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Life-cycle probabilistic loss and resilience quantification of civil infrastructure under extreme events

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Abstract

Resilience and loss assessment plays an important role in hazard risk management and mitigation. As a paramount indicator, resilience has been widely utilized to account for robustness and recovery capability of civil infrastructure. However, previous studies evaluate the resilience conditioned on a single hazard scenario, which is less likely to incorporate long-term uncertainty and multiple hazard effects. Although the life-cycle loss was commonly computed in previous research, quantification of loss has been restricted to the expectation and the stationary occurrence model. Statistical moments, such as standard deviation, skewness, and kurtosis of long-term loss interpreting uncertainty characteristics, were rarely discussed. Uncertainty associated time-dependent characteristics with respect to stochastic occurrence and intensity have not been taken into account. To address these concerns, an integrated life-cycle probabilistic resilience and loss assessment framework is developed to aid the management and decision making of civil infrastructure subjected to hazard effects.

Keywords: Long-term resilience, loss assessment, renewal process, life-cycle.

1 Introduction

Civil infrastructure is threatened by hazards such as earthquakes, hurricanes, and structural deterioration due to incessant exposure over the lifetime, thereby causing catastrophic damages and severe financial and societal losses. Mitigating potential loss and improving resilience of civil infrastructure under such hazards have become primary concerns of the decision-maker. Consequently, it plays an essential role to quantify resilience and loss over the service life.

In previous studies, resilience has been widely investigated in hazard management and mitigation. The quantification of resilience is primarily conditioned on the structural functionality and recovery capability under an individual hazard event, whereas the associated long-term uncertainty has been ignored. During the service life of civil infrastructure, there is substantial uncertainty affecting the performance of civil infrastructure. For instance, under earthquake hazards, uncertainty may spring from earthquake activities, structural performance, and consequence evaluation, etc. In particular, it is necessary to consider uncertainty in terms of hazard occurrence and intensity over a long time period. Though such long-term effect was underlined in the loss assessment in previous research, the quantification of long-term loss was limited to the expectation. Uncertainty indicated

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