

Full Scale Post Test Report

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TESTING OF AB FENCE

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TESTING OF PRODUCT

INTRODUCTION:

This report is in reference to testing of an Allan Block AB Fence at their facility on September 9, 2005, as documented in a report entitled "Allan Block In-House AB Fence Testing Full Scale Post Test Report, dated July 25, 2006, prepared by Mr. Rich Lovdal of Allan Block Corporation (copy attached). Stork Twin City Testing Corporation (Stork TCT) witnessed some of the testing described in Mr. Lovdal's report. The discussion that follows pertains to that testing. Our work was requested by Mr. Lovdal on or about November 23, 2004 and authorized by Mr. Tim Bott of Allan Block Corporation, on March 7, 2005. The scope of our testing work was as follows:

1. Travel to the Allan Block Corporation test laboratory in Edina, Minnesota to monitor the testing of the AB Fence. The AB Fence test specimen was constructed previous to the witnessed testing: Stork TCT personnel did not witness the construction of the tested specimen. Allan Block Corporation personnel also prepared the testing apparatus, which Stork TCT personnel observed.
2. Witness all testing of the AB Fence "post" specimens on September 9, 2005, and verify the data collected.
3. Review the final test report prepared by Allan Block Corporation personnel, and prepare a suitable cover letter for the purpose of verifying the test data presented therein.

CONCLUSION:

The description of AB Fence "post" test specimens, the test procedure and equipment described, as well as the test data contained in Appendix A of Mr. Lovdal's report of July 25, 2006, is consistent with the observations made by Stork TCT personnel for the tests conducted on Post 1 and Post 2. Review and validation of the remainder of the report, its discussion and/or conclusions, as well as other test data presented are beyond the Stork TCT's scope of services.

REMARKS:

Should you have any questions concerning this report, or if we may be of further assistance, please contact us at (651) 659-7340.



Allan Block AB Fence Testing
8.6' Full Scale Post Test Report

July 25, 2006

Introduction

This report gives the results for the full-scale tests on two Allan Block Fence posts. The same posts were used in both the Vertical Spreader Bar panel tests and the 12x7 Articulating Spreader Frame tests performed on the Allan Block Fence panel. All tests were performed in the Allan Block lab using Allan Block equipment and personnel along with a representative from Stork Twin City Testing (STCT) witnessing and certifying the testing procedures and results. These tests were performed in September 2005 and are an extension of the Fence Testing performed at the University of Calgary in 2003 and the Allan Block AB Fence Testing performed on the panel assembly in August 2004.

Objectives of Test Program

The principle objective of this test is to determine the actual capacity of the Allan Block Fence Post in an on-site (cantilever) configuration. The resulting data will be used to further understand the capacities of the system and to produce a more accurate design methodology for the Allan Block segmental fence system.

The Moment capacity of the Allan Block post will be determined by recording the applied force from the hydraulic ram, which is fixed at a specific point above the foundation. The position of the ram above the floor is the fixed moment arm and when multiplied by the applied load the moment capacity is determined. The realized post moment capacity can then be compared to a calculated capacity using accepted beam theory equations, See Appendix C for hand calculations. If the system capacity is higher or lower than the calculated values, the AB Fence design methodology can be adjusted to better fit the segmental nature of the Allan Block Fence Post.

Careful attention will be given to the recording of deflections and rebounds to document the potential plasticity of the post system.

Test Procedure and Results

The tested posts were previously used in the Vertical Spreader Bar panel tests and the 12x7 Articulating Spreader Frame tests. When the Panel tests were completed, the two posts were left in place after panel demolition to proceed with these cantilever moment capacity tests. The construction of the post was performed exactly as would be under field conditions. Each post consisted of 13 courses of standard post block with 4 - #5 footing dowels extending 24 inches into the post, spliced with 4 - #5 vertical post bars. As is typical for field construction, the lap splices were not tied. The hollow core of each post was filled with a bag mix concrete which tested out at an average of 4650 psi (32.0 MPa). A 25 ton (111.2 kN) hydraulic ram was fixed at 6ft above the lab floor and a 10,000 pound (44.5 kN) load cell was placed to record the applied



Figure 1: Post 1 Test Frame Set-up



Figure 2: In Place Load Cell and Deflection Transducer

load, see Figures 1 and 2. Post One was stressed and rebounded 8 times and Post Two 9 times, with the last of each to failure. See Appendix B for the actual test data. The recorded deflection data was remarkably similar for each load application, reflecting the fact that during each stressing and subsequent rebound, the composite post did not yield in any way and remained entirely plastic by nature until the final failure stressing.

Appendix C contains a set of hand calculation using no material reduction for steel or concrete strengths or any reductions for exposure. These were computed to determine a maximum expected failure moment. The calculations show the maximum moment expected for both a compressive and a tensile failure. The calculated tensile failure was nearly half that of the compressive failure. This is due to the small steel to concrete ratio. Therefore, the expected failure mode was tensile, but the ultimate failures for both posts appeared to be in compression of concrete. Figure 3 shows the failure location and resulting shear crack at the top of splice location. The ultimate moment for both posts resulted in a moment that nearly matched the calculated compressive failure exactly. This warranted a closer evaluation of the calculated moments in the base of the post. Figure 4 shows a break down of calculated moments in the three locations in and around the splice. Failure occurred in Subject Area C and not in the expected location of Subject Area A. See Appendix C for hand calculations expressing the calculated moment capacities under the failure load. The tested ultimate failure and ultimate capacity moments at Area C again matched closely. Therefore the ultimate failure appears to be a yielding of the tensile rebar at Area C which then allowed the compressive capacity to be overcome resulting in the shear crack and the inability of the post to rebound after the load was removed.

