17th Symposium on Earthquake Engineering
November 14-17, 2022
IIT Roorkee, India
Paper No. 91

A Comparative Study of Computational Modelling Frameworks for Structural Assessment of Reinforced Concrete Beam

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Abstract

Computational models play an important role in assessing the structural response of reinforced concrete (RC) buildings under seismic excitation. The computational modelling frameworks available for RC structures are i) macro-element model-ling, ii) high fidelity 3D finite element modelling, and iii) multi-scale modelling with the adoption of sub-structure technique. Macro-element models are computationally least demanding but require extensive calibration for simulating the inelastic responses of RC members and connections with complex details. Further, 3D finite element models require minimal calibration for modelling complex RC members and connections but are computationally challenging. In contrast, the multi-scale computational framework adopts 3D finite element modelling at complex detail regions and macro-elements for the rest of the structure to provide a balance between computational efficiency and calibration complexity. This paper presents the simulation of an RC beam under linear and nonlinear analysis along with the analytical or experimental validation to access the efficacy of abovementioned computational frameworks for modelling the elastic and inelastic responses of RC structures. Considering experimental results as the benchmark while predicting the inelastic response; capacity curve, estimated toughness and the computation time were used to compare the reliability and computational efficiency of abovementioned modelling frameworks. The findings show that all three computational frameworks can predict the elastic response of an RC beam close to analytical results. However, the 3D finite element and multi-scale models gave better prediction of the inelastic response of the RC beam in comparison to macro element model. The computation time taken by the three modelling techniques was maximum for the 3D finite element, intermediate for the multi-scale and minimum for the macro element model. Hence, obtained results validates the computational efficacy of multi-scale model while predicting the inelastic response of a structure accurately.

Keywords: Finite element model, Macro element model, Multi-scale model, Toughness, Computational efficiency.