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TRB #01-19



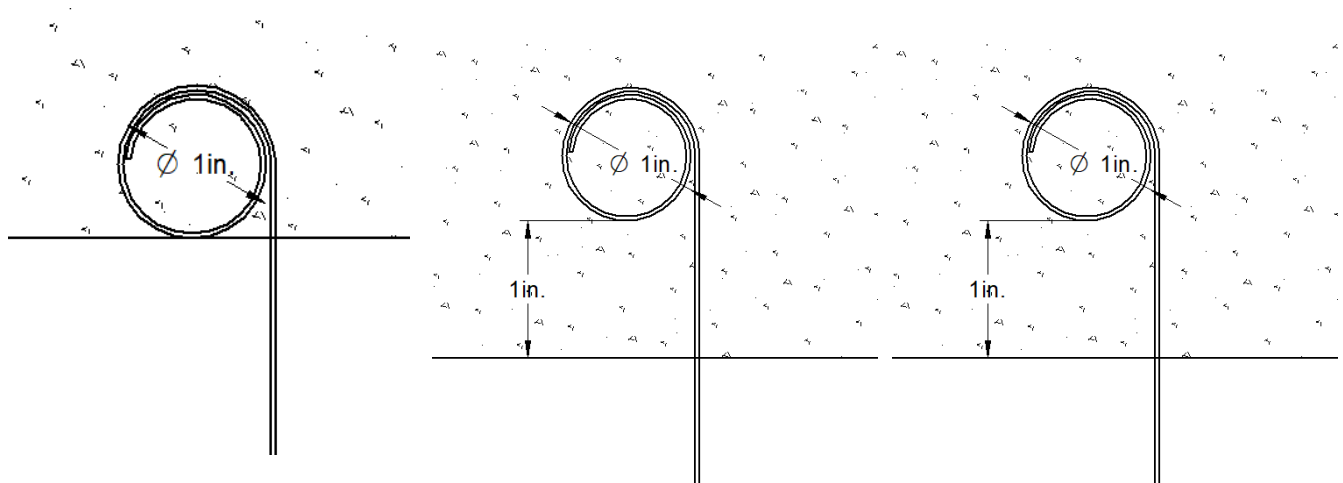
Technical Resources Bulletin

To: SMACNA Members and SMACNA Chapter Executives

From: Technical Resources Department

Subject: **Hanger Straps Embedded in Concrete Test Results**

The SMACNA Testing and Research Institute (STRI) completed load tests on three different combinations of strap embedded in concrete. The test specimens included (A) 16 ga x 1 inch wide double coil hanger strap embedded flush with the bottom of the concrete surface; average concrete compressive strength was 3,650 psi; (B) 16 ga x 1 inch wide double coil hanger strap embedded 1 inch from the bottom of the concrete surface; average concrete compressive strength was 3,600 psi; and (C) 16 ga x 1 ½ inch wide double coil hanger strap embedded 1 inch from the bottom of the concrete surface; average concrete compressive strength was 3,850 psi. Figure 1 shows the test configurations for the three types of test specimens. Each scenario was tested five times.



**Figure 1 (A) Test Sample
16 ga, x 1 in. wide**

**Figure 1 (B) Test Sample
16 ga x 1 in. wide**

**Figure 1 (C) Test Sample
16 ga x 1 ½ in. wide**

Test Samples

Figure 2 shows how the test samples were constructed. The straps extended below the concrete surface by 4 inches where two pull straps were welded on either side of the sample. Figure 3 shows more details of the pull straps.

