Design Strength of Stainless Steel PSA Inserts and Straps

Keywords

Stainless Steel, PSA, Slotted Insert, Strap, Design Strength

Introduction

This text was created to educate the design engineer on the design methodologies applicable in determining the design strength of Stainless Steel Slotted Inserts and Straps. Stainless steel inserts and straps were not specifically tested. The stainless steel inserts and straps have the same geometry as the tested PSA insert and straps. The existing test reports, see PSATestReports.pdf, along with assumed free body diagrams and basic mechanics of materials principals are employed to suggest an applicable design capacity.

Material Properties

The material designation of the tested insert are ASTM A607, GR. 50. The material designation of the stainless steel insert is SAE 304. Their specific properties can be found in the table below.

Material Property	ASTM A607, GR. 50	SAE 304
F_y Minimum Yield Stress, ksi	50	42
F_u Tensile Strength, ksi	60	84
Modulus of Elasticity	30,000	28,000

Tensile Strength of PSA Body

The test reports for the PSA show that for tensile loading, the failure is governed by either concrete breakout strength or a mechanical failure of the insert lips, where the nut in the cavity of the PSA pulls through the slot on the insert face. Figure 4.1.1 illustrates the overlap between the insert face and the nut.

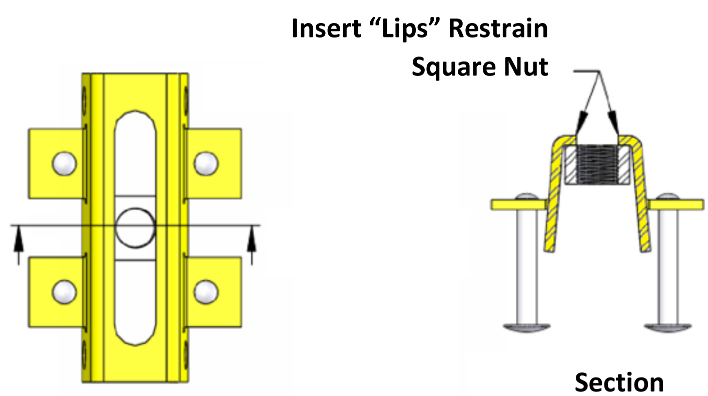


Figure 4.1.1 Insert Lips Restraining Square Nut

The mechanical failure is related to the material strengths. If it is assumed that the material remains elastic throughout the loading, the relationship between the modulus of elasticity can be used to determine a reduced capacity of the SAE 304 insert. A reduced modulus, in the elastic zone, would create a larger deformation with the same applied load. Therefore, initiating the mechanical failure under less loading. It is therefore proposed that the tested capacity of the PSA insert be reduced based on equation 4.1.1.

$$P_{SAE\ 304} = \left(\frac{E_{SAE\ 304}}{E_{A607}}\right) \cdot P_{A607}$$

$$\frac{E_{SAE\ 304}}{E_{A607}} = \frac{28{,}000}{30{,}000} = 0.9333 \simeq 0.9$$

Eq. 4.1.1

Shear Strength of PSA Body

The test reports for the PSA show that for shear loading, the failure is governed either by a mechanical failure of the insert lips or a mechanical failure in the strap. The strap design will be discussed later in this document. It is proposed to apply the same theory for shear as was applied to tension, by which the tested capacity of the PSA insert will be reduced based on a ratio of the material modulus of elasticity. Please see equation 4.1.2

