Challenge

According to the U.S. Department of Energy, construction and use of commercial and residential buildings accounted for nearly 45% of U.S. energy consumption in 2009. A new design approach known as Design for Deconstruction (DfD) has emerged to facilitate future reuse of materials.

Structural steel framing systems are particularly conducive to deconstruction at the end of a structure’s service life. However, the primary challenge of deconstructing steel buildings is addressing the monolithic construction of composite steel/concrete floor systems (Figure 1, at right). While these floor system components may be recycled, currently they cannot be easily refabricated and reused.

Solution

The proposed system (Figure 2, at left) maintains the efficiency benefits offered by composite action and steel construction, including reduced steel beam sizes, flexible floor framing patterns, and use of recycled materials, while directly addressing the need to reduce waste in the construction industry.

The research includes quantification of deconstructable composite connection behavior through full-scale testing of clamping connections and conducting full-scale tests and corroborating analyses of the proposed deconstructable floor system to validate its integrity.
Pushout Test

A series of full-scale pushout specimens were tested to study the strength and ductility of the clamping connectors. In the pushout tests, a wide range of parameters are evaluated and strength design equations are formulated.

Figure 4 illustrates the load-slip curves of different pushout specimens. Under monotonic loading, the behavior of the M24 clamps is ductile, and the clamps can retain almost 80% of their strengths at a slip of 5 in. Starting at a slip of 0.68 in., the strengths of the M20 clamps begin to decline; however, as demonstrated in the composite beam tests, the maximum slip demand for the M20 clamps is 0.35 in, much less than 0.68 in. Hence, no strength degradation is expected for the M20 clamps if used in composite beams. Under cyclic loading, the strength of the specimen using M24 clamps gradually decreases as the slip increases. Another plot is shown which focuses on the behavior of the cyclic specimen in a slip range that is typical for clamps used in composite diaphragms. The peak shear strength of a M24 clamp is 22.1 kips, very close to 21.5 kips which is the strength of a ¾” shear stud embedded in a 4 ksi solid concrete slab.

References

