LOAD TESTS ON WALL PANEL CONNECTIONS USING TWO-INCH DIAMETER CORRUGATED PLASTIC SLEEVES

by

Alex Aswad, Ph.D., P.E.
and
George G. Burnley, P.E.

Contributor:
Kathy Scholz

Project Sponsored
by
High Concrete Structures, Inc.
1995

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SYNOPSIS

Two-inch diameter corrugated plastic sleeves having lengths of 6″, 10″, 12″ and 16″ were cast into wall panels of 4″, 6″ and 8″ thicknesses, respectively. Dowel rods were grouted into the sleeves and tension loads were applied to test the pullout performance of the connection. A total of 68 tests were performed during July and August 1995.

The test loads achieved ranged from a minimum pullout capacity of 3.0 kips for the 6-in. long sleeve to a maximum capacity of 20.9 kips for the 16-in. long sleeve. The pullout capacity varied with the embedment length of the dowel.

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1. INTRODUCTION AND BACKGROUND

High Concrete Accessories markets two-inch diameter corrugated plastic sleeves (HCA calls the sleeve a Grouted Connection Tube—GCT) with lengths of 6″, 10″, 12″ and 16″, respectively. The sleeves are made of blow molded plastic and have ¼″ deep castellations (Fig. 1 and Appendix IV). The bottom of the sleeve is closed to prevent concrete intrusion and the top has a lip to aid in anchoring to the forms. The top of the sleeve is also sealed to keep out water and debris. These sleeves are typically used for grouted dowel connections between wall panels as shown in Figure 2. In the past, spiral wound corrugated metal sleeves were used to transfer tension loads in grouted dowel connections. The use of manufactured plastic sleeves offers economic and production advantages.

Section 6.5.1 of the PCI Handbook (4th or 5th. ed.) requires a minimum concrete cover for the sleeves for confinement and anchorage (Fig. 6). This investigation will test the connection capacity in panels thinner than PCI requirements and compare test results to capacity predicted by the PCI Handbook equation 6.5.1 (4th ed.).

2. OBJECTIVES

This test program had the following objectives:

- Determine the performance, behavior and load capacity of the sleeves in relatively thin panels when subjected to pullout loads. Three panel thicknesses (4″, 6″ and 8″) and four sleeve lengths (6″, 10″, 12″ and 16″) were tested.
- Draw conclusions and offer design recommendations for use of the sleeves in panel connections.

3. PULLOUT TESTS

3.1 Description of Test Panels

A total of nine full-scale test panels were produced (3 each at 4″, 6″ and 8″ thickness) as shown in Figure 3. Each panel received eight two-inch diameter sleeves (2 each at 6″, 10″, 12″ and 16″ length). One sleeve of each size was located 8″ from the end of the panel. An 8″ by 16″ panel cutout was used to simulate the end of the panel condition. The other sleeves were located away from the end of the panel.

Each panel was reinforced with one layer of 6 x 6-W4/W4 wire fabric and #3 perimeter bars. The reinforcement had a nominal yield strength of 60 ksi.

The panels were produced with a concrete mix proportioned to achieve approximately 5000 psi strength at the time of the test. Details of the concrete mix and strengths are listed in Appendix I.

The dowels, Fig. 5, were grouted into the sleeves with a premixed non-shrink, non-metallic grout mixed with water to a plastic consistency. The grout was allowed to cure for two days before testing. According to the grout manufacturer's instructions, 5000 psi strength should be achieved in two days. Details of the grout used are listed in Appendix II. The obtained strength, however, was somewhat less than 4100 psi at an age of two days.

3.2 Test Set-Up

Figure 4 shows the test setup detail. Tension loads were applied to the dowels using a hand operated hydraulic jack and a leveraged reaction beam arrangement. A compression load cell was used to determine the applied load. The calibration chart for the load cell is shown in Appendix III. Beam and load cell capacities limited the maximum tension load to the dowels to approximately 21.0 kips.

The hand operated hydraulic jack permitted a relatively slow incremental application of the tension load. Loads were applied up to the maximum attainable limit or to failure over a period of approximately 3 to 5 minutes. The test was terminated when the load cell indicated that the jack was not holding a steady load or when excessive dowel lift-off was observed.

3.3 Test Results

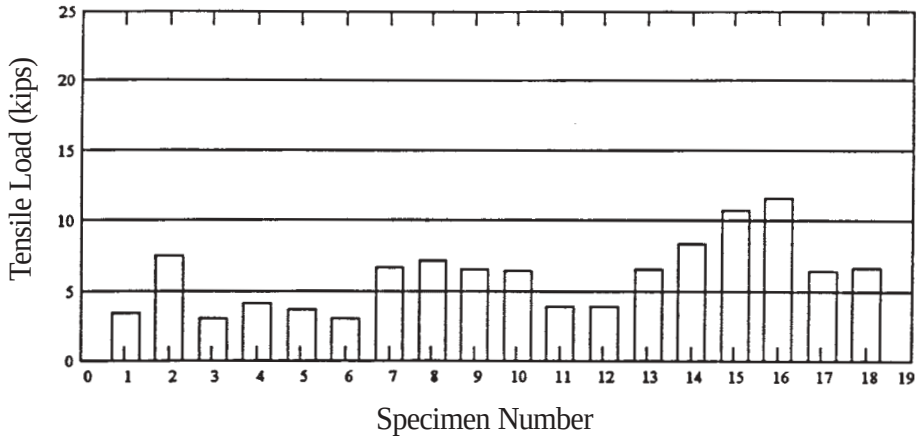
A. 6″ sleeve

¾″ all-thread rod used; 6″ embedment
Nominal Grout Strength: 4000 psi

Test No.	Panel Thickness (inches)	Panel Strength (psi)	Test Load (kips)	Mode of Failure
1*	4	5772	3.37	Sleeve pulled out
2	4	5772	7.50	Sleeve pulled out
3	4	5771	3.00	Grout pulled out
4*	4	5771	4.12	Grout pulled out
5	4	4418	3.62	Grout pulled out
6*	4	4418	3.00	Grout pulled out
7*	6	5785	6.62	Grout failed
8	6	5785	7.12	Dowel pulled out
9*	6	6974	6.50	Dowel pulled out
10	6	6974	7.12	Grout pulled out
11	6	5844	3.87	Grout pulled out
12*	6	5844	3.87	Grout pulled out
13*	8	4812	6.50	Grout pulled out
14	8	4812	8.25	Grout & sleeve pulled out
15*	8	5469	10.75	Grout pulled out
16	8	5469	11.50	Grout pulled out
17	8	5064	6.37	Grout & sleeve pulled out
18*	8	5064	6.37	Grout pulled out

**Sleeves located eight inches from cutout.*

Ultimate Tensile Load on a 6″ Sleeve



Test summary

Minimum Test Capacity—3.0 kips

Maximum Test Capacity—11.50 kips

Average Test Capacity—6.10 kips

Average test capacity by panel thickness:

4″—4.10 kips

6″—5.85 kips

8″—8.29 kips

There is a significant increase in capacity with increase in panel thickness.

