Full Scale Panel Test Report

STORK
Materials Technology

Stork Twin City Testing Corporation

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Product Evaluation • Construction Materials

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DATE: September 13, 2005

TO: Mr. Rich Lovdal, P.E.
Allan Block Corporation
5300 Edina Industrial Blvd., Suite 100
Edina, MN 55439

PROJECT: In-House AB Fence Testing

PROJECT NO.: 325011

TESTING OF AB FENCE

INTRODUCTION:

This report is in reference to testing of an Allan Block AB Fence at their facility on March 16, 2005, as documented in a report prepared by Mr. Rich Lovdal of Allan Block Corporation, dated (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 on March 16, 2005 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 specimen on March 16, 2005, and verify the data collected.
3. Review the final test report Allan Block Corporation personnel prepared, and prepare a suitable cover letter for the purpose of verifying the test data presented therein.

CONCLUSION:

The description of AB Fence test specimen and test procedure, as described in Mr. Lovdal's report alluded to above, particularly in Appendix A (pages 6 – 9), is consistent with the observations made by Stork TCT personnel for test series 13 – 18. In addition, the test data reported in Appendix B (pages 10-18) is also consistent with the test results observed by Stork TCT personnel. 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.

STORK TWIN CITY TESTING CORPORATION

Thomas A. Kolden, P.E.	Thaddeaus Harnois, P.E.
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Construction Materials Department	Construction Materials Department

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Allan Block AB Fence Testing

Full Scale Panel Test Report
12x7 Panel with an Articulating Spreader Frame

October 26, 2005

Introduction

This report gives the results for the full-scale panel tests preformed on the Allan Block fence panel. All tests were preformed 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 are an extension of the Fence Testing preformed at the University of Calgary in 2003 and the Allan Block testing preformed in August 2004. The main difference between the testing of 2004 and these current tests is the use of an articulating spreader frame assembly to simulate and distribute the wind load more evenly throughout the panel.

Objectives of Test Program

Figure 1: Articulating Spreader Frame

The principle objective of this test is to expand on what was learned in the Vertical Spreader Bar Tests and to further understand the added strength the dry-stacked units with their ball and socket configuration bring to the system. In the Vertical Spreader Bar tests the set up was designed to force a configuration that simulated a typical tributary area distribution by directing the applied load to the bond beams with a single vertical spreader bar. In these tests an articulating spreader frame (Figure 1) was used to evenly distribute the applied force to the test panel. Under this setup the eight dry-stacked courses, which comprise the majority of the tributary area of the panel, will be engaged by the spreader frame and provide a more accurate depiction of how the dry-stacked units receive, distribute and dissipate force. The added benefit to the inclusion of the dry-stacked units to resist applied forces will be the documentation of the force absorption ability of the panel. It was first observed in the Calgary panel testing that a dissipation of applied forces occurred during testing. Similar reductions were documented in the Vertical Spreader Bar tests. The expected outcome of these tests will be to reduce the design load to the post by quantifying a matrix of force reductions for fence panels of a certain height and applied wind force. These tests will record the applied force from the hydraulic ram and the received load at the posts using load cells at third points on each post, see Figure #2. For a complete description of the testing frame and equipment used see Appendix A.

Figure 2: In Place Load Cell

By simply comparing the applied to received, a percentage of lost can be determined. Again in these tests the bond beams will be subjected to repeated bending and rebounding. Careful attention will be given to the recording of deflections and rebounds to document the extraordinary plasticity of the bond beams.

Test Procedure and Results

The test procedure is very straightforward and follows the same process set forth in the Vertical Spreader Bar tests. A force is applied to the panel using the hydraulic ram and spreader frame assembly. The load cell readings are recorded and summed together to obtain the total force applied to the posts. The applied forces are based on the standard Wind Stagnation Pressures (q) formula of $q = 0.5 * \rho * V^2$ where q is in lb/ft^2 (N/m^2) and ρ is the average air density in lb/ft^3 (kg/m^3) and V is the average wind speed in ft/sec (m/sec) and are tabulated in Table 1 on page 4. For 16 of the 18 tests preformed, the panel was stress to pressures associated with 120 to 130 mph (193 to 209 kph) winds and then released to zero pressure. For test numbers 12 and 18, the panel was stressed to failure. Failure occurred by having a dry-stacked block slip out of its joint which occurred both time at pressures related to 200 mph (322 kph) winds. No catastrophic failures occurred. After all tests, including the failure tests, the panel was simply forced back into a vertical position by manually hitting each dry-stacked block with a dead blow hammer until they were once again aligned vertically. No dismantling was required and no blocks required replacing due to damage and the results of the tests that followed showed no negative effects in strength or appearance from realigning.

The results of these tests focused on the following:

- Flexibility of the bond beams and dry-stacked units.
- The absorption of force which occurs within the panel.
- The additional strength the ball and socket brings to the whole system.

Figure 3: Horizontal Bond Beam Steel after demolition

First the flexibility and durability of the bond beam continues to amaze. In the Vertical Spreader Bar tests, these exact bond beams were deflected 13 times to as much as 1.57 inches (40 mm). In these tests that followed, with the introduction of the articulating spreader frame, the recorded bond beam deflections were less because the dry-stack units were allowed to flex and contribute to the strength of the system. Each time the load was removed the bond beams relaxed back to their at-rest position and showed no visible defects or damage other than the original stress cracks which appeared after the very first test of the Vertical Spreader Bar tests. The bond beams reacted exactly how a monolithic concrete beam would react to repeated stress. The stress cracks would open slightly during stressing, which would engage the steel and would fully rebound and close when the load was removed. In total, these bond beams were used and stressed in 28 separate tests in which both bond beams flexed and rebound to zero deflection and the bottom bond beam never showed any downward deflections or sage. During dismantling of the panel a sledge hammer and great effort was required to force the bond beams destruction, Figure 3 shows the horizontal steel exposed after the removal of the bottom bond beam course which required repeated sledge hammer blows and manual cutting of the vertical stirrups to remove the lower course. The sand-mix grout shows a seamless, monolithic joining to the panel block and a complete encapsulation of the horizontal steel and the steel appears in like-new condition. This Figure clearly shows the high quality constructability the 2-course Bond Beam brings to the AB Fence system.

The absorption of forces is clearly evident in the results from the 18 separate tests tabulated in Appendix B. In none of these 18 tests did the applied forces equal the received forces at the post. Structural engineering teaches a standard static approach to applied forces in that “force in equals force out”. However, a system of dry-stacked units which have a large selfweight and a ball and socket configuration, such as the AB panel blocks have, brings a dynamic variable to the static equation. This dynamic variable can best be described as Work Energy. Work is defined as a force (wind) acting upon an object (the panel block’s ball and socket joint) to cause a displacement, see Figure 4. In the Allan Block Fence panel there are two forms of work energy being developed. First is the external work which is simply the deflection of the entire panel due to the wind force. The second occurs internally in the ball and socket joint. As the wind load is applied, the running bonds of the dry stacked block try and deflect away from the force laterally, but the socket resists any deflection due to its natural conical locking configuration. The selfweight of all the courses above a particular joint provides the downward force which serves to stiffen the joint. Thus, the lower the joint is within the panel the greater the internal resisting forces within that socket. Therefore, most of the deflection within the panel occurred in the upper half.

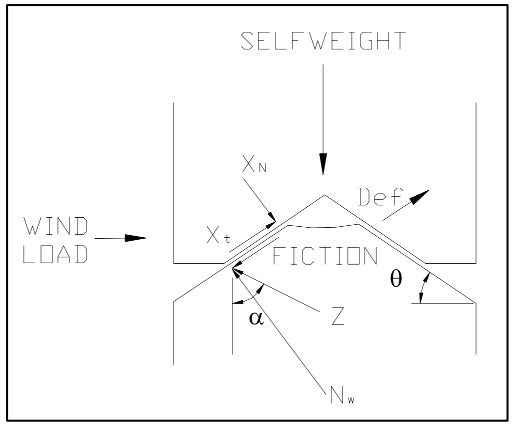


Figure 4: Work Energy Free-Body Diagram

The internal Work occurs when the applied force becomes great enough to overcome the frictional interaction within the socket, forcing deflection. There are two forms of deflection which could occur. The first is a purely horizontal translation, but this could only occur if the bottom tension edge of the panel block were to shear off horizontally allowing the socket to release, see Figure 5. This form of deflection did not occur due to the internal strength of each block. The shear strength of a block is directly related to the compression strength, therefore the stronger the block the more resistant to shear failures and the stronger the ball and socket can become.

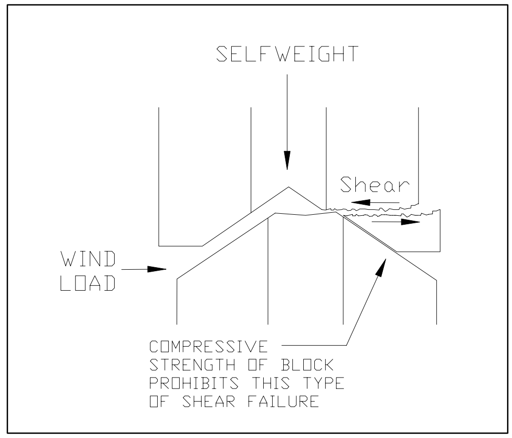


Figure 5: Possible Shear Failure Diagram

The second form of deflection, which did occur, was a movement along the natural sloped plane of the socket which provided displacement in an upward and lateral direction, variable Xt in Figure 4. Each movement when it occurred would be very small because the pressure within the socket would release and the fictional interaction would once again be greater than the applied load. Once the force was built up enough to overcome the internal resisting forces another deflection would occur. Each time an internal deflection occurred a certain amount of force was absorbed into the joint causing a reduction of applied forces to the posts. The results showed that at low pressures the received loads are quite small, lowest recorded value was 28 percent in Test Series #4. This is due to the large number of areas within the panel that had the ability to shift or deflect early on. At higher pressures the number of joints having the ability to adjust decreases because movement has already occurred making the joint more ridged, which causes the amount of force received by the post to increase. See data tables in Appendix B for results form all tests.

The overall deflection of the panel was similar to a plate bending diagram with three ridged edges with the bottom and two sides fixed and the top restrained but allowed to deflect. The bottom bond beam had very little lateral deflection compared to top bond beam because of the additional strength it received from the lower dry stacked course which had the greater selfweight above them. In practical field applications the bottom bond beam would be fully fixed laterally and vertically due to its embedment into the soil. The deflections of the top and middle sections of the panel were very consistent throughout the tests. As mentioned earlier, the top bond beam deflected and rebound to its at-rest position after each test. The dry-stacked however, did not return to a zero deflection once the force was removed. Each time an internal deflection occurred due to the work energy, the joint was placed in a new at-rest state. When the load was removed, the bond beams had tension in the steel which pulled them back to zero, but the dry-stacked had only compression built up in the back faces of the block which when released had no ability to pull the blocks back. Therefore, the maximum differential deflection between the top bond beam and the middle dry-stacked is generally equal to the total deflection or maximum bow of the center dry stacks after the load is removed. Before the next test was conducted, the dry stacked units were force back to a vertical position for retesting.

Conclusions and Recommendations

The following are a list of conclusions formulated from physical data and visual observation during testing:

- The Allan Block Fence panel has the ability to flex and absorb forces through the principle of Work Energy. The ability of the panel to absorb applied forces effectively act to resist the force and thus can be used in combination with the bond beam and post capacities to resist the applied loads. The net effect is that the structural posts can carry more tributary area which allows the posts to be spaced further apart and or less steel to be used within them.
- The AB Fence panel's ball and socket configuration becomes stronger as more courses are added to the panel by adding more selfweight with each course. The selfweight provides a downward force which converts the compressive stress of the block into a shear resisting mechanism which provides both the flexibility to the system at lower forces and the rigid, strengthening effect at higher forces. The net effect of considering the strength of the ball and socket in the design is the reduction of the number of required bond beams.
- The AB Panel bond beam, when constructed with sand mix grout and vertical stirrups as recommended by Allan Block, provides an incredible capacity to resist lateral forces while remaining plastic enough to rebound 100% from repeated deflection.
- The AB Panel bond beam while subjected to repeated horizontal deflections and rebounds showed no vertical sag of any measurable amount.
- The AB Panel bond beam is a composite beam that functions as a monolithic concrete beam. That is, the stressed beam cracked where expected, at the mid-span and not along the joints of the panel block. At the conclusion of testing all panel block of the bond beams were fully connected to the course above with no visible signs of distress other than the rebounded hairline cracks at mid span.
- If after large forces the dry-stacked panel blocks have deflected, their flexibility allows for them to be forced back into a plumb position without any damage.

The following Table 1 represents the recommended force reductions based on these test results. These reductions should only be applied to the design force acting on the posts. These values are limited to the design of the cantilever moments for fences of 8 ft (2.4 m) in height with no intermediate bond beams.

TABLE 1	Design Wind Speeds and Stagnation Pressures					
mph (kph)	70 (112)	80 (129)	90 (145)	100 (161)	110 (177)	120 (193)
Pressure lb/ft^2 (kPa)	9.45 (0.45)	12.3 (0.59)	15.6 (0.75)	19.2 (0.92)	23.25 (1.113)	27.68 (1.325)
	Percentage of Design Force For Post Design					
% *	50	55	65	70	80	90

* Percent values are a conservative reduction based on test results

APPENDIX A

Test Frame and Equipment

Test Frame and Equipment

Set-up #4 from the first round of testing was re-used for all tests in this series. The panel remained the same with the same bond beams. The dry stacked units were unstacked, inspected for defects and restacked. Also, the single vertical spreader bar was replaced with the articulating spreader frame. The panel system was made up of two typical, 7-panel block long, bond beams approximately 11'-7" (3.54m) with 8 dry stacked courses separating them. The bond beams were situated in a typical field condition with one forming the first two courses and the other forming the top two courses with the total panel height of 12 courses or 8'-0" (2.44 m). See Photos A1 - A4 for actual photos. The bottom bond beam was precast and set on top of a spacer block at each post. This was done to simulate the bottom bond beam free spanning from pier to pier. These typical Bond Beams consisted of 2-courses of standard panel block units, a #4 (10M) horizontal rebar between courses, 9 ga. (3.5 mm) wire stirrups in every other block core and a sand mix grout tested at 3100 psi (21.37 MPa) at 28 day strength, vibrated in all cores. The posts were cast at 13 course high to allow for the placement of the half block spacer at the base and the full 12 course tall test panel. Vertical wood beams were used to transfer all loads evenly to the post with the intent of having them act as a self-reacting load frame. The horizontal steel beam is supported at the mid height of the panel, allowing the ram to remain in place during stressing. The Ram was placed at the center point of the panel with the articulating spreader frame attached to the end to distribute the applied forces across the height and width of the panel see Figure 6. To record the received forces 3-1000 lb load cells were placed at each post between the panel and post lip, see Figure 2. Deflection is measured using a string line transducer recording millimeters of movement. The device is fixed to the mid-point of the top bond beam, and the mid-point of the center dry-stacked units, see Figure A1. 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 A2. All applied forces come from a SPX Power Team 25 ton hydraulic ram and hand operated pump see Figures A3 and A4. In tests 4 – 12, the forces were determined by converting the required UBC forces into a psi so the readings could be easily read on the ram gauge. Tests 1 – 3 were preformed in round one with the single vertical spreader bar. The converted force was done by using the UBC psf values and the panels tributary area and the factory determined

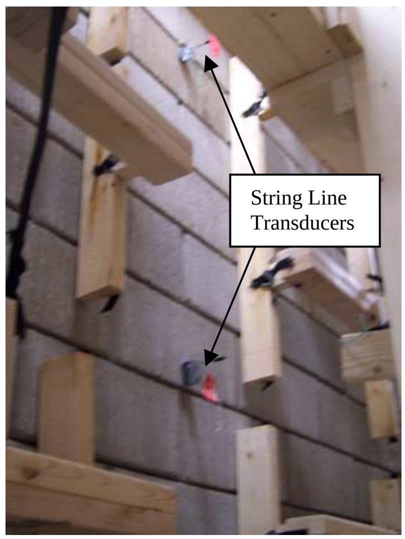


Figure A1: String Line Transducers

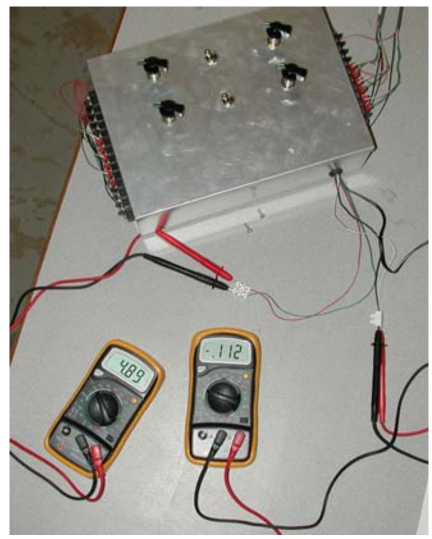


Figure A2: Switch Box and Volt Meters

Figure A3: SPX Hydraulic Hand

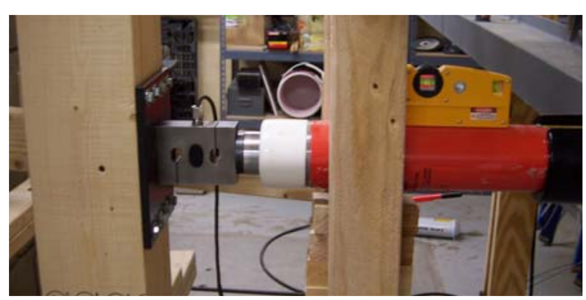


Figure A4: Hydraulic Ram

equivalent rod area of 5.15 in^2. In the last 6, tests 13 - 18 which were observed by STCT, a 10,000 pound (44.82 kN) load cell was placed on the end of the ram to provide a higher level of accuracy, see Figure A4. The results of the last 6 will be highlighted in this report, however all individual results can be found in Appendix B.

