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Seismic performance of high-strength-steel frame with buckling hinge beams in energy dissipation bays

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ABSTRACT

Although steel moment resisting frame (MRF) systems had long been recognized as effective seismic resistant structures, recent earthquake events and seismic loss estimations indicated that uniform damages of structural members and significant residual deformations would be expected after even a moderate earthquake event for steel MRF systems designed following the conventional ductility-based design philosophy, and this incompleteness produced the impetus for overhaul of design methodologies and developing innovative systems. With the goal of enhancing the seismic performance of steel MRF structures in low-to-moderate seismic regions, this research explored the seismic behavior of high-strength-steel (HSS) frame with energy dissipation bays (EDBs) equipped with buckling hinge beams, denoted as the HSSF-BHEDB system. In particular, the HSS frame is composed of steel with the nominal yield strength higher than 460 MPa, and the buckling hinge beams in the EDBs are constructed with cross-sections classified as Class 3 or Class 4 by Eurocode 3. The motive of the novel design concept was to improve the structural nonlinearity of steel MRF systems with encouraging damage evolution mode and controllable residual deformations under earthquakes, and the limited energy dissipation of both the buckling hinge beams composed of slender cross-sections and HSS members can provide a solution for structures in low-to-moderate seismic regions. In this work, the design concept and the rationale of the HSSF-BHEDB were explored in detail. Then, a large-scale quasi-static test of a structure was conducted to provide experimental evidence and assess the feasibility of the design concept, and the behavior of the specimen from inception of yielding to failure was completely investigated. The test results showed that the system was characterized by the damage-control behavior that diverted inelastic damages in the buckling hinge beams of the energy dissipation bay (EDB) in a wide deformation range. In the stage where the HSS frame initiated inelasticity and the energy dissipation of buckling hinge beams deteriorated, a ductile manner was still achieved. In addition, the controllable residual deformations of the specimen highlighted the satisfactory recentering behavior of the HSSF-BHEDB structure. Lastly, the applicability of the bilinear hysteretic model of significant post-yielding stiffness ratio and trilinear hysteretic model for featuring the hysteretic behavior of the HSSF-BHEDB system in different yielding stages were validated by the test results.

Keywords: Seismic behavior; High strength steel; Buckling hinge beams; Hysteretic model