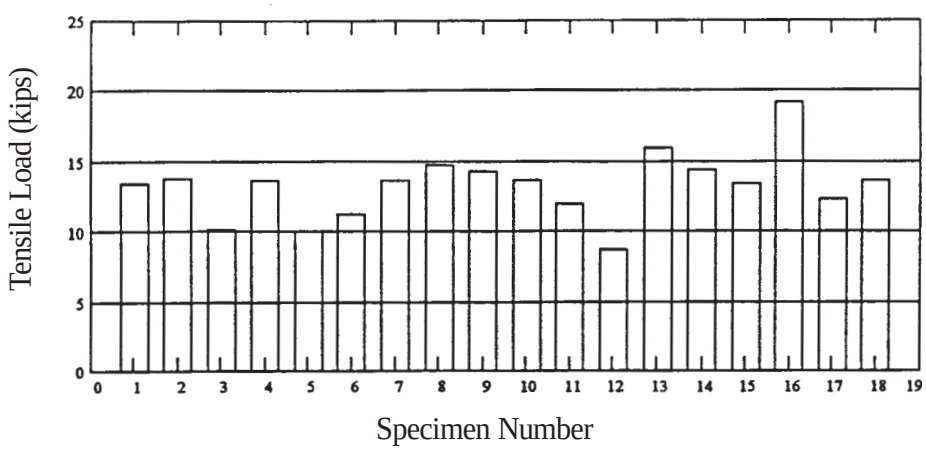
Locating the sleeve 8″ from end of panel had no significant effect on results.

B. 10″ sleeve

#5 bar used for dowel; 10″ embedment
Nominal Grout Strength: 4000 psi

Test No.	Panel Thickness (inches)	Panel Strength (psi)	Test Load (kips)	Mode of Failure
1	4	5772	13.30	Sleeve pulled out
2*	4	5772	13.75	Sleeve pulled out
3*	4	5771	10.12	Grout pulled out Face cracks
4	4	5771	13.62	Grout pulled out Face cracks
5*	4	4418	10.00	Grout pulled out
6	4	4418	11.12	Grout pulled out
7	6	5785	13.62	Grout pulled out
8*	6	5785	14.62	Bar failed
9	6	6974	14.12	Bar pulled out
10*	6	6974	13.62	Bar pulled out
11*	6	5844	11.87	Grout pulled out
12	6	5844	8.62	Grout pulled out
13	8	4812	15.87	Grout pulled out Cracks at top
14*	8	4812	14.25	Grout pulled out
15	8	5469	13.37	Grout pulled out
16*	8	5469	19.12	Grout pulled out
17*	8	5064	12.25	Grout pulled out
18	8	5064	13.62	Grout pulled out

**Sleeves located eight inches from cutout.*



Test Summary

Minimum Test Capacity—8.62 kips

Maximum Test Capacity—19.12 kips

Average Test Capacity—13.16 kips

Only 1 of 18 tests was below 10.0 kips.

Average test capacity by panel thickness:

4″—12.00 kips

6″—12.75 kips

8″—14.70 kips

There is a moderate increase in capacity with increase in panel thickness over 6″.

Locating sleeve 8″ from end of panel had no significant effect on results.

PCI equation 6.5.1 predicts a maximum pullout capacity of 15.8 kips at 10″ embedment. This is higher than the test results. Test results will control in assigning a design strength for the connection.

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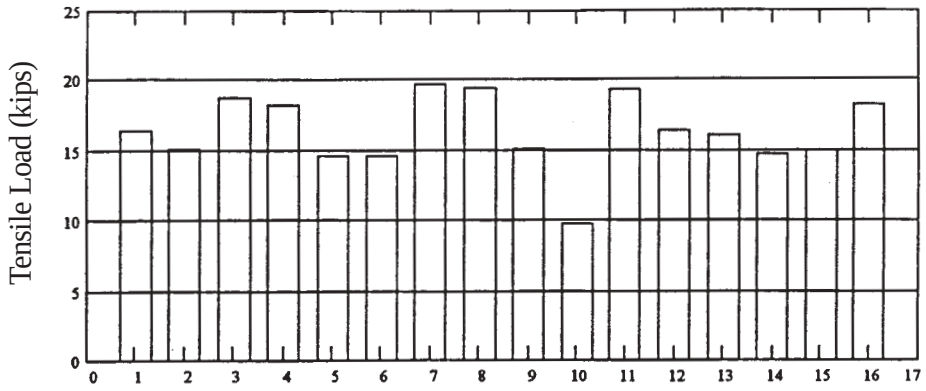
C. 12″ sleeve

#5 bar used as dowel; 12″ embedment
Nominal Grout Strength: 4000 psi

Test No.	Panel Thickness (inches)	Panel Strength (psi)	Test Load (kips)	Mode of Failure
1	4	5406	16.37	Sleeve pulled out
2*	4	5406	15.00	Sleeve pulled out
3	4	4154	18.62	Dowel failed
4*	4	4154	18.12	Held load Cracking at top
5*	4	5984	14.50	Sleeve pulled out
6	4	5984	14.50	Grout pulled out
7	6	5682	19.62	Held load
8*	6	5682	19.37	Sleeve pulled out
9*	6	7234	15.00	Grout pulled out
10	6	7234	9.75	Grout pulled out
11	8	5016	19.25	Held load
12*	8	5016	16.37	Grout pulled out
13*	8	5007	16.00	Grout pulled out
14	8	5007	14.62	Grout pulled out
15*	8	5685	14.87	Bar pulled out
16	8	5685	18.12	Grout pulled out

**Sleeves located eight inches from cutout.*

Ultimate Tensile Load on a 12″ Sleeve



Test Summary

Minimum Test Capacity—9.75 kips

Maximum Test Capacity—19.62 kips

Average Test Capacity—16.25 kips

Only 1 of 16 tests was below 10 kips. Next lowest test was 14.5 kips.

Average test capacity by panel thickness:

4″—16.2 kips

6″—15.93 kips

8″—16.54 kips

There is no significant increase in capacity with increase in the panel thickness.

Locating sleeve 8″ from end of panel had no significant effect on test results.

PCI equation 6.5.1 predicts a pullout capacity of 18.9 kips at 12″ of embedment. This is higher than test results. Test results will control in assigning a design strength for the connection.

