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Jong-Han Lee, Kun-Joon Lee, Eunsoo Choi

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Flexural Capacity and Crack-Closing Performance of NiTi and NiTiNb Shape-Memory Alloy Fibers Randomly Distributed in Mortar Beams

Jong-Han Lee[1,3], Kun-Joon Lee[1] and Eunsoo Choi[2]

[1] Department of Civil Engineering, Daegu University, Gyeongsan 38453, Republic of Korea

[2] Department of Civil Engineering, Hongik University, Seoul 04066, Republic of Korea

[3] Corresponding author : jonghan@daegu.ac.kr

Abstract

This study assesses the flexural capacity of cement mortar beams that are randomly reinforced with short-length fibers made from NiTi and NiTiNb shape-memory alloys (SMAs). To achieve this goal, material tests were first performed to analyze the element components and the thermal and mechanical properties of the SMA fibers. The phase change temperature to the austenitic phase was designed to be around 100□ without damaging the mortar matrix during the heating process. Using fiber volume fractions of 0.50, 0.75, and 1.00%, a four-point bending test was performed with beam specimens that have 40 × 40 mm^2 square cross-section with a length of 160 mm. The cracking and post-cracking strengths and the energy absorption capacity were mainly dependent on the mechanical properties and content of SMA fibers. Based on the flexural strength and energy absorption capacity, an equivalent flexural strength ratio that is commonly used in the flexural design of fiber-reinforced cement composites is proposed to account for the improvement of the ductility in the SMA fiber-reinforced beams. Additionally, this study evaluated the crack-closing performance induced by the activation of the shape memory effect of SMA fibers. The amount of the closed flexural cracks increased with increasing fiber content and depended on the recovery performance of the fiber. The linear trend analysis shows that the crack-closing stress can be generated by approximately 0.36 and 0.06 MPa per 1.00% increase in NiTi and NiTiNb fibers in cement composite beams, respectively.

Keywords: Shape memory alloy, fiber-reinforced cement composite, fiber volume fraction, residual strength, energy absorption capacity, equivalent flexural strength ratio