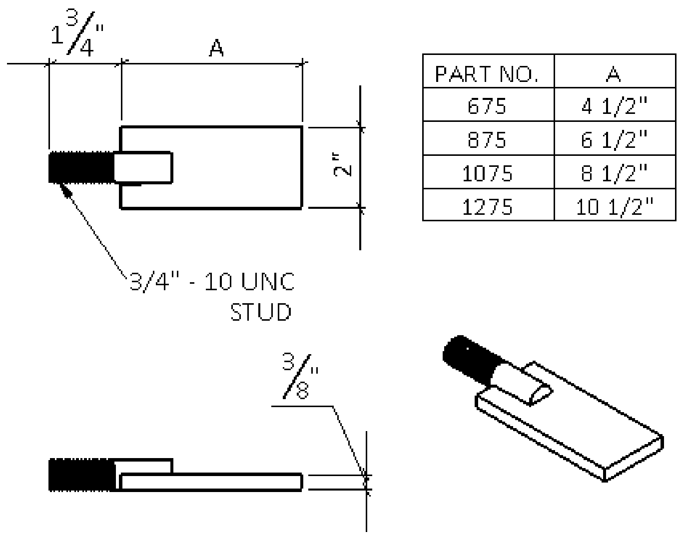
$$V_{SAE\ 304} = \left(\frac{E_{SAE\ 304}}{E_{A607}}\right) \cdot V_{A607}$$

$$\frac{E_{SAE\ 304}}{E_{A607}} = \frac{28{,}000}{30{,}000} = 0.9333 \simeq 0.9$$

Eq. 4.1.2

Tensile Strength of PSA Strap

The stainless steel strap is unique with regard to PSA straps in that the threaded stud portion of the strap is made out of the same material as the flat bar portion of the strap. Therefore, tension is critical at the location of the minimum cross-sectional area, which is located at the threaded stud portion. See figure 4.1.2 for strap geometry. The design strength of the strap in tension is limited to the tension capacity of the threaded portion as required by the appropriate design guide.



PART NO.	A
675	4 1/2"
875	6 1/2"
1075	8 1/2"
1275	10 1/2"

Figure 4.1.2 Strap Geometry

Shear Strength of PSA Strap

The test reports show that failure under shear loading can be isolated in just the strap. Testing also indicates that the strap behaves as a beam with one end fixed, the welded end, and the other end displaying at least partial restraint from rotation. Therefore, a conservative assumption when analyzing the strap, independent of testing, is to model the strap as fixed at the start of the weld and free at the face of the precast, see figure 4.1.3. The load is then assumed applied at the face of the precast. The plastic moment of the flat portion of the strap should be checked for design capacity.

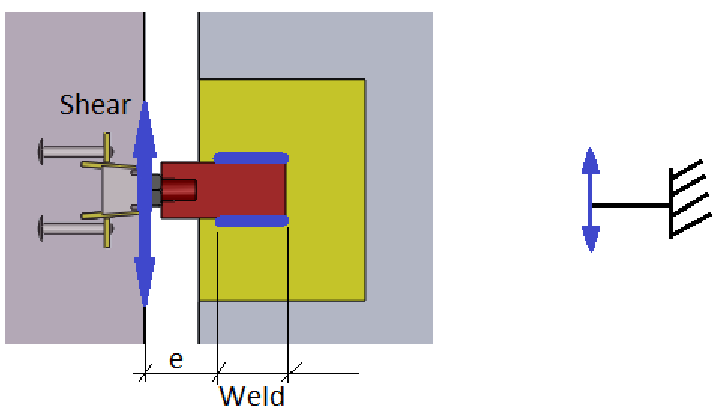


Figure 4.1.3 Conservative Beam Model

Additionally, the shear capacity of the threaded stud portion should be checked for direct shear loading per the appropriate design guide. Sample design values are shown in table 4.1.1. The accuracy of the results in Table 4.1.1 should be verified by a qualified engineer.

Eccentricity e (in)	Design Plastic Moment Capacity CA (in-kips)	Design Shear Strength @ Threaded Stud per ASCE 8-02 Eq. 5.3.4-1 (kip)	Governing Design Strength (kip)
1	14.18	9.05	9.05
1.5	9.45	9.05	9.05
2	7.09	9.05	7.09
2.5	5.67	9.05	5.67
3	4.73	9.05	4.73

Table 4.1.1 Example Design Capacity of Strap based on eccentricities and conservative beam model

References

American Society of Civil Engineers, Specifications for the Design of Cold-Formed Stainless Steel Structural Members (SEI/ASCE 8-02). ASCE, 2002

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