DS '11 KOBE
International Symposium on
Disaster Simulation & Structural Safety in the Next Generation (DS'11)
September 17-18, 2011, JAPAN

FINITE ELEMENT MODEL OF STEEL-CONCRETE COMPOSITE BEAM FOR HIGH-PRECISION SEISMIC RESPONSE ANALYSES OF FOUR-STORY STEEL FRAME

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Keywords: *E-Simulator, Steel Frame, Composite beam, Constitutive model, Solid element*

SUMMARY

The E-Simulator [1] has been developed at Hyogo Earthquake Engineering Research Center (E-Defense) of National Research Institute for Earth Science and Disaster Prevention (NIED), Japan. The purpose of E-Simulator's development is to reproduce the seismic response of building and civil structures until it reaches failure without using any macro models of structure elements. For this purpose, the E-Simulator must implement a high-precision finite element (FE) model by using solid elements, sophisticated material constitutive model and damage/failure analysis. As a platform of the E-Simulator, the parallel FE-analysis software package called ADVENTURECluster [2] is utilized to make massive numerical computation possible. It has been shown that the collapse behavior of a high-rise steel building with more than 70 million degrees of freedom can be simulated using ADVENTURECluster [3].

In this study, Modeling method and numerical simulation approach are presented for high-precision FE-analysis of steel frames considering composite beam effects.

First, a constitutive model for steel material is improved by using piecewise linear isotropic-kinematic hardening law with heuristic and implicit rules to simulate the complex cyclic elastoplastic behavior of the material. The constitutive model is verified by using cantilever subjected to cyclic forced displacement. It is shown that the responses under asymmetric deformation can be simulated accurately using this constitutive model.

Next, a detailed model of a composite beam supported by a column is constructed. To be concrete, the steel beam and column as well as RC-slab are discretized into linear hexahedral elements. The wire mesh (steel bars) in the concrete slab is also modeled using solid elements. Stud bolts are modeled using rigid beams. For concrete material, the Drucker-Prager model is used. It is demonstrated that the experimental results, which show asymmetric behaviors due to contact of the slab to the column, can be simulated accurately by conducting the high-precision FE-analysis of the composite beam.

Finally, the constitutive model for steel and the detailed model of the composite beam are incorporated into the high-precision FE-model of the four-story building frame, which is a specimen of the full-scale shake-table test conducted in E-Defense. The accuracy of the analytical result is examined in comparison with more than 500 strain data measured in the E-Defense shake-table test.

References

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