INVESTIGATION ON EFFICIENT CONNECTION TECHNOLOGY AND SEISMIC PERFORMANCE OF PREFABRICATED BRIDGE PIERS

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Extended Abstract

Driven by the burgeoning demand for the large-scale construction and retrofitting of transportation infrastructure, coupled with severe labor shortages and stringent low-carbon development mandates, Accelerated Bridge Construction (ABC) has emerged as a pivotal paradigm. It is instrumental in catalyzing industry transformation and fostering the high-quality development of urban infrastructural systems. Particularly within complex engineering environments and high-intensity seismic zones, guaranteeing the absolute reliability of connections between prefabricated components is paramount. These connections dictate the structural integrity and constructability of the bridge, serving as the linchpin for the seismic resilience of urban transportation lifelines.

To address the seismic vulnerabilities inherent in current prefabrication technologies, this study proposes and systematically investigates a novel concrete-filled steel tube (CFST) socket connection joint. The mechanical behavior and hysteretic evolution of this joint technology were comprehensively evaluated through quasi-static cyclic loading tests and refined finite element method (FEM) simulations. Findings indicate that employing a thin steel tube for hole-forming within the socket significantly enhances the energy dissipation capacity of the joint. This configuration effectively dictates the damage mechanism, localizing flexural failure within the column region and substantially mitigating post-earthquake residual displacements. Predicated on these mechanical insights, a flexural design methodology for the joints, rooted in the "capacity protection" principle, is formulated. By precisely calibrating the moment capacity hierarchy between the column section and the socket interface, this theoretical framework ensures that the joint reliably achieves an "equivalent-to-cast-in-place" failure mode and targeted seismic performance. Consequently, it provides a robust theoretical foundation for

the design and widespread engineering application of socket joints in high-seismicity regions.

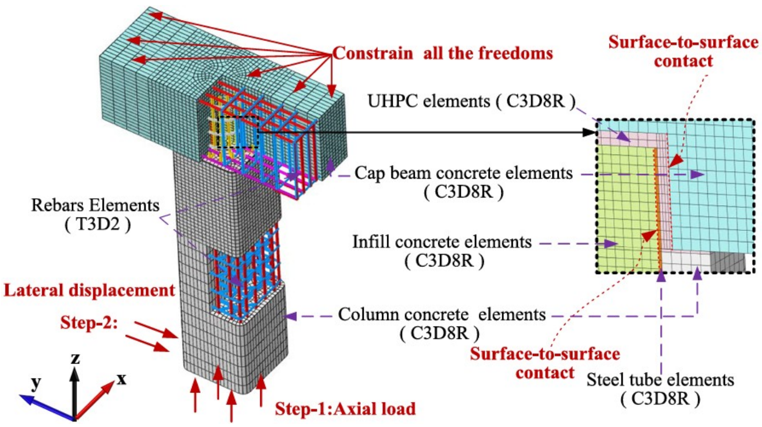
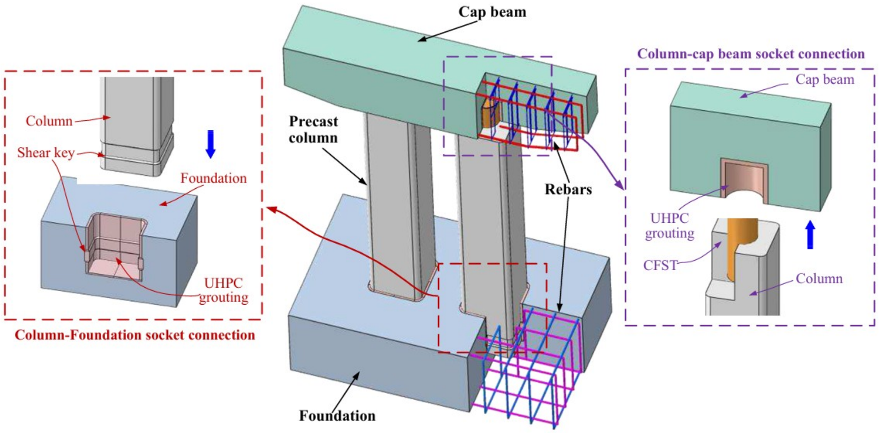


Figure 1- Three-dimensional model of socket joints.

Figure 2- Schematic of the novel precast double-column piers for accelerated bridge construction.

To rigorously validate the reliability of the proposed joint technology and design methodology at the structural level, experimental investigations on the seismic performance of prefabricated double-column pier systems were subsequently conducted. The experimental program facilitated a comparative evaluation among the proposed shear key/CFST socket connection, a corrugated duct connection, and a conventional cast-in-place double-column pier system. Results confirm that the double-column pier utilizing a shear key-socket connection with a reduced embedment depth of 1.0 times the column width (1.0b) successfully achieves capacity protection of the footing. Structural damage is precisely localized within the plastic hinge zone at the column base, thereby precluding shear failure within the socketed region. In comparison to both corrugated duct and cast-in-place connections, the shear key/CFST socket double-column pier system demonstrates superior load-bearing capacity and reduced residual displacements. Furthermore, the integration of the CFST configuration at the pier top effectively restricts the upward propagation of structural damage. Collectively, these findings corroborate the exceptional seismic efficacy of this efficient connection technology in both single- and double-column pier systems. This research contributes a comprehensive theoretical framework and robust technical substantiation for the seismic design and broader implementation of prefabricated bridge engineering in high-intensity seismic zones.



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