Architectural Testing

GUARDRAIL SYSTEM PERFORMANCE TEST REPORT

Rendered to:

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Report No.:	56429.01-119-19
Test Date:	03/10/05
Through:	03/14/05
Report Date:	04/21/05

Product: 12 ft. Rigid Polyurethane Foam Guardrail

Project Summary: Architectural Testing, Inc. (ATI) was contracted by Spectis Moulders Inc. to conduct structural performance tests on their 12 ft. Rigid Polyurethane Foam Guardrail system. The system was evaluated for the design load requirements of the following building codes and standards:

IBC-2000 / ICC - *International Code Council* including,

IRC-2000 - *International Residential Code for One- and Two-Family Dwellings*

IBC-2003 / ICC - *International Code Council* including,

IRC-2003 - *International Residential Code for One- and Two-Family Dwellings*

BOCA-1999 - *Building Officials and Code Administrators* (Reference ASCE 7-95) including,

ASCE 7-95 - *American Society of Civil Engineers* - Minimum Design Loads for Buildings and Other Structures.

IOTDC-1998 - *International One- and Two-Family Dwelling Code*

NBC-1995: National Building Code of Canada - *Part 4 Structural Design, Section 4.1.10.1. Loads on Guards.*

The railings are less than 42" in height and therefore are tested and evaluated for the design load requirements applicable to detached one- and two-family dwellings only. All railing assembly tests performed are to evaluate the structural performance of the railing assembly to carry and transfer imposed loads to the supports (posts). The support posts are not a tested component and are included in the test specimen only to facilitate anchorage of the rail brackets. Posts are evaluated separately for the required support loads.

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Test Specimen (Railing Assembly) Description: All tests were performed on a 12 ft. long rail section, preassembled by the client. The railing system, which measured 37" high from the top of the top rail to the bottom of the bottom rail, consisted of spaced balusters with 1-1/2" clearance between balusters at their ends. Aluminum angle brackets 1-1/2" by 1-1/2" by 1/8" thick and 4" length were used for mounting the rails to 5" by 5" wood posts. Because posts were not tested, pressure treated 2 x 8 Southern Yellow Pine planks were used as supports.

The top and bottom 7" by 5-1/2" contoured rails contained one continuous piece of PVC tubing (4.250" OD with 0.160" wall thickness), encased within polyurethane foam. The twenty (20) 5-1/4" by 5-1/4" (at square end) by 26" tall balusters were made up of a single PVC tube (1.625" OD) encased within polyurethane foam and were fastened to the rails with glue and six (6) finish nails per baluster (three per end). The angle brackets at the top and bottom rails were secured with three (3) 7.65mm by 63mm hex head bolts with nuts that penetrated the entire 2 x 8 support. Three (3) 6.4mm by 50mm hex head machine screws with washers having a rubber bushing penetrated through the bottom of the rail and through one side of the PVC reinforcing tube to secure the bracket to the railing.

See drawings in Appendix A and photographs Appendix B for additional detail.

Equipment: Railing assemblies are tested in a self-contained structural frame designed to accommodate anchorage of the rail assembly and application of the required test loads. The specimen is loaded using an electric winch mounted to a rigid steel test frame. High strength cables, nylon lifting straps and load distribution beams are used to impose test loads on the specimen. Applied load is measured using an electronic load cell located in-line within the loading system. Deflections are measured to the nearest 0.01" using electronic linear transducers.

Set-Up: All railing assemblies were installed and tested as a single railing section by directly securing the posts into a rigid steel test frame. The test fixture rigidly restrains the posts from deflecting. Transducers mounted to an independent reference frame are located to record movement of reference points on the railing system components (ends and mid-point) to determine net component deflections. Uniform distributed loads with simple end supports are simulated with 1/4-point loading. See photographs for individual test setups.