Photo A1: Full-Scale Set-up #4

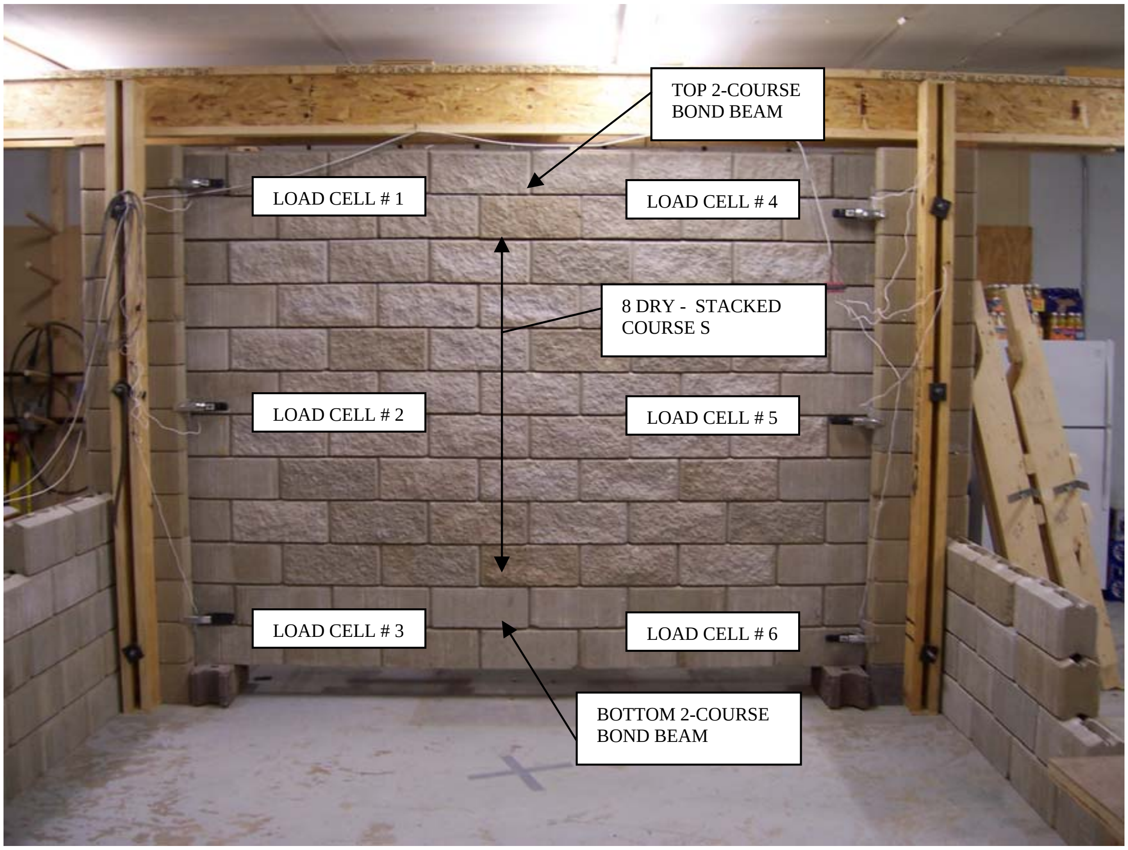


Photo A2: Beam, Ram and Spreader Frame

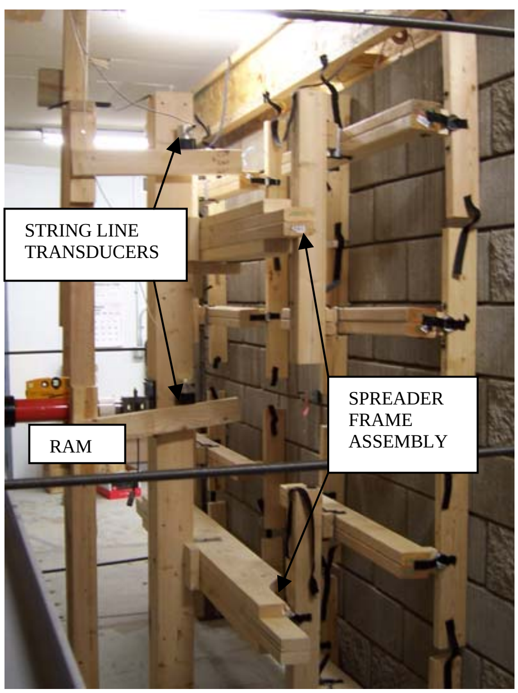


Photo A3: Spreader Frame Assembly

Photo A4: Panel During Stressing

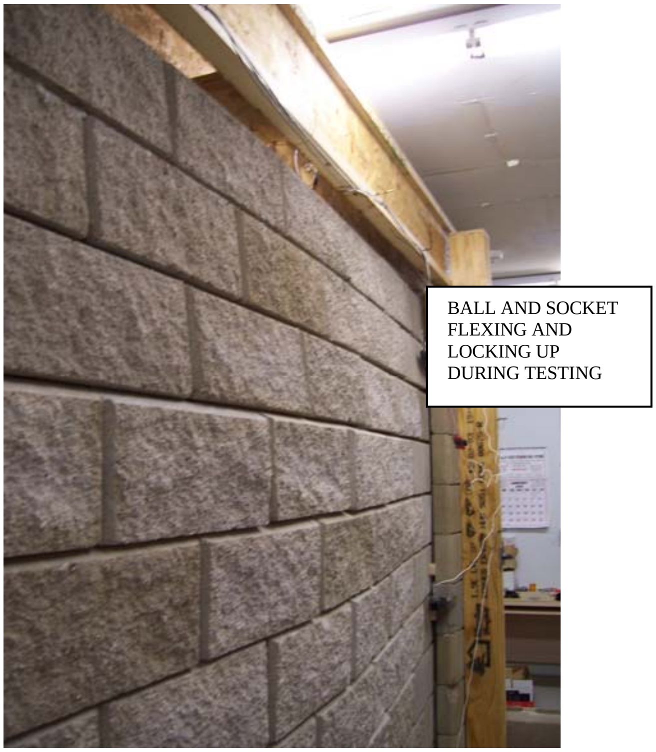


Photo A5: Spreader Frame Assembly and Block Flexing During Stressing

APPENDIX B

Test Result Data

FULL HEIGHT PANEL TEST RESULTS (ROUND 2)

SERIES # 13 - # 18

Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 13

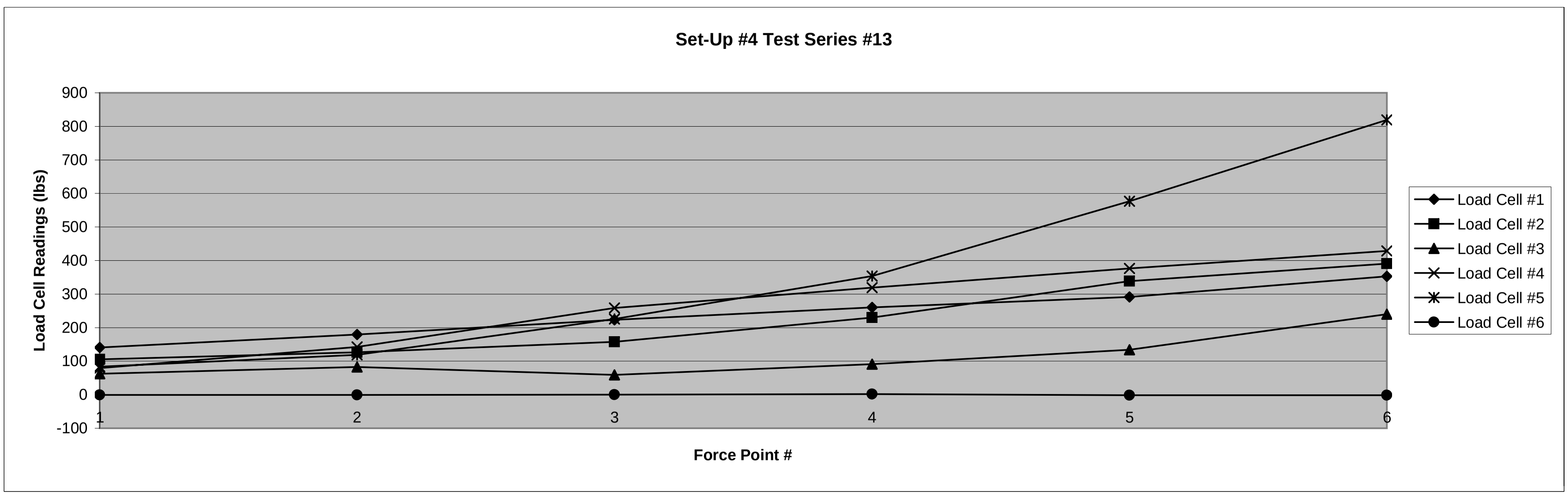
Deflection Data

Testing = 3/16/2005

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	867.0 (3.857)	1127.0 (5.013)	1437.0 (6.392)	1767.0 (7.860)	2137.0 (9.506)	2547.0 (11.330)	0.0 (0.000)
Deflection at Top (mm) =	12.000	17.000	21.000	25.000	29.000	34.000	3.000
Deflection at Top (in) =	0.472	0.669	0.827	0.984	1.142	1.339	0.118
Deflection at Mid-Panel (mm) =	10.000	15.000	23.000	28.000	36.000	46.000	15.000
Deflection at Mid-Panel (in) =	0.394	0.591	0.906	1.102	1.417	1.811	0.591

Load Cell Data

		Applied Load To Panel - lb (kN)					
	Force Point # =>	1	2	3	4	5	6
		867.0 (3.857)	1127.0 (5.013)	1437.0 (6.392)	1767.0 (7.860)	2137.0 (9.506)	2547.0 (11.330)
	Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
	1	140.571 (0.625)	179.335 (0.798)	223.200 (0.993)	259.924 (1.156)	291.548 (1.297)	352.754 (1.569)
	2	105.399 (0.469)	126.559 (0.563)	157.440 (0.700)	229.832 (1.022)	338.167 (1.504)	390.815 (1.738)
* Total Received Force	3	62.585 (0.278)	82.945 (0.369)	59.175 (0.263)	90.668 (0.403)	133.796 (0.595)	240.110 (1.068)
does not include	4	79.500 (0.354)	142.400 (0.633)	258.400 (1.149)	319.400 (1.421)	376.400 (1.674)	428.400 (1.906)
load cells #3 and #6	** 5	83.636 (0.372)	119.049 (0.530)	225.935 (1.005)	354.026 (1.575)	576.839 (2.566)	819.027 (3.643)
due to their location	6	-0.750 -(0.003)	-0.429 -(0.002)	-0.214 -(0.001)	1.928 (0.009)	-1.286 -(0.006)	-1.286 -(0.006)
Total Load transferred to Post - lb (kN) =		409.106 (1.820)	567.344 (2.524)	864.975 (3.848)	1163.182 (5.174)	1582.953 (7.041)	1990.997 (8.856)
Percentage of Applied Load Received by Post =		47%	50%	60%	66%	74%	78%



** Load Cell #5 produced results inconsistent with earlier tested. Resultant forces recorded were 2 to 3 times higher than in the same tests run in series 4 - #12

Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 14

Deflection Data

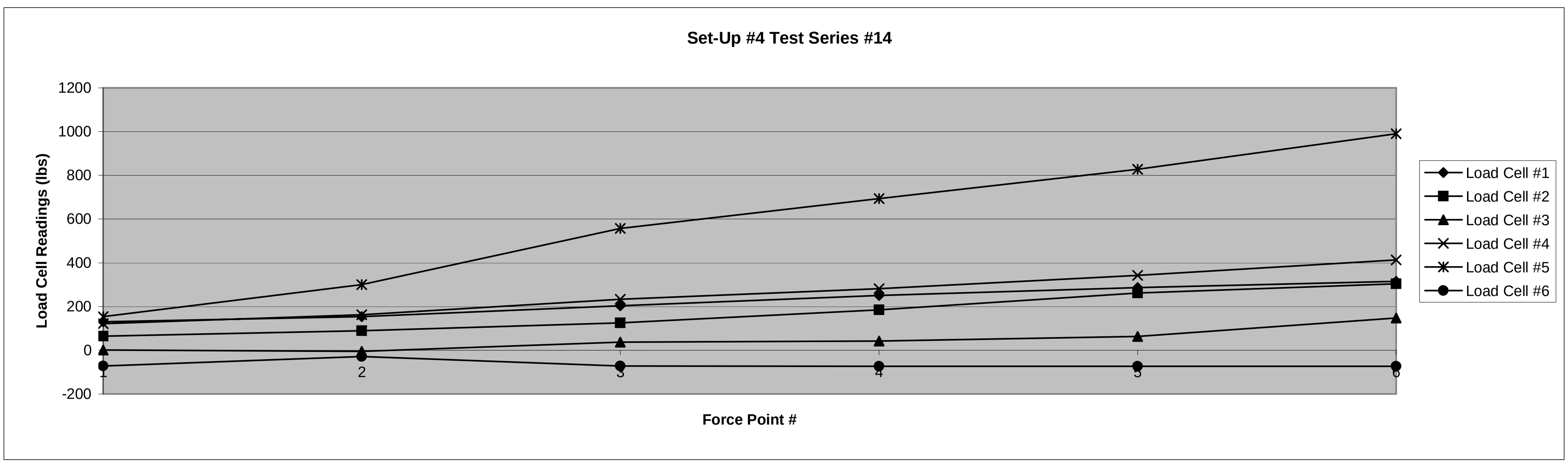
Testing = 3/16/2005

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	897.0 (3.990)	1157.0 (5.147)	1472.0 (6.548)	1797.0 (7.993)	2167.0 (9.639)	2572.0 (11.441)	0.0 (0.000)
Deflection at Top (mm) =	8.000	12.000	16.000	20.000	23.000	28.000	1.000
Deflection at Top (in) =	0.315	0.472	0.630	0.787	0.906	1.102	0.039
Deflection at Mid-Panel (mm) =	6.000	11.000	18.000	21.000	26.000	32.000	9.000
Deflection at Mid-Panel (in) =	0.236	0.433	0.709	0.827	1.024	1.260	0.354

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	897.0 (3.990)	1157.0 (5.147)	1472.0 (6.548)	1797.0 (7.993)	2167.0 (9.639)	2572.0 (11.441)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	130.013 (0.578)	153.833 (0.684)	203.818 (0.907)	250.743 (1.115)	286.447 (1.274)	315.010 (1.401)
2	63.887 (0.284)	89.098 (0.396)	125.547 (0.558)	185.283 (0.824)	261.219 (1.162)	303.743 (1.351)
3	0.702 (0.003)	-5.015 -(0.022)	37.110 (0.165)	42.125 (0.187)	63.187 (0.281)	147.436 (0.656)
4	121.100 (0.539)	161.900 (0.720)	232.900 (1.036)	281.900 (1.254)	342.900 (1.525)	412.900 (1.837)
** 5	154.247 (0.686)	300.744 (1.338)	556.926 (2.477)	693.627 (3.085)	828.176 (3.684)	989.635 (4.402)
6	-71.561 -(0.318)	-29.246 -(0.130)	-72.097 -(0.321)	-73.168 -(0.325)	-73.168 -(0.325)	-73.168 -(0.325)
Total Load transferred to Post - lb (kN) =	469.247 (2.087)	705.575 (3.139)	1119.191 (4.978)	1411.553 (6.279)	1718.742 (7.645)	2021.288 (8.991)
Percentage of Applied Load Received by Post =	52%	61%	76%	79%	79%	79%

* Total Received Force does not include load cells #3 and #6 due to their location



** Load Cell #5 produced results inconsistent with earlier tested. Resultant forces recorded were 2 to 3 times higher than in the same tests run in series 4 - #12

Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 15

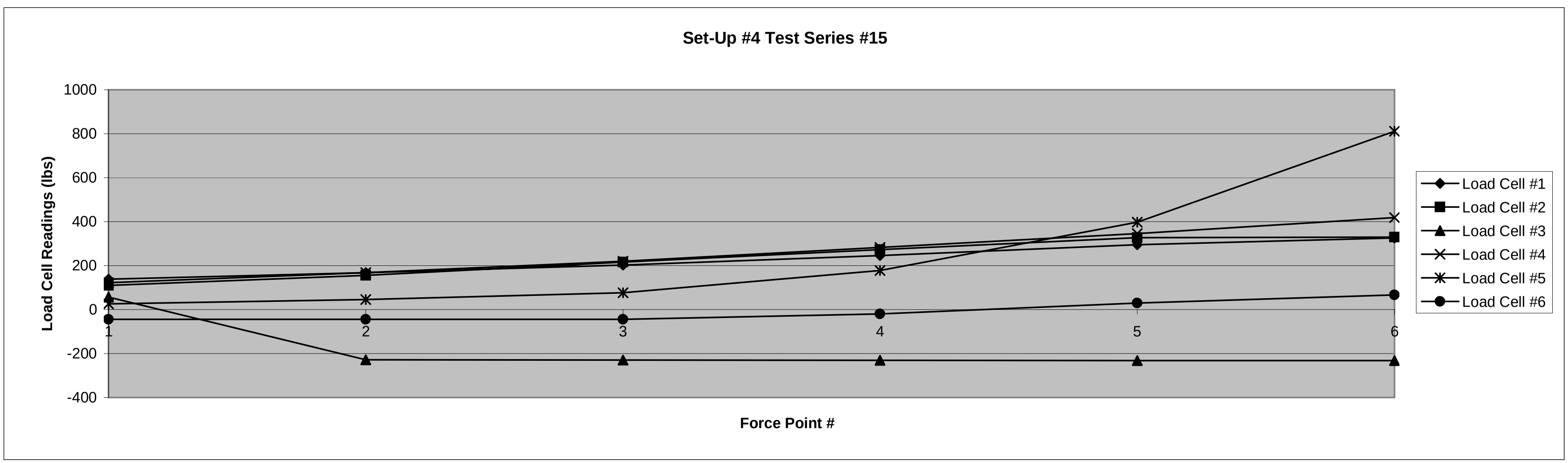
Deflection Data

Testing = 3/16/2005

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	870.0 (3.870)	1130.0 (5.026)	1435.0 (6.383)	1775.0 (7.896)	2140.0 (9.519)	2545.0 (11.321)	0.0 (0.000)
Deflection at Top (mm) =	11.000	14.000	18.000	22.000	26.000	30.000	2.000
Deflection at Top (in) =	0.433	0.551	0.709	0.866	1.024	1.181	0.079
Deflection at Mid-Panel (mm) =	10.000	13.000	18.000	23.000	28.000	34.000	9.000
Deflection at Mid-Panel (in) =	0.394	0.512	0.709	0.906	1.102	1.339	0.354

Load Cell Data

		Applied Load To Panel - lb (kN)					
	Force Point # =>	1	2	3	4	5	6
		870.0 (3.870)	1130.0 (5.026)	1435.0 (6.383)	1775.0 (7.896)	2140.0 (9.519)	2545.0 (11.321)
	Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
	1	138.735 (0.617)	168.318 (0.749)	201.982 (0.898)	245.847 (1.094)	294.812 (1.311)	325.415 (1.448)
	2	110.360 (0.491)	155.921 (0.694)	215.657 (0.959)	272.356 (1.211)	327.029 (1.455)	329.054 (1.464)
* Total Received Force	3	57.169 (0.254)	-228.676 -(1.017)	-229.679 -(1.022)	-230.682 -(1.026)	-231.685 -(1.031)	-231.685 -(1.031)
does not include	4	122.000 (0.543)	168.000 (0.747)	220.000 (0.979)	283.000 (1.259)	346.000 (1.539)	418.000 (1.859)
load cells #3 and #6	** 5	25.833 (0.115)	45.208 (0.201)	76.424 (0.340)	177.605 (0.790)	397.189 (1.767)	810.524 (3.605)
due to their location	6	-44.994 -(0.200)	-44.994 -(0.200)	-43.922 -(0.195)	-20.354 -(0.091)	29.996 (0.133)	66.419 (0.295)
	Total Load transferred to Post - lb (kN) =	396.928 (1.766)	537.448 (2.391)	714.063 (3.176)	978.807 (4.354)	1365.030 (6.072)	1882.993 (8.376)
	Percentage of Applied Load Received by Post =	46%	48%	50%	55%	64%	74%



** Load Cell #5 produced results inconsistent with earlier tested. Resultant forces recorded were 2 to 3 times higher than in the same tests run in series 4 - #12

Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 16

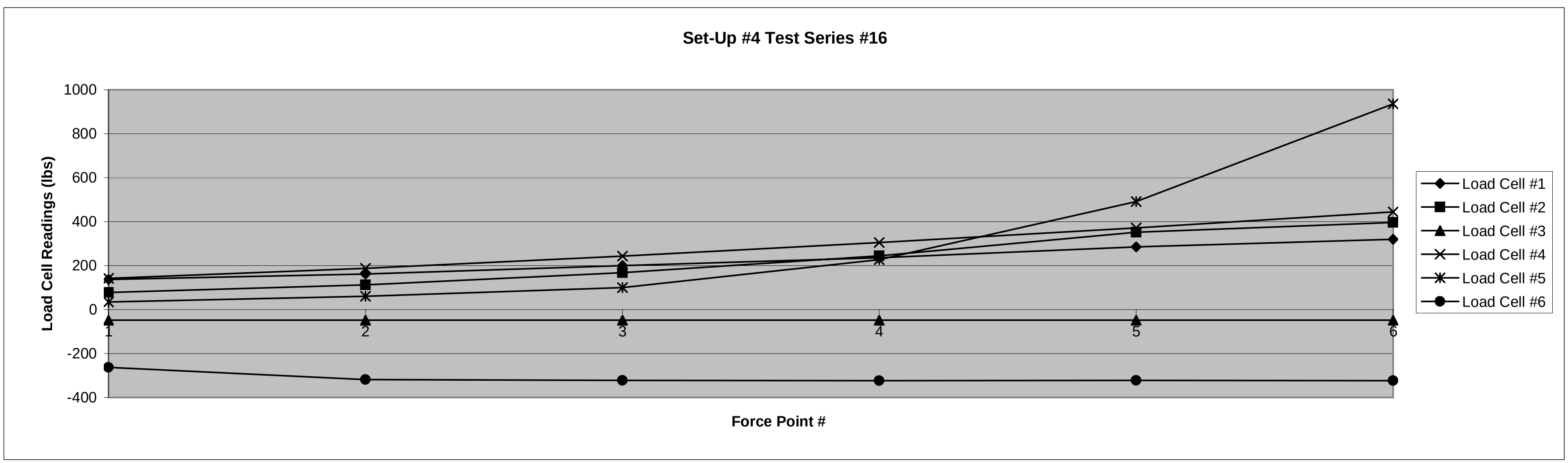
Deflection Data

Testing = 3/16/2005

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	881.0 (3.919)	1131.0 (5.031)	1441.0 (6.410)	1766.0 (7.856)	2141.0 (9.524)	2546.0 (11.325)	0.0 (0.000)
Deflection at Top (mm) =	10.000	13.000	17.000	20.000	24.000	28.000	0.000
Deflection at Top (in) =	0.394	0.512	0.669	0.787	0.945	1.102	0.000
Deflection at Mid-Panel (mm) =	8.000	11.000	15.000	19.000	23.000	29.000	3.000
Deflection at Mid-Panel (in) =	0.315	0.433	0.591	0.748	0.906	1.142	0.118

Load Cell Data

		Applied Load To Panel - lb (kN)					
	Force Point # =>	1	2	3	4	5	6
		881.0 (3.919)	1131.0 (5.031)	1441.0 (6.410)	1766.0 (7.856)	2141.0 (9.524)	2546.0 (11.325)
	Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
	1	136.695 (0.608)	161.177 (0.717)	199.942 (0.889)	235.646 (1.048)	284.611 (1.266)	320.315 (1.425)
	2	77.961 (0.347)	112.385 (0.500)	168.071 (0.748)	245.019 (1.090)	351.329 (1.563)	396.890 (1.765)
* Total Received Force	3	-48.142 -(0.214)	-48.142 -(0.214)	-48.142 -(0.214)	-48.142 -(0.214)	-48.142 -(0.214)	-48.142 -(0.214)
does not include	4	142.000 (0.632)	188.000 (0.836)	243.000 (1.081)	305.000 (1.357)	372.000 (1.655)	445.000 (1.979)
load cells #3 and #6	** 5	34.445 (0.153)	60.278 (0.268)	100.105 (0.445)	227.119 (1.010)	490.835 (2.183)	935.385 (4.161)
due to their location	6	-263.534 -(1.172)	-318.169 -(1.415)	-322.455 -(1.434)	-323.526 -(1.439)	-322.455 -(1.434)	-323.526 -(1.439)
Total Load transferred to Post - lb (kN) =		391.100 (1.740)	521.840 (2.321)	711.117 (3.163)	1012.783 (4.505)	1498.775 (6.667)	2097.590 (9.331)
Percentage of Applied Load Received by Post =		44%	46%	49%	57%	70%	82%



** Load Cell #5 produced results inconsistent with earlier tested. Resultant forces recorded were 2 to 3 times higher than in the same tests run in series 4 - #12

Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 17

Deflection Data

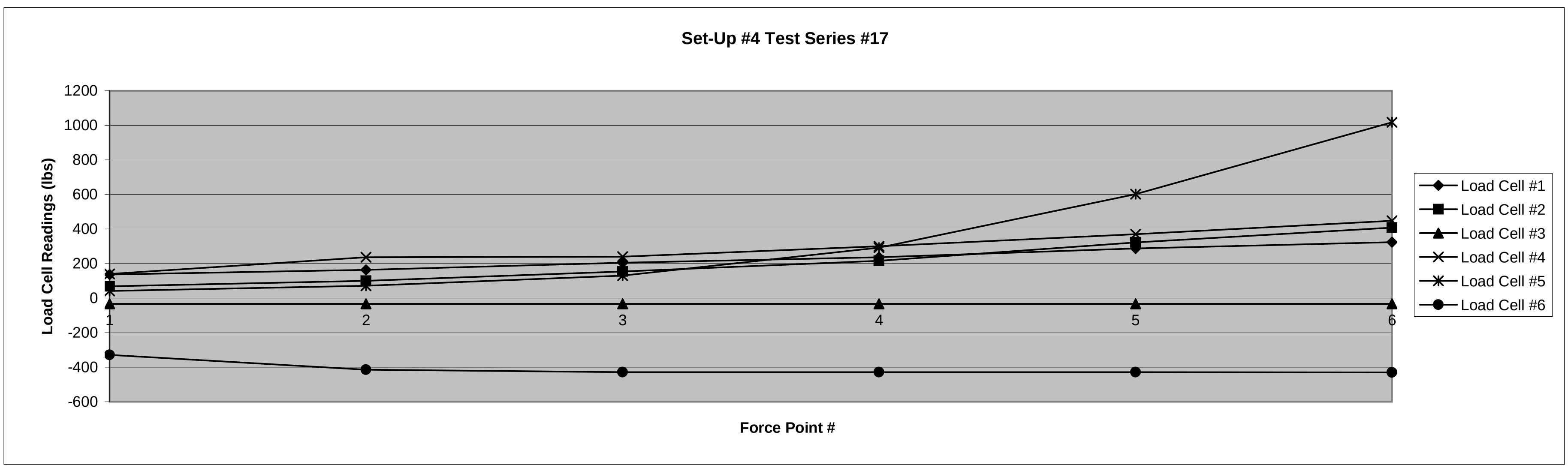
Testing = 3/16/2005

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	876.0 (3.897)	1136.0 (5.053)	1441.0 (6.410)	1771.0 (7.878)	2141.0 (9.524)	2551.0 (11.347)	0.0 (0.000)
Deflection at Top (mm) =	-10.000	-13.000	-17.000	-20.000	-23.000	-28.000	0.000
Deflection at Top (in) =	-0.394	-0.512	-0.669	-0.787	-0.906	-1.102	0.000
Deflection at Mid-Panel (mm) =	-8.000	-11.000	-15.000	-19.000	-23.000	-28.000	0.000
Deflection at Mid-Panel (in) =	-0.315	-0.433	-0.591	-0.748	-0.906	-1.102	0.000

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	876.0 (3.897)	1136.0 (5.053)	1441.0 (6.410)	1771.0 (7.878)	2141.0 (9.524)	2551.0 (11.347)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	136.695 (0.608)	164.238 (0.731)	205.042 (0.912)	236.666 (1.053)	287.671 (1.280)	324.395 (1.443)
2	67.836 (0.302)	99.223 (0.441)	153.896 (0.685)	215.657 (0.959)	322.980 (1.437)	408.027 (1.815)
3	-34.101 -(0.152)	-34.101 -(0.152)	-34.101 -(0.152)	-34.101 -(0.152)	-34.101 -(0.152)	-34.101 -(0.152)
4	139.000 (0.618)	237.000 (1.054)	239.000 (1.063)	300.000 (1.334)	370.000 (1.646)	447.000 (1.988)
** 5	41.979 (0.187)	72.118 (0.321)	130.244 (0.579)	291.702 (1.298)	601.703 (2.676)	1017.191 (4.525)
6	-328.882 -(1.463)	-414.584 -(1.844)	-428.511 -(1.906)	-428.511 -(1.906)	-428.511 -(1.906)	-429.582 -(1.911)
Total Load transferred to Post - lb (kN) =	385.510 (1.715)	572.579 (2.547)	728.182 (3.239)	1044.025 (4.644)	1582.354 (7.039)	2196.614 (9.771)
Percentage of Applied Load Received by Post =	44%	50%	51%	59%	74%	86%

* Total Received Force does not include load cells #3 and #6 due to their location



** Load Cell #5 produced results inconsistent with earlier tested. Resultant forces recorded were 2 to 3 times higher than in the same tests run in series 4 - #12

Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 18

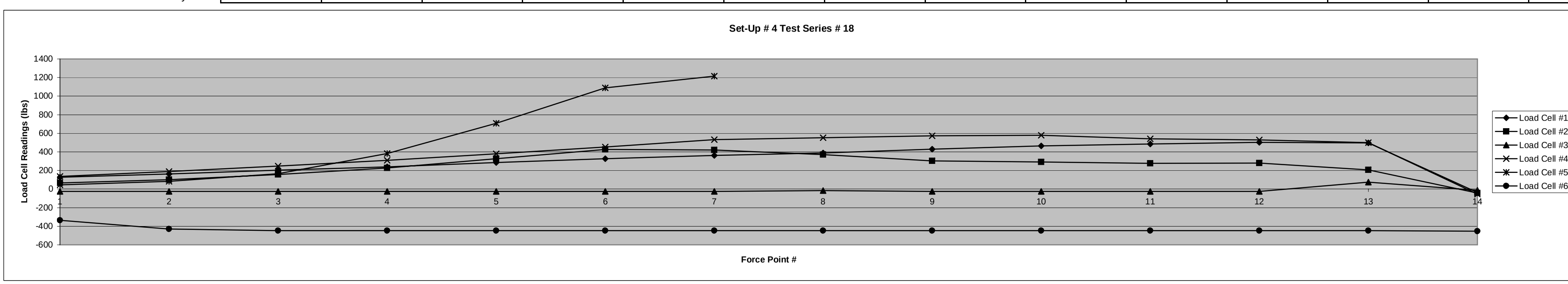
Deflection Data

Testing = 3/16/2005

	Applied Load To Panel - lb (kN)													
Force Point # =>	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	868.0 (3.861)	1133.0 (5.040)	1438.0 (6.397)	1768.0 (7.864)	2138.0 (9.510)	2548.0 (11.334)	2988.0 (13.291)	3218.0 (14.314)	3448.0 (15.337)	3678.0 (16.360)	3908.0 (17.384)	4138.0 (18.407)	4368.0 (19.430)	4588.0 (20.408)
Deflection at Top (mm) =	10.000	14.000	17.000	22.000	24.000	28.000	32.000	34.000	36.000	37.000	39.000	41.000	42.000	0.000
Deflection at Top (in) =	0.394	0.551	0.669	0.866	0.945	1.102	1.260	1.339	1.417	1.457	1.535	1.614	1.654	0.000
Deflection at Mid-Panel (mm) =	8.000	11.000	15.000	19.000	23.000	27.000	34.000	39.000	45.000	52.000	60.000	69.000	83.000	42.000
Deflection at Mid-Panel (in) =	0.315	0.433	0.591	0.748	0.906	1.063	1.339	1.535	1.772	2.047	2.362	2.717	3.268	1.654

Load Cell Data

		Applied Load To Panel - lb (kN)													
	Force Point # =>	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		868.0 (3.861)	1133.0 (5.040)	1438.0 (6.397)	1768.0 (7.864)	2138.0 (9.510)	2548.0 (11.334)	2988.0 (13.291)	3218.0 (14.314)	3448.0 (15.337)	3678.0 (16.360)	3908.0 (17.384)	4138.0 (18.407)	4368.0 (19.430)	4588.0 (20.408)
	Load Cell	Applied Load Recieved at each Load Cell - lb (kN)													
	1	128.534 (0.572)	163.218 (0.726)	203.002 (0.903)	238.706 (1.062)	286.651 (1.275)	327.456 (1.457)	361.119 (1.606)	387.642 (1.724)	430.487 (1.915)	464.150 (2.065)	484.553 (2.155)	503.935 (2.242)	495.774 (2.205)	-37.744 -(0.168)
	2	66.823 (0.297)	101.248 (0.450)	156.934 (0.698)	225.782 (1.004)	326.017 (1.450)	425.240 (1.892)	420.177 (1.869)	370.566 (1.648)	302.730 (1.347)	292.605 (1.302)	275.393 (1.225)	280.456 (1.248)	205.532 (0.914)	-43.536 -(0.194)
* Total Received Force	3	-26.077 -(0.116)	-26.077 -(0.116)	-26.077 -(0.116)	-26.077 -(0.116)	-26.077 -(0.116)	-26.077 -(0.116)	-26.077 -(0.116)	-15.245 -(0.068)	-26.077 -(0.116)	-26.077 -(0.116)	-26.077 -(0.116)	-24.071 -(0.107)	73.217 (0.326)	-14.042 -(0.062)
does not include	4	137.000 (0.609)	188.000 (0.836)	248.000 (1.103)	308.000 (1.370)	379.000 (1.686)	453.000 (2.015)	532.000 (2.366)	552.000 (2.455)	574.000 (2.553)	580.000 (2.580)	541.000 (2.406)	529.000 (2.353)	500.000 (2.224)	-56.000 -(0.249)
load cells #3 and #6	** 5	45.208 (0.201)	82.882 (0.369)	164.688 (0.733)	381.043 (1.695)	709.343 (3.155)	1089.309 (4.845)	1216.324 (5.410)	<= Load Cell #5 showing a Spike and is blocked out as to not damage load cell further						
due to their location	6	-337.452 -(1.501)	-430.654 -(1.916)	-447.794 -(1.992)	-447.794 -(1.992)	-447.794 -(1.992)	-448.865 -(1.997)	-447.794 -(1.992)	-447.794 -(1.992)	-447.794 -(1.992)	-447.794 -(1.992)	-447.794 -(1.992)	-447.794 -(1.992)	-447.794 -(1.992)	-452.079 -(2.011)
Total Load transferred to Post - lb (kN) =		377.566 (1.679)	535.347 (2.381)	772.624 (3.437)	1153.531 (5.131)	1701.011 (7.566)	2295.004 (10.209)	2529.620 (11.252)							
Percentage of Applied Load Received by Post =		43%	47%	54%	65%	80%	90%	85%							



** Load Cell #5 produced results inconsistent with earlier tested. Resultant forces recorded were 2 to 3 times higher than in the same tests run in series 4 - #12

FULL HEIGHT PANEL TEST RESULTS (ROUND 2)

SERIES # 4 - # 12

Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 4

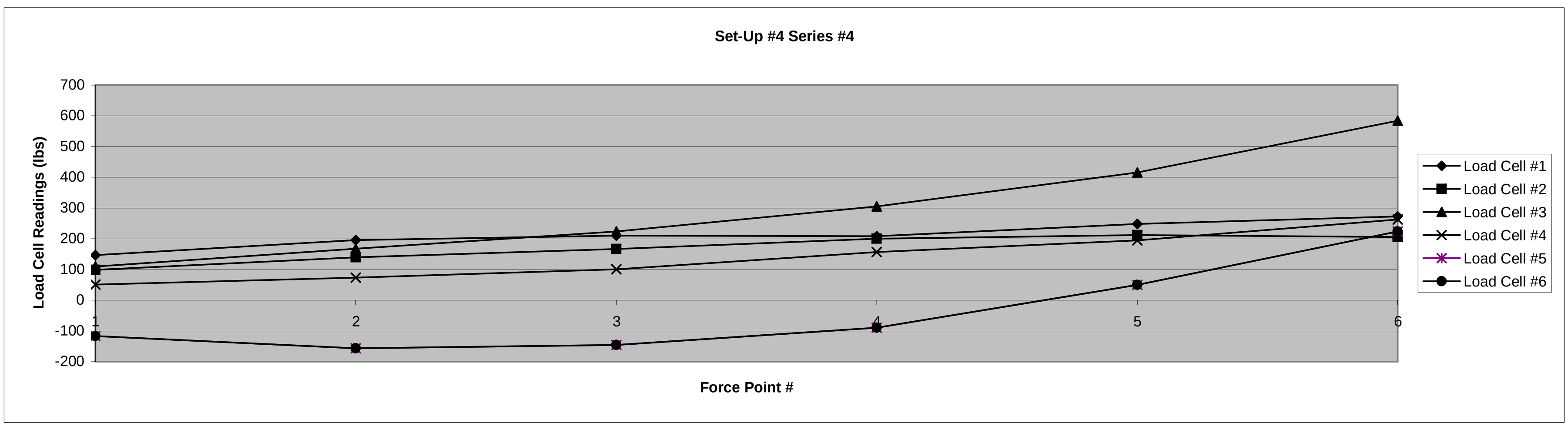
Deflection Data

Date Tested = 10/11/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	7.000	9.000	11.000	14.000	17.000	20.000	1.000
Deflection at Top (in) =	0.276	0.354	0.433	0.551	0.669	0.787	0.039

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	147.202 (0.655)	195.963 (0.872)	210.245 (0.935)	208.205 (0.926)	247.989 (1.103)	272.472 (1.212)
2	98.818 (0.440)	139.215 (0.619)	166.552 (0.741)	199.964 (0.889)	212.114 (0.944)	206.039 (0.917)
3	109.624 (0.488)	167.997 (0.747)	224.163 (0.997)	305.403 (1.358)	415.729 (1.849)	584.228 (2.599)
4	50.500 (0.225)	73.500 (0.327)	100.500 (0.447)	156.500 (0.696)	194.500 (0.865)	262.500 (1.168)
5	-0.108 (0.000)	2.260 (0.010)	40.580 (0.181)	96.445 (0.429)	166.087 (0.739)	306.018 (1.361)
6	-116.769 -(0.519)	-156.407 -(0.696)	-145.694 -(0.648)	-89.987 -(0.400)	50.350 (0.224)	223.897 (0.996)
Total Load transferred to Post - lb (kN) =	289.267 (1.287)	422.529 (1.879)	596.346 (2.653)	876.529 (3.899)	1286.769 (5.724)	1855.153 (8.252)
Percentage of Applied Load Received by Post =	28%	33%	39%	45%	56%	65%



Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 5

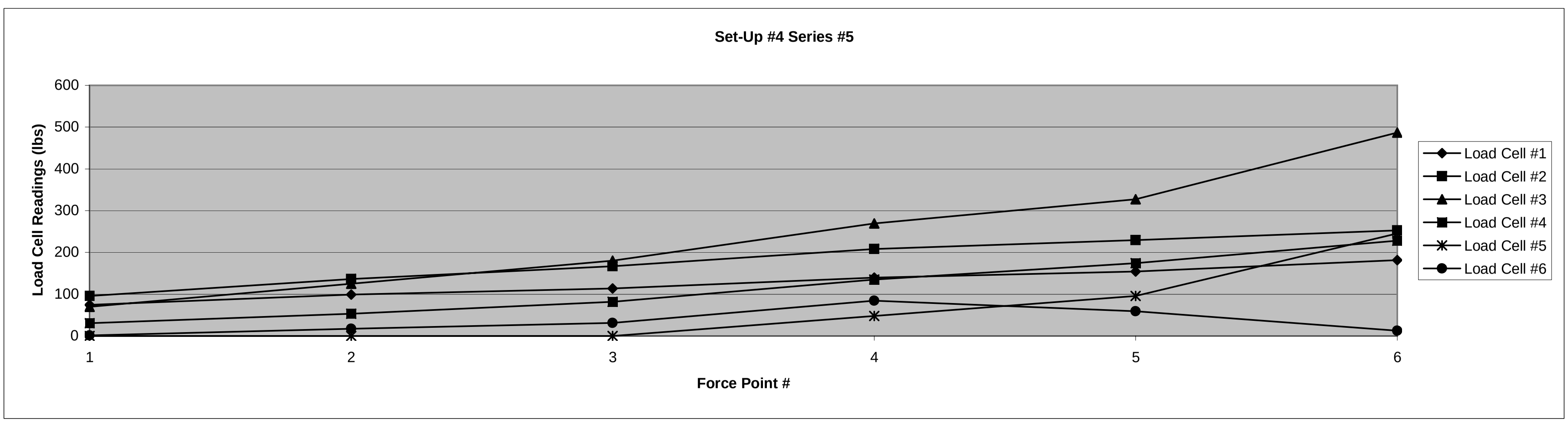
Deflection Data

Date Tested = 10/12/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	5.000	8.000	10.000	13.000	15.000	19.000	-1.000
Deflection at Top (in) =	0.197	0.315	0.394	0.512	0.591	0.748	-0.039

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	74.774 (0.333)	99.359 (0.442)	113.436 (0.505)	139.959 (0.623)	154.241 (0.686)	181.784 (0.809)
2	95.780 (0.426)	136.279 (0.606)	166.856 (0.742)	208.367 (0.927)	229.629 (1.021)	252.916 (1.125)
3	69.606 (0.310)	124.970 (0.556)	180.133 (0.801)	269.397 (1.198)	327.569 (1.457)	487.040 (2.166)
4	30.300 (0.135)	52.900 (0.235)	81.900 (0.364)	135.000 (0.601)	174.000 (0.774)	228.000 (1.014)
5	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	48.115 (0.214)	96.014 (0.427)	245.633 (1.093)
6	1.071 (0.005)	17.140 (0.076)	31.067 (0.138)	84.631 (0.376)	58.920 (0.262)	12.855 (0.057)
Total Load transferred to Post - lb (kN) =	271.531 (1.208)	430.648 (1.916)	573.392 (2.551)	885.469 (3.939)	1040.373 (4.628)	1408.228 (6.264)
Percentage of Applied Load Received by Post =	26%	33%	37%	46%	45%	50%



Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 6

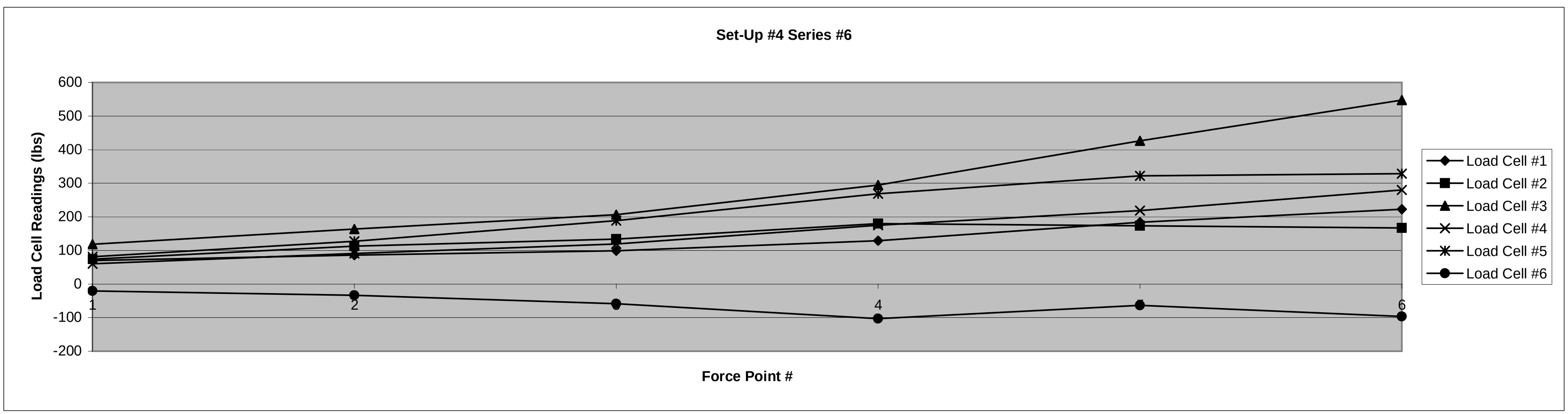
Deflection Data

Date Tested = 10/19/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	6.000	8.000	11.000	14.000	16.000	18.000	3.000
Deflection at Top (in) =	0.236	0.315	0.433	0.551	0.630	0.709	0.118
Deflection at Mid-Panel (mm) =	6.000	10.000	15.000	23.000	31.000	40.000	27.000
Deflection at Mid-Panel (in) =	0.236	0.394	0.591	0.906	1.220	1.575	1.063

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	70.082 (0.312)	85.893 (0.382)	98.951 (0.440)	128.534 (0.572)	183.620 (0.817)	222.384 (0.989)
2	73.607 (0.327)	112.790 (0.502)	133.545 (0.594)	180.119 (0.801)	173.032 (0.770)	166.957 (0.743)
3	118.651 (0.528)	163.483 (0.727)	206.611 (0.919)	294.872 (1.312)	426.261 (1.896)	547.619 (2.436)
4	60.100 (0.267)	90.900 (0.404)	118.900 (0.529)	174.900 (0.778)	218.900 (0.974)	279.900 (1.245)
5	81.052 (0.361)	127.337 (0.566)	188.692 (0.839)	268.345 (1.194)	322.164 (1.433)	328.623 (1.462)
6	-20.354 -(0.091)	-33.210 -(0.148)	-58.920 -(0.262)	-102.843 -(0.457)	-63.205 -(0.281)	-96.415 -(0.429)
Total Load transferred to Post - lb (kN) =	383.137 (1.704)	547.194 (2.434)	687.779 (3.059)	943.927 (4.199)	1260.771 (5.608)	1449.068 (6.446)
Percentage of Applied Load Received by Post =	37%	43%	45%	49%	54%	51%



Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 7

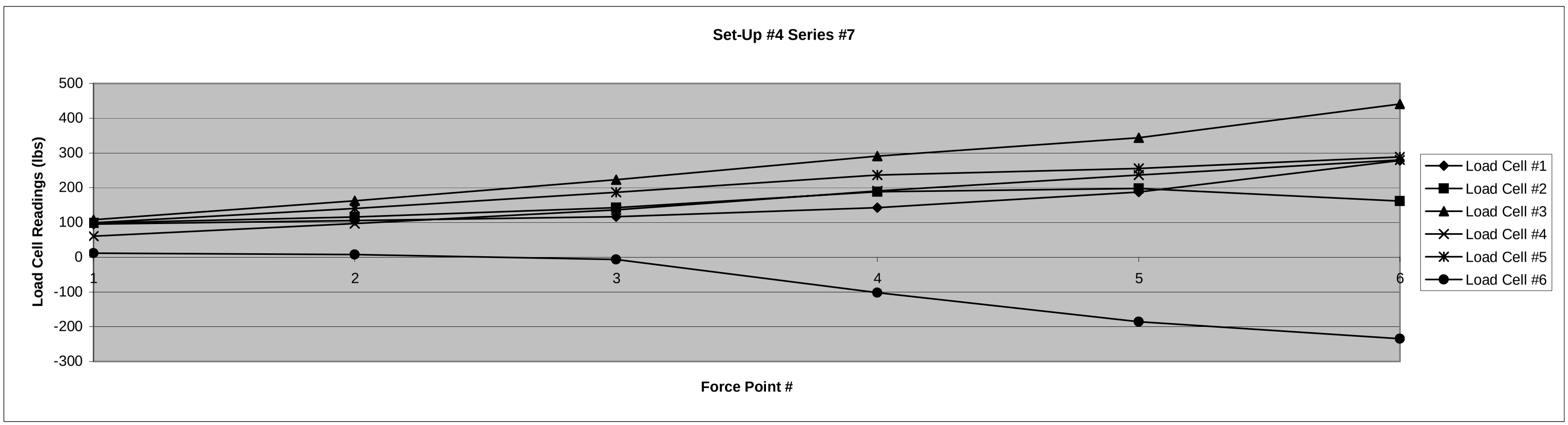
Deflection Data

Date Tested = 10/19/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	6.000	8.000	11.000	14.000	16.000	18.000	-1.000
Deflection at Top (in) =	0.236	0.315	0.433	0.551	0.630	0.709	-0.039
Deflection at Mid-Panel (mm) =	7.000	11.000	16.000	23.000	30.000	39.000	23.000
Deflection at Mid-Panel (in) =	0.276	0.433	0.630	0.906	1.181	1.535	0.906

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	94.972 (0.422)	105.173 (0.468)	116.395 (0.518)	142.917 (0.636)	187.802 (0.835)	278.592 (1.239)
2	98.413 (0.438)	115.625 (0.514)	142.961 (0.636)	188.523 (0.839)	197.635 (0.879)	161.186 (0.717)
3	108.019 (0.480)	162.180 (0.721)	223.361 (0.994)	290.559 (1.292)	343.716 (1.529)	441.004 (1.962)
4	60.500 (0.269)	96.500 (0.429)	136.500 (0.607)	190.500 (0.847)	236.500 (1.052)	279.500 (1.243)
5	99.459 (0.442)	140.362 (0.624)	186.646 (0.830)	236.161 (1.050)	255.536 (1.137)	288.904 (1.285)
6	11.784 (0.052)	7.499 (0.033)	-6.428 -(0.029)	-101.771 -(0.453)	-185.331 -(0.824)	-234.610 -(1.044)
Total Load transferred to Post - lb (kN) =	473.147 (2.105)	627.338 (2.791)	799.435 (3.556)	946.889 (4.212)	1035.858 (4.608)	1214.576 (5.403)
Percentage of Applied Load Received by Post =	46%	49%	52%	49%	45%	43%



Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 8

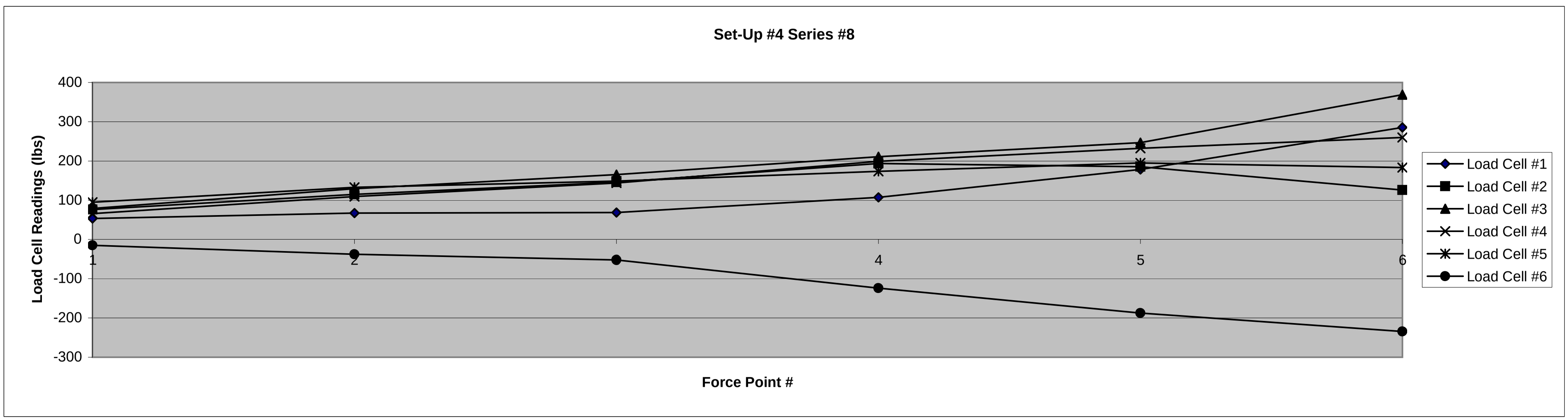
Deflection Data

Date Tested = 10/28/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	6.000	8.000	10.000	13.000	15.000	17.000	-1.000
Deflection at Top (in) =	0.236	0.315	0.394	0.512	0.591	0.669	-0.039
Deflection at Mid-Panel (mm) =	6.000	11.000	14.000	20.000	26.000	36.000	20.000
Deflection at Mid-Panel (in) =	0.236	0.433	0.551	0.787	1.024	1.417	0.787

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	53.148 (0.236)	67.429 (0.300)	68.449 (0.304)	107.214 (0.477)	178.621 (0.795)	285.733 (1.271)
2	76.138 (0.339)	114.612 (0.510)	145.999 (0.649)	193.585 (0.861)	185.485 (0.825)	125.749 (0.559)
3	79.234 (0.352)	129.383 (0.576)	165.489 (0.736)	210.623 (0.937)	246.730 (1.098)	369.091 (1.642)
4	66.100 (0.294)	109.100 (0.485)	144.100 (0.641)	199.100 (0.886)	232.100 (1.032)	260.100 (1.157)
5	94.938 (0.422)	132.612 (0.590)	148.757 (0.662)	173.514 (0.772)	195.042 (0.868)	183.202 (0.815)
6	-14.998 -(0.067)	-37.495 -(0.167)	-52.493 -(0.233)	-124.268 -(0.553)	-187.474 -(0.834)	-234.610 -(1.044)
Total Load transferred to Post - lb (kN) =	354.560 (1.577)	515.641 (2.294)	620.303 (2.759)	759.768 (3.380)	850.505 (3.783)	989.266 (4.400)
Percentage of Applied Load Received by Post =	34%	40%	40%	39%	37%	35%



Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 9

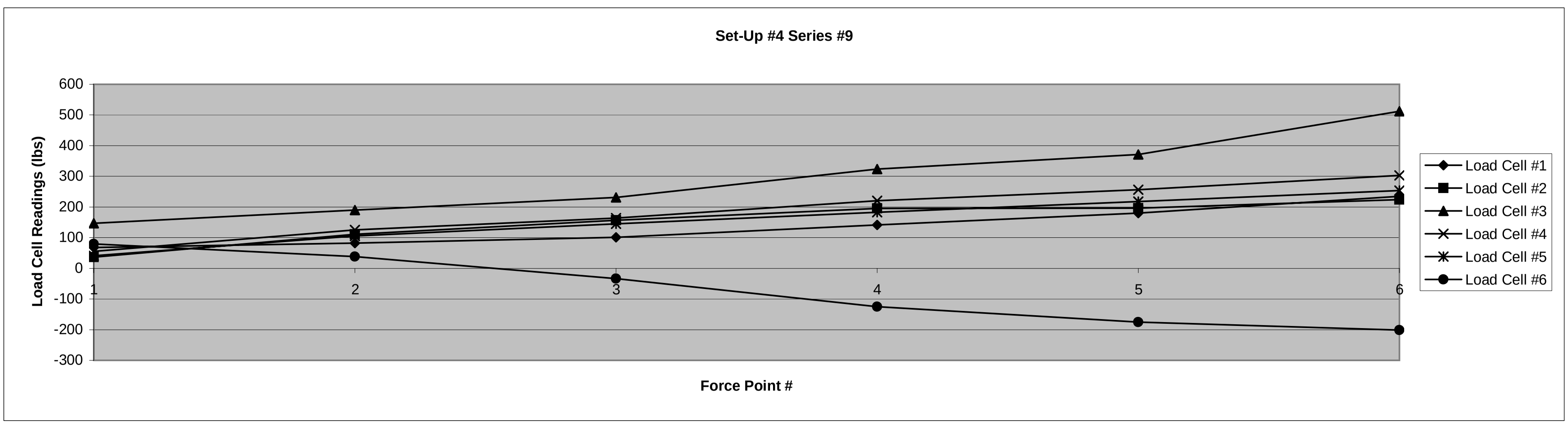
Deflection Data

Date Tested = 11/4/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	6.000	10.000	12.000	15.000	16.000	19.000	0.000
Deflection at Top (in) =	0.236	0.394	0.472	0.591	0.630	0.748	0.000
Deflection at Mid-Panel (mm) =	8.000	14.000	19.000	28.000	35.000	45.000	29.000
Deflection at Mid-Panel (in) =	0.315	0.551	0.748	1.102	1.378	1.772	1.142

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	68.245 (0.304)	82.527 (0.367)	100.889 (0.449)	141.693 (0.630)	180.458 (0.803)	234.523 (1.043)
2	36.145 (0.161)	111.069 (0.494)	156.630 (0.697)	195.104 (0.868)	196.116 (0.872)	224.466 (0.998)
3	147.135 (0.654)	190.263 (0.846)	231.384 (1.029)	323.657 (1.440)	370.796 (1.649)	512.215 (2.278)
4	55.200 (0.246)	125.200 (0.557)	164.200 (0.730)	220.200 (0.979)	256.200 (1.140)	303.200 (1.349)
5	40.903 (0.182)	105.486 (0.469)	145.313 (0.646)	182.987 (0.814)	217.431 (0.967)	254.029 (1.130)
6	79.275 (0.353)	38.566 (0.172)	-33.210 -(0.148)	-125.339 -(0.558)	-175.690 -(0.782)	-201.400 -(0.896)
Total Load transferred to Post - lb (kN) =	426.903 (1.899)	653.111 (2.905)	765.206 (3.404)	938.302 (4.174)	1045.312 (4.650)	1327.032 (5.903)
Percentage of Applied Load Received by Post =	41%	51%	50%	49%	45%	47%



Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 10

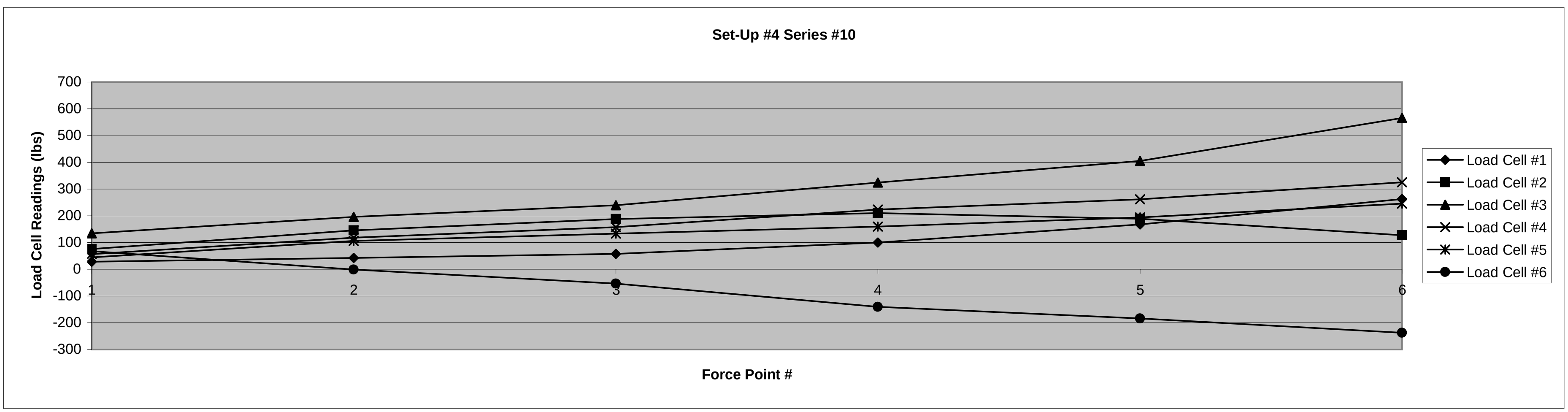
Deflection Data

Date Tested = 11/18/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	7.000	10.000	12.000	14.000	16.000	18.000	0.000
Deflection at Top (in) =	0.276	0.394	0.472	0.551	0.630	0.709	0.000
Deflection at Mid-Panel (mm) =	10.000	17.000	22.000	30.000	38.000	50.000	35.000
Deflection at Mid-Panel (in) =	0.394	0.669	0.866	1.181	1.496	1.969	1.378

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	28.155 (0.125)	42.437 (0.189)	57.738 (0.257)	99.563 (0.443)	167.910 (0.747)	262.780 (1.169)
2	75.328 (0.335)	145.189 (0.646)	187.713 (0.835)	209.987 (0.934)	188.725 (0.839)	126.964 (0.565)
3	134.397 (0.598)	195.578 (0.870)	239.709 (1.066)	323.958 (1.441)	405.198 (1.802)	565.673 (2.516)
4	56.600 (0.252)	118.600 (0.528)	157.600 (0.701)	223.600 (0.995)	261.600 (1.164)	325.600 (1.448)
5	44.132 (0.196)	106.563 (0.474)	133.473 (0.594)	159.306 (0.709)	193.751 (0.862)	245.418 (1.092)
6	67.490 (0.300)	-1.071 -(0.005)	-53.564 -(0.238)	-140.337 -(0.624)	-184.260 -(0.820)	-237.824 -(1.058)
Total Load transferred to Post - lb (kN) =	406.103 (1.806)	607.295 (2.701)	722.669 (3.215)	876.077 (3.897)	1032.925 (4.595)	1288.611 (5.732)
Percentage of Applied Load Received by Post =	39%	47%	47%	45%	45%	45%



Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 11

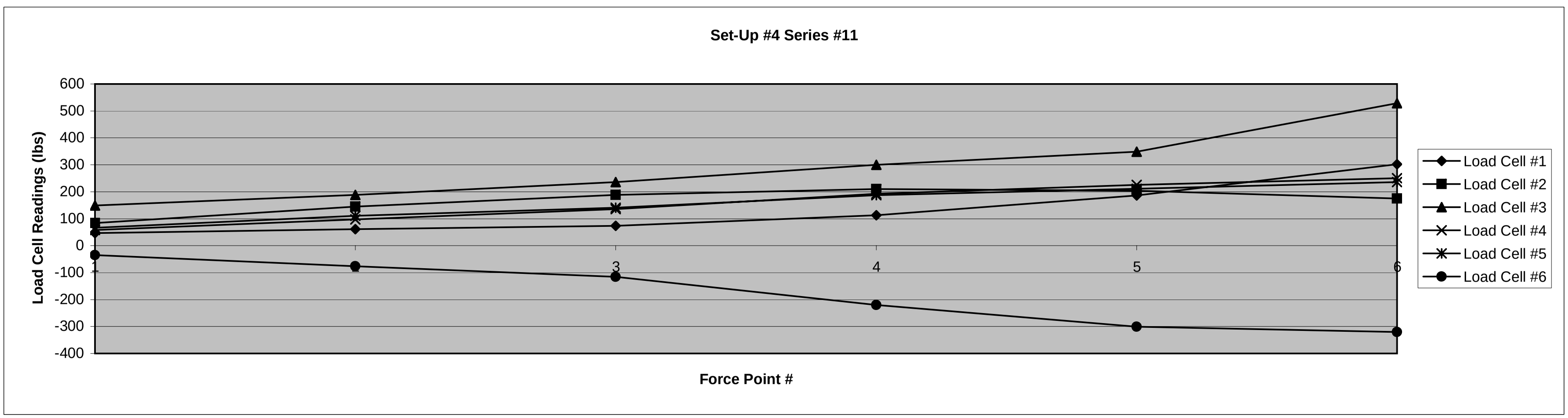
Deflection Data

Date Tested = 11/24/2004

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	4.000	7.000	9.000	12.000	14.000	16.000	-2.000
Deflection at Top (in) =	0.157	0.276	0.354	0.472	0.551	0.630	-0.079
Deflection at Mid-Panel (mm) =	6.000	10.000	15.000	24.000	30.000	42.000	27.000
Deflection at Mid-Panel (in) =	0.236	0.394	0.591	0.945	1.181	1.654	1.063

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	46.925 (0.209)	61.207 (0.272)	73.448 (0.327)	113.232 (0.504)	186.680 (0.830)	301.953 (1.343)
2	84.035 (0.374)	144.784 (0.644)	188.320 (0.838)	210.595 (0.937)	203.507 (0.905)	175.158 (0.779)
3	149.241 (0.664)	188.357 (0.838)	235.496 (1.048)	299.686 (1.333)	348.832 (1.552)	528.362 (2.350)
4	58.000 (0.258)	97.000 (0.431)	136.000 (0.605)	193.000 (0.859)	226.000 (1.005)	250.000 (1.112)
5	66.736 (0.297)	110.868 (0.493)	141.007 (0.627)	187.292 (0.833)	210.973 (0.938)	235.730 (1.049)
6	-35.352 -(0.157)	-76.061 -(0.338)	-115.698 -(0.515)	-219.612 -(0.977)	-301.029 -(1.339)	-320.312 -(1.425)
Total Load transferred to Post - lb (kN) =	369.586 (1.644)	526.155 (2.340)	658.574 (2.929)	784.194 (3.488)	874.963 (3.892)	1170.891 (5.208)
Percentage of Applied Load Received by Post =	36%	41%	43%	41%	38%	41%



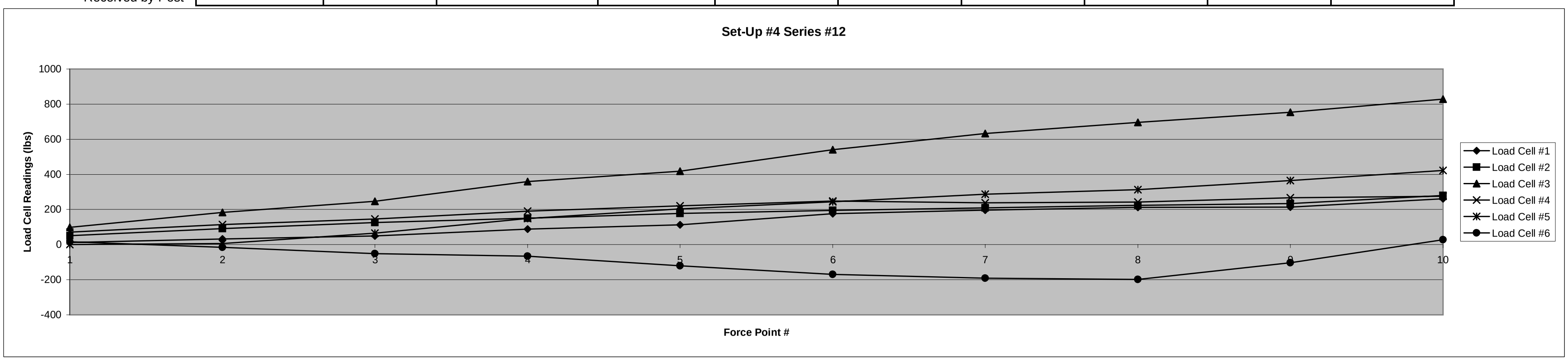
Full Scale Test Results using a Articulating Spreader Frame (Round # 2 Testing) - Set-Up # 4 - Series # 12

Deflection Data

Date Tested = 11/30/2004

	Applied Load To Panel - lb (kN)										
Force Point # =>	1	2	3	4	5	6	7	8	9	10	11
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	3090.0 (13.745)	3347.5 (14.890)	3605.0 (16.036)	3862.5 (17.181)	0.0 (0.000)
Deflection at Top (mm) =	6.000	10.000	13.000	17.000	20.000	24.000	27.000	28.000	31.000	34.000	-4.000
Deflection at Top (in) =	0.236	0.394	0.512	0.669	0.787	0.945	1.063	1.102	1.220	1.339	-0.157
Deflection at Mid-Panel (mm) =	8.000	17.000	26.000	37.000	44.000	53.000	58.000	64.000	71.000	82.000	49.000
Deflection at Mid-Panel (in) =	0.315	0.669	1.024	1.457	1.732	2.087	2.283	2.520	2.795	3.228	1.929

	Applied Load To Panel - lb (kN)									
Force Point # =>	1	2	3	4	5	6	7	8	9	10
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	3090.0 (13.745)	3347.5 (14.890)	3605.0 (16.036)	3862.5 (17.181)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)									
1	11.221 (0.050)	31.623 (0.141)	48.965 (0.218)	88.750 (0.395)	112.212 (0.499)	176.479 (0.785)	196.881 (0.876)	212.183 (0.944)	214.223 (0.953)	261.148 (1.162)
2	50.118 (0.223)	91.629 (0.408)	125.041 (0.556)	150.353 (0.669)	177.689 (0.790)	194.901 (0.867)	209.076 (0.930)	223.251 (0.993)	233.375 (1.038)	279.949 (1.245)
3	97.990 (0.436)	183.242 (0.815)	246.429 (1.096)	359.764 (1.600)	417.936 (1.859)	540.298 (2.403)	632.571 (2.814)	696.760 (3.099)	753.929 (3.354)	829.152 (3.688)
4	71.100 (0.316)	114.100 (0.508)	146.100 (0.650)	191.100 (0.850)	220.100 (0.979)	248.100 (1.104)	238.100 (1.059)	242.100 (1.077)	267.100 (1.188)	275.100 (1.224)
5	0.538 (0.002)	5.920 (0.026)	65.122 (0.290)	149.080 (0.663)	203.976 (0.907)	243.803 (1.084)	286.859 (1.276)	312.692 (1.391)	364.359 (1.621)	422.484 (1.879)
6	16.069 (0.071)	-16.069 -(0.071)	-51.421 -(0.229)	-66.419 -(0.295)	-121.054 -(0.538)	-169.262 -(0.753)	-191.759 -(0.853)	-198.186 -(0.882)	-103.914 -(0.462)	27.853 (0.124)
Total Load transferred to Post - lb (kN) =	247.036 (1.099)	410.445 (1.826)	580.235 (2.581)	872.627 (3.882)	1010.859 (4.497)	1234.319 (5.490)	1371.728 (6.102)	1488.800 (6.622)	1729.073 (7.691)	2095.687 (9.322)
Percentage of Applied Load Received by Post =	24%	32%	38%	45%	44%	44%	44%	44%	48%	54%



FULL HEIGHT PANEL TEST RESULTS (ROUND 1)

SERIES # 1 - # 3

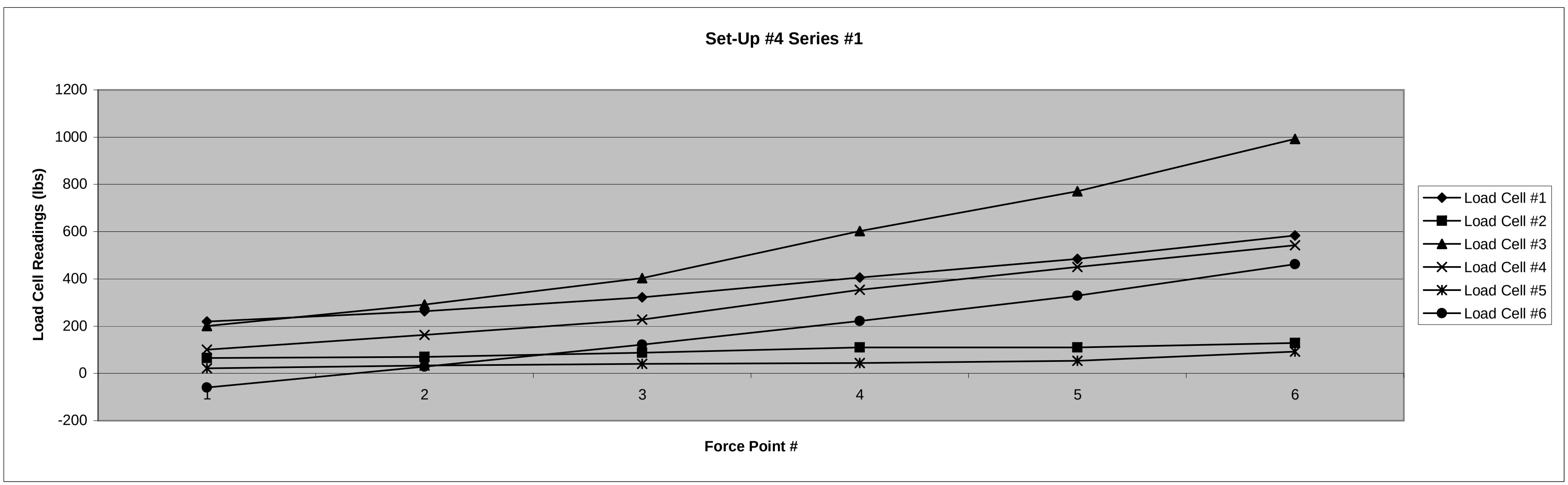
Full Scale Test Results using a Single Vertical Spreader Bar (Round # 1 Testing) - Set-Up # 4 - Series # 1

Deflection Data

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	16.000	19.000	23.000	28.000	32.000	40.000	5.000
Deflection at Top (in) =	0.630	0.748	0.906	1.102	1.260	1.575	0.197

Load Cell Data

	Applied Load To Panel - lb (kN)											
Force Point # =>	1		2		3		4		5		6	
	1030.0	(4.582)	1287.5	(5.727)	1545.0	(6.872)	1931.3	(8.591)	2317.5	(10.309)	2832.5	(12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)											
1	219.834	(0.978)	263.699	(1.173)	321.845	(1.432)	405.494	(1.804)	485.063	(2.158)	584.013	(2.598)
2	64.596	(0.287)	70.165	(0.312)	87.883	(0.391)	109.347	(0.486)	109.955	(0.489)	128.888	(0.573)
3	200.994	(0.894)	291.261	(1.296)	403.593	(1.795)	602.181	(2.679)	770.679	(3.428)	992.334	(4.414)
4	101.000	(0.449)	163.000	(0.725)	227.900	(1.014)	353.900	(1.574)	450.900	(2.006)	542.900	(2.415)
5	21.420	(0.095)	33.906	(0.151)	40.042	(0.178)	44.132	(0.196)	53.604	(0.238)	92.570	(0.412)
6	-59.884	-(0.266)	28.924	(0.129)	122.126	(0.543)	221.754	(0.986)	328.882	(1.463)	461.721	(2.054)
Total Load transferred to Post - lb (kN) =	547.960	(2.437)	850.955	(3.785)	1203.389	(5.353)	1736.809	(7.726)	2199.083	(9.782)	2802.426	(12.466)
Percentage of Applied Load Received by Post =	53%		66%		78%		90%		95%		99%	



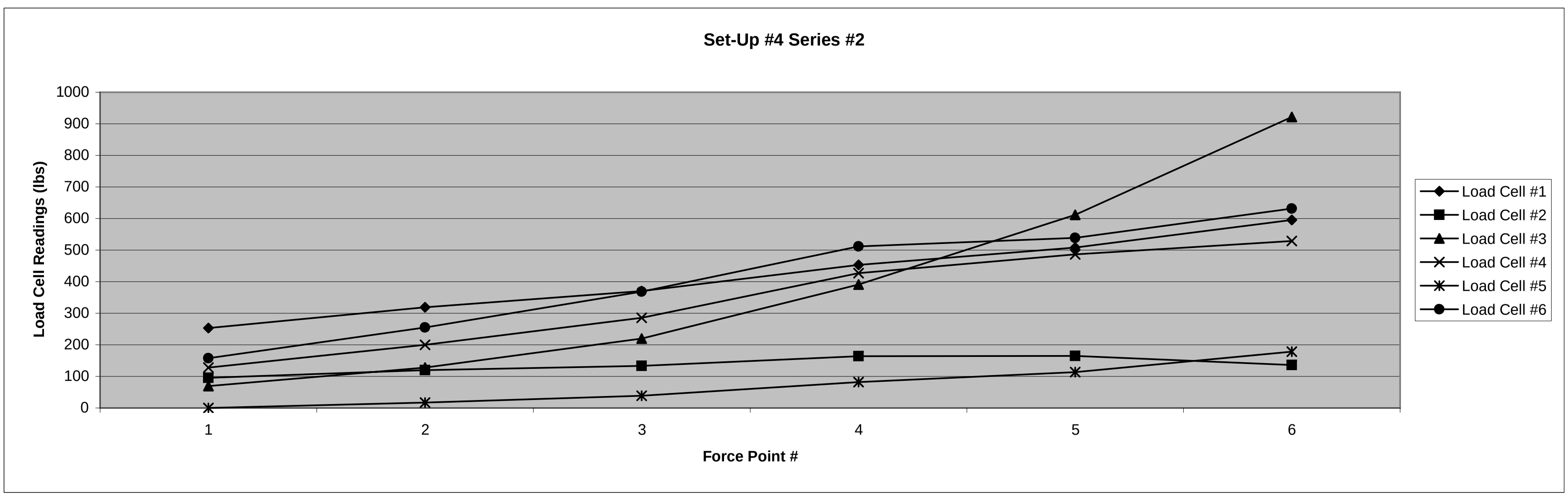
Full Scale Test Results using a Single Vertical Spreader Bar (Round # 1 Testing) - Set-Up # 4 - Series # 2

Deflection Data

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	20.000	23.000	27.000	31.000	35.000	40.000	3.000
Deflection at Top (in) =	0.787	0.906	1.063	1.220	1.378	1.575	0.118

