A Preliminary Study on Alkali Activation of Waste Concrete Powder

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Abstract : In this study, the effects of NaOH and KOH alkali activators of various concentrations on the performance of alkali activated waste concrete powder (WCP) was discussed. The samples activated by alkaline solutions were cured for up to 28 days and then compressive strength test was performed. These samples were also characterized using various techniques to explore the phase evolution, and microstructural changes. Results showed superior performance of NaOH-activated WCP. Additionally, activation of WCP by 8M concentrated alkali solutions improved the strength, reactivity and microstructure of alkali activated WCP binder sample.

Keywords : waste concrete, alkali activated materials, cement

1. Introduction

The significant increase of construction and demolition waste (C&D) in republic of Korea is inevitably observed due to the increased demolition work and development of new infrastructures caused by rapid socioeconomic growth of nation. Waste concrete consists of more than 60% of C&D generates annually which is being recycled as an aggregate for backfilling, roadbase and leveling. Owing to the uneven quality of waste concrete aggregates, it is less likely to fully used for structural concrete. Moreover, waste concrete powder (WCP) being less reactive is not highly recommended to use as a binder, therefore, the technique such as alkali activation can possibly increase the reactivity of WCP.

2. Materials, Synthesis & Test Methods

The WCP chemically composed of SiO_2= 46.58%, Al_2O_3=9.50%, CaO=17.92% MgO=4.95%, K_2O=5.55%, Fe_2O=10.02% was activated by NaOH and KOH alkali solution of various concentrations (Table 1). To ease the mixing, the additional water of 0.019 was introduced at 2 minutes of mixing while the total mixing time for each sample was set as 5 minutes. Prepared paste was molded & cured at room temperature. The compressive strength (ASTM C109) of Alkali activated WCP was measured at 7, 14 and 28 days. The hydration of samples cured for 28 days was stopped by solvent exchange method for characterization.

Table 1. Mix proportion

ID	WC4N	WC6N	WC8N	WC10N	WC12N	WC4K	WC6K	WC8K	WC10K	WC12K
Alkali-XM	NaOH-4M	NaOH-6M	NaOH-8M	NaOH-10M	NaOH-12M	KOH-4M	KOH-6M	KOH-8M	KOH-10M	KOH-12M
Alkali:precursor = 0.4										

3. Results & Discussion

Figure 1(a) shows that the compressive strength of all samples increased with curing time, indicating that the polymerization proceeded with the curing time. Comparatively, superior early strength and 28 d strength development was observed in NaOH-activated WCP. This can be explained by the smaller cation size of Na than K favoring reaction between Na and silicate ion. Moreover, the compressive strength was decreased when the solution concentration was greater than 8M. With the increasing concentration, the carbonation

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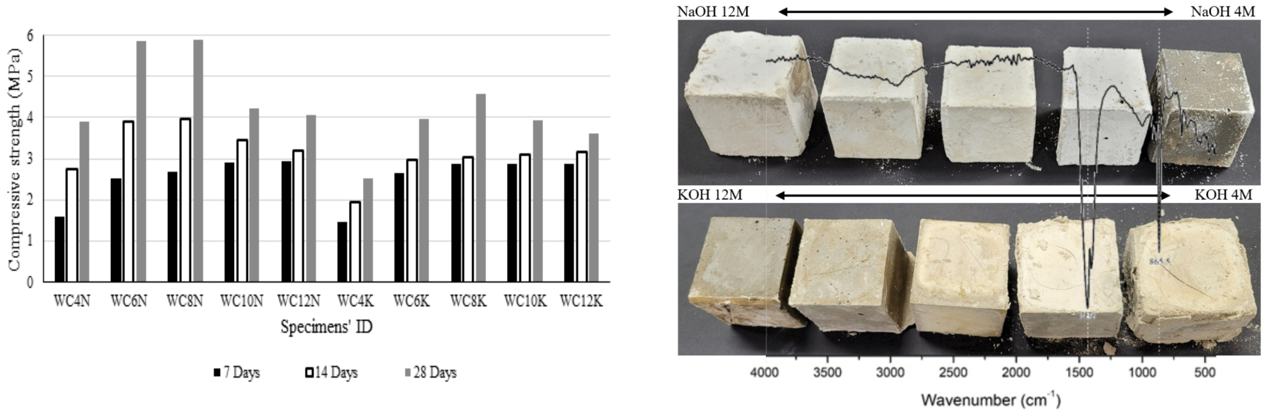
reaction was also observed. Na activated samples developed efflorescence on the surface of sample (Figure 1(b)) while the KOH developed sub-efflorescence which is apparent from FT-IR spectrum (Figure 2) and XRD pattern (Figure 3(b)) showing greater carbonation peaks in KOH activated WCP. The FT-IR spectrum further suggesting the change in Si and Al structures with increasing alkali concentration as the shift in the peak at 782 and reduction of peak at 989 wave number was observed. While the dissolution of anorthite, calcite, C-S-H and ettringite was significant in NaOH 8M activated WCP (Figure 3). Additionally, the WC-8K showed comparatively rough matrix while the WC-8N formed relatively dense microstructure.