Test Procedure: The test specimen is inspected prior to testing to verify size and general condition of the materials, assembly and installation. Any potentially compromising defects observed are noted prior to the load test. For IBC-2000, IBC-2003 and BOCA-1999 testing, the assembly is preloaded up to a level not exceeding design load. After pre-loading, all load is released and any necessary fixture adjustments are made. An initial load, not exceeding 20% of design load, is applied and initial deflections recorded or transducers zeroed. Loads are then applied at a steady uniform rate stopping at 20% design load increments to record deflections. The load/deflection procedure continues until reaching 2.0 times design load within a time period of 5-10 minutes. At 2.0 times design load, the load is released. After allowing a minimum period of one minute for stabilization, load is reapplied to the initial load used at the start of the load/deflection procedure and deflections are recorded and used to analyze recovery.

Test Procedure: (Continued)

For tests that require ultimate loads greater than 2.0 times design load, loading is reapplied and increased at a steady uniform rate until failure occurs or the required ultimate load is reached. The testing time is continually recorded from the application of initial test load until the maximum test load is reached.

For NBC-1995 testing, the following procedure was used

1. Apply a small initial load and record initial displacements.
2. Increase load to 1.0 times design load and record deflection.
3. Release load and allow a minimum of one minute for relaxation.
4. Apply initial load and record deflection as permanent set to analyze recovery.
5. Continue from the initial load level to 1.5 times design load and record deflection.
6. Release load and allow a minimum of one minute for relaxation.
7. Apply initial load and record deflection as permanent set to analyze recovery.
8. Increase load to 3.4 times design load in no less than 10 seconds.

Test Results: The following tests were performed on the rail assemblies for the design load requirements of each code as referenced. Rail and baluster test results are mid-point deflections for the given test load. Deflection and permanent set are component deflections relative to their end-points. They are not overall system displacement. All loads are horizontal except the vertical uniform load applied to the top rail. All displacement measurements are horizontal. Deflection analysis uses linear regression through the linear range of the load/deflection data to adjust for the offset from having a zero displacement reading with an initial load. The test results apply only to the components tested, which include the top rail, bottom rail, rail brackets and baluster. Posts are not a tested component and are included in the test setup only to facilitate the rail bracket anchorage.

Test Results:

Test #1 - Test Date: 03/10/05
Specimen #1 - Rigid Polyurethane Foam Guardrail
IBC and BOCA Design Load: 50 lb / 1 sq. ft. In-Fill at Center (One Baluster)

Load Level[1]	Test Load (lbs)	Test Data - Deflection (inches)				Deflection Analysis	
		End-1	Mid	End-2	Net	y = mx	Deflection
0.0	0	-	-	-	-	0.00	0.00
0.2	13	0.000	0.000	0.000	0.00	0.01	0.01
0.4	20	0.023	0.036	0.027	0.01	0.01	0.02
0.6	30	0.070	0.101	0.074	0.03	0.01	0.04
0.8	41	0.104	0.137	0.113	0.03	0.02	0.04
1.0	54	0.176	0.217	0.182	0.04	0.03	0.04
1.2	65	0.200	0.225	0.206	0.02	0.03	0.03
1.4	70	0.236	0.265	0.240	0.03	0.03	0.03
1.6	79	0.285	0.312	0.285	0.03	0.04	0.03
1.8	88	0.328	0.360	0.327	0.03	0.04	0.04
2.0	100	0.396	0.443	0.400	0.05	0.05	0.05
0.2	13	0.037	0.037	0.042	0.00	100% Recovery	
2.5	125	Maximum Test Load - *Sustained without failure.*					

[1] *Load level represents % of design load.*

Test #2 - Test Date: 03/11/05
Specimen #1 - Rigid Polyurethane Foam Guardrail
IBC and BOCA Design Load: 200 lb Horizontal Point Load at Center of Top Rail

