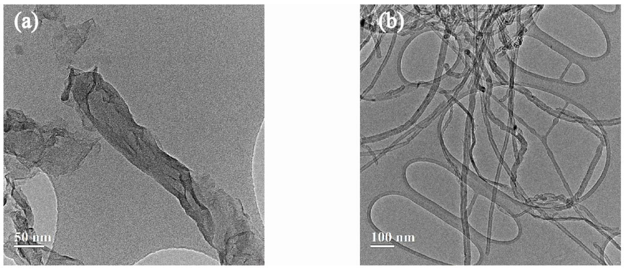

Figure 1. Structural morphology of (a) GNRs and (b) CNTs.

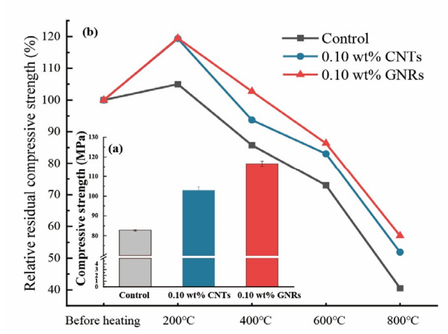

Figure 2. Compressive strength: (a) before and (b) after heating.

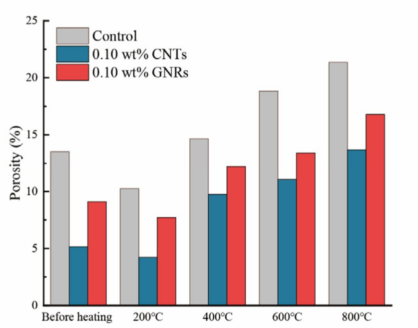

Figure 3. Porosity variation with temperatures.

3.2 공극률

The compressive strength of the samples is closely related to the porosity. Figure 3 demonstrates the relationship between temperature and the variation of porosity. Firstly, before heating, the GNRs provided the effect of refining for the pore structure; thus, the 0.10 wt% GNRs had lower porosity and denser cement matrix compared to the control and CNTs-enhanced samples. Furthermore, the variation trend of porosity with temperature is consistent with the variation trend of strength. After heating to 800 °C, the porosity of 0.10 wt% GNRs only had 13.68%, while the control sample reached a porosity of 21.36%.

4. 결 론

The experimental results indicated that GNRs, as a novel nanomaterial, exhibited great potential in improving the fire resistance properties of cementitious composites.

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