Engineering Computations of Large Infrastructures in the Presence of Uncertainty

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Abstract: Engineering computation capability has advanced exponentially in recent years. Increased computer power is one of the major reasons for this growth. It is now routine to incorporate sophisticated knowledge in computational schemes, but the presence of uncertainty must also be considered. Simulation-based schemes have been developed to address uncertainty-related problems. However, they have limited application to studying the realistic behavior of large infrastructure and the computations could be very tedious. The first part of the paper presents the incorporation of uncertainty in a finite element-based computational formulation to satisfy the underlying physics of large infrastructure, denoted as the stochastic finite element method. However, it becomes very inefficient when applied to time-domain dynamic problems. The concept is improved further by combining sensitivity analysis, model reduction techniques, efficient response surface method-based sampling schemes, and advanced factorial schemes producing compounding beneficial effect to obtain efficiency without sacrificing accuracy. It is discussed in the second part. In the third part, sophisticated computation schemes are integrated with noise-contaminated measured response information to extract features of practical interest in the context of structural health assessment. The uncertainty in the measured data cannot completely be eliminated, but measured response data are needed to be integrated with advanced computational schemes for the maximum benefits. This is a very challenging task. In the late 1970s it was erroneously concluded that such integration was not possible, but the author and his team have proven otherwise.