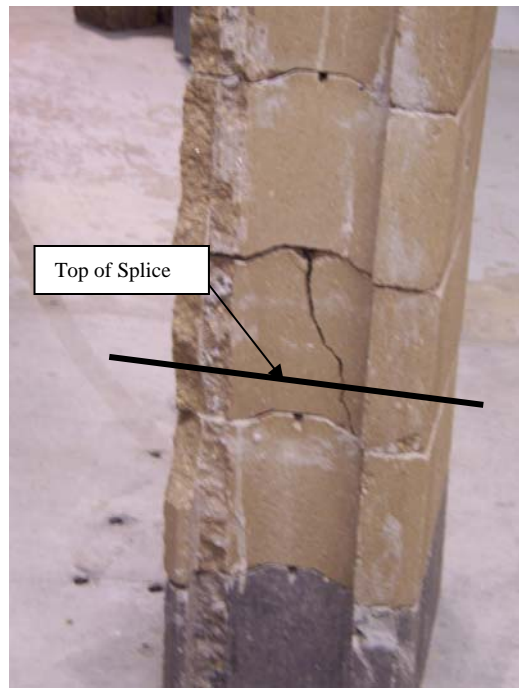


Figure 3: Post 1 after failure

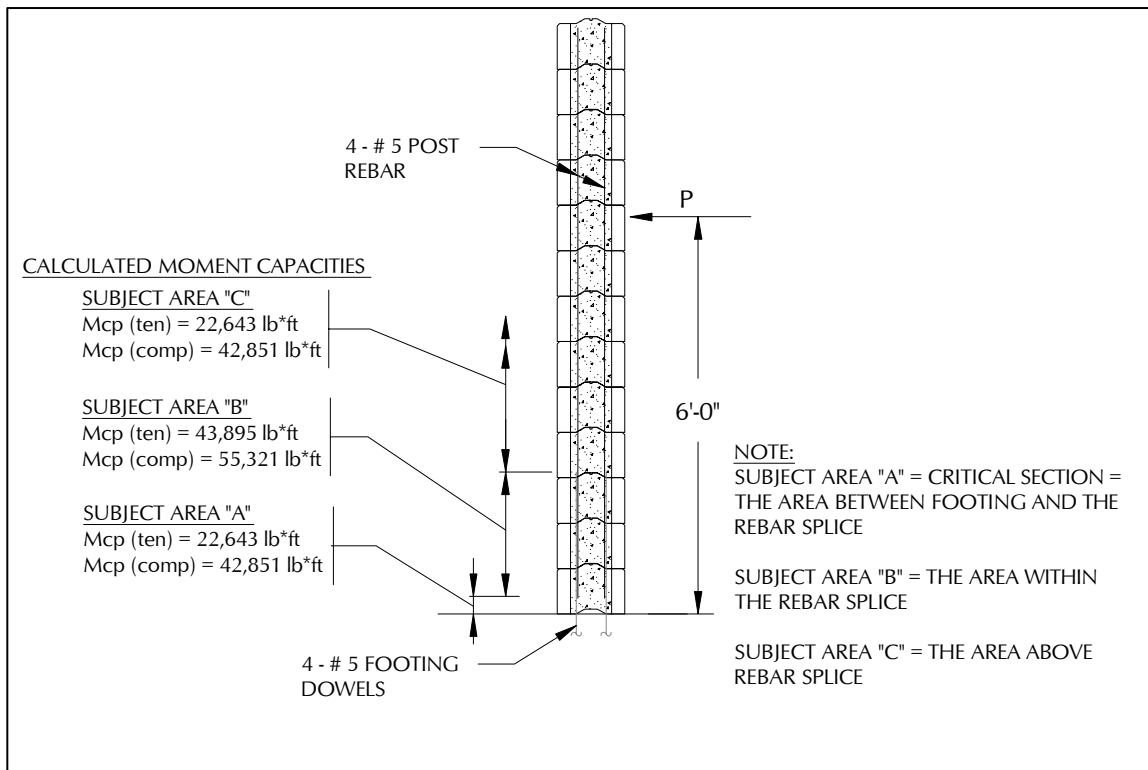


Figure 4: Calculated Test Moment in Splice location

But why did the failure not occur in Subject Area A where that failure moment is greater? Figure 5 show a typical footing dowel. The lower half is embedded into the lab floor and the threaded end can be inserted and removed. These inserts are designed to be at least 125% stronger than the actual rebar itself. The threaded insert is directly located in Area A. This insert changed the capacity moments in Area A enough to force the actual failure to occur in the next weakest area – Area C. Figure 6 shows the same location after the face shell has been removed. A jack hammer was required to remove the Allan Block face because of the extraordinary bonding which occurred during the curing process.



Figure 5: Footing Dowel Insert

Conclusions and Recommendations

These two posts tested so close to the calculated capacities using first principle beam capacity equations that there can be no recommendation to change the way the capacities are currently calculated. Additionally, it is concluded that in a field operation with continuous footing dowels the maximum moment would occur at the base and not above the splice. This matches the current design methodology. The capacity realized in these tests would be sufficient to support a panel 11'-2" in height x 33'-5" in Length (3.4m x 10.24m) with a sustained wind load of 100 mph, or 19.2 psf (160.93 Kph, or 0.92 kPa), allowing a safety factor of 1.0 with no material strength reductions, see Figure 7. The following are a list of conclusions formulated from physical data and visual observation during testing:

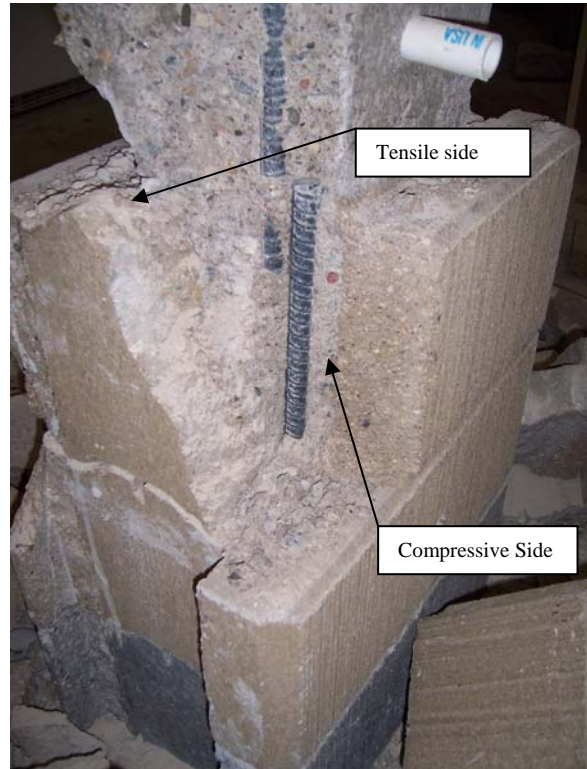


Figure 6: Post 1 Splice after dismantling

- Both Posts preformed as expected and matched calculated capacities nearly exactly.
- The composite nature of the Allan Block Post clearly performs as a monolithic cantilever beam, proving the post block can be used as part of the design section.
- The dismantling of the post showed fully encapsulated rebar with adequate concrete cover.
- The non-tied rebar splice clearly provided excess capacity proving that tying is not required.

