Numerical simulations of service life cycle of reinforced concrete structures

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Abstract

Corrosion of steel reinforcement continues to be the principal cause of deterioration of reinforced concrete structures. The associated corrosion, cracking and spalling of concrete cover, loss of steel bar cross sectional area and reduction in bond strength may therefore pose threats to the performance and safety of reinforced concrete structures.

The Finite element program DIANA's option of phased analysis is used to simulate the deterioration and repair stages of the service life cycle of a reinforced concrete beam. A large scale beam was subject to phases with loading to serviceability load, corrosion, partially unloading, repair and loading until failure.

In a 2D model it was used CQ16M plane stress elements for concrete which included the deterioration or repair part of the beam. Two sets of elements in the deterioration part of the beam were modelled representing deteriorated concrete, that must be removed, and new strain-free repair material that may be applied in the repair process, respectively. A perfect contact between the deteriorated concrete beam and new repair material was assumed. The steel reinforcement was represented by discrete beam three-node CL9BE elements with predefined circular cross-section. Bond stress-slip relations were implemented for intact and corroded bars using interface elements IP33 CL12I. New interface elements were used to model the bond between corroded reinforcement and strain-free repair material.

The concrete was modelled according to a fixed smeared crack model with a linear stress cut-off criterion. The softening branch of the stress-strain was linear or brittle. The constitutive behaviour of the reinforcing steel was assumed to follow that of an elastic-plastic material with linear strain hardening. For prediction of creep and shrinkage, CEB-FIP90 model in DIANA was used.

The results of numerical simulations will be compared with results from an experimental study carried out at Luleå University of Technology in Sweden.