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Hybrid testing for civil engineering structures: overview and future directions

Compared to other engineering systems, civil engineering structures tend to be much larger in size and unique in shape, meaning that only one sample of the same prototype is constructed. Hence, it is not economically sustainable to build other samples at full scale for the purpose of testing. Historically, engineers have been designing such systems to ensure a linear response regime, for which simple analytical models and oversimplified representation of loading may ensure safe design at the price of sub-optimal safety factors. However, today structures are expected to meet higher performance requirements, which are defined for both linear and nonlinear response regimes. In this regime, analytical models utilized for design might not be sufficiently accurate. It follows that enabling cost-effective experimentation plays a central role in validating more predictive analytical models and empirically verifying highly optimized design solutions.

My research at Aarhus University, Department of Civil and Architectural Engineering, develops in this area with a focus on hybrid testing. Instead of a physical model, hybrid testing is performed using a hybrid physical-numerical model of the structural prototype. Specifically, physical models of one or a few structural components of the prototype (physical substructure (PS)) are tested in the laboratory using servo-controlled actuators. A control system ensures displacement compatibility and force balance between NS and PS in real-time. As a result, the experimental response of the PS is excited as it was part of a realistic assembly. Hybrid testing combines elements of computational mechanics, automatic control, and, more recently, machine learning. This presentation provides an overview of my contributions and an outlook on future research directions.

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