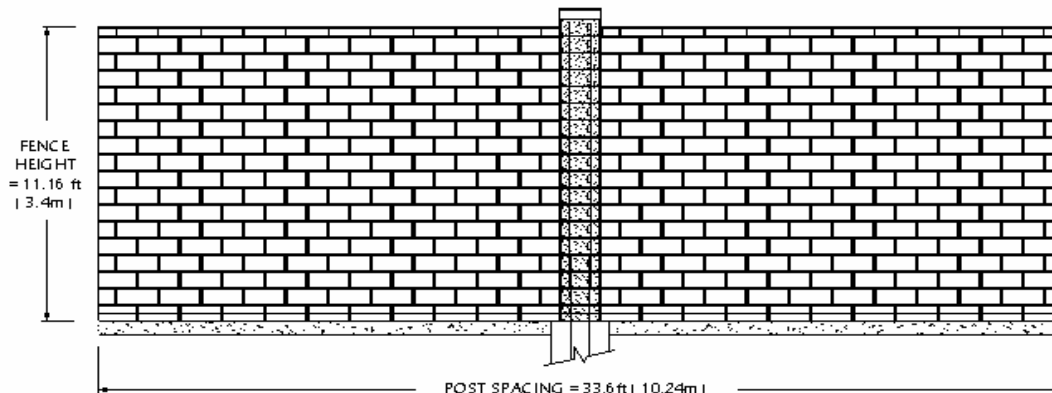


Figure 7: Projected Maximum Panel size for tested Post

APPENDIX A

Test Frame and Equipment

Test Frame and Equipment

The two Posts used for the Vertical Spreader Bar panel tests and the 12x7 Articulating Spreader Frame panel tests were left in place after the removal of the tested panels, see Figure A6. Each Post was tested to gather two sets of independent data. The steel load frame was built to withstand the overturning forces applied to the Post. It is movable and can be bolted in to the floor in multiple locations to meet the needs of future testing, see Figure A1. Each post was cast with 13 courses of standard post block with 4-#5 verticals spliced with 4-#5 footing dowels. To record the forces applied to the post a 10,000 lb load cell was placed between the steel frame and the post at a fixed position of 6ft above the floor. Deflection was measured using a string line transducer recording millimeters of movement, see Figure A2. The device is fixed at 7.25 ft above the floor. A switch box that allows up to 10 load cells and 5 deflection transducers powers both the load cells and the deflection transducer. The Switch box sends a voltage signal to the voltmeters showing either pounds of force or millimeters of deflection see Figure A3. All applied forces come from an SPX Power Team 25 ton hydraulic ram and hand operated pump see Figures A4 and A5.



Figure A1: Post 1 Test Frame Set-up

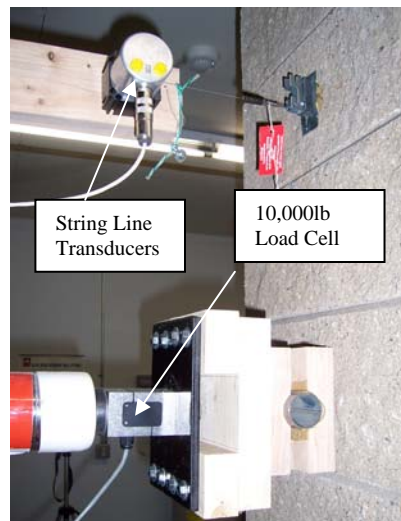


Figure A2: String Line Transducers And 10,000 lb Load Cell

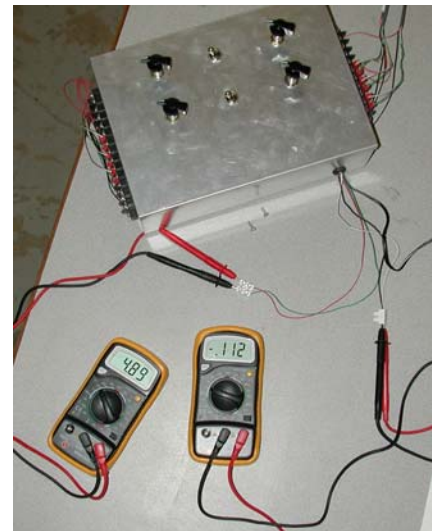


Figure A3: Switch Box and Volt Meters



Figure A4: SPX Hydraulic Hand



Figure A5: Hydraulic Ram

Figure A6: Full-Scale Panel Set-up showing Post 1 and 2



APPENDIX B

Test Result Data

POST 1

POST 1 DATA

Ram Position Above Floor = 5.958 (1.816)
 Moment Arm - ft (m) =

Series 1

pounds force - lb =	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800
pounds force (N) =	(889.64)	(1779.28)	(2668.92)	(3558.56)	(4448.20)	(5337.84)	(6227.48)	(7117.12)	(8006.76)	(8896.40)	(9786.04)	(10675.68)	(11565.32)	(12454.96)
Moment -lb-ft =	1191.66	2383.32	3574.98	4766.64	5958.3	7149.96	8341.62	9533.28	10724.94	11916.6	13108.26	14299.92	15491.58	16683.24
Moment (N*m) =	(1615.68)	(3231.35)	(4847.03)	(6462.71)	(8078.38)	(9694.06)	(11309.74)	(12925.41)	(14541.09)	(16156.76)	(17772.44)	(19388.12)	(21003.79)	(22619.47)
Deflection Reading - in =	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354	0.394	0.433	0.472	0.512	0.551	0.591
Deflection Reading (mm) =	(2.0)	(3.0)	(4.0)	(5.0)	(6.0)	(7.0)	(8.0)	(9.0)	(10.0)	(11.0)	(12.0)	(13.0)	(14.0)	(15.0)

