Investigation on the influence of self-healing on ECC's tensile mechanical properties

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Abstract: Cracks are inevitable for concrete infrastructures during their service life. The presence of cracks reduces the mechanical properties and bring potential safety hazard to infrastructure. In this study, the influence of self-healing on the ECC's (Engineered cementitious composite) tensile properties was investigated. ECC is a new kind of HPFRCC, featuring high strain capacity of 3-5%, accompanying by sequential multiple micro-cracks development, while maintaining tight crack width (about 20 μm in this study). The dog-bone shape specimens used in the tensile test were pre-loaded to the tensile strain levels of 1%, 2%, 3%, and 4%. After that, to achieve micro-cracks' self-healing, the pre-loaded cracked specimens were immersed in the water, undergoing wet-dry cycles. The self-healed specimens were then reloaded under tension. The results show that ECC can still have high tensile strain capacity of 4% and more than 90% of ultimate tensile strength after healing. The first cracking strength recovers to 50% of original cracking strength, and the stiffness recovery ratio of cracked-specimens ranges from 58% to 92%. With the tensile mechanical properties recovery caused by its self-healing behavior, ECC can be a resilient material for civil infrastructures.

1. INTRODUCTION

Concrete cracking is a result of the combined effects of mechanical loading conditions and environmental exposure, which is inevitable for concrete infrastructures during their service life. Normally, the presence of crack causes the reduction in mechanical properties of concrete materials, and decreases the service life of infrastructures. In this paper, we attempt to investigate the tensile mechanical properties recovery due to self-healing behavior in ECC.

2. MATERIALS

Table 1 lists the ECC mixture proportion used for this study. The fly ash-to-cement ratio is 2.2, while water-to-cementitious material ratio (w/cm) and silica sand-to-cementitious material ratio (s/cm) are fixed at 0.25 and 0.36, respectively.

Table 1. ECC mixture proportion

Cement (c)	Fly ash (FA/c)	Silica sand (s/cm)	Water (w/cm)	Water reducer	PVA fiber(by volume)
1.0	2.2	0.36	0.25	0.03	0.02

3. METHODS

To investigate the tensile mechanical properties' recovery of ECC, the dog-bone shaped specimen was used in this study, the detailed specimen dimensions and the tensile test set-up configuration can be found in reference 1. All specimens were demolded at the age of 24 h, and cured in air for 27 days.

The dog-bone specimens were pre-loaded to 4 different tensile strains of 1, 2, 3, 4% by uniaxial tensile test. The cracked-specimens were then cured in wet-dry cycle condition. Finally, the self-healed specimens were re-loaded. For control, cracked specimens without wet-dry cycle were also re-loaded for comparison purpose.

4. RESULTS

Figure 1 presents the tensile properties of ECC material used in this study. It shows that average tensile strain and tensile strength of ECC is 4.42% and 5.93 MPa, respectively.

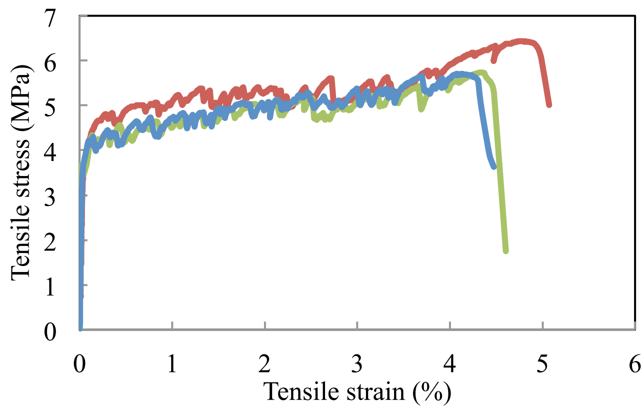


Figure 1. The tensile strain-tensile stress relationship of ECC.

Figure 2 show the curve of ECC specimen pre-loaded to 2% strain level and the re-load curve of this specimen without self-healing. It can be seen that the re-load curve did not show the first cracking stage and the stiffness after re-load decrease substantially when compared with the initial stiffness of pre-load specimen. The stiffness of ECC is defined as the slope of initial elastic stage of the tensile stress-strain curve.