Load Level[1]	Test Load (lbs)	Test Data - Deflection (inches)				Deflection Analysis	
		End-1	Mid	End-2	Net	y = mx	Deflection
0.0	0	-	-	-	-	0.00	0.00
0.2	41	0.000	0.000	0.000	0.00	0.24	0.27
0.4	84	0.021	0.220	0.017	0.20	0.49	0.47
0.6	125	0.043	0.475	0.033	0.44	0.74	0.70
0.8	161	0.076	0.733	0.053	0.67	0.95	0.94
1.0	201	0.110	1.020	0.081	0.92	1.18	1.19
1.2	242	0.146	1.283	0.098	1.16	1.43	1.43
1.4	281	0.175	1.565	0.119	1.42	1.66	1.68
1.6	324	0.212	1.861	0.137	1.69	1.91	1.95
1.8	360	0.245	2.133	0.151	1.94	2.12	2.20
2.0	402	0.276	2.434	0.169	2.21	2.37	2.48
0.2	41	0.055	0.105	0.000	0.08	96% Recovery	
2.5	500	Maximum Test Load - *Sustained without failure.*					

[1] *Load level represents % of design load.*

Test Results: (Continued)

Test #3 - Test Date: 03/11/05
Specimen #1 - Rigid Polyurethane Foam Guardrail
IBC and BOCA Design Load: 200 lb Point Load at the Post (Bracket Load Test)

Load Level[1]	Test Load (lbs)	Displacement (inches)			
		Test Data		Adjusted	
		End-1	End-2	End-1	End-2
0.0	0	-	-	0.00	0.00
0.2	45	0.000	0.000	0.01	0.01
0.4	81	0.005	0.004	0.01	0.01
0.6	129	0.015	0.013	0.02	0.02
0.8	161	0.023	0.023	0.03	0.03
1.0	203	0.032	0.037	0.04	0.04
1.2	242	0.042	0.050	0.05	0.06
1.4	281	0.052	0.062	0.06	0.07
1.6	324	0.059	0.079	0.07	0.08
1.8	360	0.066	0.092	0.07	0.10
2.0	403	0.075	0.107	0.08	0.11
0.1	45	0.007 91%	0.005 95%	Permanent Set Recovery	
2.5	509	Maximum Test Load - *Sustained without failure.*			

[1] *Load level represents % of design load.*

Test #4 - Test Date: 03/11/05
Specimen #1 - Rigid Polyurethane Foam Guardrail
NBC Design Load: 0.5 kN Load on In-Fill at Center (one baluster)

Load Level[1]	Test Load (N)	Test Data - Deflection (mm)				Deflection Analysis	
		End-1	Mid	End-2	Net	y = mx	Deflection
0.0	0	-	-	-	-	0.00	0.00
0.2	102	0.00	0.00	0.00	0.00	0.16	0.25
0.4	209	2.26	2.29	2.26	0.00	0.33	0.25
0.6	311	4.95	4.95	5.00	0.00	0.49	0.25
0.8	405	7.98	8.10	7.95	0.25	0.64	0.25
1.0	503	11.30	11.71	11.25	0.51	0.79	0.51
1.2	614	14.61	15.44	14.83	0.76	0.97	1.02
1.5	756	19.00	20.07	19.20	1.02	1.19	1.27
1.6	814	20.70	21.84	20.83	1.02	1.28	1.27
1.8	903	23.95	25.58	24.31	1.52	1.42	1.52
2.0	1,005	27.69	29.57	27.53	2.03	1.58	2.03
1.0	102	0.99	0.94	1.22	-0.25	100% Recovery	
1.5	102	1.91	2.06	2.41	0.00	100% Recovery	
3.0	1,508	Maximum Test Load - *Sustained without failure.*					

[1] *Load level represents % of design load.*

Test Results: (Continued)

Test #5 - Test Date: 03/11/05
Specimen #1 - Rigid Polyurethane Foam Guardrail
NBC Design Load: 0.75 kN/m Uniform Load Applied at Quarter Points