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	252.885 (1.125)	319.193 (1.420)	370.198 (1.647)	452.827 (2.014)	507.913 (2.259)	595.643 (2.650)
2	95.071 (0.423)	119.573 (0.532)	132.938 (0.591)	164.021 (0.730)	164.628 (0.732)	136.482 (0.607)
3	69.806 (0.311)	128.279 (0.571)	219.549 (0.977)	391.056 (1.739)	611.709 (2.721)	921.625 (4.100)
4	128.300 (0.571)	199.600 (0.888)	285.600 (1.270)	426.600 (1.898)	486.600 (2.164)	528.600 (2.351)
5	0.000 (0.000)	16.792 (0.075)	39.073 (0.174)	81.806 (0.364)	113.344 (0.504)	178.789 (0.795)
6	157.799 (0.702)	255.285 (1.136)	368.841 (1.641)	511.321 (2.274)	539.174 (2.398)	631.304 (2.808)
Total Load transferred to Post - lb (kN) =	703.862 (3.131)	1038.722 (4.620)	1416.199 (6.300)	2027.631 (9.019)	2423.369 (10.780)	2992.442 (13.311)
Percentage of Applied Load Received by Post =	68%	81%	92%	105%	105%	106%



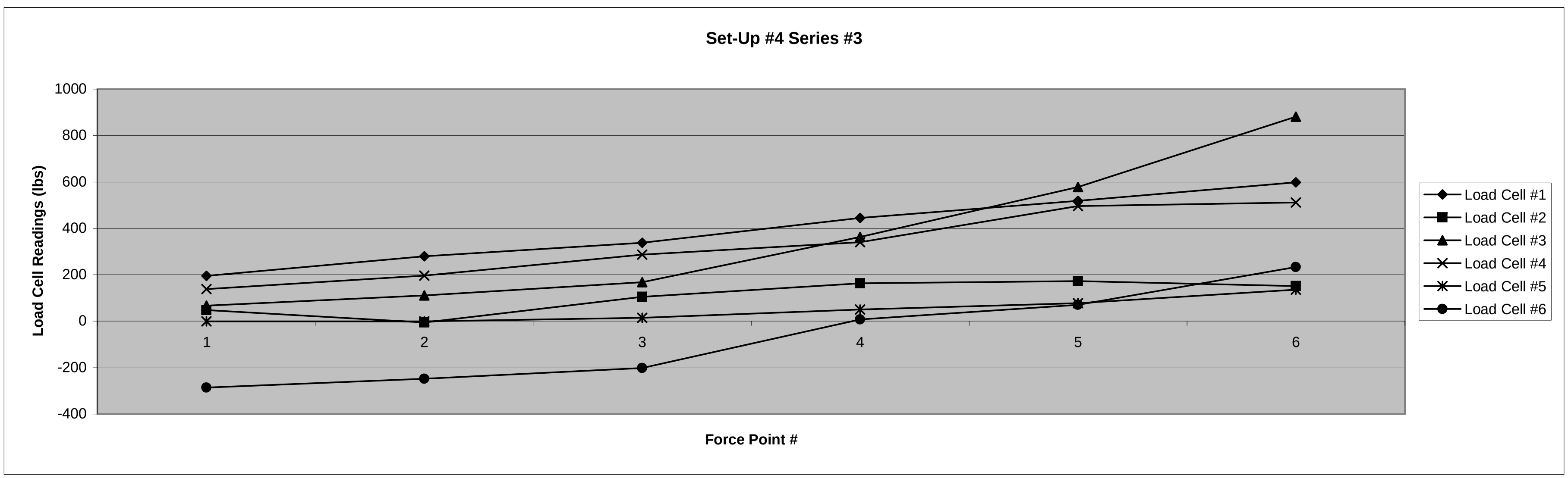
Full Scale Test Results using a Single Vertical Spreader Bar (Round # 1 Testing) - Set-Up # 4 - Series # 3

Deflection Data

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)	0.0 (0.000)
Deflection at Top (mm) =	18.000	21.000	24.000	30.000	33.000	38.000	1.000
Deflection at Top (in) =	0.709	0.827	0.945	1.181	1.299	1.496	0.039

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1030.0 (4.582)	1287.5 (5.727)	1545.0 (6.872)	1931.3 (8.591)	2317.5 (10.309)	2832.5 (12.600)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	195.759 (0.871)	279.408 (1.243)	338.575 (1.506)	444.666 (1.978)	518.114 (2.305)	598.703 (2.663)
2	47.586 (0.212)	-5.974 -(0.027)	105.297 (0.468)	163.515 (0.727)	173.133 (0.770)	150.859 (0.671)
3	67.299 (0.299)	111.430 (0.496)	168.599 (0.750)	363.174 (1.615)	577.809 (2.570)	880.704 (3.918)
4	138.800 (0.617)	196.800 (0.875)	286.800 (1.276)	340.500 (1.515)	495.800 (2.205)	511.800 (2.277)
5	-0.323 -(0.001)	-0.323 -(0.001)	14.424 (0.064)	50.052 (0.223)	77.285 (0.344)	136.056 (0.605)
6	-286.031 -(1.272)	-247.465 -(1.101)	-201.400 -(0.896)	7.499 (0.033)	70.704 (0.315)	233.539 (1.039)
Total Load transferred to Post - lb (kN) =	163.090 (0.725)	333.876 (1.485)	712.294 (3.168)	1369.406 (6.091)	1912.845 (8.509)	2511.661 (11.172)
Percentage of Applied Load Received by Post =	16%	26%	46%	71%	83%	89%



JOB NUMBER: 32-78827.2

DATE: November 13, 2006

TESTING OF AB FENCE

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JOB NUMBER: 32-78827.2 **PAGE:** 2 of 2
DATE: November 13, 2006

TESTING OF AB FENCE ASSEMBLY

INTRODUCTION:

This report is in reference to testing of an Allan Block AB Fence at their facility on August 16, 2006 and October 10, 2006, as documented in a report entitled "Allan Block AB Fence Testing, Full Scale Panel Test Report, 12x11 Panel with Articulating Spreader Frame," dated November 10, 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 tested AB Fence panel assembly 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 at the time of witnessed testing.
2. Witness all testing of the AB Fence panel assembly on August 16, 2006 and again on October 10, 2006, 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 panel assembly, the test procedure and equipment described in Appendix A, as well as the test data listed for Series 2 through 7 in Appendix B of Mr. Lovdal's report of November 10, 2006, is consistent with the observations made by Stork TCT personnel. 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

Full Scale Panel Test Report
12x11 Panel with Articulating Spreader Frame

November 10, 2006

Introduction

This report provides the results for the continuing full-scale panel tests preformed on the Allan Block fence panel. All tests were preformed 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 are an extension of the Fence Testing preformed at the University of Calgary in 2003 and the Allan Block/STCT testing preformed in August 2004 and October 2005. The main difference between the previous testing and these is the post spacing was expanded from 7-panel block long (11'-7" (3.54m)) to 11-panel block long (17'-5" (5.32m)).

Figure 1: 11-Panel block long by 12-course tall test panel

Figure 2: Articulating Spreader Frame

Objectives of Test Program

The principle objective of this test is to expand on what was learned in the two prior tests and further understand the added strength and flexibility the dry-stacked units bring to the AB Fence system in longer post spacing configurations. In the Vertical Spreader Bar tests the set up was designed to force a configuration that simulated a typical tributary area distribution by directing the applied load to the bond beams with a single vertical spreader bar. In the 12x7 Panel test an articulating spreader frame was introduced to evenly distribute the applied force to the test panel. In this 12x11 Panel test the same test procedure and similar articulating spreader frame will be used as in the 12x7 Panel Test except on a longer test panel. Under this setup the eight dry-stacked courses, which accounts for the majority of the tributary area of the panel, along with the two bond beams will be engaged by the spreader frame. This will again provide a more accurate depiction of how the dry-stacked units with a ball and socket configuration receive, distribute and dissipate force. The added benefit of the dry-stacked units to resist applied forces will be the documentation of the force absorption ability of the panel. It was first observed in the Calgary panel testing that a dissipation of applied forces occurred during testing and similar dissipations or reductions were documented in all subsequent full-scale AB Fence panel tests. The expected outcome of these tests will be to verify that similar design load reductions occur in longer panels. These tests will record the applied force from the

Figure 3: In Place Load Cell

hydraulic ram and the received load at the posts using load cells at third points on each post, see Figure #3. For a complete description of the testing frame and equipment used see Appendix A.

By comparing the applied to received, a percentage of loss can be determined. The full panel will be subjected to repeated bending and rebounding. Careful attention will be given to the recording of deflections and rebounds to document the extraordinary plasticity of the bond beams.

Test Procedure and Results

The test procedure is very straightforward and follows the same process set forth in all previous testing. A force is applied to the panel using the hydraulic ram and spreader bar assembly. The load cell readings are recorded and summed together to obtain the total force applied to the posts. The applied forces are based on the standard Wind Stagnation Pressures (q) formula of $q = 0.5 * \rho * V^2$ where q is in lb/ft^2 (N/m^2) and ρ is the average air density in lb/ft^3 (kg/m^3) and V is the average wind speed in ft/sec (m/sec) and are tabulated in Table 1 on page 5. The first five tests preformed used the standard bond beam and dry-stacked configuration and were stressed to pressures associated with 100 to 110 mph (161 to 177 kph) winds and then released to zero pressure.

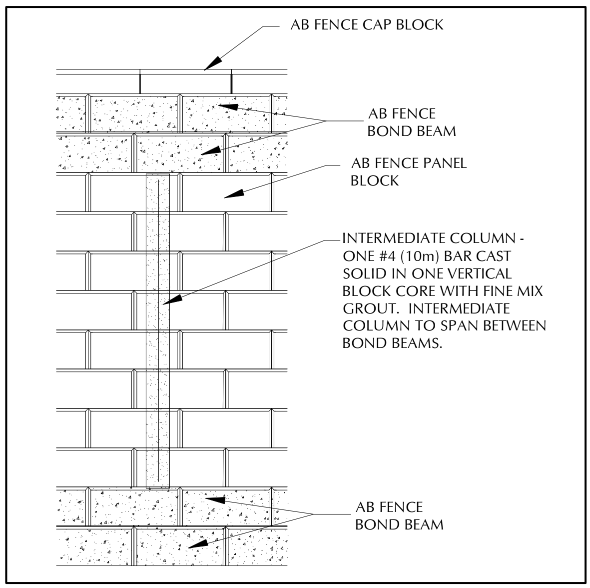


Figure 4: Intermediate Column (Tests 6 and 7 Only)

For tests 6 and 7 an intermediate column was cast into the center vertical core of the dry-stacked courses, see Figure #4. To do this, the top bond beam was lifted using the 9ga lifting hooks and the dry-stacked courses were removed in a step fashion towards the center of the panel. The courses were then restacked with a # 4 rebar placed in the center vertical core. The reinforced core was then cast solid with the same fine mix grout used in the casting of the bond beams and consolidated with a vibratory stinger. The top bond beam was then reseated and the rebuilt assembly was allowed to cure for a minimum of 28 days. The intermediate column was installed to remedy large deflections realized during the first five tests. In those tests the entire panel carried the applied load well, while also dissipating the load being transferred to the post in similar percentages as seen in the 12x7 Panel test. The major difference was the amount of deflection or bulging which occurred in the dry-stacked courses. This was not unexpected due to the increase in overall panel length from the 12x7 Panel test. It was determined that an intermediate column would greatly reduce the center bulging by adding rigidity to the dry-stacked.

The main question to resolve was whether or not this inclusion would reduce the amount of force dissipation through the Work Energy theory. The results of tests 6 and 7 showed a stiffer panel which transferred more force to the posts and had no negative center bulging. However, the force reductions were still within the scale set forth in the 12x7 Panel test and shown in Table 1 on page 5 of this report. Also the entire panel rebounded without a center budge after the load was removed. Once again, there were no catastrophic failures and after all tests the panel was simply forced back into a vertical position by manually hitting each dry-stacked block that had shifted with a dead blow hammer until they were once again aligned vertically. Much less realigning was required after the intermediate column was cast. Additionally, no dismantling was required and no blocks required replacing due to damage. The results of the tests that followed showed no negative effects in strength or appearance from realigning.

The results of these tests focused on the following:

- Flexibility of the bond beams and dry-stacked units.
- The absorption of force which occurs within the panel.
- The additional strength the ball and socket brings to the whole system.
- The structural enhancement the intermediate column brings to longer panels

The 11-Panel Block long bond beam showed great flexibility and durability throughout the seven tests. They deflected relative to the load applied and at maximum force exceeded 6.5 inches (167 mm) without failure. Each time the load was removed the bond beams relaxed back. After the first test the top bond beam did not rebound back to its full at-rest position. Subsequent tests showed no reduction in capacity and differential at-rest deflection ranging form 9 to 16mm. It was concluded that debris lodged inside the stress cracks, hindering the rebound of the bond beam. Therefore before test 5 was relaxed the cracks were blown out. The resulting differential at-rest deflection was 2mm. At the completion of all seven tests, other than the original stress cracks which appeared after the very first test, both bond beams showed no visible defects or damage. The bond beams reacted exactly how a monolithic concrete beam would react to repeated stress. The stress cracks would open slightly during stressing, which would engage the steel and would close when the load was removed. In total, these bond beams were used and stressed in 7 separate tests in which both bond beams flexed and rebound to near zero deflection.

The absorption of forces is clearly evident in the results from the 18 separate tests tabulated in the 12x7 Panel test and in the 7 from this test series. See Appendix B for lab results. In none of these 25 tests did the applied forces equal the received forces at the post. Structural engineering teaches a standard static approach to applied forces in that “force in equals force out”. However, a system of dry-stacked units which have a large selfweight and a ball and socket configuration, such as the AB panel blocks have, brings a dynamic variable to the static equation. This dynamic variable can best be described as Work Energy. Work is defined as a force (wind) acting upon an object (the panel block’s ball and socket joint) to cause a displacement, see Figure 5. In the Allan Block Fence panel there are two forms of work energy being developed. First is the external work which is simply the deflection of the entire panel due to the wind force. The second occurs internally in the ball and socket joint. As the wind load is applied, the running bonds of the dry stacked block try and deflect away from the force laterally, but the socket resists any deflection due to its natural conical locking configuration. The selfweight of all the courses above a particular joint provides the downward force which serves to stiffen the joint. Thus, the lower the joint is within the panel the greater the internal resisting forces within that socket. Therefore, most of the deflection within the panel occurred in the upper half.

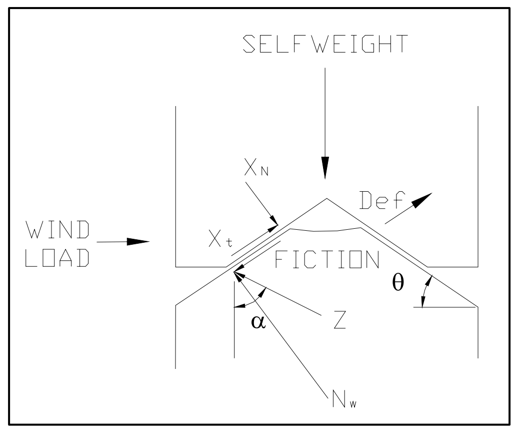


Figure 5: Work Energy Free-Body Diagram

The internal Work occurs when the applied force becomes great enough to overcome the frictional interaction within the socket, forcing deflection. There are two forms of deflection which could occur. The first is a purely horizontal translation, but this could only occur if the bottom tension edge of the panel block were to shear off horizontally allowing the socket to release, see Figure 6. This form of deflection did not occur due to the internal strength of each

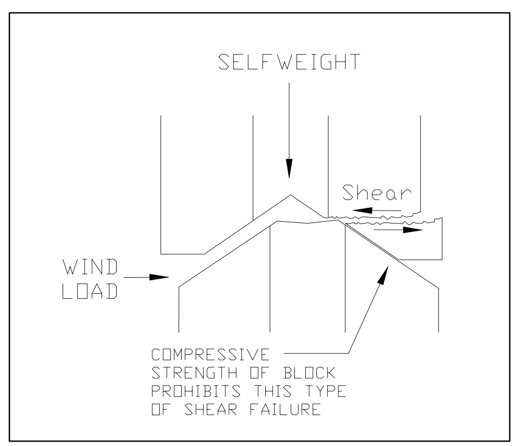


Figure 6: Possible Shear Failure Diagram

block. The shear strength of a block is directly related to the compression strength, therefore the stronger the block the more resistant to shear failures and the stronger the ball and socket can become.

The second form of deflection, which did occur, was a movement along the natural sloped plane of the socket which provided displacement in an upward and lateral direction, variable Xt in Figure 5. Each movement when it occurred would be very small because the pressure within the socket would release and the fictional interaction would once again be greater than the applied load. Once the force was built up enough to overcome the internal resisting forces another deflection would occur. Each time an internal deflection occurred a certain amount of force was absorbed into the joint causing a reduction of applied forces to the posts. In all test this was true, the least amount of transferred load occurred in the lowest pressures. This is due to the large number of areas within the panel that had the ability to shift or deflect early on. At higher pressures the number of joints having the ability to adjust decreases because movement has already occurred making the joint more rigid, which causes the amount of force received by the post to increase. The results showed that at low pressures the received loads are quite small, lowest recorded value was 19% in Test Series #7. The largest percentage was 66% in Test Series #6. This number is believed to be slightly skewed due the repeated spiking of load cell #3. In all tests, load cell #3 began to spike at 90 to 100mph loads which caused a percentage increase. In the last test, #7, load cell #3 reacted the same until after achieving the 120mph mark, where it showed a 40% reduction from the 110mph mark. The internal structure of the dry-stacked units must have shifted, relieving the stress at #3, resulting in a percentage of applied force of 56% at 120mph. See data tables in Appendix B for results from all tests.

The overall deflection of the panel was similar to a plate bending diagram having three ridged edges with the bottom and two sides fixed and the top restrained but allowed to deflect. The bottom bond beam had very little lateral deflection compared to top bond beam because of the additional strength it received from the lower dry stacked course which had the greater selfweight above them. In practical field applications the bottom bond beam would be fully fixed laterally due to its continuous contact with the leveling pad. The deflections of the top and middle sections of the panel were very consistent throughout the tests. As mentioned earlier, the top bond beam deflected and rebound to its near at-rest position after each test. The dry-stacked course however, in the first 5 tests, did not return to a zero deflection once the force was removed. Each time an internal deflection occurred due to the work energy, the joint was placed in a new at-rest state. When the load was removed, the bond beams had tension in the steel which pulled them back to zero, but the dry-stacked had only compression built up in the back faces of the block which when released had no ability to pull the blocks back. Therefore, the maximum differential deflection between the top bond beam and the middle dry-stacked is generally equal to the total deflection or maximum bow of the center dry stacks after the load is removed. Before the next test was conducted, the dry stacked units were forced back to a vertical position for retesting. In tests 6 and 7 the intermediate column was introduced. Then virtually the entire panel rebounded with no realignment required to run the next test. At the completion of the 7^{th} test the panel is without damage and stands ready for continued testing as required.

Conclusions and Recommendations

The following are a list of conclusions formulated from physical data and visual observation during testing:

- The Allan Block Fence panel has the ability to flex and absorb forces through the principle of Work Energy. The ability of the panel to absorb applied forces effectively act to resist the force and thus can be used in combination with the bond beam and post capacities to resist the applied loads. The net effect is that the structural posts can carry more tributary area which allows the posts to be spaced further apart and or less steel to be used within them.

