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COMPREHENSIVE SEISMIC RESILIENCE ASSESSMENT METHODOLOGY FOR HIGHWAY BRIDGES

Xiaowei Wang [(1)], Aijun Ye [(2)]

[(1)] *Associate Professor, Department of Bridge Engineering, Tongji University, xiaoweiwang@tongji.edu.cn*
[(2)] *Professor, Department of Bridge Engineering, Tongji University, yeaijun@tongji.edu.cn*

Abstract

Highway bridges dominate transportation road networks and are critical for post-earthquake responses, yet rigorous seismic resilience assessment is limited by the lack of *component restoration models* and unified quantification of recovery trajectories and repair costs. This paper proposes a comprehensive methodology integrating expert-informed component restoration models, bridge functionality loss–recovery modeling, repair cost estimation, and a seismic-design-code-compatible resilience rating scheme. Multi-level damage states and performance indicators are defined for primary components (piers/columns, girders, bearings, foundations, abutments) and secondary components (shear keys, expansion joints) of highway bridges. A nationwide expert-elicitation survey is conducted to model post-event traffic decisions, residual traffic capacity, decision time, repair strategies and durations, and residual functionality during repair, forming component-specific restoration models. These models are then combined to derive bridge-level recovery curves considering multi-component repair mechanisms. Repair cost is quantified via nominal cost rates and damage-dependent modification factors obtained from industry experts. A novel resilience indicator jointly reflecting functionality loss, downtime, and repair cost is proposed, with grading criteria aligned with current seismic design code, and demonstrated on a representative girder bridge. The framework enables standardized, actionable resilience evaluation and supports resilience-oriented planning, retrofit and emergency decision-making.

Keywords*: highway bridges; seismic resilience; component restoration model; repair cost; resilience indicator*