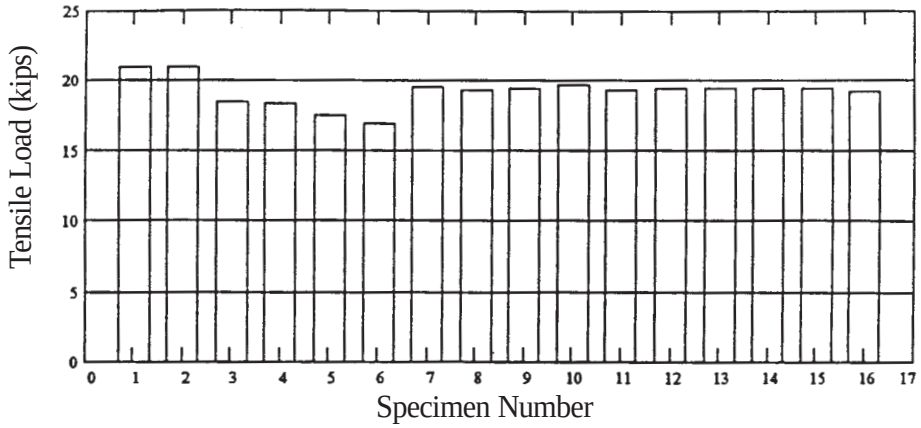
D. 16″ sleeve

#5 bar used as dowel; 16″ of embedment
Nominal Grout Strength: 4000 psi

Test No.	Panel Thickness (inches)	Panel Strength (psi)	Test Load (kips)	Mode of Failure
1*	4	5406	20.87	Held load, Cracking at top of sleeve
2	4	5406	20.87	Held load, Cracking at top of sleeve
3*	4	4154	18.37	Held load, Minor face cracking
4	4	4154	18.25	Held load, Minor face cracking
5	4	5984	17.37	Sleeve pulled out
6*	4	5984	16.87	Sleeve pulled out
7*	6	5682	19.50	Held load, Minor face cracking
8	6	5682	19.25	Held load, Minor face cracking
9	6	7234	19.37	Held load
10*	6	7234	19.62	Held load
11*	8	5016	19.25	Held load
12	8	5016	19.37	Held load
13	8	5007	19.37	Held load
14*	8	5007	19.37	Held load
15	8	5685	19.37	Held load
16*	8	5685	19.12	Bar failed

**Sleeves located eight inches from cutout.*

Ultimate Tensile Load on a 16″ Sleeve



Test Summary

Minimum Test Capacity—16.87 kips

Maximum Test Capacity—20.87 kips

Average Test Capacity —19.14 kips

Average test capacity by panel thickness:

4″—18.77 kips

6″—19.4 kips

8″—19.30 kips

There is no significant increase in capacity is noted with the increase in panel thickness.

Locating sleeve 8″ from end of panel had no significant effect on results.

PCI equation 6.5.1 predicts a pullout capacity of 25.3 kips at 16″ embedment. This is higher than the test results. Test results will control in assigning a design strength for the connection.

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4. CONCLUSIONS AND RECOMMENDATIONS

We recommend that the design ultimate pullout strength for dowel connections using the 2″ diameter sleeves be limited conservatively to the following values (kips):

Sleeve Length (inches)

Panel Thickness (inches)	6	10	12	16
4	3.0	9.5	11.0	15.5
6	3.0	9.5	11.0	19.0
8	6.0	13.0	14.5	19.0

The above table is based on test results adjusted for the recommended 5000 psi 28-day grout strength and 5000 psi nominal panel strength. The values should be used in conjunction with applicable ϕ factors.

To achieve the ultimate pullout strengths, the panels shall be made of 5000 psi nominal 28-day strength concrete. The dowels used shall be sized for the pullout load and be grouted into the sleeves with a non-shrink, non-metallic grout with a minimum 28-day strength of 5000 psi. The panels shall be reinforced appropriately for the pullout loads applied. Design should also follow local or regional codes and industry practices where applicable. Minimum panel reinforcement shall be per Fig. 3, with adequate supplemental reinforcing bars around cutouts or penetrations, if any. The test panels for this project were reinforced with #3 perimeter bars. Normally larger bars are used in 6″ and 8″ panels. Common practice in the industry is to use a #4 bar in 6″ panels and #5 bars in 8″ panels.

NOTE: The sleeves must be fully filled with flowable 5000 psi non-shrink grout. The user shall ensure that there are no air voids within the sleeve after grouting which might later allow intrusion of water.

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Figure 1.
2-in.ϕ × 6″, 10″, 12″ & 16″ Plastic Sleeves

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Figure 2.
Elevation View—Wall to Wall Panel

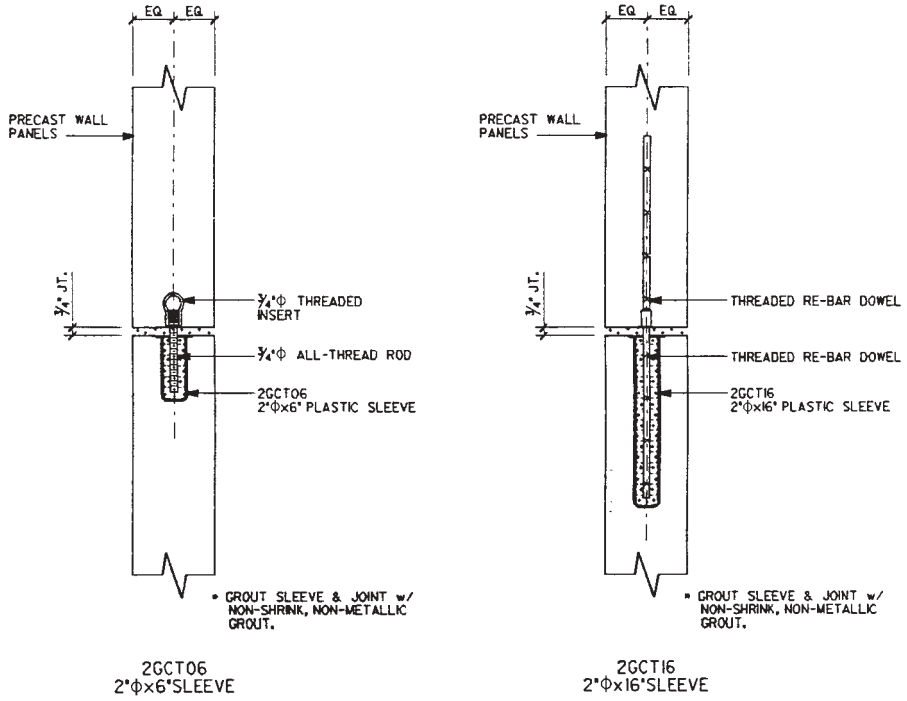

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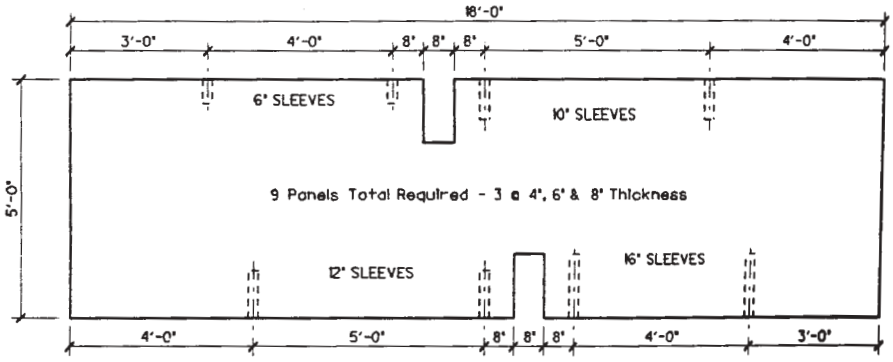
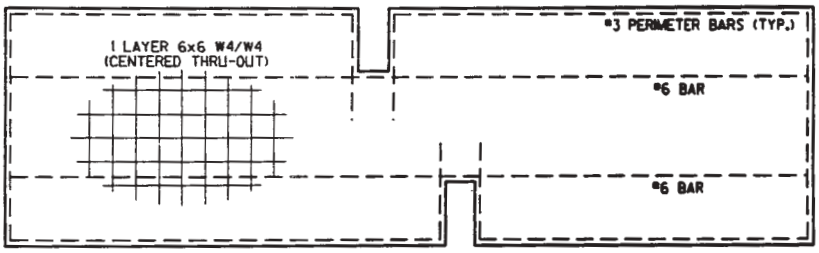
Figure 3.