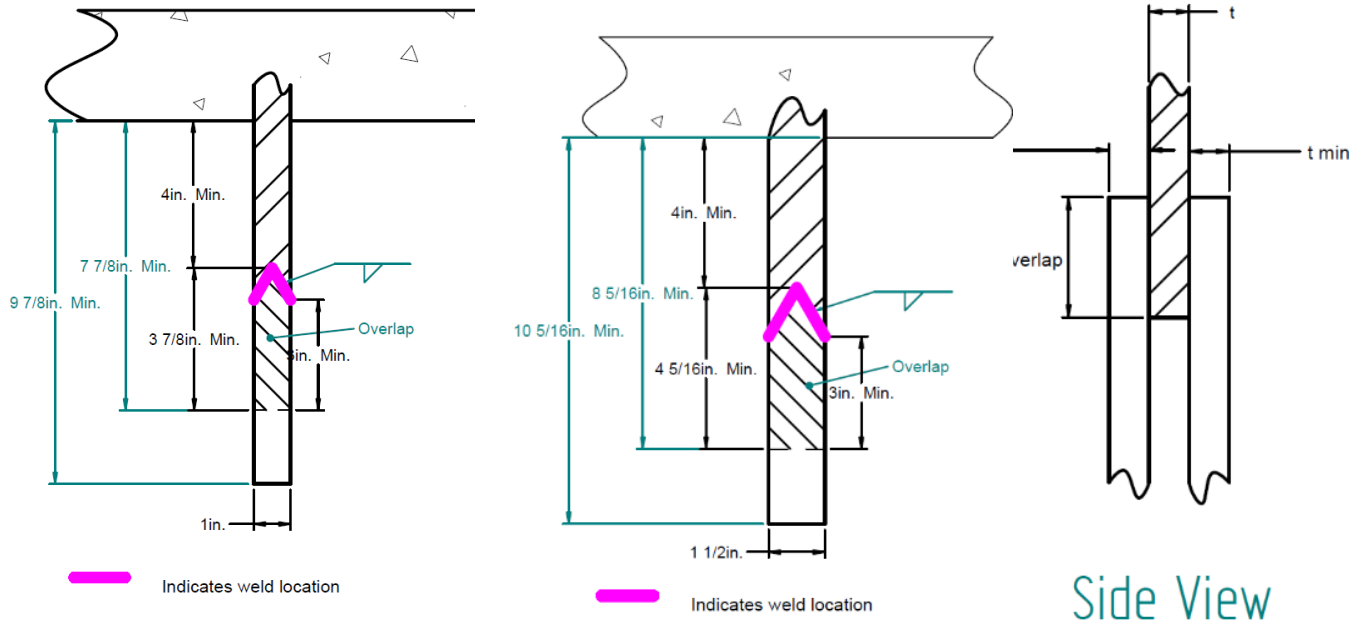
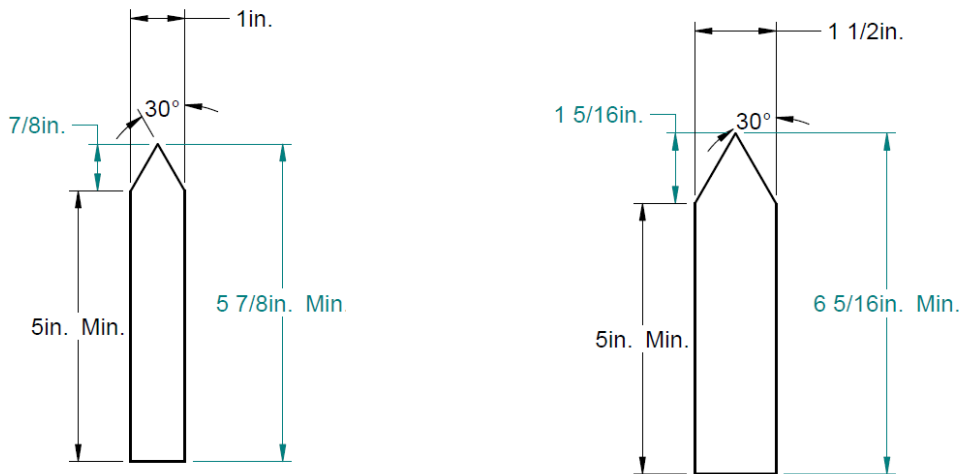


Figure 2 - 1 inch and 1 ½ inch Straps Welded to Pull Straps to Apply Load

Pull Straps



Need 2 pull straps per hanger. At least as thick as the hanger strap (16 gage) for these tests

Figure 3 - Pull Straps Details Used to Apply Loads

Test Procedure

The samples were fabricated including the pull straps and coiled ends. The straps were then placed in a form where concrete was added. Samples were allowed to cure until meeting the 3,600 psi strength requirement before loads were applied. Figure 4 shows test samples being cured. Loads were applied until failure occurred.



Figure 4 New Samples Being Cured

Test Results

Tables 1 through 3 show the results and the failure modes for the three types of test specimens.

