Real-Time Hybrid Simulation of Shape Memory Alloy Dampers

Increasing economic and technical requirements make the design of earthquake resistant civil engineering structures with traditional construction materials impossible. Shape memory alloys (SMAs) are metallic smart materials with unique characteristics. Nearly without any residual elongation, SMAs can recover their original shape after mechanical stress induced large deformations with even over 8 % strain. This is made possible by a stress and temperature induced grid transformation of the crystalline structure between austenite (high temperature phase) and martensite (low temperature phase). Due to the superelastic behavior the SMAs become an innovative alternative in comparison to the existing damper systems. A broader application of SMA based dampers in civil engineering require further research both on the numerical and experimental part. The state of the art shows discrepancies regarding the change process of the energy dissipation capacity of the SMAs. Apart from this full-scale shaking table tests with SMA dampers are missing at the experimental part as well as the improvement of existing constitutive models at the numerical part.

In this project real-time hybrid simulations (RTHS) is used to investigate the seismic behaviour of SMA dampers. RTHS method partitions the structure into physical and numerical substructures. RTHS provides a full-scale experimental solution by simulating controlled structures numerically while testing dampers experimentally.

Furthermore, for an accurate prognosis of SMA damper behavior, the research project aims to improve the existing macroscopic constitutive models [1] regarding the dynamic response of the SMA by differentiating between cyclic loading effects, meaning SMA behaviour under repeated loading conditions (harmonic load case), and transient earthquake loading effects regarding the stochastic nature of seismic loading. The experimental study considers rate-dependent, temperature evolution as well as effects of the frequency, strain amplitude and aging of SMA [2].

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