- The AB Fence panel's ball and socket configuration becomes stronger as more courses are added to the panel by adding more selfweight with each course. The selfweight provides a downward force which converts the compressive stress of the block into a shear resisting mechanism which provides both the flexibility to the system at lower forces and the rigid, strengthening effect at higher forces. The net effect of considering the strength of the ball and socket in the design is the reduction of the number of required bond beams.
- The AB Panel bond beam, when constructed with sand mix grout and vertical stirrups as recommended by Allan Block, provides an incredible capacity to resist lateral forces while remaining plastic enough to rebound 100% from repeated deflection.
- The AB Panel bond beam while subjected to repeated horizontal deflections and rebounds showed no vertical sag of any measurable amount.
- The AB Panel bond beam is a composite beam that functions as a monolithic concrete beam. That is, the stressed beam cracked where expected, at the mid-span and not along the joints of the panel block. At the conclusion of testing all panel block of the bond beams were fully connected to the course above with no visible signs of distress other than the rebounded hairline cracks at mid span.
- If after large forces the dry-stacked panel blocks have deflected, their flexibility allows for them to be forced back into a plumb position without any damage.
- The introduction of an Intermediate Column adds to the stability of longer panels while continuing to allow the remaining dry-stacked units to flex and absorb forces through the principle of Work Energy.

The following Table represents the recommended force reductions based on the test results from these current tests and the 12x7 Panel tests. These reductions should only be applied to the design force acting on the posts. These values are limited to the design of the cantilever moments for fences of 8 ft (2.4 m) in height with no intermediate bond beams.

TABLE 1	Design Wind Speeds and Stagnation Pressures					
mph (kph)	70 (112)	80 (129)	90 (145)	100 (161)	110 (177)	120 (193)
Pressure lb/ft^2 (kPa)	9.45 (0.45)	12.3 (0.59)	15.6 (0.75)	19.2 (0.92)	23.25 (1.113)	27.68 (1.325)
	Percentage of Design Force For Post Design					
% *	50	55	65	70	80	90
* Percent values are a conservative reduction based on test results						

APPENDIX A

Test Frame and Equipment

Test Frame and Equipment

The test panel was made up of two 11-panel block long bond beams approximately 17’-5” (5.32m) long with 8 dry-stacked courses separating them. The bond beams were situated in a typical field condition with one forming the first two courses and the other forming the top two courses. The total panel height was 12 courses or 8’-0” (2.44 m), see Photos A1 - A4. The bottom bond beam was precast at an earlier date, than lifted and set on top of a spacer block at each post. This was done to simulate the bottom bond beam free spanning from pier to pier. These bond beams consisted of two courses of standard panel block units, with a #4 (10M) horizontal rebar centered between the courses, and 9 ga. (3.5 mm) wire stirrups in every other block core and a sand mix grout tested at 3100 psi (21.37 MPa) at 28 day strength, vibrated in all cores. The posts were cast at 13 courses high to allow for the placement of the spacer block at the base and the full 12 course tall test panel. Vertical wood beams were used at each post to transfer all loads evenly to the post with the intent of having them act as a self-reacting load frame. The horizontal steel beam was suspended at the mid height of the panel, allowing the ram to remain in place during stressing. The Ram was placed at the center point of the panel with the articulating spreader frame attached to the end to distribute the applied forces across the height and width of the panel see Figure 2 on page 1. To record the received forces 3-1000 lb load cells were placed between the panel and post lip at each post, see Figure 3 on page 1. Deflection was measured using a string line transducer recording millimeters of movement. The devices were fixed to the mid-point of the top and bottom bond beams, and the mid-point of the center dry-stacked units, see Figure A1. 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 A2. All applied forces come from a SPX Power Team 25 ton hydraulic ram and hand operated pump see Figures A3 and A4. In all 7 tests a 10,000 pound (44.82 kN) load cell was attached to the end of the ram to provide a highly accurate measure of the applied force, see Figure A4. The results of all individual tests can be found in Appendix B.

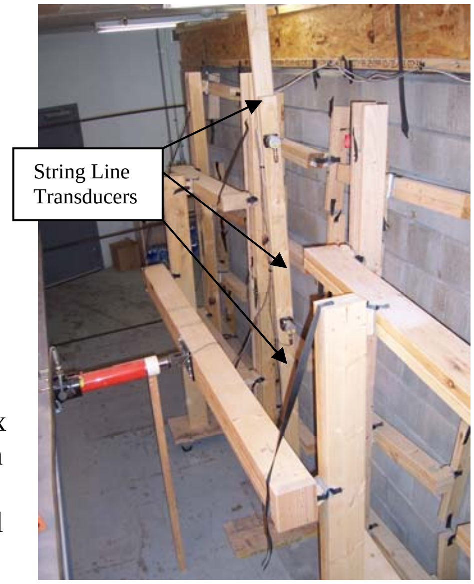


Figure A1: String Line Transducers

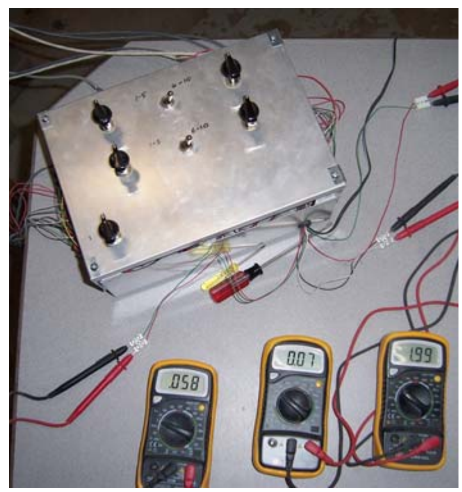


Figure A2: Switch Box and Volt Meters

Figure A3: SPX Hydraulic Hand

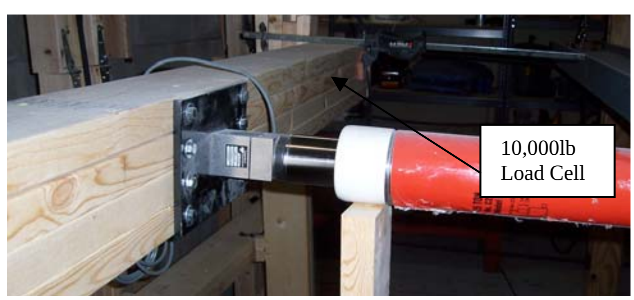


Figure A4: Hydraulic Ram

Photo A1: Full-Scale Set-up #4

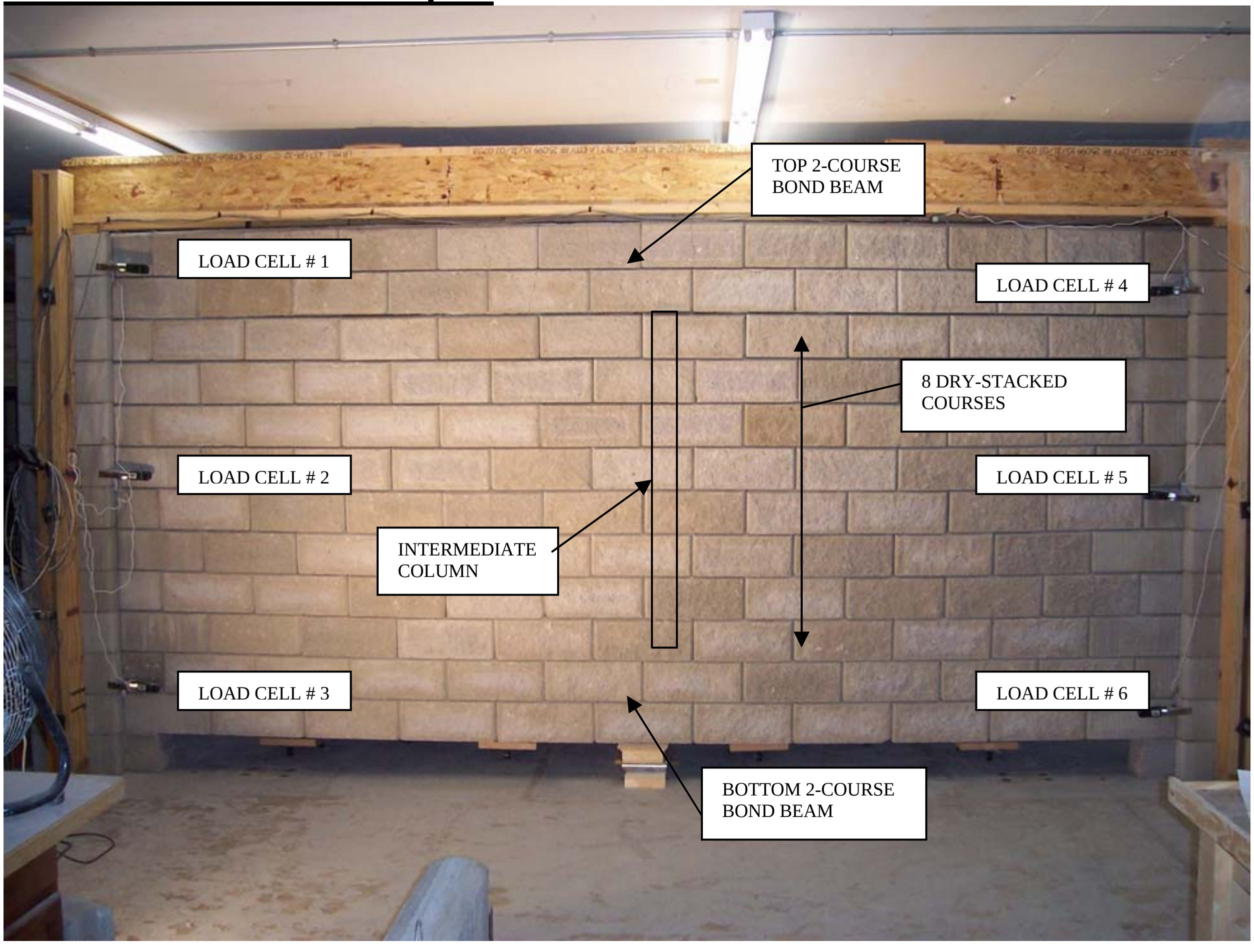


Photo A2: Beam, Ram and Spreader Frame

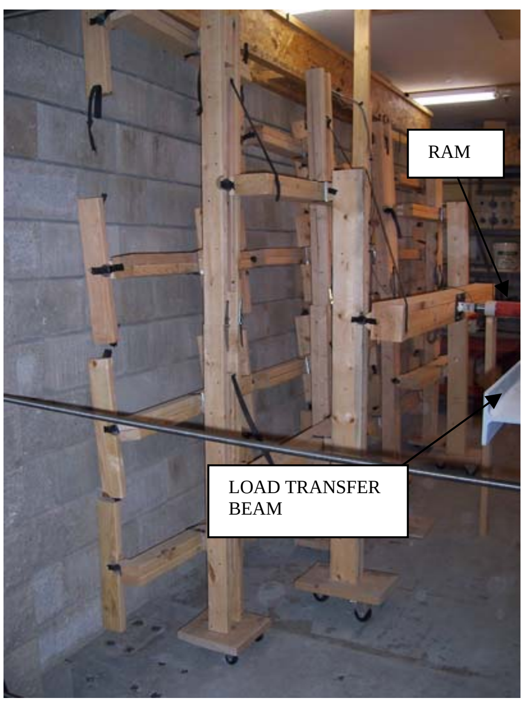


Photo A3: Spreader Frame Assembly

Photo A4: Panel During Stressing

Photo A5: Spreader Frame Assembly and Block Flexing During Stressing

APPENDIX B

Test Result Data

12x11 FULL HEIGHT PANEL TEST RESULTS

SERIES # 1 - # 7

Full Scale Test Results using a Articulating Spreader Frame (12 x 11 Panel) - Series # 1

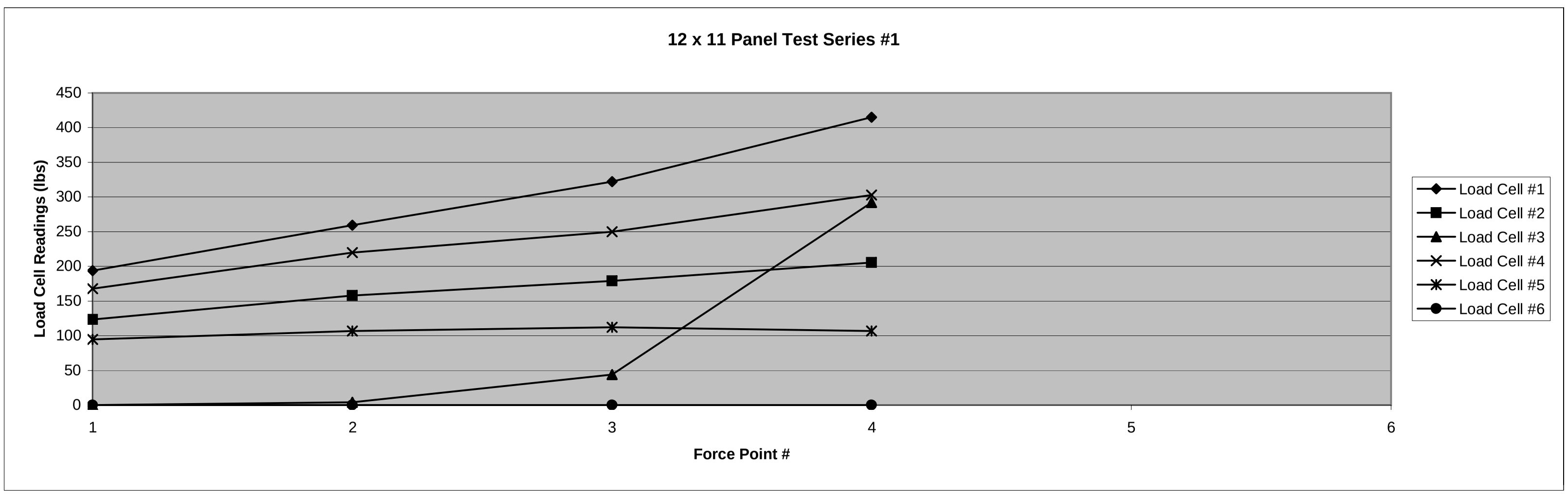
Deflection Data

8/16/2006

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4			
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)			
258.000		293.000	302.000	326.000			
Deflection at Top (mm) =	-258.000	35.000	44.000	68.000			
Deflection at Top (in) =	-10.157	1.378	1.732	2.677			
210.000		243.000	253.000	278.000			
Deflection at Mid-Panel (mm) =	-210.000	33.000	43.000	68.000			
Deflection at Mid-Panel (in) =	-8.268	1.299	1.693	2.677			
196.000		217.000	224.000	234.000			
Deflection at Bottom (mm) =	-196.000	21.000	28.000	38.000			
Deflection at Bottom (in) =	-7.717	0.827	1.102	1.496			

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4		
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)		
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	193.821 (0.862)	259.108 (1.153)	322.355 (1.434)	415.185 (1.847)		
2	123.522 (0.549)	157.946 (0.703)	179.208 (0.797)	205.532 (0.914)		
3	0.000 (0.000)	4.012 (0.018)	44.130 (0.196)	291.863 (1.298)		
4	168.000 (0.747)	220.000 (0.979)	250.000 (1.112)	303.000 (1.348)		
5	94.723 (0.421)	106.563 (0.474)	111.945 (0.498)	106.563 (0.474)		
6	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)		
Total Load transferred to Post - lb (kN) =	580.066 (2.580)	743.617 (3.308)	863.508 (3.841)	1030.280 (4.583)		
Percentage of Applied Load Received by Post =	46%	45%	45%	40%		



Full Scale Test Results using a Articulating Spreader Frame (12 x 11 Panel) - Series # 2

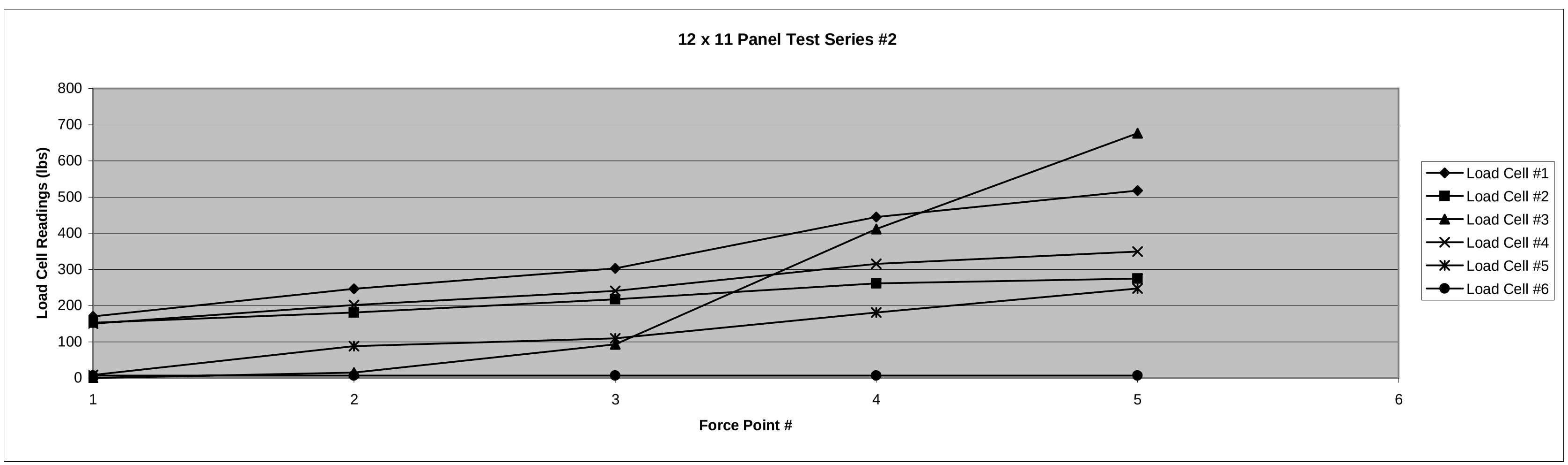
Deflection Data

8/16/2006

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5		
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)	2850.0 (12.677)		
260.000	**291.000**	**307.000**	**317.000**	**343.000**	**374.000**		
Deflection at Top (mm) =	31.000	47.000	57.000	83.000	114.000		
Deflection at Top (in) =	1.220	1.850	2.244	3.268	4.488		
223.000	**249.000**	**264.000**	**274.000**	**302.000**	**340.000**		
Deflection at Mid-Panel (mm) =	26.000	41.000	51.000	79.000	117.000		
Deflection at Mid-Panel (in) =	1.024	1.614	2.008	3.110	4.606		
195.000	**212.000**	**222.000**	**227.000**	**241.000**	**261.000**		
Deflection at Bottom (mm) =	17.000	27.000	32.000	46.000	66.000		
Deflection at Bottom (in) =	0.669	1.063	1.260	1.811	2.598		

