SIMULATION AND DAMAGE MODELS FOR PERFORMANCE ASSESSMENT OF REINFORCED CONCRETE BEAM-COLUMN JOINTS

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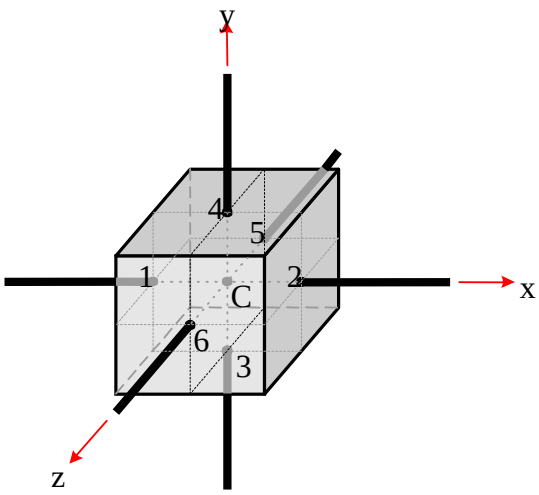
In the context of Performance Based Earthquake Engineering there is an excessive demand for robust analytical tools for damage assessment, obtaining the structural performance, as well as performing reliability analysis. This research effort advances the numerical modeling of reinforced concrete structures by enabling representation of inelastic deformation and reduced load carrying capacity resulting from beam-column joint damage. The behavior of the beam-column joints has been a considerable part of research in the field of reinforced concrete within past 40 years due to the complexity of the joint behavior; while most of the knowledge on the joints are acquired through experimental studies on isolated joints in reinforced concrete subassemblies, and the influence of the joints on the overall frame behavior and the uncertainties they may impose has been overlooked. The analytical tools proposed in this research are implemented in the OpenSees environment for practical applications.

Joint elements are formulated to simulate the nonlinear response of 2D and 3D finite-size joints under cyclic loading. The joint elements could capture the shear panel deformation and slip induced member-end rotations at the connection interfaces. A collection of material constitutive rules with response deterioration are implemented to facilitate modeling the inelastic behavior associated with the shear panel and the slip of longitudinal reinforcement anchored in the joint. A generic damage model is developed which could incorporate conventional damage formulations. The damage models are employed to degrade parameters in the force-deformation relationship, or for performance assessment. Calibration data is provided for normal weight concrete and seismic region detailing described by ACI-352 committee; while for practicing engineers, the model improves assessment and retrofit design of older reinforced concrete structures that may be susceptible to joint failure.



3D joint element

The damage models are also used to quantify the performance parameters in the form of limit-state boundaries for reliability analysis. The sensitivity of the joint response to modeling parameters is derived. The analytical models are applied to a reliability simulation for finding the design point, based on variability in the modeling and material behavior, as well as importance sampling to demonstrate the impact the joint behavior could have on the overall frame behavior.