Series 2

pounds force - lb =	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600
pounds force (N) =	(889.64)	(1779.28)	(2668.92)	(3558.56)	(4448.20)	(5337.84)	(6227.48)	(7117.12)	(8006.76)	(8896.40)	(9786.04)	(10675.68)	(11565.32)	(12454.96)	(13344.60)	(14234.24)	(15123.88)	(16013.52)
Moment -lb-ft =	1191.66	2383.32	3574.98	4766.64	5958.3	7149.96	8341.62	9533.28	10724.94	11916.6	13108.26	14299.92	15491.58	16683.24	17874.9	19066.56	20258.22	21449.88
Moment (N*m) =	(1615.68)	(3231.35)	(4847.03)	(6462.71)	(8078.38)	(9694.06)	(11309.74)	(12925.41)	(14541.09)	(16156.76)	(17772.44)	(19388.12)	(21003.79)	(22619.47)	(24235.15)	(25850.82)	(27466.50)	(29082.18)
Deflection Reading - in =	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
Deflection Reading (mm) =	(2.0)	(3.0)	(4.0)	(5.0)	(6.0)	(7.0)	(8.0)	(9.0)	(10.0)	(11.0)	(12.0)	(13.0)	(14.0)	(15.0)	(16.0)	(17.0)	(18.0)	(19.0)

Series 3

pounds force - lb =	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600
pounds force (N) =	(889.64)	(1779.28)	(2668.92)	(3558.56)	(4448.20)	(5337.84)	(6227.48)	(7117.12)	(8006.76)	(8896.40)	(9786.04)	(10675.68)	(11565.32)	(12454.96)	(13344.60)	(14234.24)	(15123.88)	(16013.52)
Moment -lb-ft =	1191.66	2383.32	3574.98	4766.64	5958.3	7149.96	8341.62	9533.28	10724.94	11916.6	13108.26	14299.92	15491.58	16683.24	17874.9	19066.56	20258.22	21449.88
Moment (N*m) =	(1615.68)	(3231.35)	(4847.03)	(6462.71)	(8078.38)	(9694.06)	(11309.74)	(12925.41)	(14541.09)	(16156.76)	(17772.44)	(19388.12)	(21003.79)	(22619.47)	(24235.15)	(25850.82)	(27466.50)	(29082.18)
Deflection Reading - in =	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
Deflection Reading (mm) =	(2.0)	(3.0)	(4.0)	(5.0)	(6.0)	(7.0)	(8.0)	(9.0)	(10.0)	(11.0)	(12.0)	(13.0)	(14.0)	(15.0)	(16.0)	(17.0)	(18.0)	(19.0)

Series 4

pounds force - lb =	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400
pounds force (N) =	(889.64)	(1779.28)	(2668.92)	(3558.56)	(4448.20)	(5337.84)	(6227.48)	(7117.12)	(8006.76)	(8896.40)	(9786.04)	(10675.68)	(11565.32)	(12454.96)	(13344.60)	(14234.24)	(15123.88)	(16013.52)	(16903.16)	(17792.80)	(18682.44)	(19572.08)
Moment -lb-ft =	1191.66	2383.32	3574.98	4766.64	5958.3	7149.96	8341.62	9533.28	10724.94	11916.6	13108.26	14299.92	15491.58	16683.24	17874.9	19066.56	20258.22	21449.88	22641.54	23833.2	25024.86	26216.52
Moment (N*m) =	(1615.68)	(3231.35)	(4847.03)	(6462.71)	(8078.38)	(9694.06)	(11309.74)	(12925.41)	(14541.09)	(16156.76)	(17772.44)	(19388.12)	(21003.79)	(22619.47)	(24235.15)	(25850.82)	(27466.50)	(29082.18)	(30697.85)	(32313.53)	(33929.21)	(35544.88)
Deflection Reading - in =	0.079	0.118	0.157	0.236	0.276	0.315	0.354	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748	0.787	0.866	0.945	1.024	1.142
Deflection Reading (mm) =	(2.0)	(3.0)	(4.0)	(6.0)	(7.0)	(8.0)	(9.0)	(10.0)	(11.0)	(12.0)	(13.0)	(14.0)	(15.0)	(16.0)	(17.0)	(18.0)	(19.0)	(20.0)	(22.0)	(24.0)	(26.0)	(29.0)

Series 5

pounds force - lb =	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800
pounds force (N) =	(889.64)	(1779.28)	(2668.92)	(3558.56)	(4448.20)	(5337.84)	(6227.48)	(7117.12)	(8006.76)	(8896.40)	(9786.04)	(10675.68)	(11565.32)	(12454.96)	(13344.60)	(14234.24)	(15123.88)	(16013.52)	(16903.16)	(17792.80)	(18682.44)	(19572.08)	(20461.72)	(21351.36)
Moment -lb-ft =	1191.66	2383.32	3574.98	4766.64	5958.3	7149.96	8341.62	9533.28	10724.94	11916.6	13108.26	14299.92	15491.58	16683.24	17874.9	19066.56	20258.22	21449.88	22641.54	23833.2	25024.86	26216.52	27408.18	28599.84
Moment (N*m) =	(1615.68)	(3231.35)	(4847.03)	(6462.71)	(8078.38)	(9694.06)	(11309.74)	(12925.41)	(14541.09)	(16156.76)	(17772.44)	(19388.12)	(21003.79)	(22619.47)	(24235.15)	(25850.82)	(27466.50)	(29082.18)	(30697.85)	(32313.53)	(33929.21)	(35544.88)	(37160.56)	(38776.24)
Deflection Reading - in =	0.079	0.157	0.197	0.236	0.276	0.315	0.354	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748	0.787	0.866	0.945	1.024	1.063	1.181	1.299
Deflection Reading (mm) =	(2.0)	(4.0)	(5.0)	(6.0)	(7.0)	(8.0)	(9.0)	(10.0)	(11.0)	(12.0)	(13.0)	(14.0)	(15.0)	(16.0)	(17.0)	(18.0)	(19.0)	(20.0)	(22.0)	(24.0)	(26.0)	(27.0)	(30.0)	(33.0)

