INSTITUT FÜR RISIKO UND ZUVERLÄSSIGKEIT

Leibniz Universität Hannover

Rheological and computational adaptations of a structural finite element model

Rheologische und rechnerische Anpassungen eines strukturmechanischen Finite-Elemente Modell

Bachelorthesis or higher

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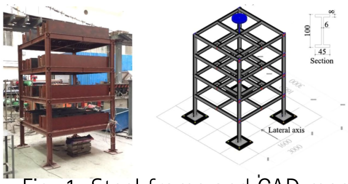

Fig. 1: Steel frame and CAD model (Bai et. al., 2021)

The computational analysis of structural designs and materials play an important role to reduce the risk of structural damage and collapse during seismic events. To further improve design in terms of finding optimal economical and safety setups, not only experiments are necessary, but also simulation models of realistic case studies. Many studies are contributed in this field to validate specific simulation models towards realistic experiments e.g. on shaking tables to either verify material assumptions and/or find critical design combinations and the causes leading to collapse or irreparable damage. However regarding e.g. steel frame structures it is not straight forward to implement suitable rheological models in the simulation in order to fit specific experimental results. For this case different adaptions can be made to refine the outcome and increase the accuracy of the simulation model. Another interesting aspect for structures exhibited to regions with frequent earthquakes is the long time material degradation. Due to the inherited epistemic uncertainty of the external influences (not every earthquake has the same magnitude and frequency, soil properties can vary highly within a earthquake endangered region). The prediction of collapse and even more the prediction of collapse under degraded material is highly uncertain. Therefore an existing Finite Element Model combining different rheological models and uncertain seismic loads with suitable descriptions to reduce the epistemic uncertainty shall be implemented.
Following this path of solving stochastic dynamic systems via numerical models, quickly computational limits will be reached. Therefore additional considerations of the implementation of a surrogate model for the Finite Element Model must be made. An existing artificial neural network for the existing Finite Element Model shall be refined to further decrease the approximation error for specific target quantities. Using this surrogate model the goal is to define failure regions in the probability space of random input material and random load parameters. These findings shall help to further improve the structural design and decrease the probability of failure.

Literature (Selection)

[1] *Bai*, Y., *Li*, Y., *Tang*, Z., *Bittner*, M., *Broggi*, M. and *Beer*, M., 2021: Earthquake-induced collapse reliability of low-rise steel moment frames with additive-mass based on shaking table test, Bulletin of Earthquake Engineering.

[2] *McKenna*, F., *Scott*, M. and *Fenves*, G., 2010: Nonlinear Finite-Element Analysis Software Architecture Using Object Composition. Journal of Computing in Civil Engineering(24).

[3] *Qian*, Y., *Mita*, A., 2008: Acceleration-based damage indicators for building structures using neural network emulators, Struct. Control Health Monit.(15):901–920.

[4] *Khorasani*, N., *Garlock*, M., Quiel, S., 2015: Modeling steel structures in OpenSees: Enhancements for fire and multi-hazard probabilistic analyses, Computers and Structures(157).

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