EXPERIMENTAL AND NUMERICAL INVESTIGATIONS ON SEISMIC PERFORMANCE OF SELF-CENTERING PREFABRICATED DOUBLE-COLUMN PIERS WITH BRBS

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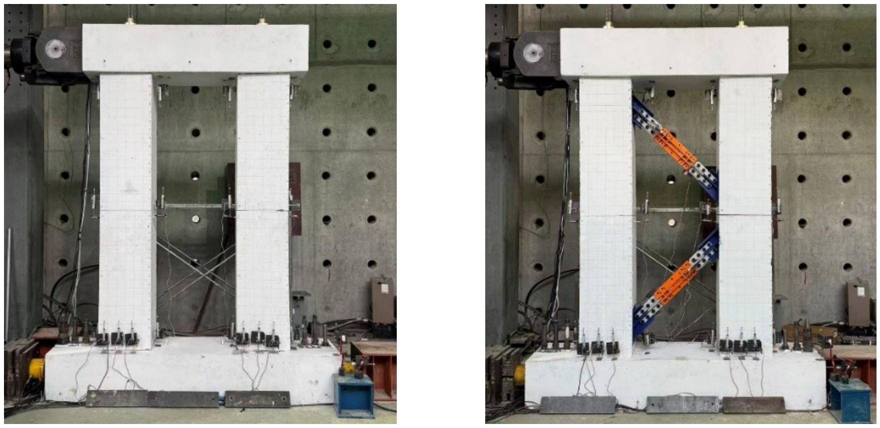
Extended Abstract

Self-centering prefabricated piers have small residual displacement, good self-centering capacity, and high construction efficiency. They are promising for accelerated bridge construction and post-earthquake functional recovery. However, their energy-dissipation capacity is usually limited because the lateral restoring force is primarily provided by prestressing tendons. This makes it difficult to meet both self-centering and energy-dissipation demands during strong earthquakes. To improve the seismic performance, buckling-restrained braces (BRBs) were introduced into a self-centering precast segmental double-column pier. A self-centering precast segmental double-column pier with BRBs was proposed.

The presentation is about two 1:4-scale specimens designed and constructed from a prototype double-column bridge pier, as shown in Figure 1. One was the self-centering precast segmental double-column pier, denoted as specimen SCDP. The other was the self-centering precast segmental double-column pier with BRBs, denoted as specimen SCDP-BRBs. Both specimens used a two-segment configuration. Quasi-static tests were conducted. The hysteretic behavior, lateral strength, stiffness degradation, energy dissipation capacity, self-centering capacity, damage characteristics, and force mechanism of the two specimens were compared.



(a) Specimen SCDP (b) Specimen SCDP-BRBs

Figure 1- Details of self-centering precast segmental double-column pier models with and without BRBs

The test results showed that both specimens exhibited flag-shaped hysteretic behavior, indicating good self-centering capacity. Compared with specimen SCDP, specimen SCDP-BRBs showed fuller hysteretic loops and an upward-shifted skeleton curve. The initial stiffness, lateral strength, and energy dissipation capacity were significantly improved. The initial stiffness increased from 15533.10 kN/m to 37458.48 kN/m, a 141.2% increase. At a displacement of 120 mm, the positive and negative peak lateral forces increased from 198.36 kN and -198.98 kN to 264.13 kN and -259.90 kN, respectively. The cumulative hysteretic energy increased from 62.17 kN·m to 284.66 kN·m, a 357.9% increase. The maximum equivalent viscous damping ratio increased from 0.026 to 0.195. These results show that the BRBs worked together with the pier body during the effective working stage, providing additional lateral stiffness, lateral strength, and energy dissipation capacity.

Finite element models (Figure 2) of specimens SCDP and SCDP-BRBs were established in OpenSees to reproduce the experimental results, including hysteretic curves, skeleton curves, secant stiffness, and cumulative hysteretic energy.

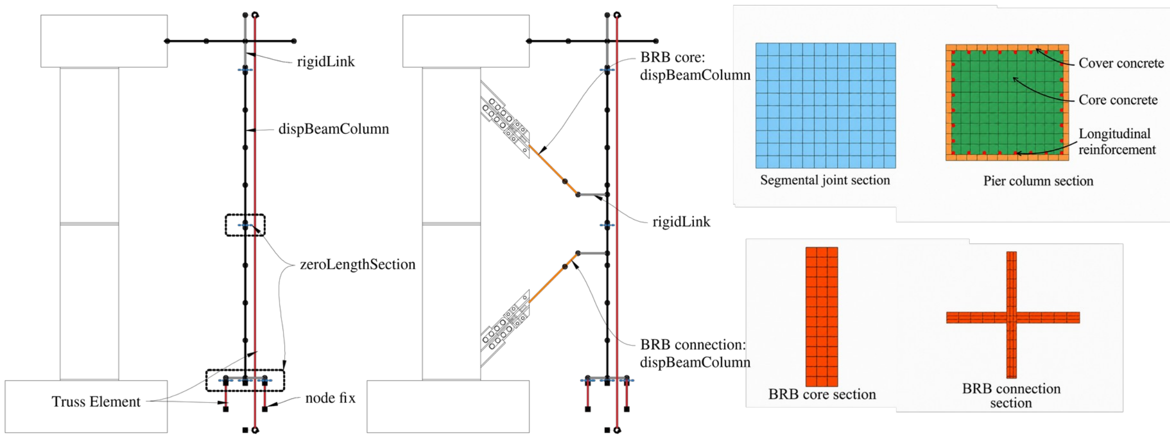


Figure 2- Numerical models of self-centering precast segmental double-column pier with and without BRBs

The simulation results showed that the finite element models reasonably reproduced the flag-shaped hysteretic behavior, the development of lateral strength, stiffness degradation, and the cumulative energy dissipation trend for the two specimens. For specimen SCDP, the model captured the increase in hysteretic loop area after yielding of the energy-dissipating rebars. The average errors for the skeleton curve and secant stiffness were 5.5% and 5.7%, respectively. For SCDP-BRB specimens, a staged BRB element-removal method was used to simulate the gradual loss of BRB contribution after failure. The loading process was divided into three stages: both BRBs participating in lateral resistance, only one BRB continuing to work, and both BRBs being removed from the resisting system. The average errors for the skeleton curve and secant stiffness were 8.6% and 8.7%, respectively. At a maximum displacement of 120 mm, the cumulative hysteretic energy error was 7.6%. These results indicate that the finite element model can reliably simulate the overall seismic response and staged force mechanism of the proposed system.

Keywords: *Self-centering precast segmental double-column pier; Buckling-restrained brace; Quasi-static test; Numerical simulation; Seismic performance*