Series 6

pounds force - lb =	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600
pounds force (N) =	(889.64)	(1779.28)	(2668.92)	(3558.56)	(4448.20)	(5337.84)	(6227.48)	(7117.12)	(8006.76)	(8896.40)	(9786.04)	(10675.68)	(11565.32)	(12454.96)	(13344.60)	(14234.24)	(15123.88)	(16013.52)	(16903.16)	(17792.80)	(18682.44)	(19572.08)	(20461.72)	(21351.36)	(22241.00)	(23130.64)	(24020.28)	(24909.92)
Moment -lb-ft =	1191.66	2383.32	3574.98	4766.64	5958.3	7149.96	8341.62	9533.28	10724.94	11916.6	13108.26	14299.92	15491.58	16683.24	17874.9	19066.56	20258.22	21449.88	22641.54	23833.2	25024.86	26216.52	27408.18	28599.84	29791.5	30983.16	32174.82	33366.48
Moment (N*m) =	(1615.68)	(3231.35)	(4847.03)	(6462.71)	(8078.38)	(9694.06)	(11309.74)	(12925.41)	(14541.09)	(16156.76)	(17772.44)	(19388.12)	(21003.79)	(22619.47)	(24235.15)	(25850.82)	(27466.50)	(29082.18)	(30697.85)	(32313.53)	(33929.21)	(35544.88)	(37160.56)	(38776.24)	(40391.91)	(42007.59)	(43623.26)	(45238.94)
Deflection Reading - in =	0.079	0.157	0.197	0.236	0.276	0.315	0.354	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748	0.787	0.866	0.945	1.024	1.063	1.181	1.220	1.378	1.575	1.811	2.008
Deflection Reading (mm) =	(2.0)	(4.0)	(5.0)	(6.0)	(7.0)	(8.0)	(9.0)	(10.0)	(11.0)	(12.0)	(13.0)	(14.0)	(15.0)	(16.0)	(17.0)	(18.0)	(19.0)	(20.0)	(22.0)	(24.0)	(26.0)	(27.0)	(28.0)	(30.0)	(31.0)	(35.0)	(40.0)	(46.0)

Series 7

pounds force - lb =	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600
pounds force (N) =	(889.64)	(1779.28)	(2668.92)	(3558.56)	(4448.20)	(5337.84)	(6227.48)	(7117.12)	(8006.76)	(8896.40)	(9786.04)	(10675.68)	(11565.32)	(12454.96)	(13344.60)	(14234.24)	(15123.88)	(16013.52)	(16903.16)	(17792.80)	(18682.44)	(19572.08)	(20461.72)	(21351.36)	(22241.00)	(23130.64)	(24020.28)	(24909.92)
Moment -lb-ft =	1191.66	2383.32	3574.98	4766.64	5958.3	7149.96	8341.62	9533.28	10724.94	11916.6	13108.26	14299.92	15491.58	16683.24	17874.9	19066.56	20258.22	21449.88	22641.54	23833.2	25024.86	26216.52	27408.18	28599.84	29791.5	30983.16	32174.82	33366.48
Moment (N*m) =	(1615.68)	(3231.35)	(4847.03)	(6462.71)	(8078.38)	(9694.06)	(11309.74)	(12925.41)	(14541.09)	(16156.76)	(17772.44)	(19388.12)	(21003.79)	(22619.47)	(24235.15)	(25850.82)	(27466.50)	(29082.18)	(30697.85)	(32313.53)	(33929.21)	(35544.88)	(37160.56)	(38776.24)	(40391.91)	(42007.59)	(43623.26)	(45238.94)
Deflection Reading - in =	0.079	0.157	0.197	0.236	0.276	0.315	0.354	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748	0.787	0.866	0.945	1.024	1.063	1.181	1.220	1.378	1.575	1.811	2.008
Deflection Reading (mm) =	(2.0)	(4.0)	(5.0)	(6.0)	(7.0)	(8.0)	(9.0)	(10.0)	(11.0)	(12.0)	(13.0)	(14.0)	(15.0)	(16.0)	(17.0)	(18.0)	(19.0)	(20.0)	(22.0)	(24.0)	(26.0)	(27.0)	(28.0)	(30.0)	(31.0)	(35.0)	(40.0)	(46.0)

Series 8

POST 2

APPENDIX C

HAND CALCULATIONS

Sample Hand Calculations
For Capacity Check

Fence Design Hand Calculations

Project Name: Post Capacity Calculations	Date: 02/03/2006	Fence Number:
Project Number:	Designed by: RJL	Section Number:

****Input variables are in boxed areas****

Allan Block Parameters:

Wall Length: $WI := 104 \cdot ft$

Course height: $h := 0.6354ft$

Panel Block depth: $t := 0.469ft$

Panel Block length: $w := 1.4688ft$
(See Table 1)

Post Block length: $PI := 1.4692ft$

Post Block depth: $Pd = 0.9688 ft$
(See Table 1)

Post Block Notch depth: $Pnd = 0.125 ft$
(See Table 1)

Corner Post Block Length: $Pc := 1.0ft$

Amount of grout per post block: $PostGrout = 48 lbf$

Post Block Selection:

Small Post = 1

Large Post = 2

$Post := 1$

Table 1

Post Block Options	
Small Post Block	$Pd = 0.9688 ft$
	$Pnd = 0.125 ft$
	$PostGrout = 48 lbf$
Large Post Block	$Pd = 1.6667 ft$
	$Pnd = 0.1667 ft$
	$PostGrout = 98 lbf$

Fence Parameters:

Number of full size block per panel to determine length: $s := 25.5$

Panel Length Only: $PanelL := s \cdot w$
 $PanelL = 37.4544 ft$

Post Spacing - Center of Post Block to Center of Post Block (used for design)

