Polymorphic uncertainty in time-domain dynamic analysis of buildings under earthquake excitation using metamodels

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ABSTRACT

Earthquake engineering deals especially with the design of buildings under strong seismic ground motion. Their structural response is affected by non-linear and non-monotonic influences, e.g., plastic deformation or base excitation itself. Further and not ignorable aspects are the uncertainties of these influences, complicating the design process. This makes a deterministic prediction of the structural behavior practically impossible. For simple structures, design spectra and safety coefficients take this uncertainties into account. To gain more precise insights, or for analysis of complex non-symmetrical buildings, simulations in the time domain become necessary. In doing so, the probabilistic essence of response spectra is dropped and multiple simulations, e.g., with different ground motion signals have to be performed. Thus, objective is the consideration of structural and loading uncertainties directly in nonlinear time-domain dynamic analysis of base excited buildings. In this work, to keep things simple, a symmetric multistory-frame is analyzed. Story stiffnesses and damping values as well as ground motion signals are taken into account as underlying uncertainties. A distinction is made between epistemic and aleatoric uncertainties in order to consider both inherent variability and lack of data. In practical terms, epistemic uncertainty can be reduced with more information, whereas aleatoric can not. The mathematical model is a combination of stochastics and fuzzy set theory known as polymorphic uncertainty (Graf et al. (2015)) . Optimization regarding the computation time is performed taking advantage of the metamodel strategy. Since the input parameters are modeled as fuzzy stochastic variables, the structural response is also an uncertain quantity. Therefore, not only the definition of the uncertain input but also the interpretation of the fuzzy stochastic output must be performed carefully. Finally, the fuzzy stochastic results are compared to the ones obtained by response spectra analysis.

References

[1] Graf et al. (2015): Analysis of dynamical processes under consideration of polymorphic uncertainty, in Structural Safety 52, p.194-201.