Load Level[1]	Test Load (N)	Test Data - Deflection (mm)				Deflection Analysis	
		End-1	Mid	End-2	Net	y = mx	Deflection
0.0	0	-	-	-	-	0.00	0.00
0.2	552	0.00	0.00	0.00	0.00	12.15	12.70
0.4	1,108	1.22	12.67	1.50	11.43	24.39	24.13
0.6	1,650	2.90	26.31	3.12	23.37	36.32	36.07
0.8	2,193	4.45	39.90	4.52	35.31	48.28	48.26
1.0	2,749	5.92	54.48	5.92	48.51	60.52	61.47
1.2	3,278	7.24	66.55	7.09	59.44	72.16	72.14
1.5	4,097	9.68	90.53	9.40	81.03	90.19	93.73
1.6	4,355	10.62	98.22	10.31	87.88	95.87	100.58
1.8	4,991	12.73	116.31	12.32	103.89	109.87	116.59
2.0	5,516	14.61	132.44	14.07	118.11	121.43	130.81
1.0	552	0.30	1.73	0.25	1.52	97% Recovery	
1.5	552	0.58	3.43	0.46	2.79	96% Recovery	
3.0	8,171	Maximum Test Load - *Sustained without failure.*					

[1] *Load level represents % of design load.*

Test #6 - Test Date: 03/14/05
Specimen #1 - Rigid Polyurethane Foam Guardrail
NBC Design Load: 1.5 kN /m Vertical Load Applied To Top Rail

Load Level[1]	Test Load (N)	Test Data - Deflection (mm)				Deflection Analysis	
		End-1	Mid	End-2	Net	y = mx	Deflection
0.0	0	-	-	-	-	0.00	0.00
0.2	1,108	0.00	0.00	0.00	0.00	3.79	4.06
0.4	2,193	0.58	3.58	0.28	3.05	7.51	7.11
0.6	3,301	0.94	7.44	0.66	6.60	11.30	10.67
0.8	4,408	1.50	11.71	1.12	10.41	15.09	14.22
1.0	5,516	2.11	16.48	1.75	14.48	18.89	18.54
1.2	6,610	2.79	21.08	1.75	18.80	22.63	22.86
1.5	8,278	3.45	42.06	2.82	38.86	28.34	42.93
1.6	8,892	2.21	105.11	5.33	101.35	30.44	105.16
1.8	9,897	2.44	107.19	5.79	103.12	33.88	106.93
2.0	11,009	2.82	109.19	6.22	104.65	37.69	108.71
1.0	1,108	1.07	1.93	0.79	1.02	93% Recovery	
1.5	1,094	0.86	5.21	0.66	4.57	89% Recovery	
3.0	17,922	Maximum Test Load - *Sustained without failure.*					

[1] *Load level represents % of design load.*

Summary and Conclusions: The railing systems and components tested and reported herein sustained loads equal or greater than 2.5 times the design loads for IBC and BOCA building codes, and equal or greater than 3.0 times the design loads for the NBC building code. In addition, components subjected to flexural bending recovered greater than 96% of the deflection from 2.0 times the design loads for IBC and BOCA, and greater than 89% of the deflection from 1.0 and 1.5 times the design loads for NBC. Recovery was not considered a factor for bracket load tests.

A copy of this report and all supporting data will be retained by ATI for a period of four years. This report is the exclusive property of the client so named herein and is applicable only to the sample tested. Results obtained are tested values and do not constitute an opinion or endorsement by this laboratory. This report may not be reproduced, except in full, without the written approval of Architectural Testing.

For ARCHITECTURAL TESTING, INC.

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Andrew O'Neill
Technician

Joseph A. Reed

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Joseph A. Reed, P.E.
Director - Engineering/Product Testing

APO:apo/nlb

Attachments (pages)
Appendix A - Drawings (3)
Appendix B - Photographs (3)

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JOSEPH A. REED
ENGINEER
No.
PE-044401-E

