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Exploring The Impact Of Excitation And Structural Response/Performance Modeling Fidelity In The Design Of Seismic Protective Devices

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The design of seismic protective devices (SPDs), such as fluid viscous dampers, tuned mass dampers and inerter-based vibration absorbers, requires the adoption of appropriate models for describing the excitation, for estimating structural response and for quantifying performance. This study investigates the impact of modeling fidelity on the design of SPDs focusing on these different aspects of the problem formulation that are carefully chosen so that consistency is established. For the excitation, both stationary and non-stationary descriptions are adopted, and for the non-stationary formulation the use of either stochastic ground motion models or scaling of recorder ground motions is considered. Consistency across these characterizations is achieved by establishing compatibility of the corresponding response spectrum. For the structural response, the use of either linear or non-linear structural models is examined, and for the performance quantification both average response and risk-based estimations are considered. The structural models in the case study are originally developed in OpenSees, and to achieve higher efficiency in the SPD design optimization, the reduced order modeling framework recently developed by the first two authors is leveraged. To accommodate a comprehensive comparison for the SPD designs, a bi-objective performance assessment framework is adopted, similar to previous studies from the authors [2,3], considering both the structural vibration suppression and the device control forces as objectives. The impact of the model fidelity is examined by comparing the performance of the designs established through the lower fidelity modeling assumptions (stationarity assumption, linear structural model, average performance estimation) to the performance of the designs corresponding to the higher fidelity assumptions (non-stationary description, nonlinear structural model, risk-based performance estimation), the latter considered to offer the higher accuracy representation of the actual performance. Implementation for all the aforementioned devices are examined, for two different benchmark structures. Results reveal that the use of lower fidelity models may indeed provide sub-optimal performance in certain settings and may compromise the effectiveness of the protective device. References 1. Patsialis D, Taflanidis A, Giaralis A (2021) Tuned-mass-damper-inerter optimal design and performance assessment for multi-storey hysteretic buildings under seismic excitation. Bulletin of Earthquake Engineering:1-36, 1573-1456 2. Patsialis D, Taflanidis AA (2020) Reduced order modeling of hysteretic structural response and applications to seismic risk assessment. Engineering Structures 209, 110135. doi:ARTN 11013510.1016/j.engstruct.2019.110135 3. Taflanidis AA, Giaralis A, Patsialis D (2019) Multi-objective optimal design of inerter-based vibration absorbers for earthquake protection of multi-storey building structures. Journal of the Franklin Institute 356 (14):7754-7784