General Panel Dimensions and Sleeve Locations



Reinforcement Details

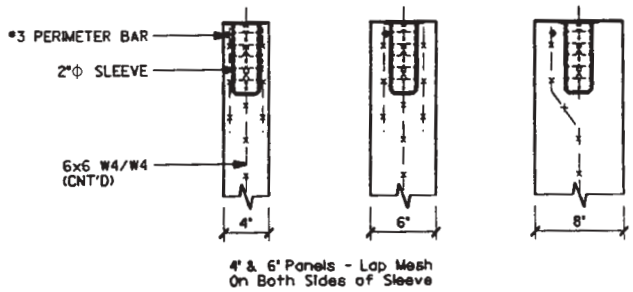


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Figure 4.
Test Set-Up

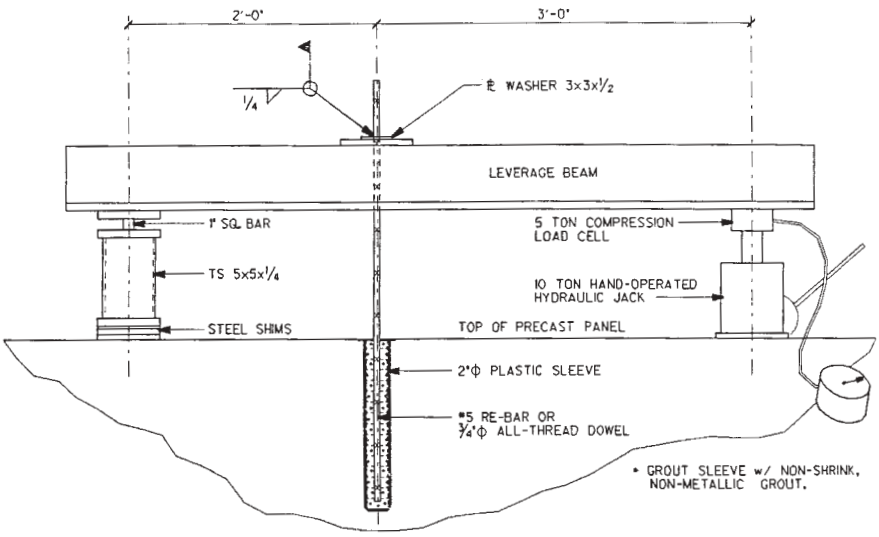

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Figure 5.
Grouted Dowel Installation

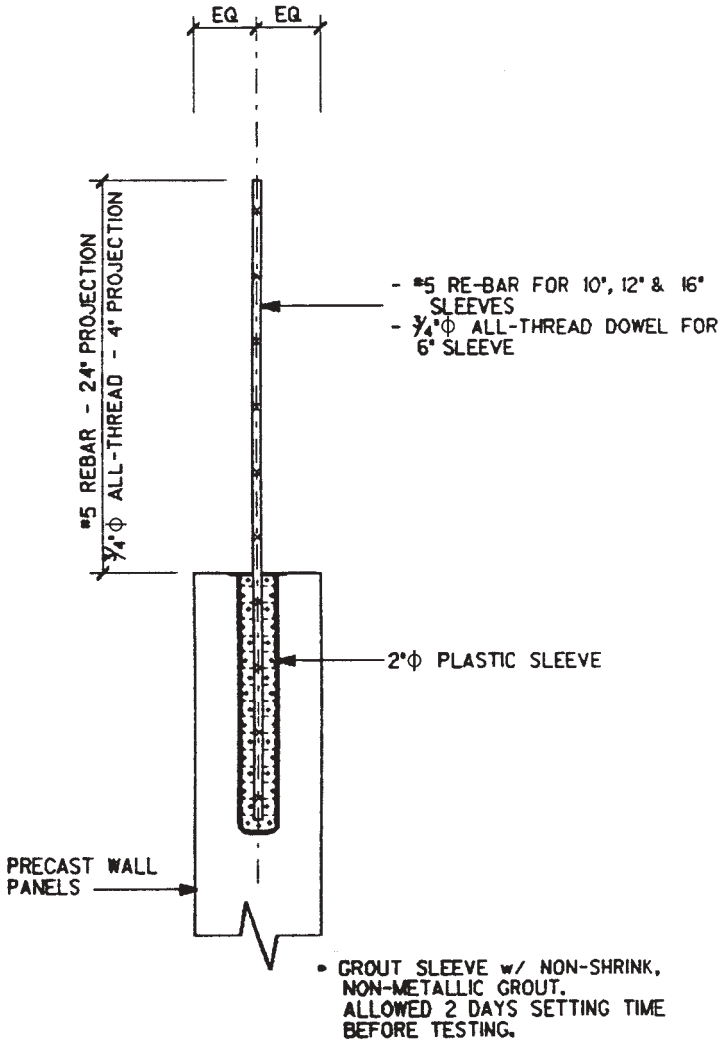

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Figure 6.
P.C.I. Handbook—4th Edition Section 6.5.1

6.5.1 Reinforcing Bars

Reinforcing bars are usually anchored by bonding to the concrete. Very often, there is insufficient length available to anchor the bars by bond alone, and supplemental mechanical anchorage is required. This can be accomplished by hooks or welded cross-bars as shown in Fig. 6.11.1. Load transfer between bars may be achieved by welding, lap splices or mechanical couplers. Required development lengths and standard hook dimensions are given in Chapter 11.

Reinforcing bars may be anchored by embedment in flexible metallic interlocking conduit using grout as shown in Fig. 6.5.1. The conduit must have sufficient concrete aound it as shown in Fig. 6.5.1 for adequate confinement. This scheme can be used to transfer tension or compression forces and is convenient for certain connections, such as column to footing and column to column connections.

