Derivation of Bridge Functionality Loss Curves for the Resilience Analysis of a Road Network exposed to Seismic Risk

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ABSTRACT

An infrastructure is conventionally represented as a system of systems, where individual components are heavily interdependent. In this context, the assessment of the robustness or the resilience of an infrastructure requires to quantify a set of appropriate system performance indicators. The latter are usually accessed through the prediction of the functionality level of the components, and not only their physical damage states.
Therefore the present study details a procedure for the derivation of probabilistic functionality loss curves, applied to the seismic fragility assessment of roadway bridges. The proposed approach may be decomposed into the following steps:

- Identification of the bridge's structural components and corresponding damage mechanisms (e.g. yielding of pier columns, deformation of bearings, deck unseating, etc.);
- Association of each component damage mode with a probabilistic distribution of functionality loss and repair duration, through an expert elicitation process;
- Construction of a Bayesian Network (BN) in order to update the probabilistic distributions of losses at the bridge level, which result from the combinations of damage events at the component level [1].

The resulting curves directly express the probability of reaching or exceeding some predefined functionality levels given the seismic intensity at the bridge location. The use of BNs allows for the joint probability of functionality loss and repair duration to be accessed, which constitute crucial information for the design of restoration strategies.
The derived functionality curves are then applied to a simplified road network, where thousands of probabilistic earthquake scenarios are generated in order to derive the distribution of the resilience index [2], with the inter-city travel time as the main performance indicator. Finally, various assumptions about restoration resources are also tested (e.g. possibility or not to perform repair operations at the same time), in order to check their effect on the restoration strategy.

Keywords: *bridges, Bayesian Networks, functional losses, restoration, fragility curves*

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