ANALYSIS AND TEST RESULTS REPORT FOR SLENDERWALL ARCHITECTURAL PANEL CONCRETE / STEEL STUD CONNECTION

Prepared For:
SMITH-MIDLAND Corporation
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August, 1993

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VERTICAL SHEAR TEST OF PANEL AND STUD FRAME

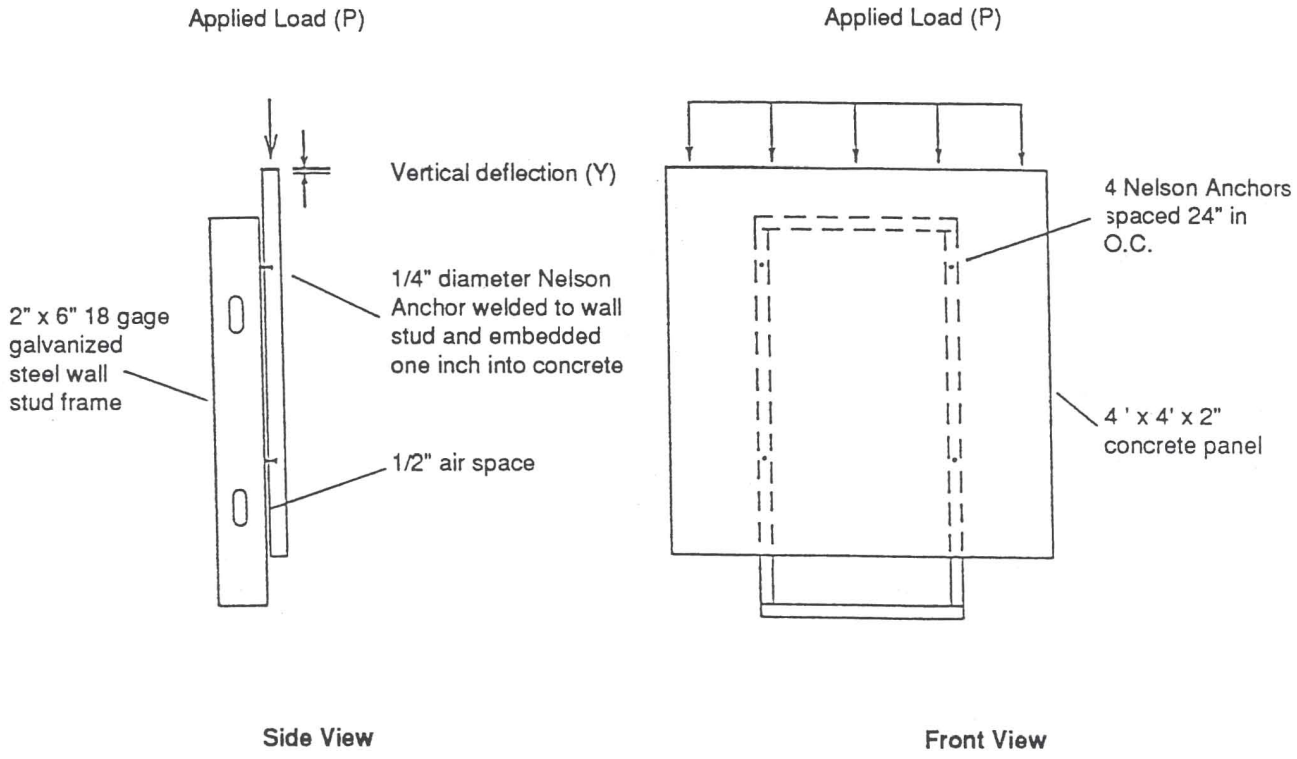


Figure 1. *Set up of Shear Load Test*

TEST PARAMETERS

- A typical 4' x 4' wall section was used
- Steel stud frame was fixed in place while load (P) was applied downward on concrete panel
- Weight of concrete panel = 387 lb.
- Yield point at 1740 lb.; Ultimate point occurred at 2580 lb.
- Factor of safety $= \frac{\text{yield point}}{\text{Weight of panel}} = \frac{1740 \text{ lb.}}{387 \text{ lb.}} = 4.50$
- This results in a static factor of safety of 4.50

(See page 2 for graphed and tabulated data points)

VERTICAL SHEAR TEST OF PANEL AND STUD FRAME, CONT.