For No. 8 and smaller uncoated reinforcing bars, where the bar is forced into the grout-filled flexible conduit, the embedment length is given by:

$$\ell_e = 0.04\, A_b f_y / \sqrt{f'_c} \geq 12 \text{ in.} \qquad \text{(Eq. 6.5.1)}$$

where:

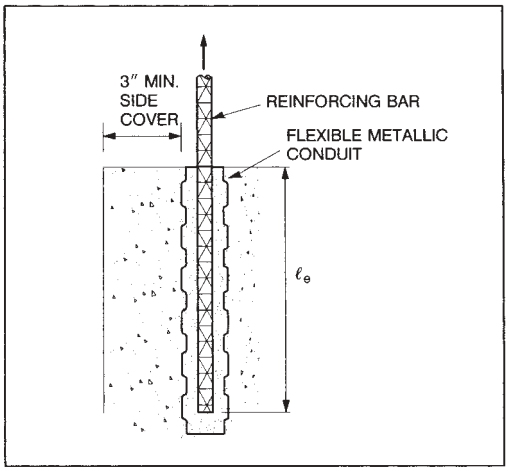
ℓ_e = embedement length, in.

A_b = area of bar, sq in.

f_y = steel yield strength, psi

f'_c = concrete strength, psi

Figure 6.5.1 Anchorage in grouted conduit



APPENDIX I

Concrete report on test panels

Mix. No. 19966—5000 psi structural gray concrete mix

Mix Composition:
Materials/cubic Yard
Cement: Allentown, Type 3—658 lbs
Fine Aggregate: York Orange Sand—1278 lbs
Coarse Aggregate: Lancaster Lime Stone—1834 lbs
Water—30 gallons
Admixtures/cubic Yard
Entrained Air: Master Builders MBVR—7 ozs
Retarder: Master Builders 100 XR—20 ozs
Water Reducer: Master Builders 400N—106 ozs

Concrete Test Results (psi):

Cast Date	Panel Thickness (inches)	Stripping Strength	7-Day Strength	Test Date* & Strength		28-Day Strength
7/17/95	4	3501/15.5 Hrs	5270	7/27	5406	6225
				8/3	5771	
	6	4510/15 Hrs	5478	7/28	5785	7092
	8	3289/16.5 Hrs	4421	7/31	4812	5447
				8/4	5007	
7/18/95	4	3784/15 Hrs	5712	7/27	5772	6349
				8/2	5984	
	6	5482/17 Hrs	6862	7/28	6974	7643
				8/3	7234	
	8	3431/16 Hrs	4934	7/31	5016	5182
				8/4	5064	
7/19/95	4	2759/15 Hrs	4067	7/28	4154	4987
				8/2	4418	
	6	5058/18 Hrs	5359	7/31	5682	6490
				8/3	5844	
	8	3608/18 Hrs	5146	7/31	5469	6278
				8/4	5685	

**Test date strength determined by linear interpolation between 7-day and 28-day strengths.*

Concrete Strength Summary: Low—4154 psi
High—7234 psi
Average—5533 psi

APPENDIX II

Grout report for two-inch diameter sleeve pullout tests

Grout Mix: Premixed non-shrink, non-metallic grout

Manufacturer and Product name:
IPA Systems, Inc.—Penngrout
Admixtures, Inc.—B/C Non-Metallic Grouting Compound

Water used: Water added to mix grout to a plastic consistency

1. Dowels grouted on 7/25/95:
   Grout cubes tested on 7/27/95: 3575, 4125, and 4526 psi.
   (average strength: 4075 psi)

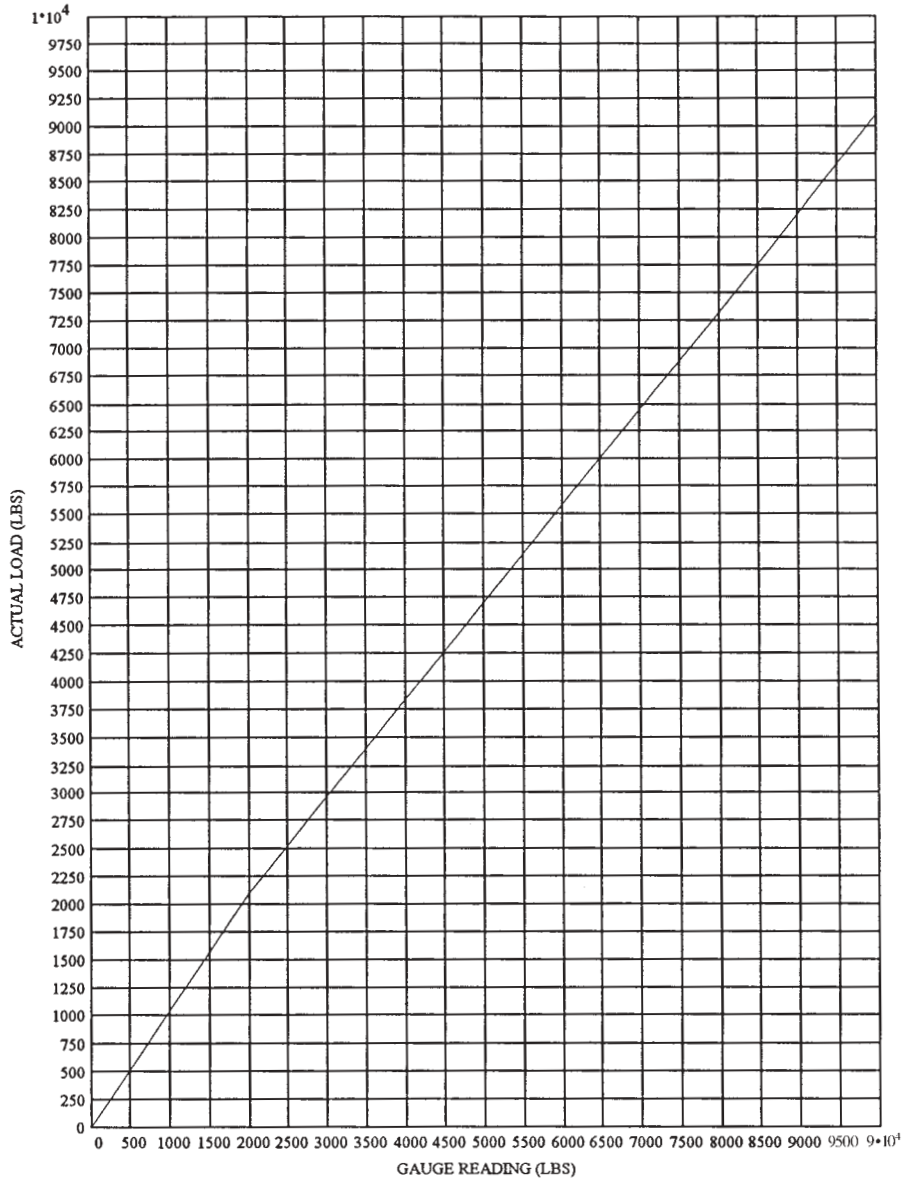
   Panels tested 7/27/95 thru 7/31/95.

2. Dowels grouted on 7/31/95:
   Grout cubes tested on 8/2/95: 3938, 3500, and 3699 psi.
   (average strength: 3712 psi)

   Panels tested 8/2/95 thru 8/4/95

APPENDIX III

Calibration chart for ENERPAC Five Ton Hydraulic Load Cell.



