PDHonline Course S241 (2 PDH)

Pin Connections for Cold-Formed Steel with Spreadsheet

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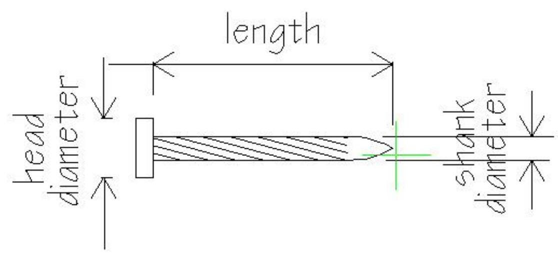
INTRODUCTION

Steel pins have been code approved for making connections to steel and concrete for over 20 years (Ref. 1, p. 1). There is great potential for the increased use of pneumatically driven pins in light weight cold-formed steel construction as a substitute for or supplement to screws. The use of pneumatic pin coil fastening tools in cold-formed steel construction might be compared to the use of nail guns in wood construction. They promise very significant gains in productivity and in the reduction of waste (Ref. 2). Manufacturers have used universities and independent testing agencies to determine the structural capacities of steel pins in light weight cold-formed steel. For example, Aerosmith lists several such reports on its website (www.aerosmithfastening.com/testing and approvals). One of these reports, LGSRG 2-96, "Design Provisions for Aerosmith, Inc. Steel Pins," is the major basis of this course and can be downloaded free of charge.

STEEL PINS

Steel pins are proprietary products made by several different manufacturers. They are pneumatically driven and used to connect steel to steel or other materials (plywood, hardiplank, etc.) to steel or to concrete as an alternative to screws or other fasteners. The pins are made of high carbon steel and are heat treated for hardness and ductility (Ref. 1, p. 1). For example, Aerosmith pins are manufactured from AISI 1060 steel, are heat treated to Rockwell C hardness between 52 and 56, and have a minimum tensile strength of 240 ksi. They come in several shank diameters, (.190", .165", .145", .121", .100") and several head diameters (1/4", 5/16", 21/64", 3/8") (Ref. 3, p.1). (Head diameters available for particular shank diameters are given in the accompanying Excel© PINX spreadsheet.) Pins are available in lengths ranging from 3/4" to 2 ½". The point of a driven pin should extend at least ¼" beyond the assembled connected members (Ref. 1, p.2). The smaller sized pins are used for connecting light gauge cold-rolled steel. The pins have knurled shafts and ballistic points both of which contribute to their structural capabilities. The manufacturer's literature explains that the holding strength comes from the piercing action of the pin and the subsequent rebounding and gripping action of the pierced steel. This creates a very tight fit unlike what might be imagined by the use of the word "pin" which to a structural engineer implies no resistance to axial rotation. Pins are available with several finishes with varying degrees of corrosion resistance (Ref. 1, p. 2). The pins are assembled in coils or strips compatible with a particular pneumatic fastening tool. Figure 1 shows the typical pin configuration. For attaching two or more light gauge cold-formed steel members the knurling should go all the way to the head. In some cases where attaching other thicker materials to steel, the knurling may not go all the way to the head.

Figure 1. Typical Steel Pin Configuration



COMMENTS ON "Design Provisions for Aerosmith, Inc. Steel Pins"

The measured loads of the steel pins in shear and withdrawal are compared to values obtained using the AISI screw equations (pp. 13-16). For lap shear connections, similar, but not identical, equations are proposed for pins. For tension pull-out an equation identical to that used for screw pull-out is proposed. For tension failure, no reference was made to the pull-over mode which is also checked for screws. The equation for this has been refined in the 2007 AISI Standard "North American Specification for the Design of Cold-Formed Steel Structural Members," but due to the nature and diameter of pin heads the refinement does not apply to pins. The formula for tension failure in pull-over for screwed connections is

$$P_{nov} = 1.5 t_1 d_w F_{u1} \quad \text{wherein}$$

P_{nov} = nominal pull-over force (pounds)
t_1 = thickness of the steel at the screw head (inches) - the "main" plate in the "Design Provision …." document.
d_w = diameter of the screw head (inches)
F_{u1} = the minimum tensile strength of the steel in contact with the screw head.

The diameter(s) of the pin heads used in the Aerosmith test were ¼" or 5/16", and there were no failures in the pull-over mode. However, it is conceivable that such a failure could occur with the combination of a small pin head, a thin main plate and a thick holding plate. I recommend that the pull-over mode of failure using the formula above be checked for pins, and it is included in the PINX spreadsheet. The tension capacity of a pin connection should be the smaller of the pull-out and the pull-over value.

SAFETY FACTOR

In the 2007 AISI publication, "North American Specification for the Design of Cold-Formed Steel Structural Members" (Ref. 4), steel pin connections are covered in Chapter F. This chapter requires that structural capacity be determined by independent laboratory testing and gives formulas for determining appropriate safety factors (Ref. 4, pp. 104-109; Ref. 5, pp. 134, 135). The safety factor is a function of the consistency of the materials involved in the connection and the variation of the test results. A 2007 publication by the Cold-Formed Steel Engineers Institute described such a test of a single shear pin connection (Ref. 6, pp. 1-8). Based on that particular test, the safety factor for working stress design, Ω, was 2.65. [The safety factor for non-diaphragm screw connections is 3.0 (Ref. 4, p. 98)]. Minimum safety factor values, Ω_d, for floor, roof or wall diaphragms are given in Chapter D (Ref. 4, pp. 73, 74; Ref. 5, pp. 112, 113). Therein, Ω_d for wind load is 2.35 and Ω_d for seismic load is 2.50 for both screws and pins. A 2008 report issued by ICC Evaluation Service, Inc., for power driven pins for shear wall (diaphragm) assemblies with cold formed steel framing and wood structural panels recommends a safety factor 2.0 for wind loads and 2.5 for seismic loads (Ref. 7, p.5). This is consistent with the values given for Type 1 shear walls by Reference 8, pages 6 and 7. Currently, the Technical Development Committee of the Cold-Formed Steel Engineers Institute (CFSEI) is developing new standards and design guides to clarify and unify appropriate safety factors (Ref 2).

