NONLINEAR BEHAVIOUR OF CORRODED RC COLUMNS UNDER CYCLIC LOADING

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Many structures in regions of high seismicity are also exposed to corrosive environments. Corrosion of reinforcing steel is the most common reason for the premature deterioration of RC structures. Recent experimental testing shows that corrosion can significantly diminish the strength and drift capacity of RC elements (e.g. beams and columns). Therefore, material deterioration due to corrosion must be considered in assessing the earthquake vulnerability of existing RC structures in corrosive environments.

In recently developed methods of nonlinear analysis of RC structures subject to seismic loading, a lot of attention has been given to the fibre element technique. In this method the material nonlinearity is modelled using uniaxial constitutive material models of steel and concrete. Accordingly, there has been a series of comprehensive experimental investigations conducted at the Earthquake Engineering Research Centre (EERC) of the University of Bristol. In these experiments the nonlinear constitutive behaviour of corroded reinforcing bars subject to monotonic (tension and compression) and cyclic loading with the effect of buckling have been investigated. The experimental results showed that corrosion has a substantial influence on the ultimate capacity and ductility of corroded bars in tension and significantly reduces the buckling capacity of corroded bars in compression. It was also observed that corrosion has a significant influence on low-cycle high amplitude fatigue degradation of corroded bars under cyclic load history.

Here a numerical model is presented that enables simulation of the nonlinear flexural response of RC components with corroded reinforcement. The model employs the force-based beam-column element and the fibre-type section model that are available in OpenSees. A new phenomenological hysteretic model that simulates the buckling of longitudinal reinforcement under cyclic loading, the impact of corrosion on buckling strength and low-cycle high amplitude fatigue degradation is used (Figure 1).

This phenomenological hysteretic model is validated through comparison of simulated and observed response for RC columns with uncorroded reinforcement. Typical concrete constitutive models are employed to simulate the response of components with corroded reinforcement; cover concrete strength is adjusted to account for corrosion induced damage and core concrete strength and ductility adjusted to account for corrosion induced damage to transverse reinforcement. The model is used to simulate the response of several recently tested reinforced concrete components with corroded reinforcement and to investigate the impact of corrosion on the nonlinear behaviour of RC columns.

Furthermore, an advanced 3D optical measurement technique has been employed to measure the non-uniform pitting corrosion along the length of corroded bars (Figure 2). Using the data from optical measurement, a simple methodology has been developed for calculation of the residual diameter of corroded bars. This approach provides a more realistic estimate of residual diameter of corroded bars compare to the earlier models based on uniform mass loss.

This paper summarises the results of this research project which are crucial input parameters for probabilistic spatial-time-variant seismic reliability analysis of deteriorating systems. An example graph of the simulated response of a corroded RC column is shown Figure 3.

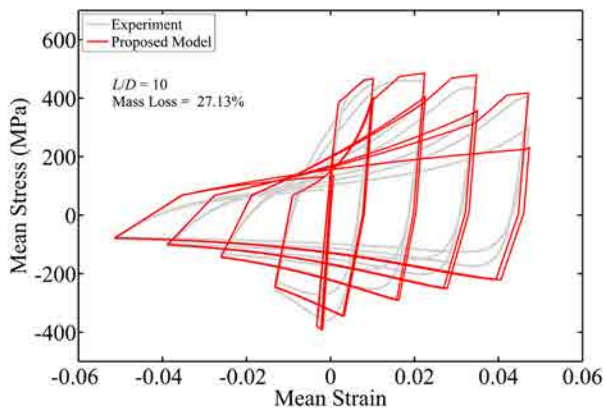

Figure 1. Comparison of the new phenomenological hysteretic model and experimental data

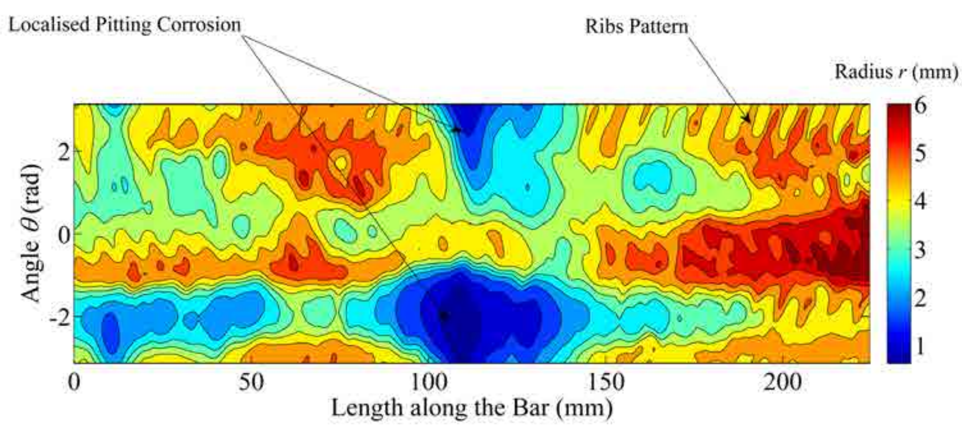

Figure 2. Corrosion pattern of a corroded bar with 54.23% mass loss

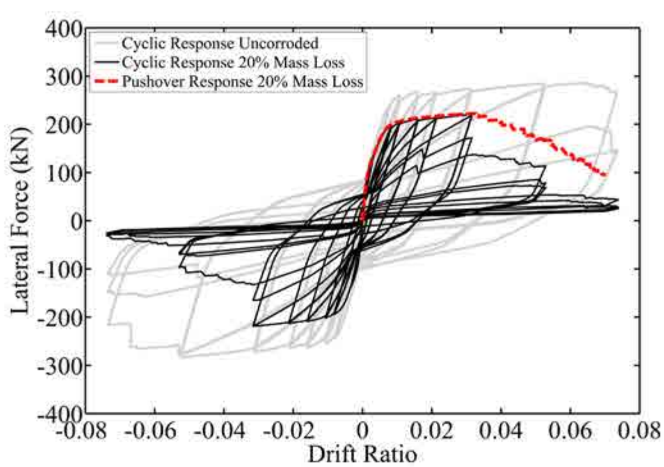

Figure 3. An example of the predicted response of a corroded column with 20% mass loss