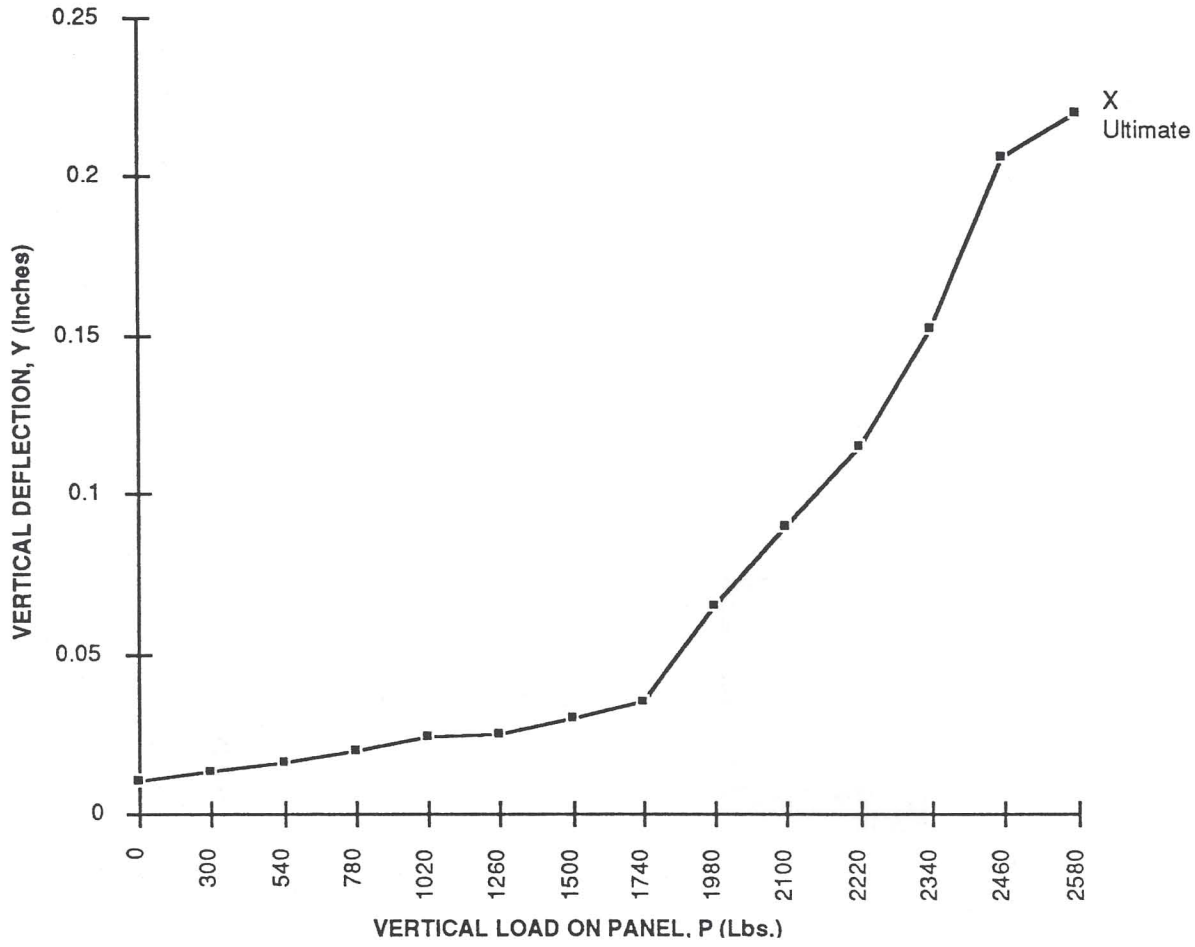


Figure 2. Vertical Shear Test of 4' x 4' Slenderwall Panel

TABULATED RESULTS

Load, P (Lbs.)	Deflection, Y (inches)	Load, P (Lbs.)	Deflection, Y (inches)
Weight of Panel	0.01	1740	0.035
300	0.013	1980	0.065
540	0.016	2100	0.09
780	0.02	2220	0.115
1020	0.024	2340	0.152
1260	0.025	2460	0.206
1500	0.03	2580	0.22

PULLOUT OF PARTIALLY EMBEDDED NELSON ANCHOR IN CONCRETE

The tension capacity of the Nelson Anchor embedded in concrete was determined by calculation and by pullout test

CONNECTION SPECIFICATIONS

- 1/4/" diameter Nelson Headed Anchor with 1" embedment
- 5,000 psi concrete 2" thick
- Load applied axially along anchor

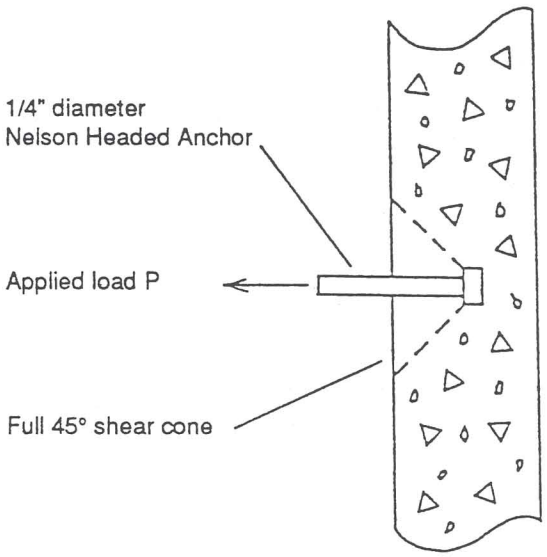


Figure 3. *Pullout of Nelson Headed Anchor*

CALCULATED RESULTS

P_{uc} = Ultimate concrete tension capacity

$$P_{uc} = \phi C K A_{fc} \sqrt{f'_c}$$

Where $A_{fc} = \pi\sqrt{2}\ L_e\ (L_e + D_h)$

$= \pi\sqrt{2}\ (1.0)\ (1.0 + .5) = 4.165\ in^2$

$$P_{uc} = .85\ (1.0)\ (4.0)\ (6.664)\ \sqrt{5000}$$

P_{uc} = 1602 lb. for 1" embedment

TEST RESULTS

The ultimate concrete tension capacities for 3 pullout tests are as follows:

a) 1600 lb.
b) 1660 lb.
c) 1700 lb.

PULLOUT OF NELSON ANCHOR WELDED TO GALVANIZED WALL STUD

CONNECTION SPECIFICATIONS

- 1/4" diameter Nelson Anchor which is stud welded to either 18 or 16 gage galvanized wall studs
- 18 gage stud minimum thickness = .0478"
- 16 gage stud minimum thickness = .0598"
- Ultimate strength of steel = 33 ksi

