

Steel Deck Design with Mechanical Fasteners

BY ROBERTO RISMAN AND WILLIAM GOULD



FIGURE 1



FIGURE 2

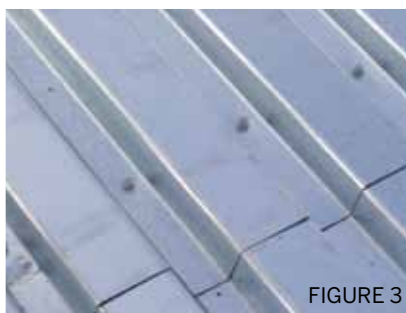


FIGURE 3

Figure 1 – Powder-Actuated Fastening of Steel Deck.

Figure 2 – Steel Deck Diaphragm Test Frame - FSRL, Schaan, Liechtenstein.

Figure 3 – Steel Deck Endlap with Powder-Actuated Fasteners foreground.

powder-actuated fastened or welded-with-washer deck-to-frame connectors demonstrated a higher ability to maintain their capacity under inelastic loading cycles.

Alternatives to Welding and Button Punching

According to the NBC 2005, the primary SLRS of the building must have ductile properties in order to qualify for a seismic force reduction factor. Future research in this area is needed and continues, and could result in different R-values. Research has shown that steel deck diaphragms fastened with button punched side laps and standard fusion welds to the supporting frame, were found to be unsuitable as seismic energy dissipating elements.

In 2005, the Canadian National Building Code introduced several new provisions for the design of buildings in seismic areas. Based on these changes, the design of roof deck diaphragms requires ductile behavior. Design engineers across the country have investigated new methods for fastening of roof deck to the building steel frame. Arc spot puddle welds used to be the industry standard, but because of the new building code changes, guidelines have been developed for the use of increasingly popular mechanical fasteners such as powder-actuated fasteners and screws.

General Changes on the NBC 2005/CSA S16.01

The Province of British Columbia has adopted the new structural steel code, CSA S16.01. There are several new provisions along with a requirement for the roof diaphragm to be designed to meet or exceed the strength of the seismic load resisting system (SLRS). The new requirement will have consequences on the design of large diaphragm structures in seismic areas. Buildings that incorporate stiff concrete or masonry shear walls may require diaphragm capacities well beyond the available range of steel deck.

Steel Deck Seismic Research

Professor Robert Tremblay at Ecole Polytechnique Montreal has conducted research into the performance of steel deck diaphragms to examine whether the steel deck can perform as a ductile resisting element. Results of monotonic, reversed cyclic, quasi-static, and simulated earthquake motion tests of steel deck diaphragms have been conducted. According to research, possible relaxation can be considered for diaphragms where ductile response can be demonstrated.

The Behavior of Roof Deck Diaphragms under Quasi-static Cyclic Loading

Professor Tremblay conducted many large-scale diaphragm system tests on different steel deck assemblies, including button punches, welds, welds-with-washers, screws and powder-actuated fasteners. Monotonic tests showed that the SDI (Steel Deck Institute) Diaphragm Design Method was adequate for predicting the strength and stiffness of diaphragms provided that proper fastener properties were used. Generally, the results of the cyclic tests show that diaphragms with welded deck-to-frame connections without washers have limited ductility. On the other hand, diaphragms with typical B-deck profile sheets, screwed side lap connectors and either

Additional inelastic, cyclic load tests of steel deck diaphragms with powder-actuated fasteners were conducted in 2007 at the Hilti Fastening Systems Research Laboratory in Schaan, Liechtenstein in order to complement former tests done by Professor Tremblay, et al. The objectives were to investigate the general cyclic load performance as well as the effect of screwing the endlap instead of using powder-actuated fasteners. All cyclic test results from FSRL showed a pinched shape due to dominating sidelap and sheet failure modes. Cyclic test results tracked well with reference static test curves. The static performance thus provided a reliable indication on the cyclic performance. Ductile behavior was developed in all tests.

The general diaphragm failure mode for 22 ga. and 20 ga. deck was ductile sidelap failures in combination with ductile sheet slotting at the deck-to-frame connections. The method of endlap connection however, was found to have very little effect on the diaphragm performance. For thicker deck tests (20 ga. and 18 ga.), the deviations were negligible. For the 22 ga. tests, the powder-actuated fastened endlap outperformed the screwed endlap by approximately 10 per cent. Based on the available results and observed failure behavior, extrapolation of 22 ga. and 20 ga. cases appears acceptable for other geometrical configurations than those which were tested.

In case of the thicker 18 ga. deck, however, extrapolation to other geometries than tested is currently not recommended as the static pre-test showed less ductility than the corresponding cyclic test. The 18-ga test behaviour shows a higher scatter with respect to ductility and, therefore, is currently less accurate and predictable considering the small number of tests available to date.

Mechanical fasteners with proven ductile behavior, confirmed through research testing, have been used on most roof deck diaphragm designs in British Columbia. Additional seismic research and new fastener developments continue. Cooperation between industry representatives, structural engineers and construction professionals will lead to the next chapter in steel deck design and construction. **CB**

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