EXAMPLE PROBLEMS USING FORMULAS FROM "DESIGN PROVISIONS …"

1. Determine the shear capacity of three adequately spaced, properly installed Aerosmith steel pins with the following parameters: pin head diameter .25 inches, pin shank diameter .100 inches, thickness of steel directly under the pin head = .043 inches, thickness of other steel = .056 inches. F_{u1} of 18 gauge sheet steel is 45 ksi. F_{u2} of 16 gauge sheet steel is 65 ksi. Assume a safety factor of 3.0. Using formula 6 on page 14:

t_2/t_1 =.056 in/.043 in = 1.30   1.30 < 3.0

$P_{ns} = 2.5(t_1t_2)^{.5}d\ (F_{u2}) = 2.5[(.043\ in)(.056\ in)]^{.5}(.100\ in)(65{,}000\ lb/in^2) = 797\ lbs$

Allowable shear per pin = P_{ns}/Ω = 797 lb/3.0 = 266 pounds

Total shear capacity = 3 screws x 266 lb/screw = 797 lbs

2. Determine the tension capacity of three adequately spaced, properly installed Aerosmith steel pins with the following parameters: pin head diameter .25 inches, pin shank diameter .100 inches, thickness of steel directly under the pin head = .043 inches, thickness of other steel = .056 inches. F_{u1} of 18 gauge sheet steel is 45 ksi. F_{u2} of 16 gauge sheet steel is 65 ksi. Assume a safety factor of 3.0. Using formula 6 on page 15:

Pull-Out $P_{not} = 0.85(t_2)d\ (F_{u2}) = .85(.056\ in)(.100\ in)(65{,}000\ lb/in^2) = 309\ pounds$

Using the formula given in "Comments …" above:

Pull-Over $P_{nov} = 1.5(t_1)(d_w)(F_{u1}) = 1.5(.043 \text{ in})(.250 \text{ in})(45{,}000 \text{ lb/in}^2) = 726$ pounds

P_{nt} = smaller $P_{ns} / \Omega = 309 \text{ lb}/3 = 103$ pounds

Total tension capacity = 3 screws x 103 lb/screw = 309 lbs

USING THE SPREADSHEET

The Excel© 2003 spreadsheet, PINX©, has the appropriate formulas embedded and provides some useful technical data. These are in protected cells so that they will not be inadvertently changed. Information provided by the user is entered into yellow colored unprotected cells. An unprotected tan "Job Notes" pad is also provided. Results of the calculations are provided in purple cells and red fonts. Insofar as possible, the nomenclature used in the foregoing explanation is used in the spreadsheet. Many of the cells have explanatory notes attached.

Example Problem 1, 2: Solve above Example 1, 2.

The values entered into the various spreadsheet cells are shown in Table 1.

Table 1. Spreadsheet Entries for Example Problem 1, 2.

Cell	F9	F10	F11	F12	F13	F14	F15	F16
Value	.250	.100	.043	.056	45000	65000	3	3

The answer provided based for shear capacity is 797 pounds in cell E20.
The answer provided based for tensile capacity is 309 pounds in cell E24.

Example Problem 3: Verify the predicted value in Table 13, page 16 for the following: tension capacity of a .144 inch pin attaching 20 gauge steel to 16 gauge steel. Assume the pin head diameter is 5/16 inch. Use the steel thicknesses and tensile strengths given in Tables 5, p. 3.

The values entered into the various spreadsheet cells are shown in Table 2.

Cell	F9	F10	F11	F12	F13	F14	F15	F16
Value	.312	.144	.0329	.0538	45000	65000	1	1

The answer provided for tensile capacity is 428 pounds in cell E24 which is as given in Table 13.

REFERENCES

1. “Tech Note (561b),” 3/99, Light Gauge Steel Engineers Association, 2400 Crestmoor Road, Nashville, TN 37215, tel 615-386-7139

2. “Pin Fastening A Key to Success For Cold-Formed Steel,” Metal Construction News, March, 2007.

3. ES Report ER-5667, 12/02, ICBO Evaluation Service, Inc., 5360 Workman Mill Road, Whittier, CA 90601.

4. “North American Specification for the Design of Cold-Formed Steel Structural Members,” 2007 Ed., American Iron and Steel Institute, ANSI S100-2007.

5. “Commentary on North American Specification for the Design of Cold-Formed Steel Structural Members,” 2007 Ed., American Iron and Steel Institute, ANSI S100-2007.

6. “Using Chapter F of the North American Specification for the Design of Cold-Formed Steel Structural Members,” Tech Note G100-07, Cold-Formed Steel Engineers Institute, 1201 15th Street, NW, Suite 320, Washington, D.C. 20005 tel 202-785-2022.

7. “Acceptance Criteria for Power-Driven Pins for Shear Wall Assemblies with Cold-Formed Steel Framing and Wood Structural Panels,” AC230, ICC Evaluation Services, Inc., November 1, 2008, 5360 Workman Mill Road, Whittier, CA 90601.

8. “North American Specification for Cold-Formed Steel Framing – Lateral Design,” 2007 Ed., American Iron and Steel Institute.