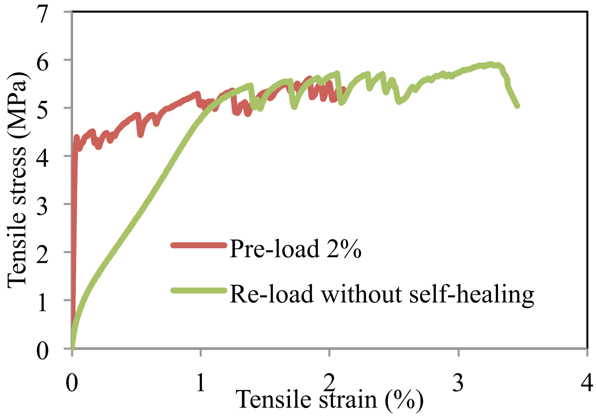
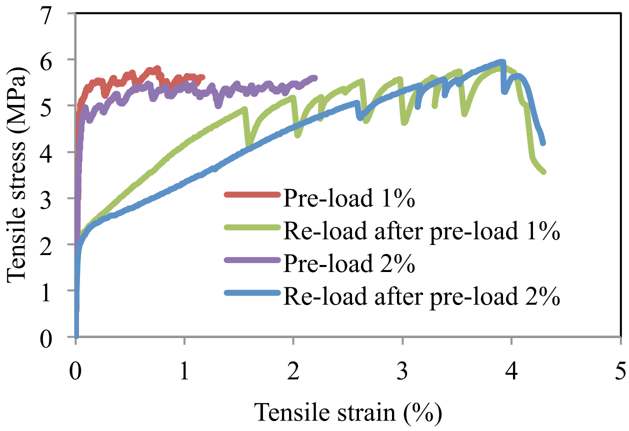
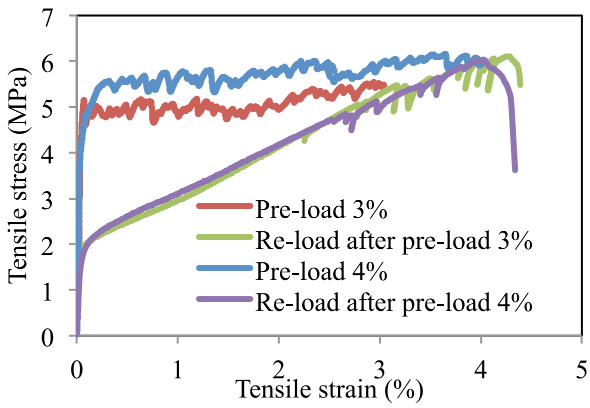


Figure 2 Relationship between tensile strain and stress of pre-load and re-load specimen without self-healing.

Figure 3 shows the relationship between tensile strain and stress of pre-load specimens after self-healing. After self-healing, for the specimens at different pre-load levels, ECC can still have high tensile strain capacity of 4% and more than 90% of ultimate tensile strength. Meanwhile, the first cracking strength recovers to about 50% of its original value.



(a)



(b)

Figure 3 Tensile strain-stress curves of pre-load specimens after self-healing.

Figure 4 illustrates the stiffness recovery of ECC due to self-healing. It shows that the stiffness recovery ratio of cracked-specimen range from 58% to 92%.

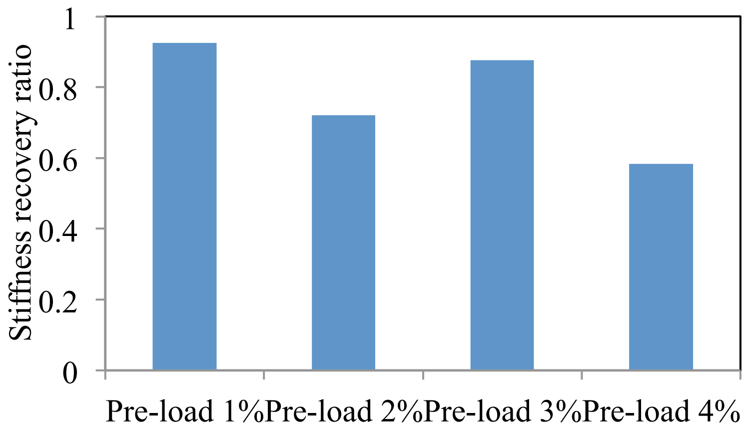


Figure 4 Stiffness recovery ratio due to self-healing.

5. CONCLUSIONS

Based on this study, it can be concluded that self-healing leads to recovery of tensile mechanical properties in ECC material after crack damage.

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