



## STRUCTURAL ENGINEERS ASSOCIATION OF CALIFORNIA

February 6, 2008

**Subject:** Wood structural panel diaphragms and shear walls using staple fasteners – informational bulletin

Based on recent tests conducted by Ben Schmid, structural engineer in Southern California, SEAOC Building Code Committee expressed concern that damage to staples from earthquake lateral forces cannot be visibly evaluated because the staple crowns showed no visible distress regardless of movement or failure of the legs. Common nails, on the other hand, reveal the degree of distress by nail heads bent and with lateral displacement of the shaft as a slot in the outer surface of the plywood. SEAOC Building Code Committee recommends staples fasteners values under Tables 2306.3.1, 2306.3.2 and 2306.4.1 be used with guarded caution for structures assigned to Seismic Design Category C, D, E or F under the 2007 California Building Code (CBC).

The question of staples used in the 2007 CBC came into question during the review of Los Angeles Regional Uniform Code Program (LARUCP) in LA Basin Chapter Structural Committee meetings attended by a minimum of eight Building Department officials and four local Structural Engineers from the months of May through September this year. The purpose of the meetings was to amend some provisions in the 2007 CBC to more strict provisions due to the geologic threat of the approximate 20-years repetition of earthquakes affecting the Los Angeles basin.

When the shear values listed for staples were reviewed, the question of how the listed values were obtained was raised. A representative of the American Plywood Association (APA) provided the web address to obtain the International Code Council Evaluation Service Report ESR-1559 (65 pages) as the basis for the staple tables in the 2007 CBC. The predecessor legacy report was the National Evaluation Service NER-272, Power-driver staples and nails in all types of building construction, issued to International Staples, Nail and Tool Association, La Grange, Illinois.

A review of the ESR-1559, listed in Paragraph 3.2.3 Page 2, Staple Bending Moments (m) provides the following:

16 ga. staples = 3.6 in.-lbs.

14 ga. staples = 4.3 in.-lbs.

The listed bending moment means that you can put a staple in a vice, with 1-inch of the crown above the vice jaws and bend the staple with your thumb.

Paragraph 3.3.2 Page 2, Nail Bending Strength ( $F_y$ ), provides the following yield strengths for common nails:

8d common nails, 0.131 in. dia. = 100 ksi

10d common nails, 0.148 in. dia. = 90 ksi

With this data (although not given in ESR-1539), the Nail Bending Moment is  $F_y \times$  Section Modulus.

8d = 22.5 in.-lbs. (3 times 16 ga. Staples with two legs)

10d = 28.6 in.-lbs. (3 times 14 ga. Staples with two legs)

The lateral load equations for nailed connections are given in Appendix A, Page 59 and stapled connections, Page 60. However, these equations are for static loading. Cyclic loading for testing of nailed fasteners on Plywood and Oriented Strand Board (OSB) panels were undertaken at UCI and CUREE from 2000 to 2002. Such cyclic loading is used for the design and response of structures in earthquakes. Additional concern was also expressed regarding possible limited resistance of staples to corrosion versus nails.

In the tests conducted by Ben Schmid, the first set of tests was based on COLA/ SEAOSC testing criteria. The second set of tests was based on the CUREE test protocol. The results showed the Strength Limit State (SLS) for the 16 ga. staples occurred at 1 inch drift (0.01h). The SLS for the 8d common nails at the same spacing was twice the strength and at 1.6 inch drift (0.016h). Both sets of tests showed that the staples provide somewhat similar shear value at small panel drifts up to ½ inch, but at larger drifts beyond 1-inch, stapled sheathing loses shear values in comparison with common nails. Beyond 1-1/2 inch panel drift, using staples, life safety becomes a concern. Nailed sheathing drift extends to 3-1/2 inch before becoming a life safety concern. The noted cyclic test data for the staples and nails are included as attachment.

After the tests, it was noted that failure of the staples occurred between the back-side of the plywood sheet and the face of studs after only 10 or 12 reversed cycles. Nails exhibited heavy bending either at the head or in slots in the plywood face or studs by nail bending. In contrast, after staple failure or heavy bending, the crown of the staple showed no sign of the stapled legs distress, appearing the same as first installed. Thus, it would be impossible to evaluate the degree of loss of shear strength in stapled panels after seismic shaking without partially removing the panel. Four photos (included as an attachment), after removing the plywood from the frame, show the typical shearing of the staple legs while the crown is unaffected.

In summary, we believe there are sufficient life safety concerns to warrant notifications to the building officials in regions of Seismic Design Categories C to F within California. Until a formal proposal to the California Building Standards and/ or the International Code Council can be reviewed and approved, local jurisdictions in California may adopt amendment to limit the use of staple fasteners only with the validation tests and approval of building officials. Engineers who use this information should use independent professional judgment. For further information, please contact SEAOC Building Code Committee.