Table 1 Sample Specimen A, Test Results for 16 Gage 1 Inch Coil Straps, Hanger Flush with Bottom of Concrete Surface, 3,650 psi Compressive Strength Concrete

Specimen	Load at Failure (lbs.)	Failure Mode
A-1	2,310	Cone Type Failure of Concrete (see Figures 5 and 6)
A-2	1,920	Cone Type Failure of Concrete (see Figures 5 and 6)
A-3	2,240	Cone Type Failure of Concrete (see Figures 5 and 6)
A-4	1,890	Cone Type Failure of Concrete (see Figures 5 and 6)
A-5	2,010	Cone Type Failure of Concrete (see Figures 5 and 6)
Average	2,074	
Standard Deviation	190	

- Note: 1. Steel hanger exhibited no deterioration or stretching.
 2. Concrete cracked adjacent to steel shell prior to testing.



Figure 5 Sample Specimen Failure Mode for 16 Gage 1 Inch Wide Double Wide Coil Straps, Hanger Flush with Bottom of Concrete Surface

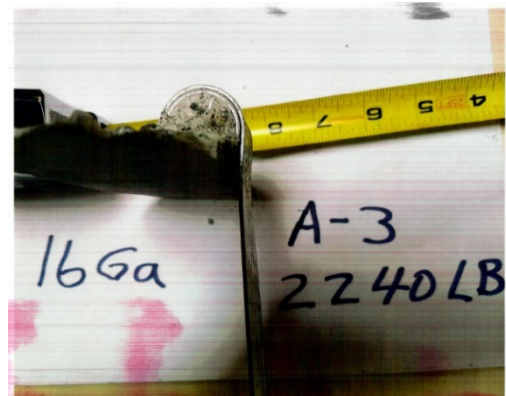


Figure 6 Sample Specimen A-3 Failure Mode for 16 Gage 1 Inch Wide Double Coil Straps, Hanger Flush with Bottom of Concrete Surface

Table 2 Sample Specimen B, Test Results for 16 Gage 1 Inch Wide Coil Straps, Hanger Embedded 1 Inch From Concrete Surface, 3600 psi Compressive Strength Concrete

Specimen	Load at Failure (lbs.)	Failure Mode
B-1	2,650	Steel Strap Specimen Pulled Out of Concrete (See Figure 7)
B-2	2,410	Steel Strap Specimen Pulled Out of Concrete (See Figure 7)
B-3	2,290	Steel Strap Specimen Pulled Out of Concrete (See Figure 7)
B-4	2,790	Steel Strap Specimen Pulled Out of Concrete (See Figure 7)
B-5	2,310	Steel Strap Specimen Pulled Out of Concrete (See Figure 7)
Average	2,490	
Standard Deviation	220	

