

Summary

Efficiency analysis for strengthening of post-tensioned girders with use of prestressed CFRP laminates

The subject of this dissertation is strengthening of post-tensioned concrete structures using prestressed carbon fibre reinforced polymer (CFRP) laminates. The motivation to undertake the work was the participation in the Polish-Swiss Research Program "*Innovative Structural Health Monitoring in Civil Engineering Infrastructure Sustainability*", TULCOEMPA, focused on the development of an innovative method of strengthening of concrete structures.

The main purpose of the work was to carry out a pioneer strengthening of a bridge structure with prestressed CFRP composites using the "gradient method", on the bridge which remains in operation. The goal was achieved by analysing the state-of-the-art in the field of strengthening of reinforced concrete and post-tensioned concrete structures with prestressed CFRP laminates, conducting an experimental research program and analysing its results.

The experimental research program included two post-tensioned girders with a span of 18.0 m and a cross-section height of 1.26 m. The girders built in the EMPA laboratory were an exact reconstruction of structure of the bridge designated for the strengthening. Of the two specimen one was used as a reference member, while the other was strengthened for flexure with prestressed CFRP laminates applied with gradient method, and for shear vertical CFRP sheet wraps. The girders were tested for flexural load capacity and shear load capacity. As part of the research program, a methodology has been developed to prepare the post-tensioned girder for strengthening, in particular to reprofile the bottom surface of the girder. For this purpose, a series of tests on the adhesion of reprofiling mortars and CFRP laminates to concrete was carried out.

The results of laboratory tests have shown a very high efficiency of strengthening of post-tensioned girders with use of prestressed CFRP laminates anchored with gradient method. The strengthened girder showed a 12% increase in the cracking moment, a 21% increase in the load capacity, and a 19% reduction in the maximum deflection, compared to the non-reinforced girder. The girders also showed higher than assumed shear capacity. The analysis of the test results allowed to determine the loss of prestressing force in the girder cables, compare the test result with the results of standard calculations and test simulations using FEM models, and determine the factors affecting the difference between experimental and computational results.

Based on the results of experimental research, a pioneer strengthening was carried out on the bridge in Szczercowska Wieś. Five post-tensioned bridge girders were prepared for reinforcement according to the developed methodology, and strengthened with 10 prestressed CFRP laminates using the gradient method.