SHAKING TABLE TESTS ON A PRECAST CONCRETE-FILLED STEEL TUBULAR BRIDGE WITH ROCKING-FEATURED SOCKET CONNECTIONS

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Extended Abstract

Precast concrete-filled steel tubular rocking piers have significant potential for accelerated bridge construction and earthquake-resilient bridge design because of their high structural efficiency, rapid construction, low residual deformation, and post-earthquake recoverability. This study investigates the seismic performance of an innovative rocking-featured socket connection for precast concrete-filled steel tubular bridge piers, referred to as the PCFT-RS system. In this system, the steel tube of the pier is divided into an in-socket segment and an above-socket segment, which are temporarily connected by a detachable steel ring during construction. After the pier is inserted into the grouted footing socket and the grout has cured, the detachable ring is removed, allowing a concentrated gap to open and close at the pier base during earthquake excitation. The post-tensioning bar provides restoring force for self-centering behavior, while the internal mild steel bars serve as energy-dissipation bars.

A large-scale system-level single-span bridge model was tested on a shaking table to evaluate the dynamic response, rocking mechanism, damage evolution, and self-centering capacity of the proposed PCFT-RS bridge system. The bridge model consisted of two PCFT-RS piers with different bearing conditions: one side was connected through fixed bearings, while the other side was supported by sliding bearings. Material properties of concrete, grout, steel tubes, mild steel bars, and post-tensioning bars were examined before testing, and the friction behavior of the sliding bearings was also evaluated. The model was subjected to El Centro and San Fernando ground motion records with successively increasing seismic intensities.

The loading sequence covered the elastic response stage, rocking initiation and gap-opening stage, and strong earthquake damage-evolution stage, with the maximum input peak ground acceleration reaching approximately 1.5 g.

The test program monitored the global and local seismic responses of the bridge system, including superstructure displacement, residual displacement, bearing deformation, fixed-bearing shear force, pier lateral force–drift behavior, base rotation, dynamic properties, and strain responses of the steel tube, post-tensioning bar, and energy-dissipation bars. The experimental results showed that the fixed PCFT-RS pier developed stable and controlled rocking behavior at the pier base. During moderate excitation, the rocking interface began to open, while the pier shaft remained essentially elastic. Under strong earthquake excitation, the damage was mainly localized at the rocking interface and was characterized by concrete cracking, spalling, and local crushing near the pier base. Even under PGA = 1.5 g, no obvious local buckling of the steel tube was observed, the energy-dissipation bars did not fracture, and the post-tensioning bar remained elastic, indicating favorable deformation capacity and low-damage behavior.

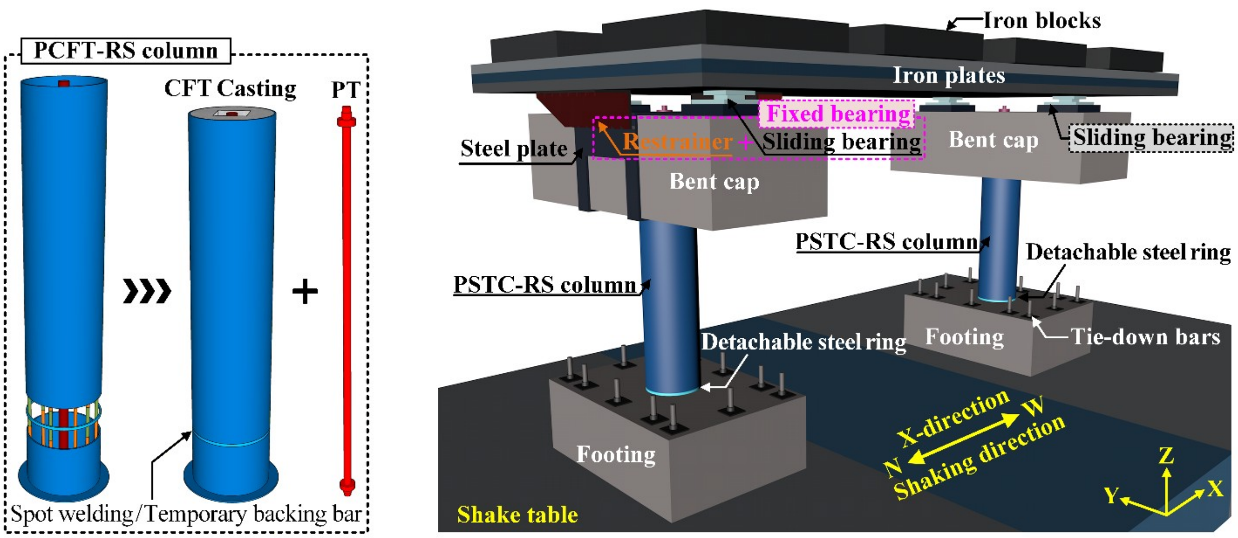

Figure 4- Illustration of PCFT-RS column and the corresponding bridge model used in shaking table test.

The PCFT-RS bridge system also exhibited excellent self-centering performance. Although the peak displacement of the superstructure increased significantly under strong earthquake excitation, the residual displacement remained small. After the 1.5 g excitation, the residual displacement of the superstructure was only about 6.3 mm, and the residual drift of the fixed pier was approximately 0.30%, which was much smaller than the peak drift response. In contrast, the sliding-bearing pier experienced significantly reduced seismic demand due to the isolation effect of

bearing sliding, resulting in limited base rotation, negligible residual drift, and almost no visible damage throughout the tests.

Overall, the experimental results demonstrate that the proposed PCFT-RS bridge system can effectively combine accelerated construction, controlled rocking, localized damage, energy dissipation, and strong self-centering capability. The system provides a promising low-damage and easy-to-repair solution for bridge structures in moderate and high seismic regions. The measured test data can further support numerical model validation and parametric studies for the seismic design and practical application of PCFT-RS bridge systems.

Keywords: *Precast bridge; Concrete-filled steel tubular pier; Self-centering; Rocking-featured socket connection; Shaking table test;*