$s1 := s \cdot w + PI - 2 \cdot Pnd + 2 \cdot (0.5 \cdot in)$ $s1 = 38.7569 ft$

Tributary Area:

$Ta := s1 \cdot H$ $Ta = 309.354 ft^2$

Number of block in each post: $PostH := 13$

$PH := PostH \cdot h + 4.75in$ $PH = 8.656 ft$

Number of block for panel height: $z := 12$

Panel Fence height:

$H := (z - 1) \cdot h + 7.16 \cdot in + 4.75 \cdot in$ $H = 7.982 ft$

Reinforcement Parameters:

Post:

Quantity number of rebar in post: $Nb := 4$

Post bar Size: $size := 5$

Radius of bar: $r := \frac{(size \cdot in)}{2 \cdot 8}$
 $r = 0.3125 in$

Bond Beam:

Quantity number of bond beams: $Nbb := 2$

Bond beam bar Size: $sizebb := 4$

Radius of bar: $rbb := \frac{(sizebb \cdot in)}{2 \cdot 8}$
 $rbb = 0.25 in$

Concrete Parameters:

Compressive strength of concrete: $fm := 4650 \cdot psi$

Calculated Moments

Compressive Stress Calculations

Compressive stress in masonry

* f_m is the uniaxial compressive strength of concrete.

$$f_m = 4650 \text{ psi}$$

$$f_b := \frac{1}{1} \cdot f_m$$

$$f_b = 4650 \text{ psi}$$

Area of Steel in post per bar:

$$A_b := 3.1416 \cdot r^2$$

$$A_b = 0.307 \text{ in}^2$$

The moment at the service load for panel (M_p):

Post section length:

$$b_s := P_l - 2P_n d$$

$$b_s = 1.2192 \text{ ft}$$

Post section width:

$$d_s := P_d - 2.25 \cdot \text{in} - 1 \cdot \text{in} - r$$

$$d_s = 0.6719 \text{ ft}$$

Total Area of Steel per post:

$$A_s := A_b \cdot N_b$$

$$A_s = 1.227 \text{ in}^2$$

Ratio of steel area per post area:

$$q := \frac{A_s}{2 \cdot b_s \cdot d_s}$$

$$q = 0.0052$$

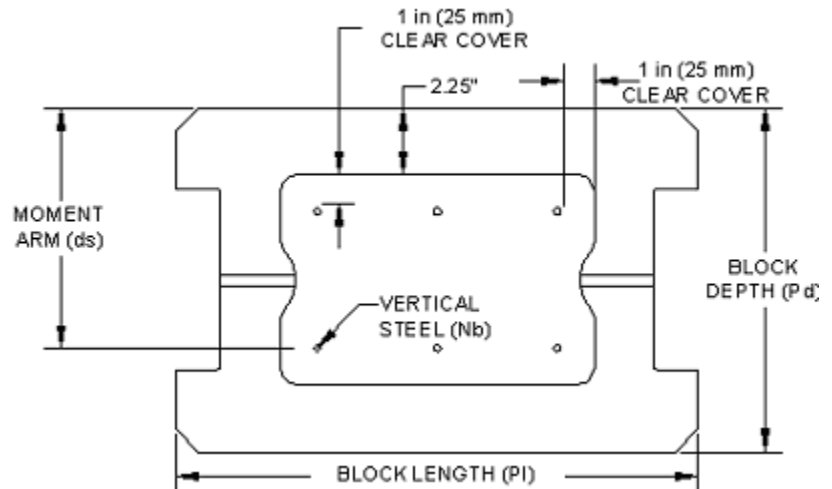


Figure 9: Vertical Steel Placement

E_s is the modulus of elasticity for all nonprestressed steel, this value is taken as 29,000,000 psi from UBC 2106.2.12.2

$$E_s := 29000 \text{ ksi}$$

E_m is modulus of elasticity of masonry. This value is taken as $750 \cdot f_m$ from UBC 2106.2.12.1

$$E_m := 750 \cdot f_m$$

$$E_m = 3487.5 \text{ ksi}$$

$$n := \frac{E_s}{E_m}$$

$$n = 8.315$$

k and j are coefficients used for internal moments and definition of neutral axis.

To solve for these variables we equate the first moments about the neutral axis of the masonry and steel areas

$$k := \sqrt{(n \cdot q)^2 + 2 \cdot n \cdot q} - n \cdot q$$

$$k = 0.254$$

$$j := 1 - \frac{k}{3}$$

$$j = 0.9153$$

Moment Capacity based on Compressive Stress in Pilaster (M_p):

$$M_p := \frac{f_b \cdot b_s \cdot d_s^2 \cdot j \cdot k}{2}$$

$$M_p = 42850.7 \text{ lbf} \cdot \text{ft}$$

Moment Capacity based on Tensile Stress in Pilaster (M_{cp}):

$$f_y := 60 \text{ ksi}$$

$$f_s := 1.0 \cdot f_y$$

$$f_s = 60 \text{ ksi}$$

$$M_{cp} := f_s \cdot \frac{A_s}{2} \cdot j \cdot d_s$$

$$M_{cp} = 22642.7 \text{ lbf} \cdot \text{ft}$$

The calculations indicate that the post should fail in Tension before the concrete crushes.