(a) (b)

Figure 1. (a) Compressive strength (b) Efflorescence formation of the samples and FT-IR spectrum of efflorescence

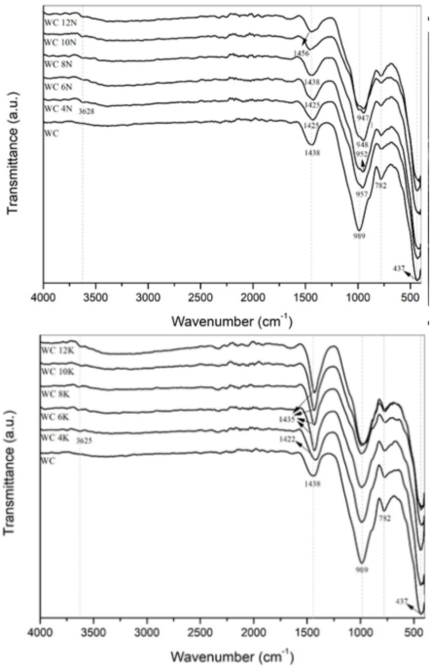


Figure 2. FT-IR of alkali activated WCP

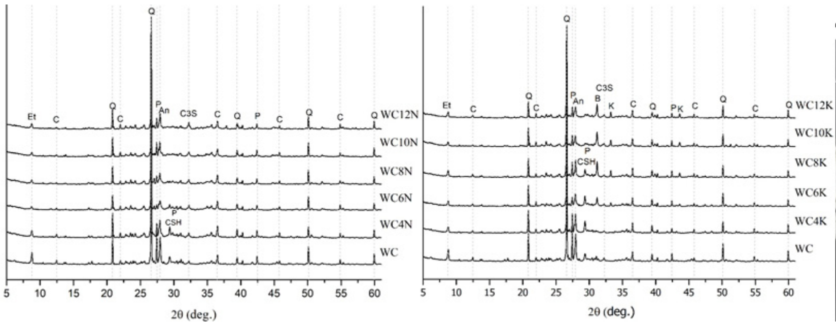
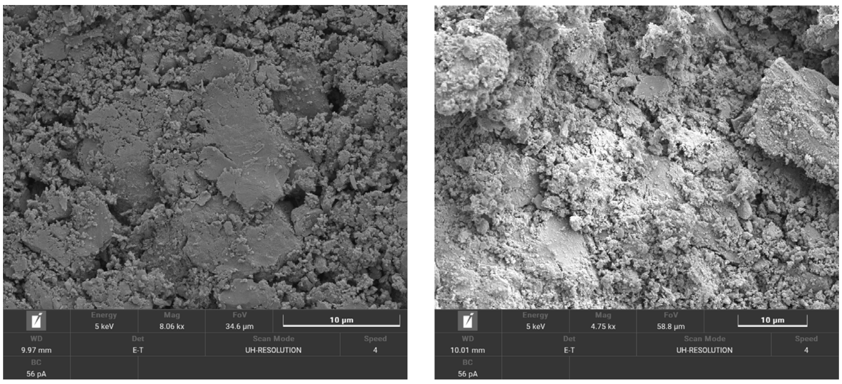


Figure 3. XRD of alkali activated WCP samples



WC8N WC8K

Figure 4. Micrograph alkali activated WCP samples

4. Conclusion

Increasing concentrations of alkali solutions to up to 8M increased the compressive strength of alkali activated WCP. The increase was higher for the NaOH solutions than for the KOH solutions. Results indicate that the alkali activation increased the reactivity of WCP to some extent therefore, it has potential to be used as supplementary precursor.