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APPENDIX IV

Plastic Used to Manufacture Sleeves:

Plastic resin (HiD 9416) made by Phillips Petroleum, Inc.
HDPE—High density polyethylene blow mold grade plastic
0.080-inch average thickness
Inert from chemical attack
Deflection (creep) temperature—270° F
Melt temperature—450° to 470° F
Made by blow molding

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SYNOPSIS

Corrugated plastic sleeves (MP-1) were used in 8-in. and 10-in. thick panels. #7 "Richmond" type dowels were pre-grouted in the wall panels and subjected to a maximum pull-out force of 40 kips in eight separate tests.

It was found that wall panel dowels sustained the maximum test load (40 kips) with only minor surface hairline cracks even in the case of off-center dowels. Quality control information was obtained from the precast manufacturer and other suppliers and is included in an appendix. Finally, recommendations are offered in regard to load capacities.

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1. INTRODUCTION AND BACKGROUND

Currently there is a variety of hardware used in connections, including reinforcing bars, studs, coils, bolts, threaded rods and corrugated sleeves. Reinforcing bars are usually anchored by bonding to the concrete, or by embedment in corrugated conduits using grout as shown in Fig. 1. As per PCI practice, the conduit must have sufficient concrete around it for adequate confinement (6″ to 7″ as shown Fig. 1). In the past, corrugated metal conduits were routinely used. However, plastic conduits with deformations, Fig. 2, offer economic and production advantages. This scheme can be used to transfer tension in certain connections such as a horizontal joint in a wall panel-to-panel connection, Fig. 3.

Pull-out tests on this type of connection (MP-1) and using actual geometries and material properties matching those furnished for High Concrete projects were not available and prompted the testing project described here below.

2. OBJECTIVES

The test program had the following goals:

a. To investigate the behavior of the MP-1 connection which consists of #7 "Richmond" dowels grouted in standard 3″ corrugated plastic sleeves and subject to a fairly high pull-out force (40 kips). Two panel thicknesses will be investigated, namely t = 8″ and t = 10″.

b. Draw conclusions and offer recommendations pertinent to ultimate (design) load capacities of such connections.

Figure 1.
Anchorage in grout-filled conduit

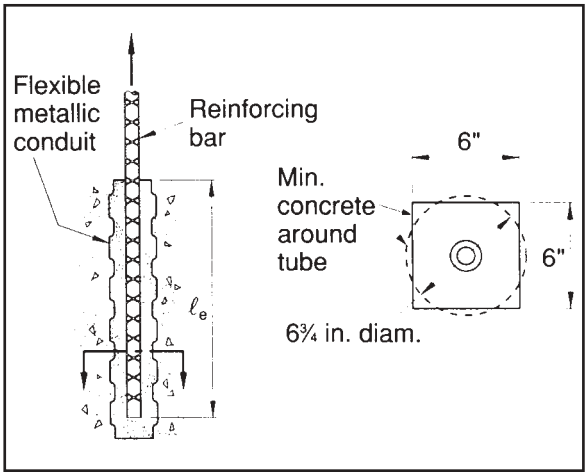

Figure 2.
Plastic Conduit with deformations

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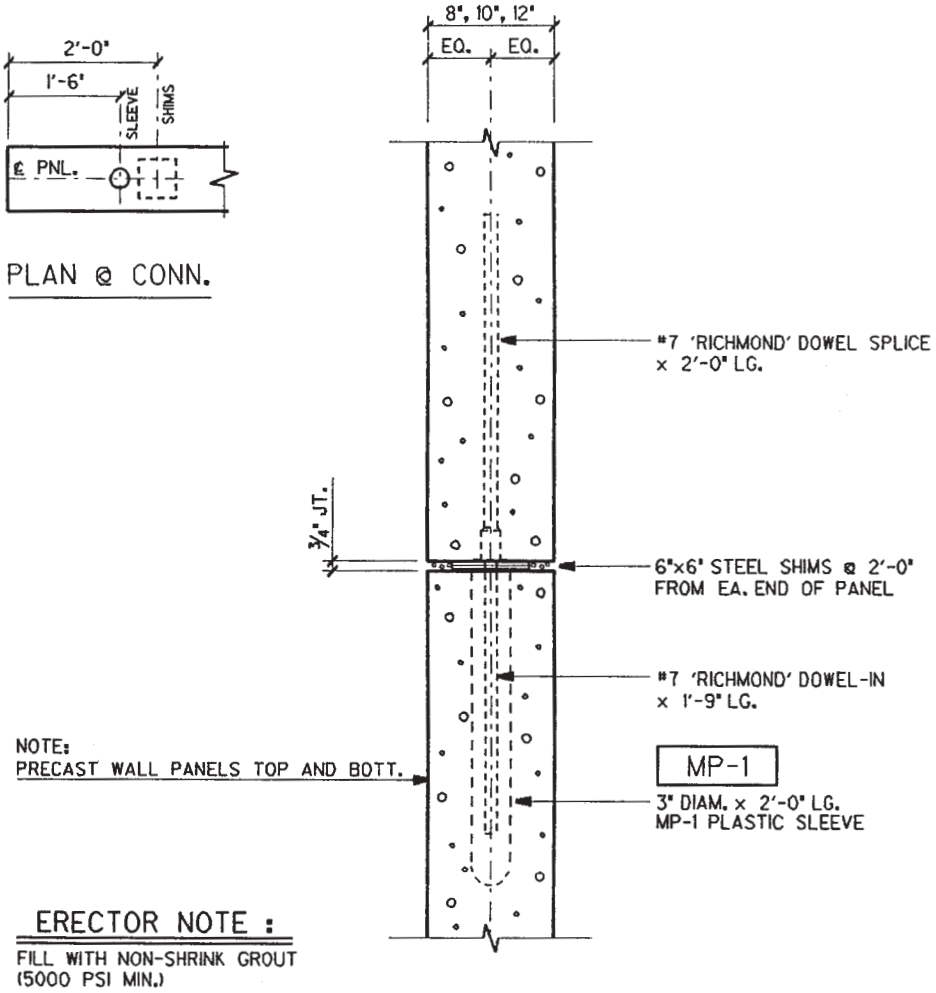
Figure 3.
Wall Panel/Panel



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3. PULLOUT TESTS ON MP-1 CONNECTIONS

3.1 Description of Test Panels

The 8″ and 10″ concrete test panels were produced using a mix with a predicted nominal strength of 5000 psi at test time. Details of the concrete mix and strengths are listed in Appendix I to this report.

Grade 60 reinforcing and welded wire fabric were used in the 6′ 0″ × 3′ 6″ panels' fabrication as shown in Fig. 4. The plastic sleeve was a standard 3″ diameter × 2′ 0″ long, while the #7 Richmond dowel bar had an embedded length of 1′ 9″. The nominal yield strength for the dowel is 60 ksi.

The dowels were grouted two days before the testing date using a nominal 5000 psi grout. On test day, September 1, 1993, the actual concrete specimen strength was an average f'_c = 5323 psi, while the grout tested at 5215 psi.

Three of the panels were 10″ thick with centered bars and three others were 8″ thick. Two additional 8″ panels with off-center dowels were also produced to simulate inaccuracies in dowel positioning.