Sample Hand Calculations
To Determine the Maximum
Panel Size based on Tested
Failure Moment

Fence Design Hand Calculations

Project Name: Applied Moment Calculations	Date: 02/03/2006	Fence Number:
Project Number:	Designed by: RJL	Section Number:

****Input variables are in boxed areas****

Allan Block Parameters:

Wall Length: $WL := 104 \cdot ft$

Course height: $h := 0.6354ft$

Panel Block depth: $t := 0.469ft$

Panel Block length: $w := 1.4688ft$
(See Table 1)

Post Block length: $Pl := 1.4692ft$

Post Block depth: $Pd = 0.9688 ft$
(See Table 1)

Post Block Notch depth: $Pnd = 0.125 ft$
(See Table 1)

Corner Post Block Length: $Pc := 1.0ft$

Amount of grout per post block: $PostGrout = 48 lbf$

Fence Parameters:

Number of full size block per panel to determine length: $s := 22.0$

Panel Length Only: $PanelL := s \cdot w$
 $PanelL = 32.3136 ft$

Post Spacing - Center of Post Block to Center of Post Block (used for design)
 $s1 := s \cdot w + Pl - 2 \cdot Pnd + 2 \cdot (0.5 \cdot in) \quad s1 = 33.6161 ft$

Tributary Area:
 $Ta := s1 \cdot H \quad Ta = 375.1191 ft^2$

Reinforcement Parameters:

Post: $Nb := 4$

Quantity number of rebar in post: $Nb := 4$

Post bar Size: $size := 5$

Radius of bar: $r := \frac{(size \cdot in)}{2 \cdot 8}$
 $r = 0.3125 in$

Bond Beam: $Nbb := 2$

Quantity number of bond beams: $Nbb := 2$

Bond beam bar Size: $sizebb := 4$

Radius of bar: $rbb := \frac{(sizebb \cdot in)}{2 \cdot 8}$
 $rbb = 0.25 in$

Post Block Selection:

Small Post = 1

Large Post = 2

$Post := 1$

Table 1

Post Block Options	
Small Post Block	$Pd = 0.9688 ft$
	$Pnd = 0.125 ft$
	$PostGrout = 48 lbf$
Large Post Block	$Pd = 1.6667 ft$
	$Pnd = 0.1667 ft$
	$PostGrout = 98 lbf$

Number of block in each post: $PostH := 18$

$PH := PostH \cdot h + 4.75in \quad PH = 11.833 ft$

Number of block for panel height: $z := 17$

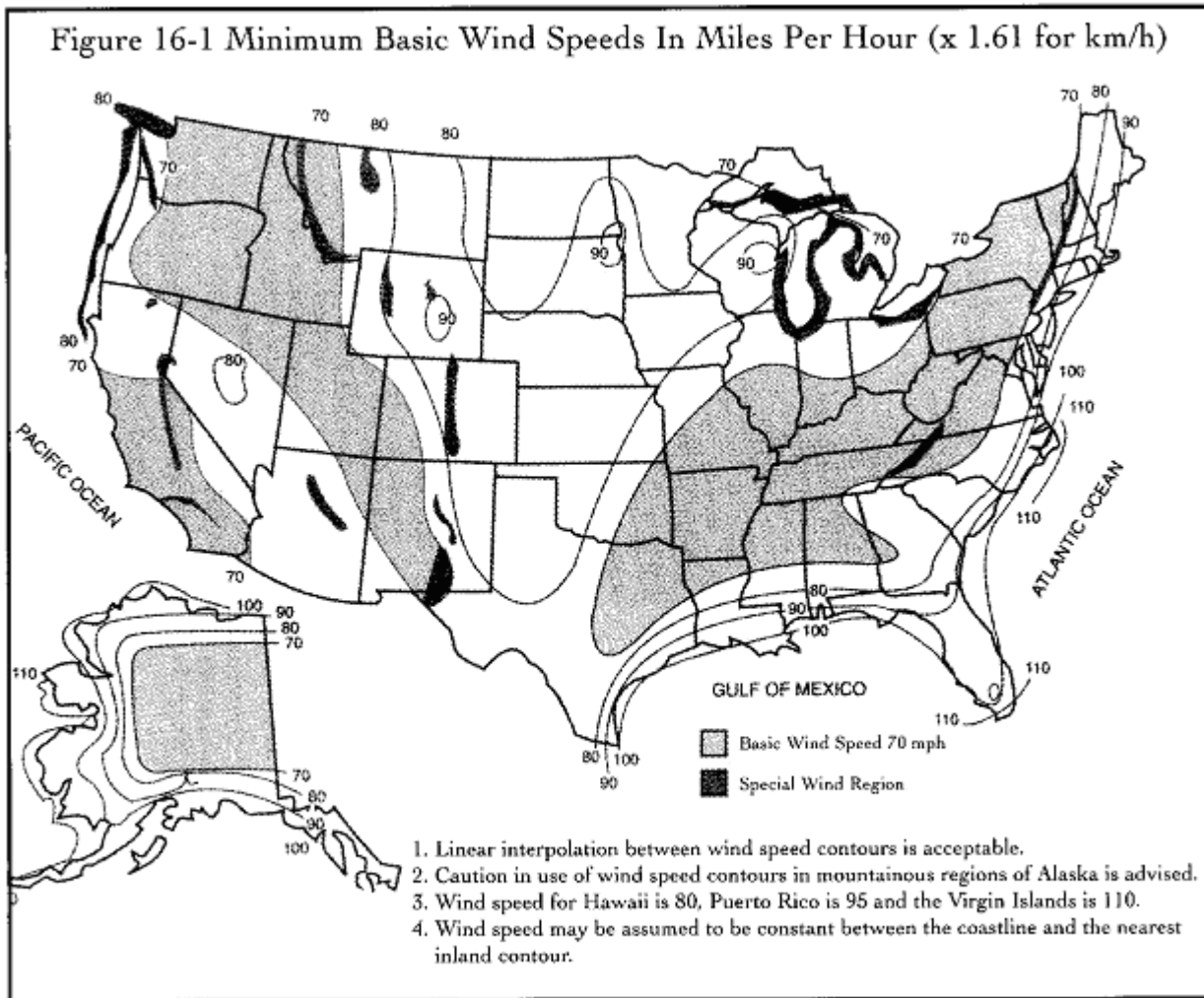
Panel Fence height:
 $H := (z - 1) \cdot h + 7.16 \cdot in + 4.75 \cdot in \quad H = 11.159 ft$

Concrete Parameters:

Compressive strength of concrete: $fm := 4650 \cdot psi$

The following tables are reproduced from the 1997 Uniform Building Code, Volume 2

Wind Pressure Conditions:



Basic Wind speed: speed := 100 mph

Table 16-F WIND STAGNATION PRESSURE (qs) AT STANDARD HEIGHT OF 33 FEET

Basic wind speed (mph)	70	80	90	100	110	120	130
Pressure qs (psf)	12.6	16.4	20.8	25.6	31	36.9	43.3

