AISI S400-15/S1-16

American Iron and Steel Institute

AISI STANDARD

Supplement 1 to 2015 Edition of North American Standard for Seismic Design of Cold-Formed Steel Structural Systems

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The material contained herein has been developed by the American Iron and Steel Institute (AISI) Committee on Framing Standards. The Committee has made a diligent effort to present accurate, reliable, and useful information on seismic design for cold-formed steel structures. The Committee acknowledges and is grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. Specific references are included in the *Commentary* on the *Standard*.

With anticipated improvements in understanding of the behavior of cold-formed steel and the continuing development of new technology, this material will become dated. It is anticipated that AISI will publish updates of this material as new information becomes available, but this cannot be guaranteed.

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SUPPLEMENT 1 TO 2015 EDITION OF NORTH AMERICAN STANDARD FOR SEISMIC DESIGN OF COLD-FORMED STEEL STRUCTURAL SYSTEMS

1. Revise AISI S400-15 Sections E1.3.3, E2.3.3, and E6.3.3 as indicated below:

E1.3.3 Expected Strength [Probable Resistance]

The expected strength [probable resistance] ($\Omega_E V_n$) shall be determined from the *nominal strength* [*resistance*] in accordance with this section.

In the U.S. and Mexico, the expected strength factor, Ω_E, shall be 1.8 for shear walls sheathed with wood structural panels. ~~equal to overstrength factor, Ω_o, determined in accordance with the *applicable building code*.~~

> ~~**User Note:**~~
> ~~In the U.S. and Mexico, for *cold-formed steel* light frame *shear walls* sheathed with wood structural panels, specific research on the expected strength of the walls based on energy dissipation at the *connection* between the sheathing and *studs* has not been completed. As a result, the overstrength factor, Ω_o, obtained from the *applicable building code* is used as a coarse estimate at this time. Based on ASCE 7, Ω_o=3 for bearing wall systems and 2.5 for building frame systems.~~

In Canada, the expected strength factor, Ω_E, shall be 1.33 for walls with DFP wood-based structural panel sheathing or OSB wood-based structural panel sheathing, and 1.45 for walls with CSP wood-based structural panel sheathing.

E2.3.3 Expected Strength [Probable Resistance]

The expected strength [probable resistance] ($\Omega_E V_n$) shall be determined from the *nominal strength* [*resistance*] in accordance with this section.

In the U.S. and Mexico, the expected strength factor, Ω_E, shall be 1.8 for shear walls with steel sheet sheathing.~~be equal to the overstrength factor, Ω_o, determined in accordance with the *applicable building code*.~~

> ~~**User Note:**~~
> ~~In the U.S. and Mexico, for *cold-formed steel* light frame *shear walls* with *steel sheet sheathing*, specific research on the expected strength of the walls based on energy dissipation at the *connection* between the sheathing and *studs* has not been completed. As a result, the overstrength factor, Ω_o, obtained from the *applicable building code* is used as a coarse estimate at this time. Based on ASCE 7, Ω_o=3 for bearing wall systems and 2.5 for building frame systems.~~

In Canada, the expected strength factor, Ω_E, shall be 1.4 for walls with *steel sheet sheathing*.

E6.3.3 Expected Strength

The expected strength ($\Omega_E V_n$) shall be determined from the *nominal strength* in accordance with this section. The expected strength factor, Ω_E, shall be equal to 1.5 for shear walls with gypsum board or fiberboard panel sheathing.~~the overstrength factor, Ω_o,~~

~~determined in accordance with the *applicable building code*.~~

~~**User Note:**~~

~~In the U.S. and Mexico, for *cold-formed steel* light frame *shear walls* sheathed with gypsum board panels or *fiberboard* panels, specific research on the expected strength of the walls based on energy dissipation at the *connection* between the sheathing and *studs* has not been completed. As a result, the overstrength factor, Ω_o, obtained from the *applicable building code* is used as a coarse estimate at this time. Based on ASCE 7, Ω_o=2.5 for bearing wall systems and building frame systems.~~

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SUPPLEMENT 1 TO 2015 EDITION OF COMMENTARY ON NORTH AMERICAN STANDARD FOR SEISMIC DESIGN OF COLD-FORMED STEEL STRUCTURAL SYSTEMS

1. Revise AISI S400-15-C by adding Section B3.3, and revising Sections E1.3.3 and E6.3 as indicated below:

B3.3 Expected Strength [Probable Resistance]

The expected strength [probable resistance] may be expressed as a factor (Ω_E) times the nominal strength.

In the United States and Mexico: In AISI S400-15, an upperbound (conservative) value for $\Omega_E = \Omega_o$ was employed when additional information for determining Ω_E was unavailable, e.g., in Section E1.3.3. In 2016, a more precise upperbound estimate for Ω_E was recognized. At the design limit, $\phi V_n = V_{be}/R$ where V_{be} is the elastic base shear demand. The expected equilibrium between the demand and capacity is $\Omega_o V_{be}/R = V_n + V_o$, where V_o is the lateral resistance of elements outside of the *seismic force-resisting system* (SFRS). Substituting the design limit for V_n and assuming, as an upperbound, that no force is carried outside of the SFRS ($V_o = 0$) results in an upperbound estimate of $\Omega_E = \phi\Omega_o$. This upperbound would appear to reward systems with low ϕ (i.e. highly variable). As an additional check, it is considered that the exceedance probability of the upperbound capacity ($\Omega_E V_n$) should be the same as the lowerbound failure probability, assuming a symmetrical probability distribution. This implies: $\Omega_E V_n = V_n + (V_n - \phi V_n)$, or $\Omega_E = 2 - \phi$. Thus, an upperbound is established that $\Omega_E = \max(\phi\Omega_o, 2 - \phi)$. This upperbound is applied in this *Standard* when additional information is unavailable for determination of Ω_E.

