Probabilistic Structural Identification And Prognosis Of A Full–Scale Bridge Pier Subjected To Base Excitation

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This work presents the online damage identification and deterioration prognosis of a full–scale bridge pier subjected to base excitation generating a highly nonlinear behavior, with a particular emphasis on consideration of uncertainties at both the estimation and prediction phases. Results of this analysis have a twofold utility. First, the online identification study (estimation) provides useful input for finite element model updating and provides validation for nonlinear hysteretic laws used to capture reinforced concrete cyclic behavior. Secondly, the prognostic study (prediction) provides an indicator of future deterioration, dependent on the dissipated energy, which could potentially be of use in maintenance scheduling. The dynamic data comes from a full-scale bridge pier which was instrumented and tested at a shake table facility at the University of California, San Diego (PEER Report No. 2015/02). The moment-curvature relationship is modeled using a highly flexible Bouc–Wen type of hysteretic law, capable of capturing a wide range of asymmetric responses. Online structural identification from the recorded dynamic data is implemented with a nonlinear Bayesian filtering algorithm (unscented Kalman filter for joint state and parameter estimation), allowing for consideration of both process and measurement uncertainties. Hysteresis models of different complexities are also compared. During the identification process, a deterioration pattern was established with respect to the parameter related to stiffness. A prognostic analysis, which is still a relatively unexplored topic in structural dynamics, of the stiffness deterioration is therefore attempted. In this experimental application, deterioration is not a function of time, but rather of dissipated energy. The outcome of the prognosis analysis, given a user–defined failure threshold, is then a distribution of dissipated–energy–at–failure, which can be used to predict the probability that the structure will fail during a future event of a given intensity. This distribution is constructed with a gamma process model considering two different scenarios for expected deterioration: a power law, and a hyperbolic law. Again, Bayesian methods are used for estimation of the degradation parameters, allowing a thorough investigation of the various uncertainties – the aleatory uncertainties arising from the inherent stochasticity of the deterioration process, and the epistemic uncertainties that arise from the lack of knowledge in the parameters.