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)	2850.0 (12.677)	
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	170.358 (0.758)	246.867 (1.098)	302.973 (1.348)	444.768 (1.978)	518.216 (2.305)	
2	152.884 (0.680)	181.233 (0.806)	217.682 (0.968)	261.219 (1.162)	274.381 (1.221)	
3	0.000 (0.000)	15.044 (0.067)	93.276 (0.415)	411.216 (1.829)	675.999 (3.007)	
4	150.000 (0.667)	202.000 (0.899)	241.000 (1.072)	315.000 (1.401)	349.000 (1.552)	
5	8.288 (0.037)	88.264 (0.393)	109.792 (0.488)	180.834 (0.804)	247.570 (1.101)	
6	6.749 (0.030)	6.749 (0.030)	6.749 (0.030)	6.749 (0.030)	6.749 (0.030)	
Total Load transferred to Post - lb (kN) =	481.530 (2.142)	718.364 (3.195)	871.447 (3.876)	1201.821 (5.346)	1389.167 (6.179)	
Percentage of Applied Load Received by Post =	38%	44%	45%	47%	49%	



Full Scale Test Results using a Articulating Spreader Frame (12 x 11 Panel) - Series # 3

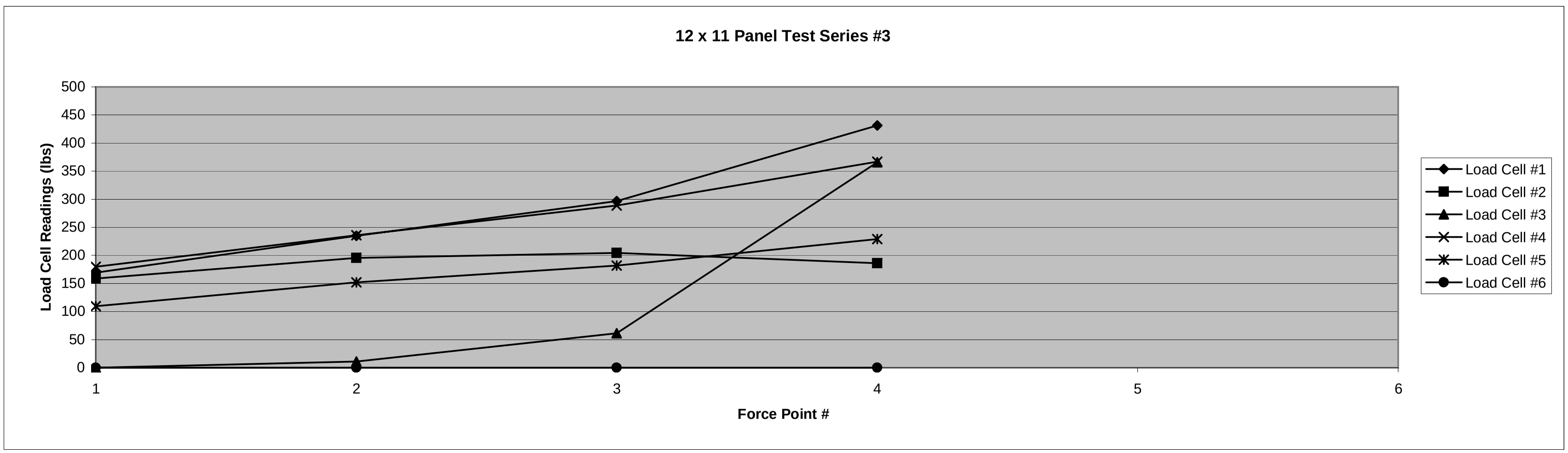
Deflection Data

8/16/2006

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4			
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)			
276.000	**315.000**	**328.000**	**339.000**	**366.000**			
Deflection at Top (mm) =	39.000	52.000	63.000	90.000			
Deflection at Top (in) =	1.535	2.047	2.480	3.543			
254.000	**289.000**	**302.000**	**314.000**	**354.000**			
Deflection at Mid-Panel (mm) =	35.000	48.000	60.000	100.000			
Deflection at Mid-Panel (in) =	1.378	1.890	2.362	3.937			
196.000	**214.000**	**223.000**	**230.000**	**245.000**			
Deflection at Bottom (mm) =	18.000	27.000	34.000	49.000			
Deflection at Bottom (in) =	0.709	1.063	1.339	1.929			

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4		
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)		
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	169.338 (0.753)	234.625 (1.044)	296.852 (1.320)	431.507 (1.919)		
2	158.959 (0.707)	195.408 (0.869)	204.520 (0.910)	186.295 (0.829)		
3	0.000 (0.000)	11.033 (0.049)	61.181 (0.272)	366.083 (1.628)		
4	180.000 (0.801)	236.000 (1.050)	289.000 (1.286)	367.000 (1.632)		
5	109.792 (0.488)	151.771 (0.675)	181.910 (0.809)	229.272 (1.020)		
6	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)		
Total Load transferred to Post - lb (kN) =	618.089 (2.749)	817.804 (3.638)	972.282 (4.325)	1214.074 (5.400)		
Percentage of Applied Load Received by Post =	49%	50%	51%	48%		



Full Scale Test Results using a Articulating Spreader Frame (12 x 11 Panel) - Series # 4

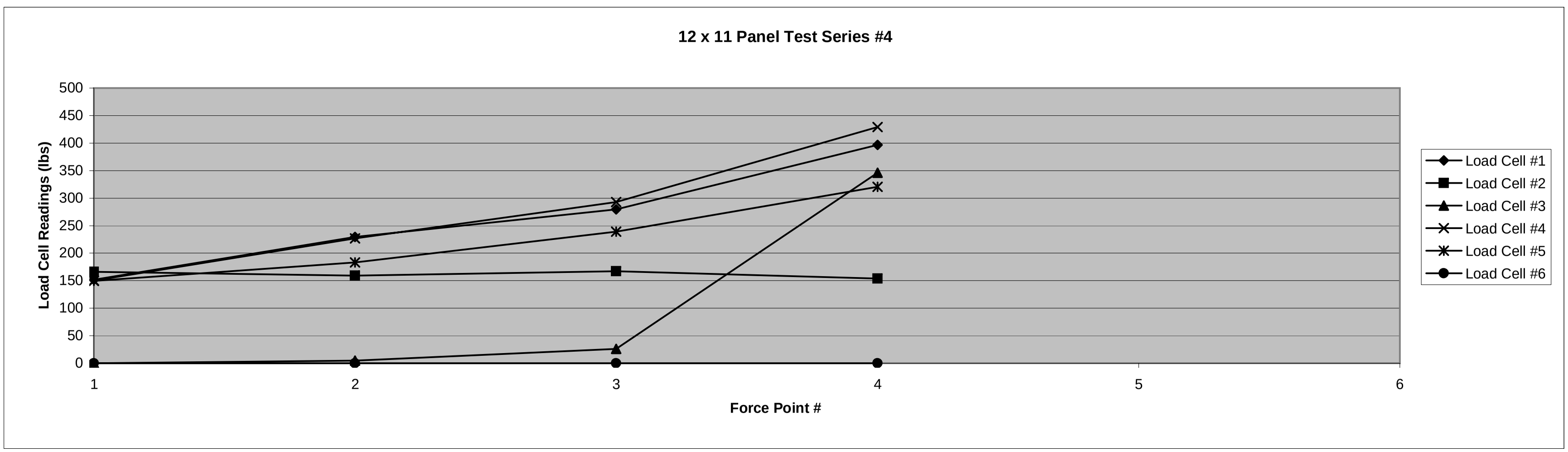
Deflection Data

8/16/2006

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4			
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)			
273.000	**306.000**	**324.000**	**334.000**	**359.000**			
Deflection at Top (mm) =	33.000	51.000	61.000	86.000			
Deflection at Top (in) =	1.299	2.008	2.402	3.386			
251.000	**281.000**	**300.000**	**312.000**	**345.000**			
Deflection at Mid-Panel (mm) =	30.000	49.000	61.000	94.000			
Deflection at Mid-Panel (in) =	1.181	1.929	2.402	3.701			
196.000	**213.000**	**225.000**	**232.000**	**249.000**			
Deflection at Bottom (mm) =	-38.000	-26.000	-19.000	-2.000			
Deflection at Bottom (in) =	-1.496	-1.024	-0.748	-0.079			

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4		
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)		
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	151.996 (0.676)	229.525 (1.021)	279.510 (1.243)	396.823 (1.765)		
2	166.046 (0.739)	158.959 (0.707)	167.058 (0.743)	153.896 (0.685)		
3	0.000 (0.000)	5.015 (0.022)	26.077 (0.116)	346.023 (1.539)		
4	150.000 (0.667)	227.000 (1.010)	293.000 (1.303)	429.000 (1.908)		
5	149.619 (0.666)	182.987 (0.814)	238.959 (1.063)	320.765 (1.427)		
6	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)		
Total Load transferred to Post - lb (kN) =	617.661 (2.747)	798.470 (3.552)	978.528 (4.353)	1300.484 (5.785)		
Percentage of Applied Load Received by Post =	49%	49%	51%	51%		



Full Scale Test Results using a Articulating Spreader Frame (12 x 11 Panel) - Series # 5

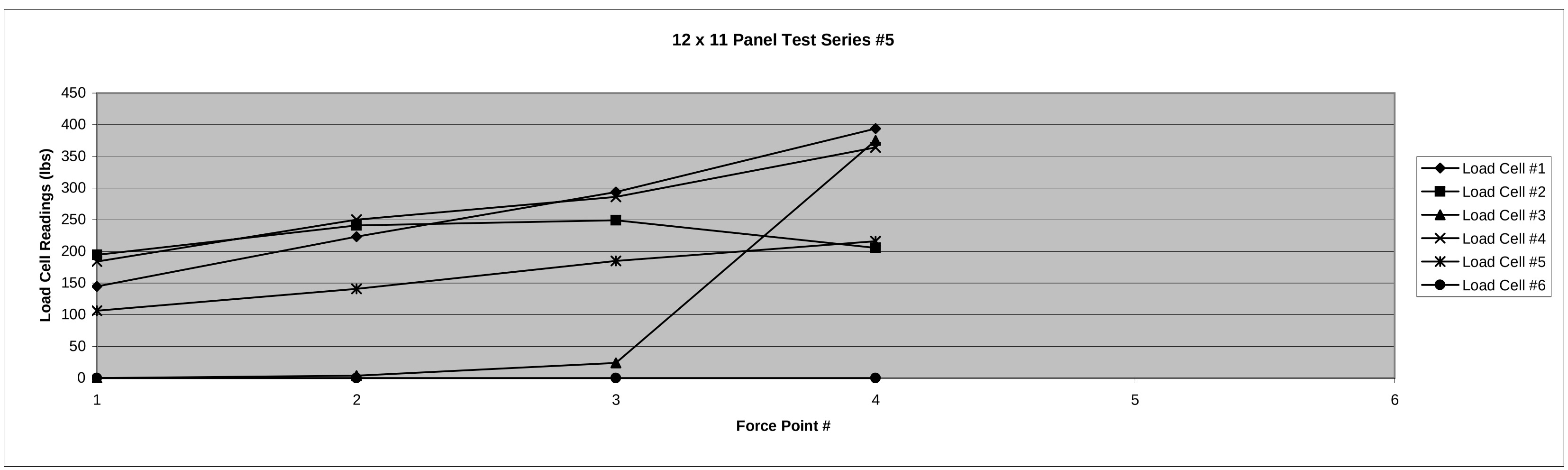
Deflection Data

8/16/2006

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4			
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2500.0 (11.121)			
269.000	**314.000**	**332.000**	**342.000**	**369.000**			
Deflection at Top (mm) =	45.000	63.000	73.000	100.000			
Deflection at Top (in) =	1.772	2.480	2.874	3.937			
266.000	**301.000**	**324.000**	**337.000**	**388.000**			
Deflection at Mid-Panel (mm) =	35.000	58.000	71.000	122.000			
Deflection at Mid-Panel (in) =	1.378	2.283	2.795	4.803			
195.000	**211.000**	**223.000**	**229.000**	**249.000**			
Deflection at Bottom (mm) =	16.000	28.000	34.000	54.000			
Deflection at Bottom (in) =	0.630	1.102	1.339	2.126			

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4		
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2500.0 (11.121)		
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	144.856 (0.644)	223.404 (0.994)	293.792 (1.307)	393.763 (1.752)		
2	194.395 (0.865)	240.969 (1.072)	249.069 (1.108)	205.532 (0.914)		
3	0.000 (0.000)	4.012 (0.018)	24.071 (0.107)	375.109 (1.669)		
4	184.000 (0.818)	250.000 (1.112)	286.000 (1.272)	364.000 (1.619)		
5	106.563 (0.474)	141.007 (0.627)	185.140 (0.824)	216.355 (0.962)		
6	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)		
Total Load transferred to Post - lb (kN) =	629.814 (2.802)	859.393 (3.823)	1038.071 (4.618)	1554.759 (6.916)		
Percentage of Applied Load Received by Post =	50%	52%	54%	62%		



Full Scale Test Results using a Articulating Spreader Frame (12 x 11 Panel Testing) - Series # 6 (with an Intermediate Column)

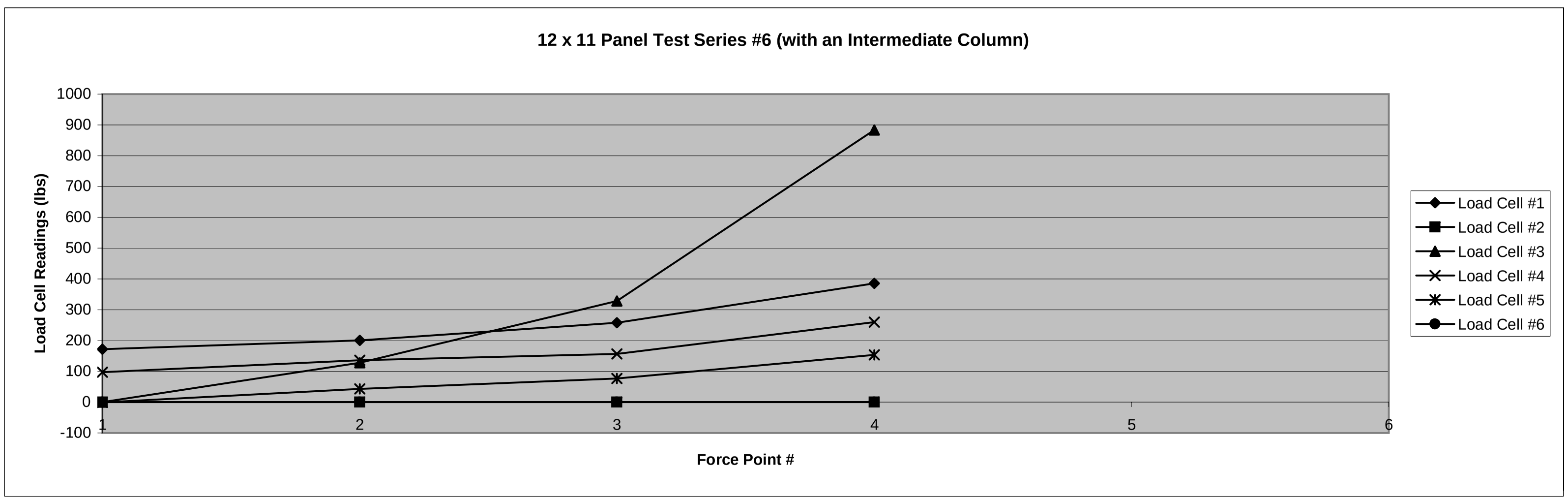
Deflection Data

Testing = 10/10/2006

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4			
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)			
260.000	**282.000**	**300.000**	**316.000**	**357.000**			
Deflection at Top (mm) =	22.000	40.000	56.000	97.000			
Deflection at Top (in) =	0.866	1.575	2.205	3.819			
222.000	**240.000**	**256.000**	**269.000**	**302.000**			
Deflection at Mid-Panel (mm) =	18.000	34.000	47.000	80.000			
Deflection at Mid-Panel (in) =	0.709	1.339	1.850	3.150			
192.000	**207.000**	**220.000**	**229.000**	**249.000**			
Deflection at Bottom (mm) =	15.000	28.000	37.000	57.000			
Deflection at Bottom (in) =	0.591	1.102	1.457	2.244			

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4		
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)		
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	172.399 (0.767)	200.962 (0.894)	258.088 (1.148)	385.602 (1.715)		
2	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)		
3	0.000 (0.000)	128.380 (0.571)	327.970 (1.459)	883.613 (3.930)		
4	97.000 (0.431)	136.000 (0.605)	157.000 (0.698)	260.000 (1.157)		
5	-1.076 -(0.005)	43.056 (0.192)	76.424 (0.340)	153.924 (0.685)		
6	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)		
Total Load transferred to Post - lb (kN) =	268.322 (1.194)	508.397 (2.261)	819.482 (3.645)	1683.139 (7.487)		
Percentage of Applied Load Received by Post =	21%	31%	43%	66%		



Full Scale Test Results using a Articulating Spreader Frame (12 x 11 Panel Testing) - Series # 7 (with an Intermediate Column)

Deflection Data

Testing = 10/10/2006

	Applied Load To Panel - lb (kN)						
Force Point # =>	1	2	3	4	5	6	Released
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)	3095.0 (13.767)	3670.0 (16.325)	0.0 (0.000)
282.000	307.000	320.000	331.000	357.000	379.000	449.000	345.000
Deflection at Top (mm) =	25.000	38.000	49.000	75.000	97.000	167.000	63.000
Deflection at Top (in) =	0.984	1.496	1.929	2.953	3.819	6.575	2.480
240.000	260.000	272.000	280.000	301.000	319.000	376.000	284.000
Deflection at Mid-Panel (mm) =	20.000	32.000	40.000	61.000	79.000	136.000	44.000
Deflection at Mid-Panel (in) =	0.787	1.260	1.575	2.402	3.110	5.354	1.732
204.000	218.000	226.000	232.000	245.000	257.000	296.000	219.000
Deflection at Bottom (mm) =	14.000	22.000	28.000	41.000	53.000	92.000	15.000
Deflection at Bottom (in) =	0.551	0.866	1.102	1.614	2.087	3.622	0.591

Load Cell Data

	Applied Load To Panel - lb (kN)					
Force Point # =>	1	2	3	4	5	6
	1260.0 (5.605)	1640.0 (7.295)	1925.0 (8.563)	2555.0 (11.365)	3095.0 (13.767)	3670.0 (16.325)
Load Cell	Applied Load Recieved at each Load Cell - lb (kN)					
1	115.272 (0.513)	147.916 (0.658)	151.996 (0.676)	331.536 (1.475)	406.004 (1.806)	501.894 (2.233)
2	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	8.100 (0.036)	50.624 (0.225)
3	25.074 (0.112)	101.300 (0.451)	203.602 (0.906)	858.539 (3.819)	1102.260 (4.903)	658.949 (2.931)
4	99.000 (0.440)	156.000 (0.694)	195.000 (0.867)	253.000 (1.125)	303.000 (1.348)	430.000 (1.913)
5	0.000 (0.000)	33.368 (0.148)	97.952 (0.436)	163.612 (0.728)	192.674 (0.857)	332.605 (1.479)
6	0.000 (0.000)	0.000 (0.000)	-1.071 -(0.005)	0.000 (0.000)	0.000 (0.000)	64.277 (0.286)
Total Load transferred to Post - lb (kN) =	239.347 (1.065)	438.584 (1.951)	647.479 (2.880)	1606.686 (7.147)	2012.038 (8.950)	2038.349 (9.067)
Percentage of Applied Load Received by Post =	19%	27%	34%	63%	65%	56%