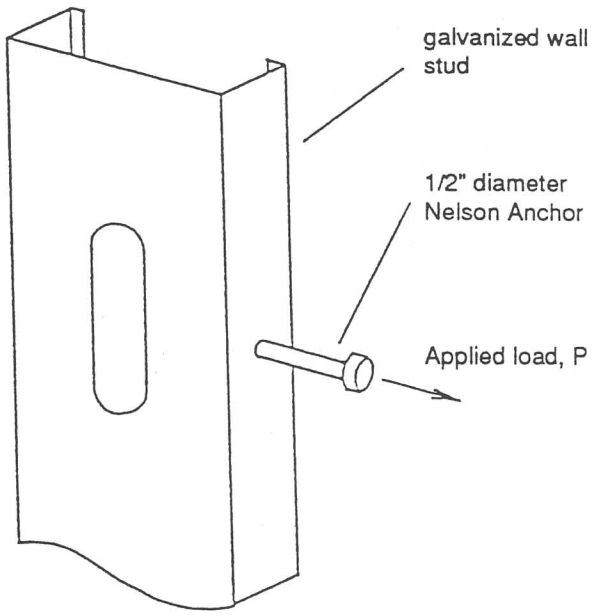


Figure 4. *Pullout of Nelson Anchor welded to galvanized wall stud*

CALCULATION OF ULTIMATE PULLOUT STRENGTH, P_u

A_w = shear area of weld

A_w = (minimum stud thickness) x (anchor circumference)
for 18 gage: $Aw = (.0478") (.25)\pi = .0375\ in^2$

$$S_u = \frac{P_u}{A_w} \rightarrow P_u = S_u A = (33{,}000\ lb/in^2)\ (.0357 in^2) = 1238 lb.$$

P_u (18 gage) = 1238 lb. P_u (16 gage) = 1550 lb.

ULTIMATE PULLOUT TEST RESULTS AT THE WELD FOR 18 GAGE STUD

a) 1250 lb.
b) 1360 lb.
c) 1300 lb.

HEAT TRANSFER TEST — EMBEDDED NELSON ANCHOR WITH 1/2 INCH AIR SPACE VS. EMBEDDED WALL STUD

TEST PARAMETERS

- The test was conducted using dry ice to maintain a temperature of -105°F on the exterior surface of the concrete.
- A thermocouple was used to measure corresponding surface temperatures
- The test pieces were placed on the dry ice and the temperature changes of the galvanized wall stud were measured until they stabilized after approximately 30 minutes.

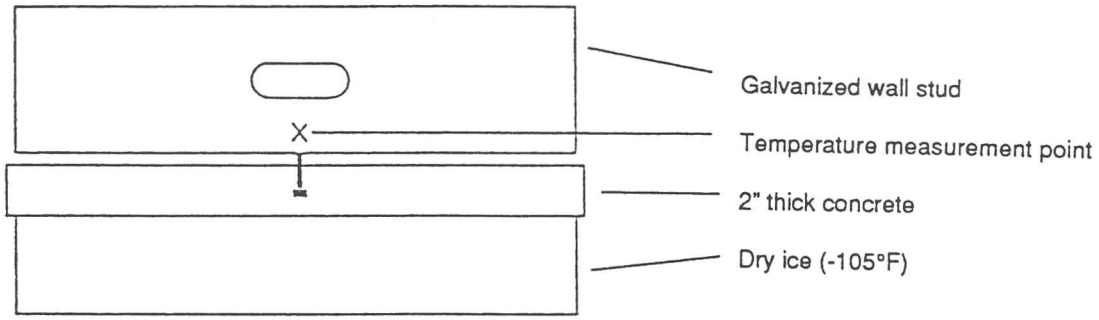


Figure 5. *Heat Transfer Test utilizing Nelson Headed Anchor with 1/2" air space between concrete and wall stud*

