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JOINT RETURN PERIODS OF SCOUR, EARTHQUAKE AND LIQUEFACTION FOR BRIDGES

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Abstract

Multi-hazard coupling effects of scour, earthquake and liquefaction have been increasingly reported to pose critical challenges to the safety and resilience of bridge infrastructure. However, joint return periods of such a complex multi-hazard scenario have never been documented. To fill in this gap, this study proposes a comprehensive probabilistic framework to calculate the joint return periods of scour, earthquakes, and earthquake-induced liquefaction. The methodology begins by computing site-specific scour depth hazard curves based on hydrological data and probabilistic scour models, while deriving bedrock ground motion hazard curves from regional seismic models. Subsequently, liquefaction potential is estimated at discrete depths using a probabilistic triggering framework. This approach accounts for uncertainties in both seismic inputs and site properties to generate hazard curves for Liquefaction Severity Indices (e.g., LPI_{ISH} or LSI_{ru}) in terms of Annual Exceedance Probability. Ultimately, by synthesizing the scour and seismic hazard curves with probabilistic liquefaction outcomes, the study constructs joint return period isosurfaces for the combined scour-earthquake-liquefaction hazards. This framework provides a rigorous quantitative basis for the performance-based design and risk assessment of bridges in complex multi-hazard environments.

Keywords: *Multi-hazard; Earthquake; Scour; Liquefaction; Joint return period; Probabilistic method*