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ANALYSIS & TESTING OF TUBE SYSTEM FOR ROOF-LOAD TRANSFER TO JOISTS

Summary

Chicago Clamp Company's tube system, for the transferring of roof loads to joists, consists of steel components: End Clamps, framing members (tubes), T-brackets, hanger clamps and hardware. The End Clamps connect the primary tubes to the top chords of the joists. The T-brackets connect the secondary tubes to the primary tubes. The positions of the secondary tubes between joists can be adjusted by sliding the T-brackets.

Analysis of the Standard End Clamp indicates that it can support an allowable static load (net load) of 750 lbs and the Joist Grip End Clamp can support an allowable load of 1,000 lbs. The smallest maximum load, applied in static testing, was 3,610 lbs per bracket. The bracket's static fracture load was not reached. Analysis and testing included consideration of both shear in and bending of the bolts that transfer load from the tubes to the clamps. The bolts are SAE J429 (Grade 5), tightened to a usual snug condition. Analysis and testing were based on the worst-case position of support. In that case, the center of the support is 5" from the near edge of the clamp's deep section (i.e., the shallow section spans 5").

Analysis of the T-bracket indicates an allowable static load of more than 1,000 lbs. A static test load of 4,910 lbs per bracket was applied with no failure.

The tested framing system consisted of cold-formed HSS 4" x 2" x 1/8" tubes (4" vertical, weighing 4.75 pounds per foot and conforming to A500 Grade B [46 ksi minimum yield]). The maximum span tested was 10'. Analysis was based on the 2005 edition of the AISC Specification (13th edition of the Steel Construction Manual) and a safety factor of 2.0, which exceeds the minimum required value of 1.67 for flexure. A static strength-based allowable of 1,572 lbs was calculated for a concentrated load applied at the middle of an 8' span, and 1,249 lbs for a 10' span. For spans of 6' or less, the allowable load is limited to 2,000 lbs. Tubes are considered in this analysis to be braced only at the ends. A maximum static test load of 3,400 lbs was applied at the center of a 10' span, without failure. Allowable loads are also limited so that the tube's calculated deflection does not exceed span/240. This deflection limit is often used as a serviceability criterion for roof framing, but permissible design deflection is to be determined by the responsible design professional.

The hanger clamp was tested to a maximum static load of 4,000 lbs, without total failure. At this load, noticeable bending occurred in both the 3/8" bolt and the clamp's bottom flat at the level of the 5/8" nut. At 2,000 lbs, bending was not noticeable. The hanger clamp was also analyzed, for an allowable static load of 1,000 lbs, based on a minimum safety factor of 2.0. As part of the analysis, the bending strength of the bottom flat was modeled using three inelastic hinges (one at the middle and at each corner). The results indicated that the allowable load is appropriate and that the formation of three "plastic" hinges conservatively approximates the observed behavior at the highest test load.

Adjustments of maximum test loads were made to account for possible differences between minimum and actual values of yield stress and of thickness. The actual maximum test load was multiplied by the ratio of the tube's minimum-specified yield stress to the yield stress based on a test coupon. This partially-adjusted test value was then multiplied by 0.93 to account for the possibility that the tested tube had nominal rather than minimum thickness. The ratio of the fully-adjusted test load to the tube's allowable load was found to exceed 2.0. Similar adjustments were made for the strength of the End Clamp. The ratio, of the adjusted test load to clamp or bracket allowable, also exceeded 2.0.

The Engineer of Record is responsible for the design adequacy of the joists or beams that support the tube system.