

Investigating the effect of concrete cover and stirrup confinement on pull-out behavior of corroded reinforcement using mesoscale 3D discrete analysis

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Abstract:

The damage induced due to reinforcement corrosion on structures continues to be a major problem affecting infrastructure maintenance. However, preventive maintenance strategies require precise evaluation of residual capacity of the structures. Accurate determination of post corrosion performance is difficult due to non-uniform nature of the induced damage. Local damages in the form of cover cracking, reduction in cross-section, and change in shape of reinforcement, etc., cause deterioration of bond. The rate and degree of bond deterioration is also dependent on confinement from concrete cover and presence of transverse reinforcement.

Many experimental studies have been performed to understand and quantify the effect of cover cracking and stirrup confinement on bond deterioration. However, separating the effects of cover depth and stirrups is difficult as significant variance is present in observed experimental results. In this study, the effect of cover and stirrups on crack initiation, propagation and pull out behavior was investigated at meso scale through discrete 3D Rigid Body Spring Model (RBSM). The developed simulation scheme was divided into two stages. Different degrees of corrosion were introduced through incremental interface strains in stage 1 and then the corroded reinforcement is pulled out from the cracked concrete in stage 2. The discretization of concrete through random meshing reduces mesh bias in cracking and modelling of actual reinforcement rib geometry makes 3D RBSM suitable to simulate bond deterioration. The simulation results clearly show that the initiation of corrosion cracking is delayed as the cover thickness increased. However, once the crack initiates, models with thicker cover showed faster rate of crack opening. The investigation of internal stress conditions showed that the reactionary compressive stresses generated by stirrups restricted crack growth. The load displacement curves showed reductions in pull-out capacity, ductility and stiffness in corresponding models with increase in degree of corrosion. The effect of concrete cover on rate of bond degradation was found to be limited, but, the stirrup confinement played a major role in reducing the rate of deterioration. The simulation also showed that the stirrup confinement continued to restrict further widening of corrosion cracks even during pull-out. These simulation results quantitatively confirm existing experimental understanding regarding corrosion and its effect on bond deterioration.