Applications of shape memory alloys for active flexural strengthening of reinforced concrete elements

Active flexural strengthening of reinforced concrete beams and slabs reduces cracking, reduces deflections and significantly increases stiffness. Prestressing with iron-based shape memory alloys (FeSMA) can be an interesting alternative to conventional methods of prestressing existing structures. It is characterized by easy and fast application. Tensioning devices are not required to obtain the prestressing force, only heating the FeSMA material to a certain temperature.

The purpose of this study was to analyze the feasibility and effectiveness of active flexural strengthening of RC members using shape memory reinforcement. Its realization was achieved by analyzing the state of the art in using FeSMA materials for active flexural strengthening, conducting experimental studies and performing computational analyses.

The experimental research program included testing five RC beams in a four-point bending scheme. The first beam served as a reference, while the others were strengthened with external strips that were not bonded to the concrete but were end-anchored. Two beams were strengthened with FeSMA strips, and another two with carbon composite strips. The axial stiffness of the strips and the prestressing force were chosen to be at a similar level for both types of reinforcement.

The effectiveness and efficiency of prestressing were confirmed for both methods of active strengthening, as these beams exhibited a marked increase in cracking and steel yielding load. The prestressed beams showed significantly smaller crack widths and deflections at the same load level compared to the reference beam. The critical point of strengthening with FeSMA strips turned out to be the anchorage, which had prematurely failed. However, the load capacity of these elements still increased by 50 % compared to the unstrengthened beam.

The presented computational models showed a fairly good correlation with the results of experimental studies. Ensuring sufficient anchorage or reducing the element's load capacity due to anchorage is a key issue in the design of this type of strengthening.

Keywords: Shape memory alloys, FeSMA, reinforced concrete, strengthening.

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