A comprehensive numerical simulation of steel-concrete composite beam incorporating compression failure of concrete

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Abstract

We present a high fidelity numerical simulation technique to analyze the collapse behavior of a composite beam under cyclic loading. The analysis is performed by utilizing the in-house software package called E-Simulator [1], which is developed at Hyogo Earthquake Engineering Research Center (E-Defense) of National Institute of Earth Science and Disaster Prevention (NIED), Japan, with aim to replicate the seismic responses of building and civil structures. The E-simulator is incorporated with sophisticated material constitutive material model and damage/failure analysis. It uses the parallel FE-analysis software package: ADVENTURECluster [2], as platform to accomplish massive numerical computations.

A heuristic and implicit approach with piecewise linear isotropic kinematic hardening law is used simulate the complex cyclic behavior of steel. The constitutive model is verified with simulation of a cantilever beam subjected to a cyclic forced displacement. Further, as a constitutive model for concrete, extended Drucker-Prager model has been employed and the parameters are identified so that compressive and tensile behavior of concrete can be reproduced. We are intended to improve the unloading behavior of composite beam, which was obtained in previous work [3] by including the compression failure of concrete into Drucker-Prager model. The effect of compression failure has been adopted by reducing the density of corresponding element, depending upon the plastic strain $\bar{\varepsilon}^p$, which is controlled by parameter called cavity rate f_{cave}. The cavity rate parameter is defined as

$$f_{cave} = 0.9\frac{\bar{\varepsilon}^p - e_0}{e_1 - e_0}$$

where, e_0 and e_1 are the function of the first invariant of I_σ.

A relation between the bending moment at the beam-to-column connection and the average deflection angle for composite beam has been analyzed and compared with experiment results, obtained in cycling loading test of full scale partial frame during E-Defense blind analysis contest. Numerical results are in good agreement with experiment results.

Keywords: E-Simulator, Composite Beam, Isotropic-Kinematic Hardening, Drucker-Prager Model, Compression Failure.

References

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