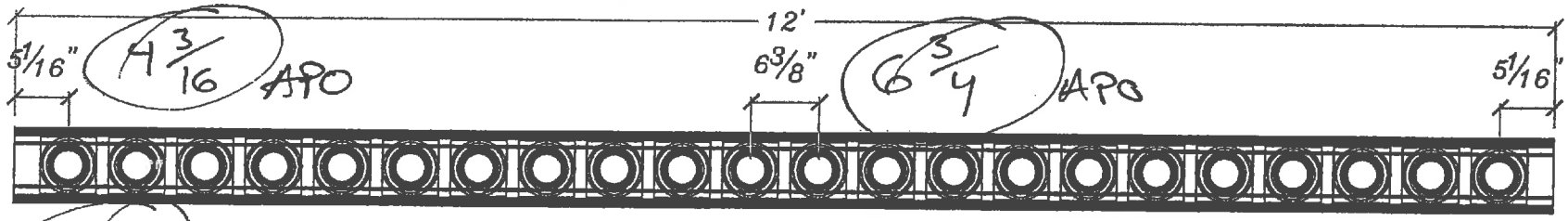
Joseph A Reed
4/21/05

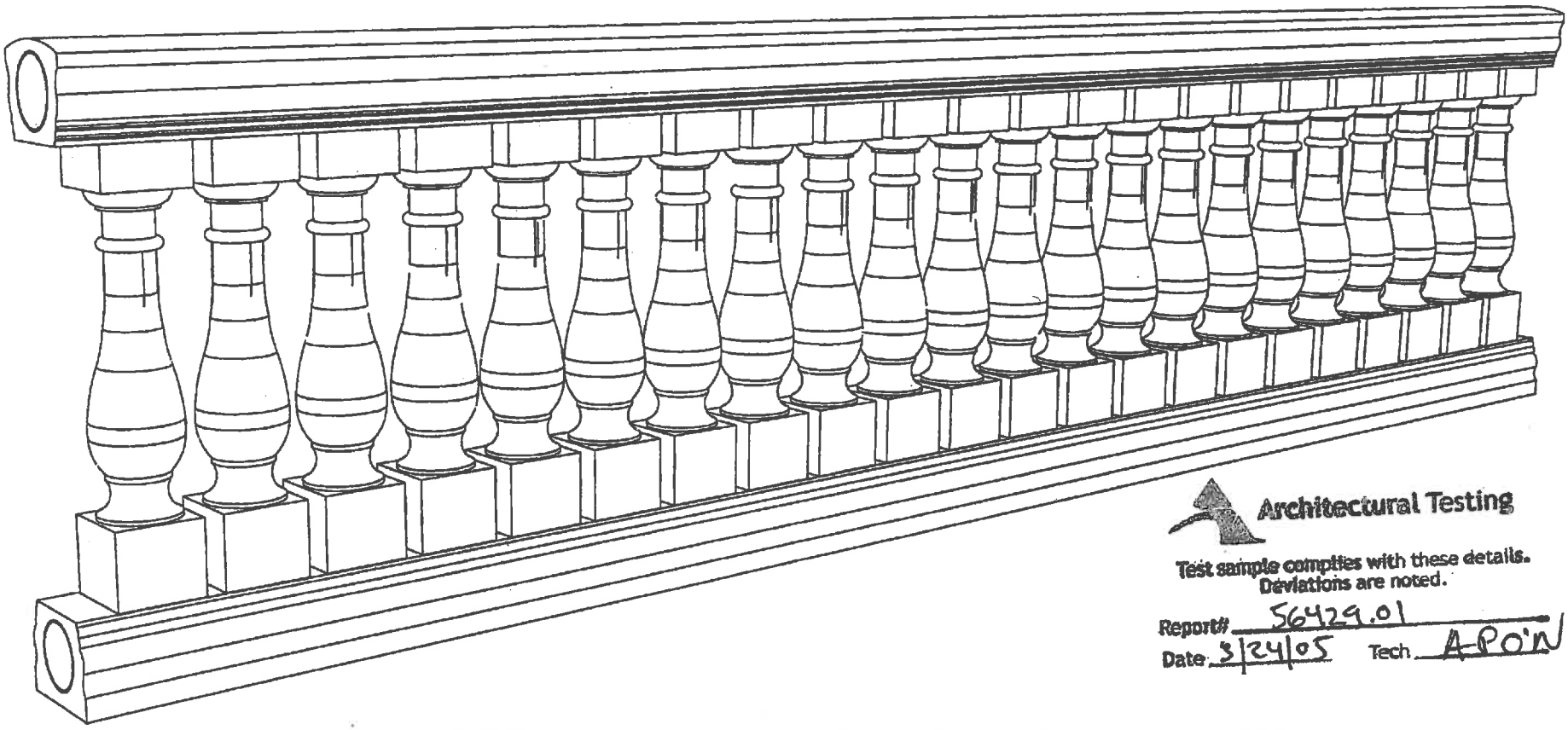
Revision Log

Rev. #	Date	Page(s)	Revision(s)
0	04/21/05	N/A	Original report issue.