3.2 Test Set-up

The pullout test set-up is described in Fig. 5. Each panel was positioned vertically on two saddle-type supports. Then a structural steel reaction beam was placed on top of the panel, Fig. 6. A 1″ diameter, high-strength bolt was threaded vertically to the coupler on top of the Richmond dowel and passed through a center-hole ram supplied and operated by the Lang Co. The calibration chart for the jacking system, monitored through analog and digital dials, is shown in Appendix II.

The pullout jacking force was applied slowly and continuously until a load of 25 or 32 kips was reached. Then load was maintained for 2 minutes (±) followed by an increase in the load to 35, 37.5 and 40 kips, respectively. After each increment, load was also maintained for about 2 minutes while observations for possible cracks in the panel and grout were made. The maximum load was set at 40 kips for safety reasons. Test duration averaged about 20–35 minutes per panel.

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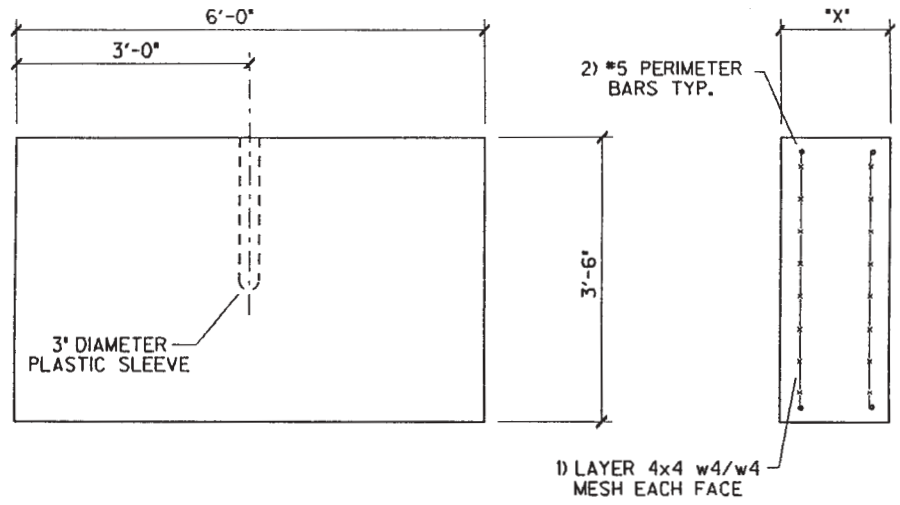
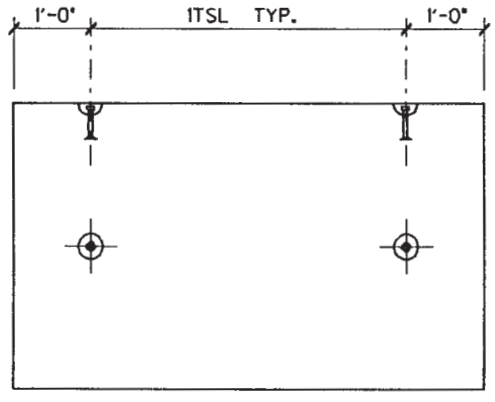
Figure 4.
Samples For Testing of 3″ Diameter Plastic Sleeve



NUMBER OF SAMPLES = 8

5) X = 8" THICK
3) X = 10" THICK

1" CLEAR MIN.



PICKING LOCATIONS FOR STRIPPING AND HANDLING

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Figure 5.
Load Test 3″ Diameter Corrugated Sleeve MP-1

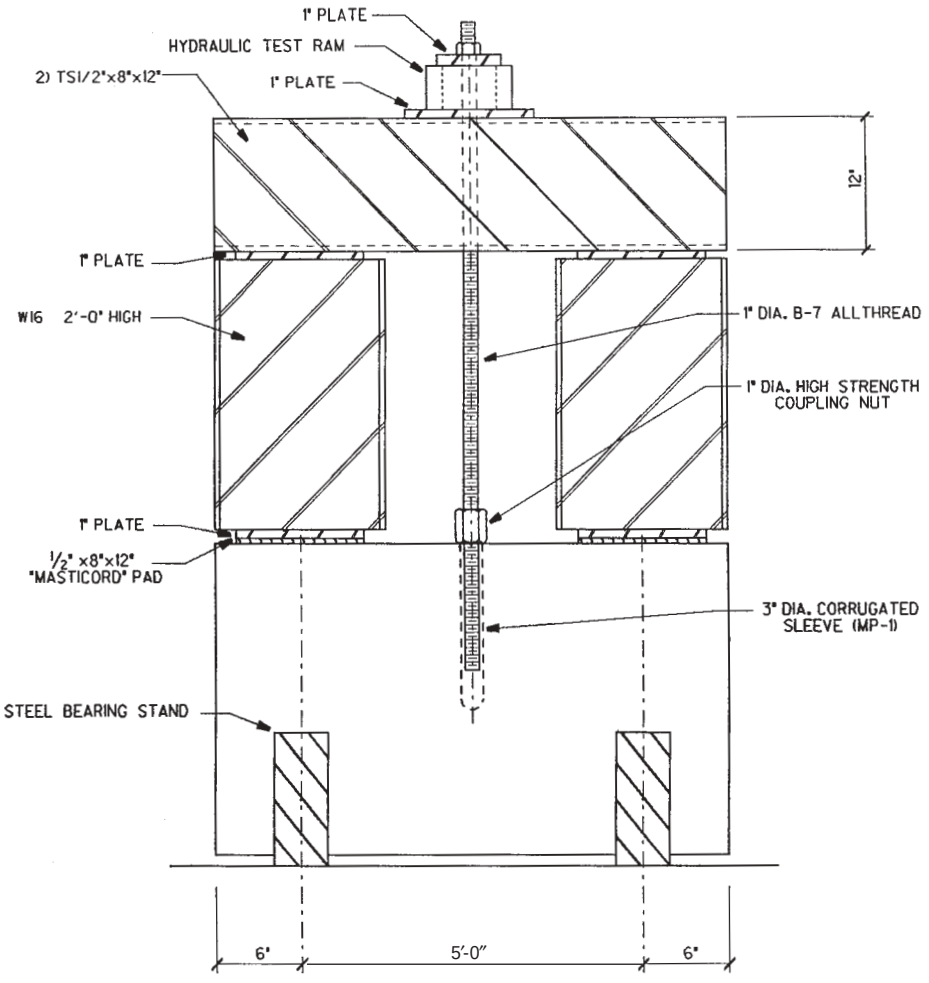

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Figure 6.
Richmond Dowel tip (top) and test setup (bottom)

3.3 Test Results

The observations obtained from each of the 8 tests on Sept. 1, 1993, are described in the following paragraphs. Figure 7 shows specimen P-4 after the test completion.

Specimen P-1: 10″ thick panel.

Load levels: 32, 35, 37.5 and 40 kips.

No hairline cracks or slippages observed.

Specimen P-2: 8″ thick panel.

