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INVESTIGATION ON SEISMIC PERFORMANCE OF SHEAR KEYS IN SKEW BRIDGES UNDER PSEUDO-STATIC TESTS

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Extended Abstract

Skew bridges are frequently adopted to accommodate road alignment. However, records from major earthquakes have consistently shown that skew bridges suffer much severer damage than straight bridges. The typical damage modes include significant in-plane rotation, bearing dislocation, shear key failure or even complete girder unseating. For example, during the 2008 Wenchuan earthquake, 14 bridges along the National Highway G213 between Yingxiu Town and Wenchuan County suffered severe or higher-level damage, and all of them were skew bridges. The primary reasons for this vulnerability include: weak restraining effect of transverse shear keys, excessive in-plane rotation of bridge girders, and insufficient supporting length for unseating prevention.

Shear keys play a critical role by restraining the transverse displacement of bridge girders. Properly designed shear keys significantly improve seismic performance. Different from straight bridges where shear keys are mainly subjected to conventional bending and shear forces, transverse shear keys in skew bridges sustain coupled bending, shear and torsion under seismic loads. Without sufficient experimental research and theoretical analysis, adopting the constitutive model applicable to straight bridge shear keys will severely impair calculation accuracy.

Four major deficiencies exist in the research on skew bridge shear keys: unclear failure mechanism, insufficient experimental data, distorted numerical models and lack of design codes. To address this gap, four transverse exterior reinforced concrete shear key specimens, with skew angles of 0°, 30°, 45°, and 60°, were designed and constructed for pseudo-static testing in order to assess the constitutive models and lateral capacity of shear keys. The specimens were designed based on the actual dimensions of shear keys in terms of vertical height and transverse width, while the thickness was kept constant. The seismic performance of skewed shear keys was then evaluated in terms of crack development, force-displacement responses, strain distribution, torsional effects and energy dissipation. The results indicate that the failure mode of shear keys in skew bridges undergoes a fundamental transformation as the skew angle increases. The shear key of straight bridges (DK1) presents symmetric diagonal shear failure, while shear keys with large skew angles (DK3, DK4) suffer pronounced torsional effects, leading to highly asymmetric crack distribution. Moreover, as the skew angle increased, the peak load capacity exhibited a systematic decline. The failure mode evolves from symmetric shear failure to combined torsional failure. Specifically, the peak load of specimen DK4 was only half that of specimen DK1. In contrast to the relatively ductile shear failure observed in straight bridge shear key, failures triggered by skew bridges tend to be more brittle. These failure modes are characterized by diminished deformation capacity, shorter warning times, and consequently, a higher potential risk.

Keywords*: shear key, pseudo-static test, skew angle, seismic performance.*