APPENDIX A

Drawings





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Test sample complies with these details.
Deviations are noted.

Report# 56429.01

Date 3/24/05 Tech A-Po'N

SPECTIS MOULDERS INC.
CUSTOM POLYURETHANE PRODUCTS

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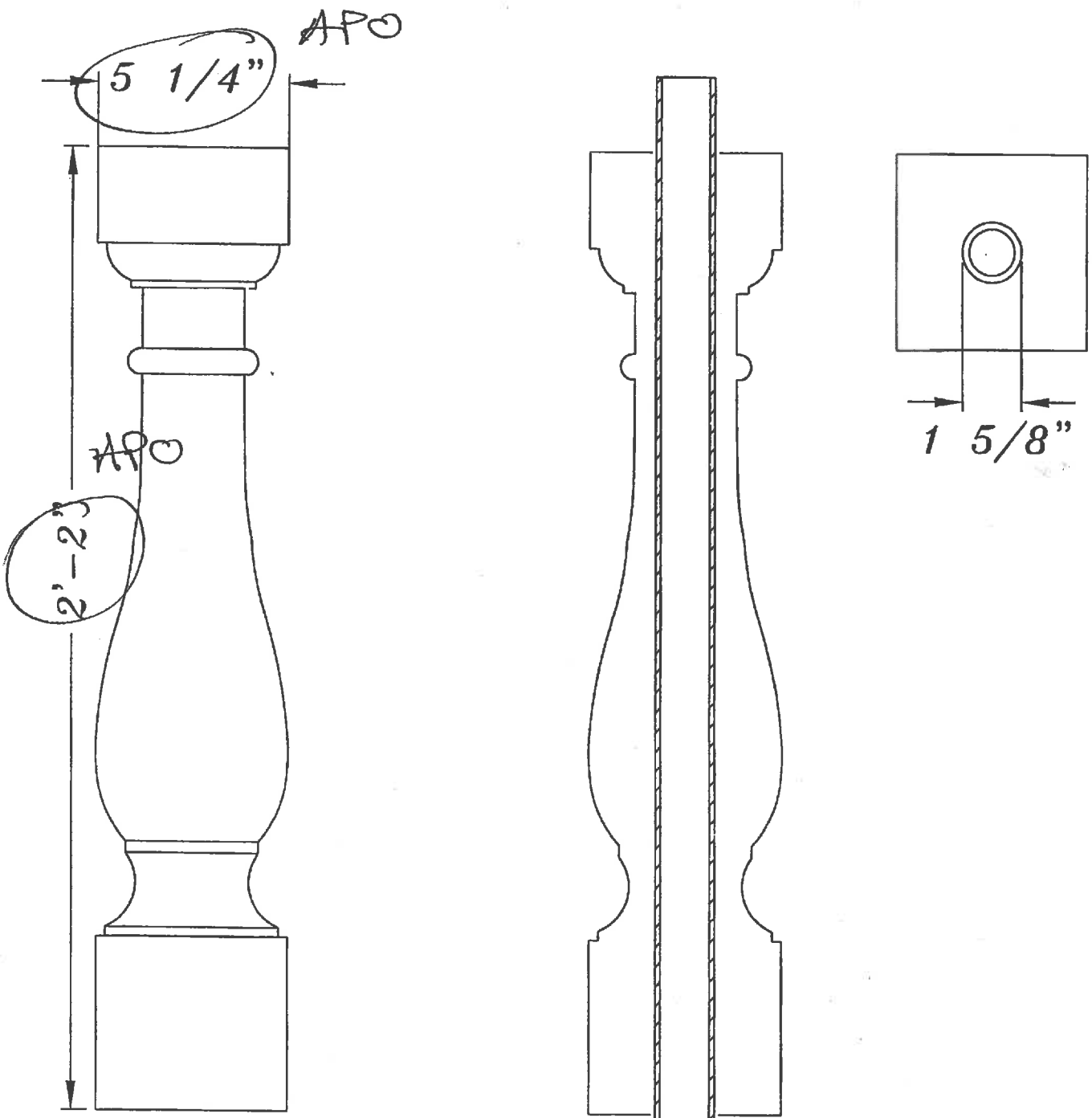
CUSTOMER/PRO. NAME & QUOTE#:	TITLE:	
STANDARD PRODUCT	BALUSTRADE SECTION	
BILL OF MAT / PART #:	SCALE:	DATE:
RAL 2100 TOP & BOT, BAL 2027-26	1/8 = 1"	05/03/16
	DWG BY: JB	REV



