Seismic Risk Analysis of Highway Systems Using Loss Estimation Methodology with Geospatial Technologies

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Abstract

Effects of earthquake damage to highway components (e.g., bridges, tunnels, roadways, etc.) can go well beyond life-safety risks and costs to repair the damaged components. Such damage can also disrupt traffic flows which, in turn, can impact the region's economic recovery and emergency response. These impacts will depend not only on the seismic performance of the components, but also on the characteristics of the overall highway system such as its network configuration and roadway-link characteristics (e.g., link locations, redundancies, and traffic capacities). Unfortunately, such traffic impacts are usually not considered in seismic risk reduction activities at state transportation departments. One reason for this has been the lack of a technically-sound and practical tool for estimating these impacts. Therefore, since the mid-1990s, the FHWA has sponsored multi-year seismic-research projects at MCEER that have included development and programming of such a tool with geospatial technologies. This has led to new software named REDARS (Risks from Earthquake DAmage to Roadway Systems) that was released for public use in March 2006.

REDARS is a multi-disciplinary tool for seismic risk analysis (SRA) of highway systems nationwide based on geospatial technologies. For any given earthquake, REDARS uses state-of-knowledge models to estimate: (a) the seismic hazards (ground motions, liquefaction, and surface fault rupture) throughout the system; (b) the resulting damage states (damage extent, type, and location) for each component in the system; and (c) how each component's damage will be repaired, including its repair costs, downtimes, and time-dependent traffic states (i.e., its ability to carry traffic as the repairs proceed over time after the earthquake). REDARS incorporates these traffic states into a highway-network link-node model, in order to form a set of system-states that reflect the extent and spatial distribution of roadway closures at various times after the earthquake. Then, REDARS applies network analysis procedures to each system-state, in order to estimate how these closures affect system-wide travel times and traffic flows. Finally, REDARS estimates corresponding economic losses and increases in travel times to/from key locations or along key lifeline routes. These steps can be applied for single earthquakes and no uncertainties (deterministic analysis) or for multiple earthquakes and simulations in which uncertainties in earthquake occurrence and in estimates of seismic hazards and component damage are considered (probabilistic analysis). This presentation will provide the overview of the FHWA seismic risk analysis program, REDARS.

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