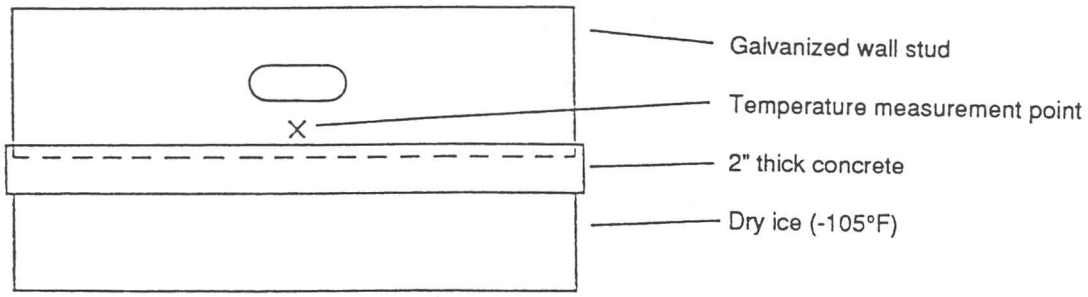


Figure 6. *Heat Transfer Test with wall stud continuously embedded in concrete*

HEAT TRANSFER TEST — URETHANE COATED NELSON ANCHOR VS. DIRECT CONCRETE / ANCHOR CONNECTION, CONT.