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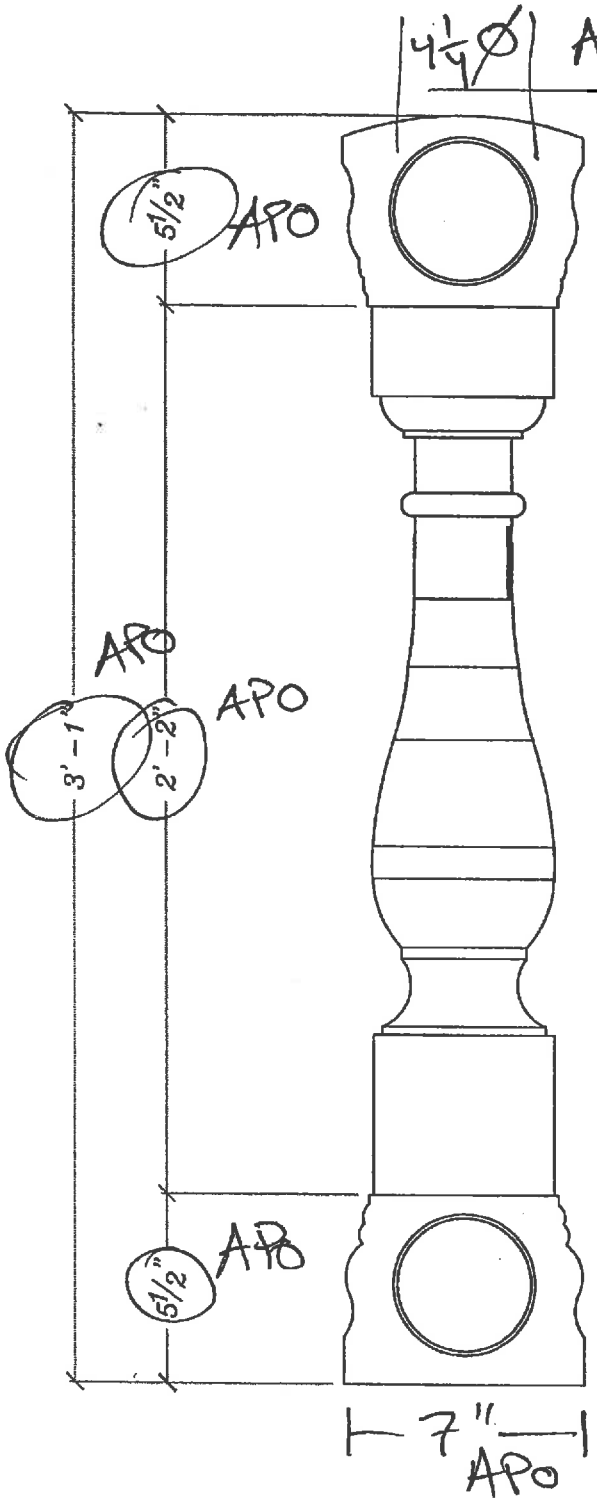
Report# 56429

Date 3/24/05 Tech A PO'N

SPECTIS MOULDERS INC.