Note - The wind speed shall be determined from the wind zone map in Figure 16-1

WIND STAGNATION PRESSURE (qs) FOR FENCES UNDER 12 FEET

Basic wind speed (mph)	70	80	90	100	110	120	130
Pressure qs (psf)	9.45	12.3	15.6	19.2	23.25	27.675	43.3

Stagnation pressure: qs := 19.2 psf

WIND EXPOSURE COEFFICIENT

Exposure D - represents the most severe exposure in areas with basic wind speeds of 80 mph or greater and has terrain that is flat and unobstructed facing large bodies of water over 1 mile or more in width relative to any quadrant of the building site. Exposure D extends inland from the shoreline 1/4 mile or 10 times the building height, whichever is greater

Exposure C - has terrain that is flat and generally open, extending 1/2 mile or more from the site in any full quadrant.

Exposure B - has terrain with buildings, forest or surface irregularities, covering at least 20 percent of the ground level area extending 1 mile or more from the site.

Exposure type: Et := "NONE"

Table 16-G COMBINED HEIGHT, EXPOSURE AND GUST FACTOR COEFFICIENT (Ce)

Height above average level of adjoining ground (ft.)	Exposure D	Exposure C	Exposure B
0-15	1.39	1.06	0.62
20	1.45	1.13	0.67
25	1.5	1.19	0.72

Combined height, exposure and gust factor coefficient: Ce := 1.0

Table 16-H PRESSURE COEFFICIENTS (Cq)

Structure of part thereof	Description	Cq Factor
7. Signs, Flagpoles, lightpoles, minor structures		1.4

Pressure coefficients: Cq := 1.0

Table 16-K OCCUPANCY CATEGORY

Occupancy Category	Occupancy or functions of structure	Wind Importance Factor, Iw	Seismic Importance Factor, Ip
4. Standard occupancy structures	All structures housing occupancies or having functions not listed in Category 1,2, or 3 and Group U Occupancy towers	1.0	1.0

Wind Importance Factor: Iw := 1.0

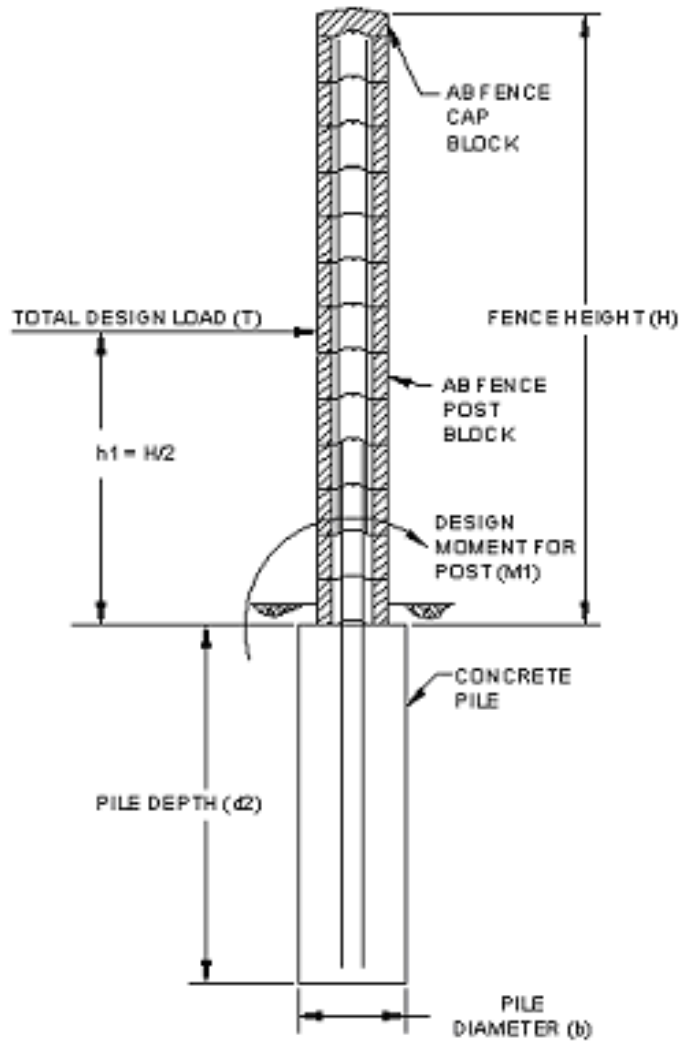
Seismic Importance Factor: Ip := 1.0

Calculation for Wind Pressure (P):

$P := C_e \cdot C_q \cdot q_s \cdot I_w$ $P = 19.2 \text{ psf}$

Design Moments:

$M_{\text{wind_seis}} := \frac{P \cdot s_1 \cdot H^2}{2}$ $M_{\text{wind_seis}} = 40184.8 \text{ lbf} \cdot \text{ft}$ $< 40500 \text{ lbf} \cdot \text{ft}$ (Tested Moment at Failure)



Sample Hand Calculations
To Determine Moment Above and
Below the Rebar Lap Splice

Fence Design Hand Calculations

Moment Above Splice	Date: 02/03/2006 Designed by: RJL	
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Post 2 Results:

Ram Force at Failure: $P := 7200 \cdot \text{lb}$

Total Height of Post: $L := 8.656 \text{ ft}$

Ram position above footing: $b := 5.958 \text{ ft}$

Maximum Moment: $M_{\text{max}} := P \cdot b$
 $M_{\text{max}} = 42897.6 \text{ lb ft}$

Calculated Moment Capacity from Figure 4:

42,851 lb*ft Compression
22,643 lb*ft Tension

Post height above Ram position: $a := L - b$ $a = 2.698 \text{ ft}$

Top of Splice height above footing: $h_s := 1.906 \text{ ft}$

Distance from top of post to top of splice: $x := L - h_s$ $x = 6.75 \text{ ft}$

Moment at top of splice: $M_x := P \cdot (x - a)$
 $M_x = 29174.4 \text{ lb ft}$