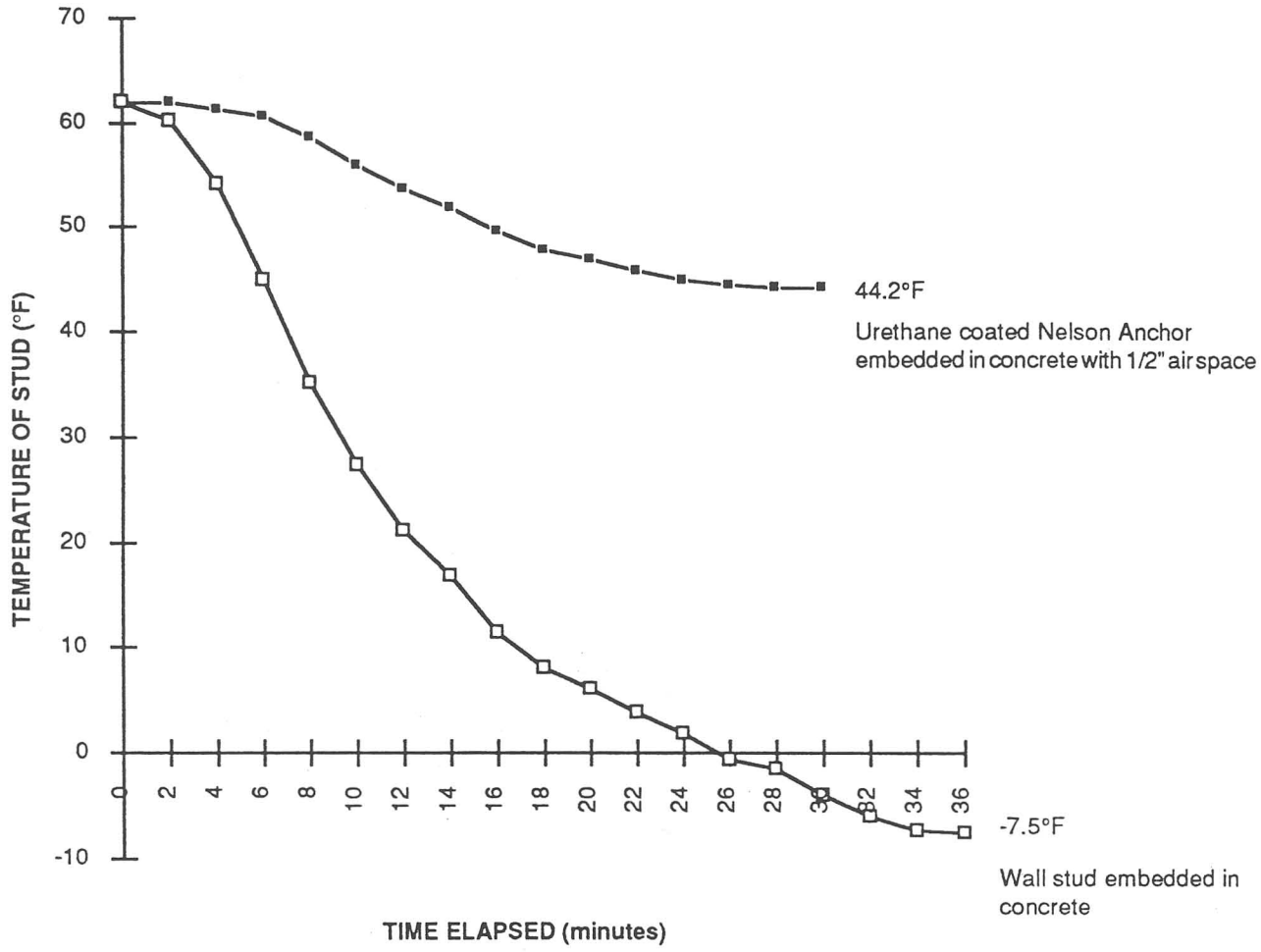


Figure 7. Heat Transfer rates of embedded stud vs. non-embedded stud

TABULATED RESULTS

Time (minutes)	Anchor Temp. (°F)	Embedded Stud Temp. (°F)	Time (minutes)	Anchor Temp. (°F)	Embedded Stud Temp. (°F)
0	62	62	20	46.9	6
2	62	60.1	22	45.8	3.9
4	61.2	54.1	24	45	1.9
6	60.5	45	26	44.6	-0.7
8	58.6	35.1	28	44.2	-1.5
10	55.8	27.2	30	44.2	-4
12	53.6	21	32	—	-6
14	51.9	16.8	34	—	-7.4
16	49.7	11.5	36	—	-7.5
18	47.9	8.1			

HEAT TRANSFER TEST — URETHANE COATED NELSON ANCHOR VS. DIRECT CONCRETE / ANCHOR CONNECTION

TEST PARAMETERS

- The test was conducted on a 510°F 1/2" steel plate