Load levels: 18, 32, 35, 37.5 and 40 kips.

Minor surface hairline cracks were observed at the 35k level. They were about ¾″ long, radiating from the bar center and almost parallel to the panel face.

Specimen P-3: 10″ thick panel.

Load levels: 32, 35, 37.5 and 40 kips.

No hairline cracks or slippages observed.

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Figure 7.
Test Panel P-4 after test completion

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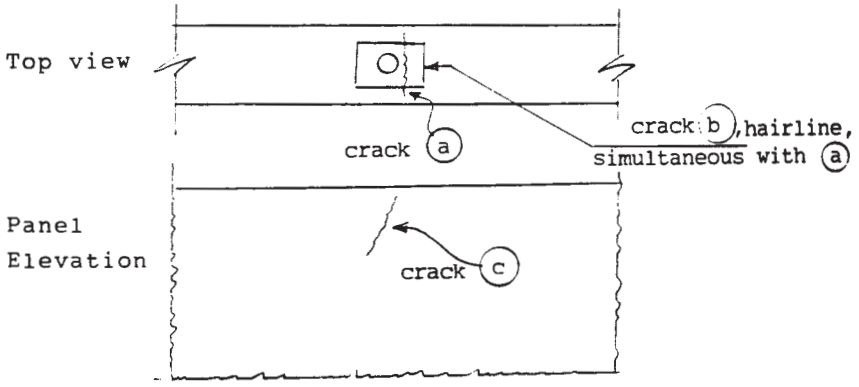
Specimen P-4: 8″ thick panel.

Load levels: 25, 32, 35, 37.5 and 40 kips.

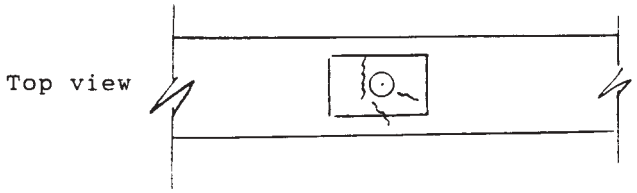
Embedded "Richmond" dowel was intentionally located off-center and close to the sleeve. Before loading started, a minor circular crack between grout and sleeve was observed. At a load level of 32 kips, crack 'a' in a vertical plane appeared next to the dowel as shown in the sketch below. At a level of 37.5 kips, crack 'c' appeared on the panel face and its length was about 10″. At the maximum test load of 40 kips, grout top lifted slightly ($1/32$″ ±).



Specimen P-5: 10″ thick panel.

Load levels: 25, 32, 35, 37.5 and 40 kips.

At a load level of 32 kips, minor hairline cracks appeared around the bar as shown in sketch below. At 37.5 kips, cracks expanded slightly. At the maximum load level of 40 kips, a very minor lifting of the grout top was observed (< $1/32$″).



Specimen P-6: 8″ thick panel.

Load levels: 25, 32, 35, 37.5 and 40 kips.

Embedded “Richmond” dowel was intentionally located off-center and close to the sleeve. At a load level of 32 kips, minor radial hairline cracks emanating from bar appeared on grout surface. Increased loading did not result in further crack propagation.

Specimen P-7: 8″ thick panel.

Load levels: 32, 35, 37.5 and 40 kips.

Before loading started, a slight shrinkage crack was present around the grout. At a load of level of 35 kips, this shrinkage crack became more visible. No further cracking appeared.

Specimen P-8: 8″ thick panel.

Load levels: 32, 35, 37.5 and 40 kips.

At a load level of 32 kips, an incomplete circular crack appeared around the grout. When load was increased to 37.5 kips, a 1 ¼″ long, minor radial hairline crack appeared. At the maximum load of 40 kips, another 1 ¼″ long radial crack appeared.

4. CONCLUSION

The #7 “Richmond” type dowel bar grouted within the 3″ diameter plastic type connection (MP-1) as described earlier can be designed for an ultimate tensile capacity of 36 kips. Concrete and grout strengths must be a minimum of 5000 psi with wall panels at least 8″ thick and reinforced as per Fig. 4 and other PCI practices for each particular job. Load and capacity reduction factors are to be applied in the usual manner.

NOTE: The sleeves must be fully filled with flowable 5000 psi non-shrink grout. The user shall ensure that there are no air voids within the sleeve after grouting which might later allow intrusion of water.

APPENDIX I

CONCRETE REPORT ON MP-1 TEST PANELS (PULL-OUT TESTS)

Mix No. 19966, Special R&D. Nominal 5000 psi. Date poured: 8-15-93. Yards on Truck: 1 ½. Slump: 6″

Mix Composition:

Cement: Allentown, type 3.....658 lbs
Coarse Aggregate: ¾″ (#67).....1834 lbs
Fine Aggregate: Tuckahoe S&G.....1278 lbs
Water (0.40 W/C ratio).....31.6 gallons
Air-entraining agent.....6 ozs
Retarder.....20 ozs
Type F Super-plasticizer.....35 ozs

Concrete Strength at Stripping Time (8-16-93): 4,457 psi

Concrete Strength at Test Time (9-1-93):
(5164 + 5482) / 2 = 5323 psi (at 9:30 a.m.)

GROUT REPORT FOR MP-1 TEST PANELS (PULL-OUT TESTS)

Mix Designation: nominal 5000 psi, with highly reduced H.R.W.R.

Date of Pour: 8-30-1993, between 4:30 and 5:00 p.m.

Test Date: 9-1-1993, starting 10:00 a.m.

Grout Strength on Test Date: (5431+ 4998) / 2 = 5215 psi.

B/C non metallic, non shrink grout.....50 lbs

Water.....1.125 gallons

APPENDIX II

E. L. CONWELL & Co.

ESTABLISHED 1894

ENGINEERS - CHEMISTS - INSPECTORS

July 13, 1993

Lang Tendons, Inc.
143 N. Newark Road
Toughkenamon, PA 19374

LANG TENDONS INC.
JUL 14 1993
RECEIVED

Attention: Mr. Mike Cordivano

Re: Load Cell
Calibration

Gentlemen:

The following is a report of our calibration of a load cell submitted by you July 12, 1993.

LABORATORY NO. 462332

Pertinent Information

Load Cell: Load Cell #1

Dial Gauge: Dial #LC-2
Digital Serial #B001370

Testing Machine: Baldwin-Emery, 300,000 capacity
Serial #483450

Dial Gauge Reading	Load on Testing Machine Dial LC-2	(Average of 3 Runs (lbs.) Digital B001370
1000	4800	6467
2000	11700	13083
3000	18000	19683
4000	24500	26167
5000	30900	32600
6000	37733	39067
7000	44167	46350
7600	48317	49333

Pressure versus load curves enclosed.

Respectfully submitted,

E. L. CONWELL & CO.

D. S. Spitzer, P.E.

DSS/nm
Enclosures
7/13/93 faxed at 1:30 p.m. to (215) 268-3053 nm

CONTINENTAL BUSINESS CENTER, FRONT & FORD STS., BRIDGEPORT, PA 19405 (215) 277-2402

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