UNIVERSITY OF LEEDS

Time-Dependent Flexural Performance and Loss of Tension Stiffening of Corroded Reinforced Concrete Beams

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by

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Abstract

One of the major causes of early deterioration, reduction of durability and service life of reinforced concrete (RC) structures exposed to chloride environments is corrosion of the reinforcing steel bars. Prediction of the time-dependent performance of corroded RC structures is important to prevent any serious premature damage owing to the progression of corrosion.

The research aims to evaluate the influence of concrete strength and cover depth on the bond characteristics, the corrosion levels, and to determine the time-dependent loss of tension stiffening and the long-term structural performance of RC beams thereby measuring deflections and longitudinal surface strains.

This research presents the results of a series of experimental investigations deigned to characterize the combined effect of chloride-induced corrosion and sustained load on the structural behaviour of RC beams. An accelerated corrosion method was utilised to induce corrosion of the steel bars. At the same time, to delay corrosion, improved concrete characteristics in terms of concrete quality and cover depth are utilised.

The results of tests under corrosion conditions indicate that reinforcement corrosion had an insignificant effect on the tension stiffening behaviour and the deflection of the corroded beams during the early ages of testing. However, a significant influence of the reinforcement corrosion was observed with loss of tension stiffening for corroded specimens and the long-term performance deterioration for the later ages of testing. Further, the results of RC beams with a higher strength concrete and thicker cover depth exhibited a superior corrosion resistance, leading to delayed initiation and propagation of the reinforcement corrosion, with subsequently, less deflection development for the RC beams.

A novel separation-time model has been proposed to predict the time for when separation initiates between the tension stiffening behaviour corresponding to the un-corroded and corroded curves (i.e., see tension stiffening vs. time curves). Further, an analytical investigation was conducted to evaluate the suitability of the Eurocode 2 procedure to predict the long-term deflection of RC beams subjected to the combined effect of sustained load and corrosion. It was found that there were shortcomings to the Eurocode 2 model when predicting the long-term performance under corrosion conditions. Therefore, a deterioration function for the time- dependent deflection (i.e., correction factor) of the corroded beams was proposed based on the experimental data and the results calculated by the Eurocode 2.

Finally, a 3D finite element FE model was implemented using the commercial software Midas FEA which included the development of an approach for predicting the long-term deflection of

corroded RC beams. This approach was validated against experimental data presented within this study and an extended parametric study was further conducted. The results indicated that reducing the reinforcement diameter in order to simulate corrosion led the model to overestimate the developed deflection only during the early ages.

CE Database subject headings: Corrosion, Curvature, Loss of tension stiffening, concrete structures; Cracking; Deflection; Serviceability, Mass loss, Stiffness, Crack widths; Accelerated corrosion.