- A thermocouple was used to measure corresponding surface temperatures
- The test compared the rate of heat transfer of two connection configurations:

  1) Nelson Anchor embedded in concrete

  2) Nelson Anchor with a urethane coating embedded in concrete

- The exterior concrete side of the test pieces were placed on 510°F steel plate surrounded by fiberglass insulation and the temperature of the exposed anchor was measured against time

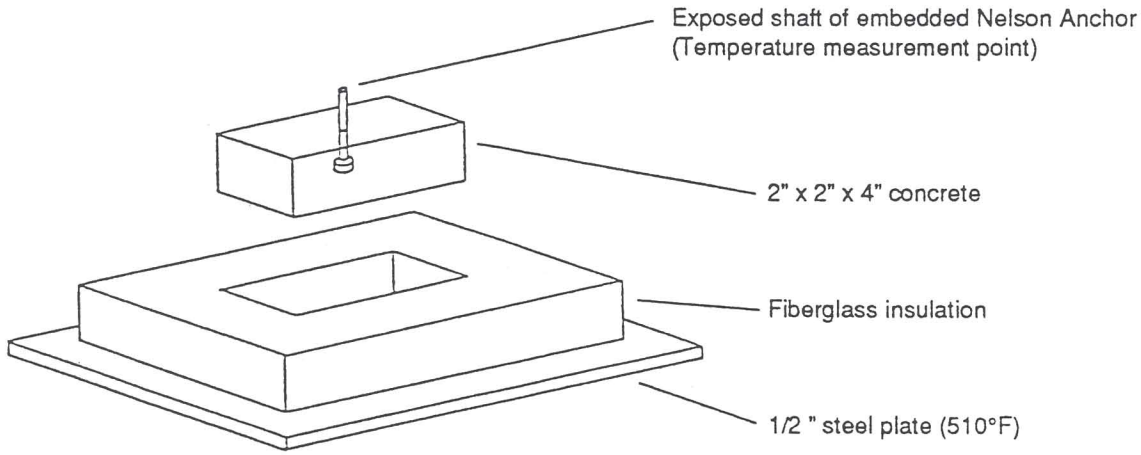


Figure 8. *Set up of Heat Transfer Comparison Tests*

HEAT TRANSFER TEST — URETHANE COATED NELSON ANCHOR VS. DIRECT CONCRETE / ANCHOR CONNECTION, CONT.

