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BOOK OF ABSTRACTS

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80: Performance-Based Design of Inundated Coastal Structures

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Finite element models for modeling the structural response of structures to earthquakes and wind loading are well developed. However, the applicability of these numerical models to other hazards such as wave loading due to extreme wind storms is less well understood, particularly due to complex nature of waves interacting with real geometries. This paper presents a unique application to performance-based design development using a numerical model of a wave flume. The model is shown to be able represent the physical 2-D wave flume at Oregon State University including the wave maker, flume and test specimens with sufficient accuracy for design code development applications. Wave spectra at the location of the test specimens were compared to wave spectra in shallow water to ensure they matched the design hurricane waves. Two existing laboratory tests, namely a full-scale transverse wood wall subjected to wave loading and a large scale I-10 bridge subjected to wave loading, were used to confirm the accuracy of the modeling approach. The same approach is used for a full-scale numerical model of a bridge section to illustrate the use of fragility curves for performance-based design of inundated coastal infrastructures.

589: Performance-Based Multi-Hazard Topology Optimization of Structural Systems

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Recently there has been growing interest in developing probabilistic topology optimization techniques for the reliability-/performance-based conceptual design of structural systems. Research efforts have focused on developing frameworks for the topology optimization of building systems subject to a variety of natural hazards, e.g. wind or seismic actions [1,2]. In general, these approaches have been applied to single hazard design scenarios. This is, however, in contrast to the often multiple natural hazards, such as earthquakes, tsunamis, windstorms, and floods, which may be experienced by a structure over its lifespan. Therefore, if truly optimal systems are to be found, a new generation of multi-hazard design and optimization frameworks must be developed. This paper focuses on the initial development of such a framework for the topology optimization of structural systems of buildings subject to significant wind and seismic hazards. In particular, the goal is to describe the performance of the system in terms of metrics, e.g. damage ratios, consistent with the next generation of probabilistic performance-based design (PBD) [3]. The multi-hazard annual exceedance probabilities of these metrics are then estimated through a simulation-based framework that allows a probabilistic auxiliary variable vector (AVV) to be defined for each realization of the simulation. This AVV can then be used to define an optimization sub-problem that not only approximately decouples the optimization problem from the multi-hazard simulation framework, but also allows the optimization problem to take on a classic static and deterministic form. This permits the use of extremely efficient and well established optimization algorithms to be used for finding solutions. By sequentially solving a series of sub-problems, a sequence of steadily improving designs are found. Because each sub-problem is exact in the point in which it is formulated, the final designs rigorously meet the performance constraints of the original optimization problem. The potential of the proposed performance-based multi-hazard topology optimization framework is illustrated through the topology design of a lateral load resisting system of a 2D building subject to significant wind and seismic hazard risks. A parametric study is also carried out in order to investigate the sensitivity of the lateral load resisting system to different natural hazards.
References: [1] S. Bobby, S. M. J. Spence, E. Bernardini, A. Kareem, Performance-based topology optimization for wind-excited tall buildings: A framework, Eng. Struct. 74, 242-255, 2014. [2] J. Chun, J. Song, G. H. Paulino,