E1.3.3 Expected Strength [Probable Resistance]

This *Standard* incorporates a *capacity-based design* approach in which an element (fuse) of the *seismic force-resisting system* of a structure is designed to dissipate energy. The fuse element, known as the *designated energy-dissipating mechanism*, must be able to carry seismic *loads* over extensive inelastic displacements without sudden failure. It is expected that the fuse element will fail in a ductile, stable and predictable manner, at which time it will reach and maintain its maximum load-carrying resistance. In a structure that makes use of *cold-formed steel* framed *shear walls* with *wood structural panel*s as lateral force-resisting elements, the *shear walls* themselves can initially be thought of as the fuse elements in the larger *lateral force-resisting system*. More specifically, it is the sheathing-to-steel framing *connections* of the *shear wall* that have been shown to fail in a ductile fashion and hence, it is these *connections* that are the *designated energy-dissipating mechanism* – i.e., the fuse. Thus, we seek the expected strength of this mechanism so that it can be protected.

The *capacity-based design* approach stipulates that all other *component*s and *connections* in the lateral load-carrying path must be designed to withstand the expected [probable] strength of the *designated energy-dissipating mechanism* (fuse) element, where the expected strength takes into account expected overstrength (strength above nominal) that may exist. In the case of a *cold-formed steel* framed *shear wall*, the *system* includes the *chord studs*, field *studs*, *hold-down* and anchorage, *track*, etc.; these *component*s are designed to carry the expected [probable] strength of the *shear wall* while the sheathing-to-framing *connections* fail in a ductile manner. To design the *chord studs* and other *component*s of the *seismic force-resisting system*, it is necessary to estimate the probable capacity of the *shear wall* based on a sheathing *connection* failure mode. This can be achieved by applying an overstrength factor to the *nominal resistance* (Figure C-E1.3.3-1).

In the United States and Mexico: It should be noted that the *nominal strengths* shown in Table E1.3-1 are based on a degraded backbone curve determined using the SPD cyclic protocol (Figure C-E1.3.1-1). Testing of similar specimens with the SPD and CUREE cyclic protocol were 20 percent higher using the CUREE cyclic protocol (Boudreault, 2005). Thus, expected strengths in the United States and Mexico are at least 1.2 times v_n in Table E1.3-1. However, no additional analysis has been conducted for finding expected strength. As a result, the upperbound estimate introduced in *Commentary* Section B3.3 is employed: $\Omega_E = \max(\phi\Omega_o, 2 - \phi)$.~~a conservative approach has been adopted at this time: the system overstrength factor, Ω_o, obtained from the *applicable building code* is used as a coarse (and conservative) estimate.~~ For this system, $\phi = 0.6$, and ~~B~~based on ASCE/SEI 7-10, $\Omega_o = 3$ for bearing wall systems and 2.5 for building frame systems, resulting in $\Omega_E = 1.8$.

(No changes to the rest of this section.)

E6.3 Shear Strength

The requirements for *nominal strength* of *shear walls* with gypsum board or *fiberboard* panel sheathing are comparable to those of *shear walls* with *wood structural panel* sheathing. Refer to Section E1.3.1, and also the following sections for additional commentary.

Strength of *Type I shear walls* with *fiberboard* panel sheathing are based on studies by the NAHB Research Center (NAHB, 2005) and by the American Fiberboard Association (PFS, 1996; and NAHB, 2006). The *nominal strength* values for *shear walls* faced with *fiberboard* in Table E6.3-1 were based on monotonic tests of *fiberboard* sheathed, *cold-formed steel* framed *shear walls* and were compared to the monotonic and cyclic tests that are the basis of the building code tabulated capacities for *fiberboard* sheathed, wood framed *shear walls*. For the 2-inch (50.8 mm) and 3-inch (76.2 mm) edge screw spacing, the *nominal strength* values in Table E6.3-1 were based on the average peak load from tests of two 8-foot (2.438-m)-wide by 8-foot (2.428-m)-tall wall specimens. These *nominal strength* values were found to be within 90 percent of the *nominal strength* values for similarly sheathed wood framed walls. The ratio of steel-to-wood *nominal strength* values increased as the edge (perimeter) fastener spacing increased and, therefore, extrapolating the 2/6 (92% ratio) and 3/6 (96% ratio) design values to 4/6 using a ratio of 90% was conservative. For the 4-inch (101.6 mm) edge screw spacing, the *nominal strength* values were calculated as 90 percent of the *nominal strength* value for a similarly sheathed wood framed wall.

In the United States and Mexico: The upperbound estimate for expected strength introduced in *Commentary* Section B3.3 is also used for gypsum board and fiberboard shear walls. For these shear walls, per ASCE/SEI 7-10 with bearing wall systems, $\Omega_o = 2.5$, and $\phi = 0.6$, results in an upperbound $\Omega_E = 1.5$.

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