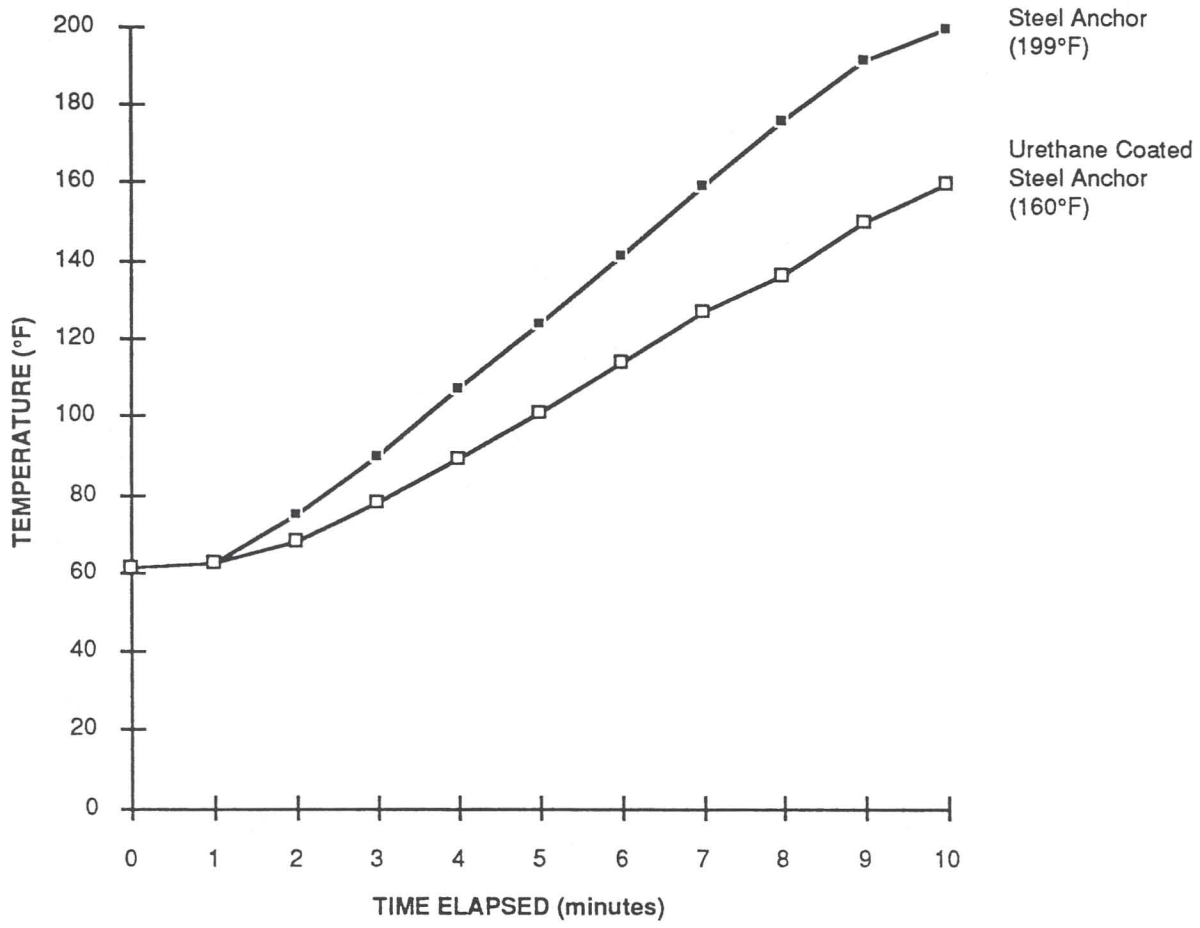
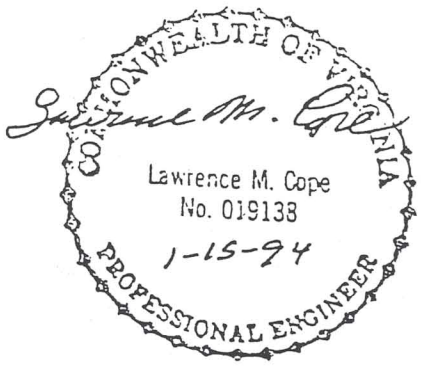


