Development of Modular Connections for Steel Special Moment Frames

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Abstract

Modular connections have been developed for use in seismic-resistant steel moment frames. The connections are engineered specifically to meet performance requirements corresponding to optimal seismic response. The versatility in design required to accomplish this task is not readily available with traditional rolled shapes. Thus, the designs rely on advancements in casting technology to create connections specifically configured for seismic performance.

The impetus for developing the modular connections is the recently discovered susceptibility to fracture of welded connections in steel special moment frames (SMFs) during earthquakes. The consensus from subsequent research on steel moment connections is that an effective earthquake-resistant connection design should be based on a combination of weld fracture mitigation measures and changes of connection configuration aimed at reducing the stress levels or redirecting the stress flow in the connection Thus, major features of the modular connections are both the minimization of stress/strain and the removal of the field weld from the critical cross-section.

To date, the following prototypes had been fully developed: (1) a panel zone dissipator modular node (PZ-MN); and (2) a bolted modular connector (MC). The PZ-MN dissipates energy through stable panel zone yielding without column kinking and no weld distress; the MC dissipates energy in a variable-arm connector that minimizes plastic strain demand and prying forces. A plastic hinge dissipator and a post-tensioned connection system are also under development.

The PZ-MN and MC final prototypes were developed through a comprehensive analytical investigation of trial configurations and key parameters using nonlinear (material and geometry) finite element analysis. Full-scale prototypes of the PZ-MN and MC have been created and tested under the FEMA-350 protocol. These connections exhibited excellent performance in terms of energy dissipation, stability and ductility; far exceeding qualifying drift capacities.