Prediction of residual strength of corrosion-damaged reinforced concrete beams

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Abstract:

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In the present work, an effort has been made to first observe the effect of reinforcement corrosion on flexural behavior of a reinforced concrete beam and then to develop a model to predict the residual flexural strength of a reinforced concrete beam subjected to rebar corrosion. The experimental variables include: applied corrosion current density, corrosion duration, rebar diameter, and thickness of concrete cover.

Considering all variables, a total of 56 reinforced concrete beams (150 mm × 150 mm × 1100 mm) were cast using a common concrete mix, of which 8 beams were tested in four-point bend test as control beams and the remaining 48 beams were subjected to accelerated rebar corrosion and then tested in flexure. After flexural testing, gravimetric test was carried out on the corroded rebar samples, extracted from the tested beams, to measure the weight loss of bars.

It has been observed, among others, that the product of corrosion current density and corrosion period, $I_{cor}T$, is a key factor affecting the flexural strength of a corroded beam. Diameter of rebar has also been found to have an effect on the percentage of metal loss for identical $I_{cor}T$. The effect of cover thickness in the loss of flexural strength is found to be small for a given beam at constant $I_{cor}T$. A comparison of the residual flexural strength of corroded beams with the theoretical strength predicted by using only reduced cross-sectional area of bars due to corrosion indicates that such a theoretical prediction would be acceptable only at a lesser value of $I_{cor}T$ for which implication of bond strength can be ignored. However, at a higher value of $I_{cor}T$, the loss of bond is significant, a factor that must be accounted for in the theoretical strength prediction.
Based on the experimental data, a two-step approach has been proposed to predict the residual flexural strength of a corroded beam. In this approach, the flexural strength is calculated first, using the reduced area of corroded bars, and then this value is multiplied by the proposed correction factor to take into account bond slip and other applicable factors. The residual strength of a corroded beam predicted in this manner is found to have a reasonably good agreement with test data.

The usefulness of the proposed approach for prediction of the residual strength of the corroded beams for which information on corrosion current density, corrosion period, the beam cross-section and strength of materials are available has been indicated through numerical examples. Prediction of the residual strength of the corroded beams may be utilized to gauge the structural safety of the corroding beams and also to decide on the necessary repair.