Figure 9. Heat Transfer Rates of Steel Anchor vs. Urethane Coated Steel Anchor

TABULATED RESULTS

Time (minutes)	Steel Anchor Temp. (°F)	Urethane Coated Steel Anchor Temp. (°F)
0	61	61
1	62.3	62.2
2	74.8	67.7
3	89.7	78
4	107.1	88.7
5	123.8	101
6	141	113.7
7	158.7	127
8	175.7	136.3
9	190.9	149.6
10	199	159.6



SMITH-MIDLAND CORPORATION
MIDLAND, VIRGINIA

SLENDERWALL BOLTED CONNECTION TEST #2

Date: 12-03-93
Place: Smith-Midland Plant, Midland, Virginia

Object: To test the capacity of 2 - 3/8 inch ASTM A307 bolts and 2" square by 1/4" thick washers connecting a 1/4 inch plate bracket to a 18 gage metal stud in tension.

Testing Apparatus:

Jack: 60 Ton Ram Calibrated By Jerry Atkinson on 11-29-93 to VSL Load Cell No. 007-72.

Ram Calibration Curve For:
Ram N0. SFI60-6-1 Gage No. SFI60-6-1

Apparatus: Built by Smith-Midland with a 6" - 18 GA metal stud attached by 3 - 1/2" bolts to a base plate bracket. 2 - 3/8" bolts attach the hanger bracket plate to the metal stud with 2 - 2" square by 1/4" thick washers on opposite side. The stressing rod is connected to hanger bracket plate. The ram pulls on the stressing rod and jacks against the base plate. The two bolts carry the full stress of the applied loads.

Results:

Gage Pressure PSI	Force KIPS	Observations
200	1	Seating of apparatus, no apparent movement.
450	3.5	No Sign of Yielding, Pressure Holds.
600	6	No Sign of Yielding, Pressure Holds
650	7	Pressure Drops Slightly.
700	8	Pressure Drops Shearing Failure.

Conclusions:

Failure occurred by stud yielding around washers. Some shearing of stud at bolts was observed. The design of this connection was for 1 kip capacity. From this test the safety factor should be about 6 to 1.

The use of larger washer and tight bolted connections greatly increase the capacity of the joint.

The testing should be repeated with a smaller capacity ram so that more accurate gage pressures can be observed.

February 15, 1994

Mr. Rodney Smith
Smith-Midland Corporation
P.O. Box 300
Midland, Virginia 22728

Re: Consolidated Testing Lab Report of Slenderwall Design

Dear Mr. Smith

I have reviewed this report and can testify that the results represented in it are representative of the test results that were made on this project when I was working for the Smith-Midland Corporation. Our R & D Committee ran many tests similar to the ones in this report during the years of 1989 and 1990.

Many tests were made on the stud types and attachments to the metal stud. Comparisons were also made and tested against the attachment systems of competing products.

Heat transfer tests similar to the those represented here were made on many different coating materials on the studs. Pullout tests were also run to check the pullout of the coated studs.

Heat transfer tests were conducted to compare the Slender Wall System to competitive systems.

This report expresses results similar to the testing that I witnessed and was a party to.

Sincerely

L. Melvin Cope, P.E.