Efficiency of Flexural Strengthening of Reinforced Concrete Elements with Pretensioned Strips Made of Carbon Fiber Polymers

Until now studies conducted on reinforced concrete (RC) specimens strengthened in flexure with externally bonded (EB) fiber reinforced polymers (FRPs) have indicated poor strengthening effectiveness due to premature FRP debonding from the concrete surface before reaching ultimate FRP strain. It should be emphasized that although strengthening with nonpretensioned FRP composites increases the load bearing capacity of RC specimens, it exhibits insignificant effect on the serviceability limit state (cracking moment and deflections). Prestensioning of FRP material has been proposed to increase the utilization of the composite's tensile strength and to improve the strengthening efficiencyin terms of serviceability limit state.

An experimental research consisted of three series of RC slabs with the difference in longitudinal steel reinforcement ratio (4#12 ρ_s=0.49% and 4#16 ρ_s=0.87%), concrete strength, preloading level before strengthening and adhesion between the CFRP and the concrete surface and adopted anchorage system.

The practical aspect of the experimental program focuses on the influence of the specimens preloading on the strengthening effectiveness with pretensioned CFRP laminates. Preloaded RC structural members can be found very often in the engineering practice. Moreover, structures with exceeded service limits (cracking and deflections) are very common. The influence of the specimens preloading level before strengthening has been investigated only very rarely until now. In the present work two preloading levels were considered: self-weight and self-weight with and additional external load. The self-weight preloading level corresponded to 25% and 14% of the yield strength of the nonstrengthened member in specimens with lower and higher internal steel reinforcement ratio, respectively. The higher preloading level, equal to 76% of the yield strength of the nonstrengthened member, was chosen to approach the elastic limit of the specimen behavior.

Experimental tests yielded promising results for the ultimate and serviceability limit states of the strengthened slabs. The strengthening ratio, defined as a ratio of a difference between values of the ultimate load of the strengthened and non-strengthened slabs to the ultimate load of the non-strengthened slab, reached values in the range of 0.64 to 1.20. Influence of all investigated parameters on the strengthening efficiency is discussed herein, therefore tensile steel reinforcement ratio, adhesion between the CFRP laminate and concrete, preloading level before strengthening and pretensioning limit of the CFRP laminate.

An calculation model has been proposed for the nonlinear analysis of the RC structures pliability at all range of loading. Different preloading levels can be taken into consideration in the proposed model. Good compatibility of the specimens behavior can be found between results obtained from the calculation model and experiments.