Note: The concrete was initially cracked parallel to the plane of the strap

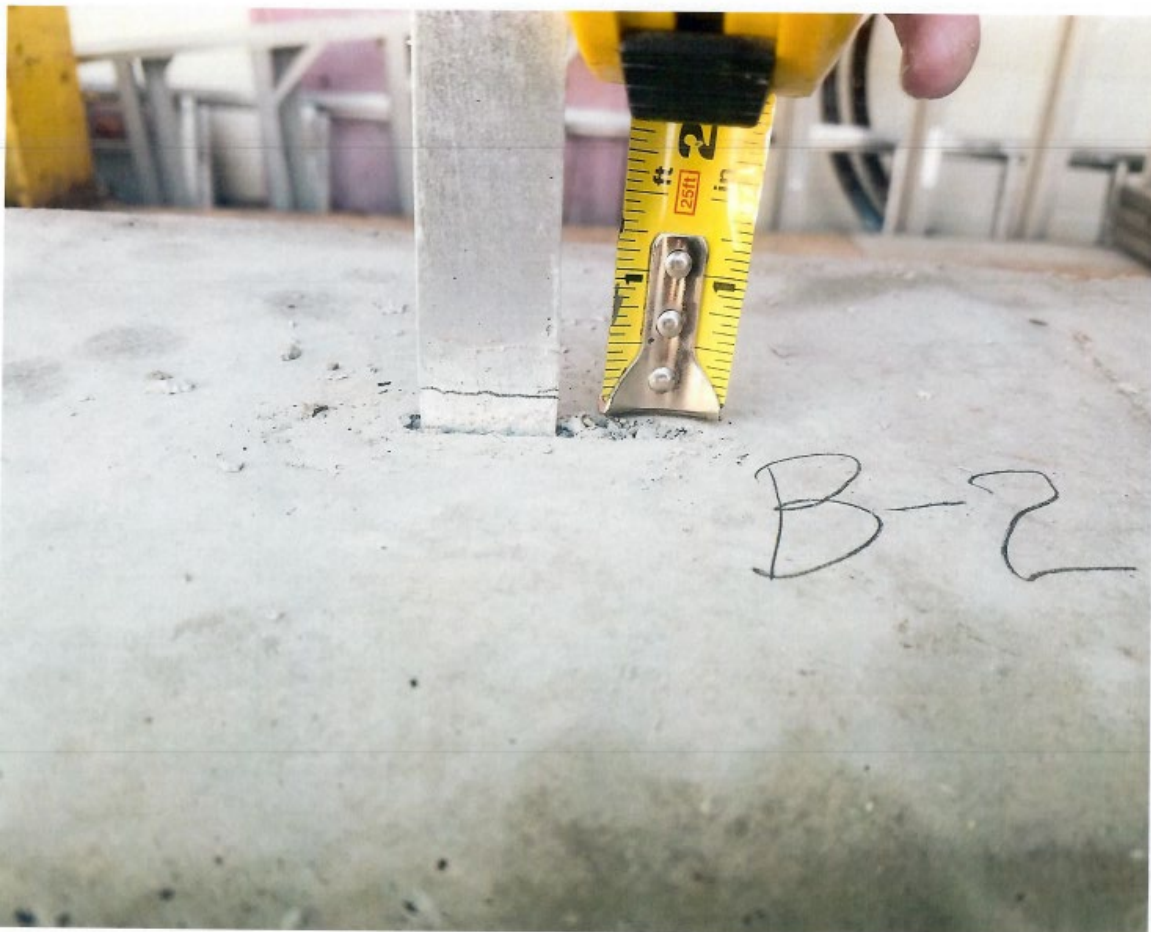


Figure 7 Sample Specimen B-2, Failure Mode for 16 Gage 1 Inch Wide Double Coil Straps, Hanger Embedded 1 Inch From the Concrete Surface

Table 3 Sample Specimen C, Test Results for 16 Gage 1 ½ Inch Wide Double Coil Straps, Hanger Embedded 1 Inch From the Concrete Surface, 3850 psi Compressive Strength Concrete

Specimen	Load at Failure (lbs.)	Failure Mode
C-1	4,020	Steel Strap Specimen Pulled Out of Concrete (See Figure 8)
C-2	3,780	Steel Strap Specimen Pulled Out of Concrete (See Figure 8)
C-3	4,350	Steel Strap Specimen Pulled Out of Concrete (See Figure 8)
C-4	3,910	Steel Strap Specimen Pulled Out of Concrete (See Figure 8)
C-5	4,090	Steel Strap Specimen Pulled Out of Concrete (See Figure 8)
Average	4,030	
Standard Deviation	214	

Note: The concrete was initially cracked parallel to plane of strap



Figure 8 Sample Specimen C-3, Failure Mode for 16 Gage 1 ½ Inch Double Wide Coil Straps, Hanger Embedded 1 Inch From the Concrete Surface

Study - Findings

- None of the hanger straps failed.
- The mode of failure was the concrete gave way in a cone shape for (A) specimens
- The mode of failure was the hanger strap pulled out of the concrete for (B) specimens
- The mode of failure was the hanger strap pulled out of the concrete for (C) specimens

Study - Summary

SMACNA Testing and Research Institute tested three types of coiled hanger strap embedded in concrete.

