Report Title:

DISASTER RESISTANCE PERFORMANCE OF HIGHWAY BRIDGES: FROM SINGLE TO CASCADING HAZARDS

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Abstract

The mountainous regions of southwestern China are characterized by complex geological conditions and frequent strong earthquakes, which often trigger secondary landslides. The resulting earthquake-landslide cascading hazards pose a severe threat to the safety of highway bridges. Current disaster mitigation strategies primarily focus on isolated hazard events, failing to accurately capture the damage accumulation and structural degradation mechanisms under sequential loads. Consequently, there is an imperative need to transition bridge performance assessment frameworks from single-hazard to cascading multi-hazard scenarios. To address this gap, this study presents a groundbreaking multi-hazard physical testing program designed to simulate the sequential impact of an earthquake and a subsequent landslide, elucidating the mechanical behavior and damage accumulation mechanisms of bridge structures under combined loading. Building upon the experimental findings, a comprehensive numerical simulation incorporating multi-hazard and soil-structure interaction (SSI) was conducted. A full-scale analytical model of a girder bridge accounting for SSI was developed through customized computational subroutines to investigate the effects of post-earthquake landslides on the dynamic disaster evolution and residual vertical load-carrying capacity of the bridge. Finally, a

multi-hazard probabilistic framework based on Copula functions was proposed to evaluate structural failure risk, explicitly accounting for the nonlinear correlation between seismic and landslide intensity parameters.

Keywords: Seismic; Highway girder bridge; Hazard-resistant performance; Earthquake–landslide cascading hazards; Residual vertical load-bearing