Seismic Behavior and Performance Evaluation of Steel Structures Equipped with a Pure Bending Yielding Damper System in Terms of Lateral Displacement and Residual Displacement

Amir Mohammad Gohari Anaraki, Farhad Behnamfar, 2023

Different systems have been developed for steel structures to cope with natural disasters such as earthquakes, and seismic fuses are common components of such systems. These fuses concentrate structural damage on one member or a group of members during an earthquake such that such members enter the inelastic phase earlier than the others and protect them from damage. Fuses are easily replaceable in some of these systems. Pure bending dampers are a new technology in this respect. These steel yielding dampers are placed in the middle section of concentrically braced frames, and the axial force of lateral loading on the concentrically braced frame is transferred to these dampers. This axial force is converted into pure bending by the four-point loading system at the center of transverse plates that are perpendicular to the frame axis. The plates enter the inelastic range under pure bending. This study evaluated a special concentrically braced frame (SCBF) (Chevron-braced) and a pure bending damper (PBD)-equipped system with damper-brace stiffness ratios of 0.30, 0.50, 0.67, and 0.85 with four, eight, and twelve stories. Once the structures had been designed in ETABS, dampers were designed for the predefined stiffness ratios. Nonlinear analyses were carried out in OpenSEES. To validate the braced frame models, the results were compared to an experimental braced frame model, and good agreement was observed between the numerical and experimental models. To validate the numerical damper model, ten experimental PBD models were simulated, demonstrating agreement between the numerical and experimental models. Nonlinear static and dynamic analyses were performed under eleven seismic record pairs, and it was found that the PBD showed almost the same tensile and compressive behaviors. It also improved the ductility of the structure and increased plastic deformation absorption. The interstory drift and residual drift were below 1.5% and 1% of the story height, representing the effective stiffness and ductility of the system. Moreover, the analysis of energy dissipation in the nonlinear region showed that the SCBF system dissipated the highest energy through its braces and brace connections, while the PBD system dissipated this energy through PBDs. It was found that the PBDs had the largest contribution to energy dissipation, suggesting that the damage was concentrated on the PBDs. Such a structure could be restored at the minimum cost and in the shortest time after an earthquake.

Keywords:

Damper, Pure bending yielding damper, Structural damper, Concentrically brace, Steel structure, Nonlinear static analysis, Nonlinear dynamic analysis.