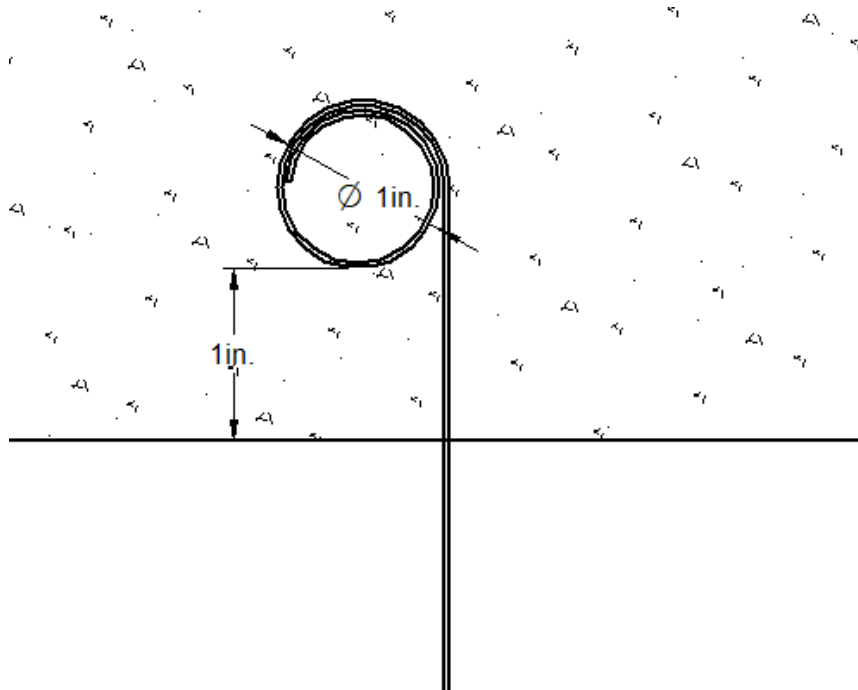


Figure 4

Unless otherwise approved, the allowable load on an upper attachment is $\frac{1}{4}$ of the failure load. For properly installed coils (embedded at least one inch), increasing the strength of the concrete would make no anticipated change in capacity assuming a minimum of 3,600 psi compressive strength because the concrete did not fail. The concrete strength would make a difference in a flush mounted coil, at least until the mode of failure becomes strap slippage, but that is not a recommended approach. The hanger strap thickness would only make a difference if the strap capacity is less than the “coil capacity”. This is because the straps themselves did not fail either. Since the mode of failure was slippage which is related to “friction” and as the testing indicated wider straps which have more surface area had a higher capacity. Since the upper attachment, the coil in this case, is only part of the hanger system you must consider the capacity of the strap itself before determining the total capacity of the hanger embedded in concrete using a 1 inch coil. Table 4 below shows the suggested capacities for the coils and Figure 9 shows the strap capacities found in Table 5-1 of SMACNA’s HVAC Duct construction Standards Metal and Flexible 3rd edition. You must use the lower of the two capacities based on your construction options.

Table 4 – Suggested Maximum Loading for Coil Upper Attachment in Concrete			
Type of Hanger Strap	Distance Embedded in the Concrete	Average Failure Load (lbs.)	Recommended Maximum Loading (lbs.)
1 inch wide x 1 inch diameter (A)	Coil Embedded Flush with the Surface	2,074	500
1 inch wide x 1 inch diameter (B)	Bottom of coil Embedded 1 inch from Surface	2,490	625
1 ½ inch wide x 1 inch diameter (C)	Bottom of coil Embedded 1 inch from Surface	4,030	1,000

Single Hanger Maximum Allowable Load	
Strap	Wire or Rod (Dia.)
1" × 22 ga - 260 lbs.	0.106" - 80 lbs.
1" × 20 ga - 320 lbs.	0.135" - 120 lbs.
1" × 18 ga - 420 lbs.	0.162" - 160 lbs.
1" × 16 ga - 700 lbs.	¼" - 270 lbs.
1½" × 16 ga - 1100 lbs.	⅜" - 680 lbs.
	½" - 1250 lbs.
	⅝" - 2000 lbs.
	¾" - 3000 lbs.

Figure 9

Study - Conclusion

Capacity for a 1 inch diameter coil embedded in concrete based on research from the SMACNA Testing and Research Institute shows that the coil is a suitable method for an upper attachment and that the coil typically exceeds the allowed capacity of the associated strap even if the coil is flush to the concrete. The two exceptions would be for 16 gage strap (1 and 1 ½ inch wide) where the capacities of the strap (700 & 1,100 lbs.) slightly exceed the suggested capacity of the coil (625 & 1,000 lbs.) but still well below the lowest failure loads in either case. (1,890 – flush, 2,290 & 3,780 embedded lbs.)