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A transverse seismic performance assessment framework for diamond-shaped pylons based on the damaged inter-cross-beam drift ratio

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Abstract

Diamond-shaped pylons are widely adopted in modern bridges due to their superior mechanical and aesthetic performance. However, their unique structural configuration poses significant challenges for seismic damage assessment. Existing methods, which predominantly rely on either localized microscopic responses or global displacements, struggle to quantify the damage state of pylons through macroscopic observable data, thereby limiting the efficacy of post-earthquake rapid diagnosis and performance evaluation. Consequently, this study aims to establish a seismic damage assessment framework for diamond-shaped pylons based on macroscopic deformation indicators. Firstly, the lateral deformation components of the pylon are decomposed, explicitly distinguishing the undamaged component of the inter-beam drift angle (induced by rigid rotation at the base cross-beam) from the damaged component (resulting from force-induced deformations between pylon legs). The latter is proposed as the key macroscopic indicator for characterizing pylon damage. Subsequently, a practical calculation formula for the damaged inter-beam drift angle is derived using a geometric approach. Next, the influence of the pylon inclination angle on structural performance limits is investigated, and limit state criteria for different damage levels are quantified. Based on this, a transverse seismic performance state assessment framework for diamond-shaped pylons is proposed. The results demonstrate that the derived analytical expression effectively predicts the damaged inter-beam drift angle under lateral deformation, offering simplicity in calculation and high accuracy. Furthermore, the assessment conclusions derived from this macro-scale indicator demonstrate consistency with evaluations based on the micro-scale index of sectional curvature, and align with experimental observations, thereby validating the reliability of the assessment framework.

Keywords*: Cable-stayed bridge; diamond-shaped pylon; seismic performance; performance indicator; assessment method*