1-800-685-9981

TITLE: BALUSTER	DATE: 03/21/00	PART NO.: BAL 2027-26
	SCALE: 1/4 = 1"	QUANTITY:
DRAWN BY: P.A.C.	ORDER NO.:	
CHECKED BY:	REVISION:	SHEET: 2



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Report# 56429.01

Date 3/24/05 Tech APO'N

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	BILL OF MAT / PART #: RAL 2100 TOP & BOT, BAL 2027-26	SCALE: 3/8 = 1"	DATE: 05/03/18
		DWG BY: JB	REV

APPENDIX B

Photographs

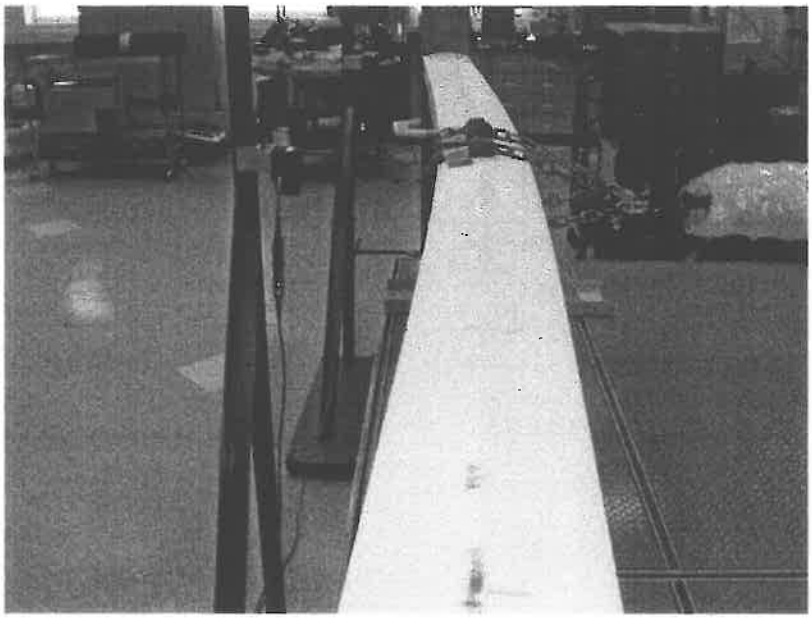
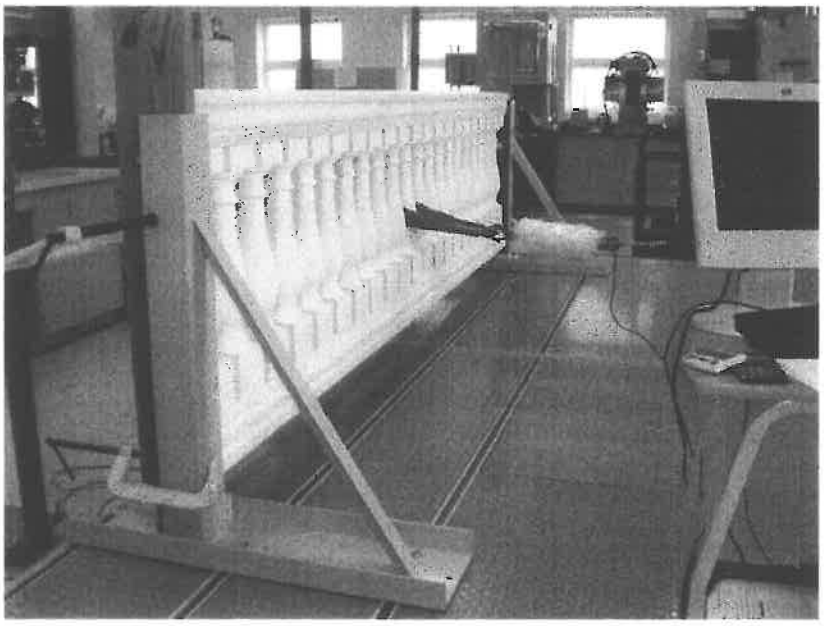


Photo No. 1
Point Load at Top Rail



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In-Fill Load Test

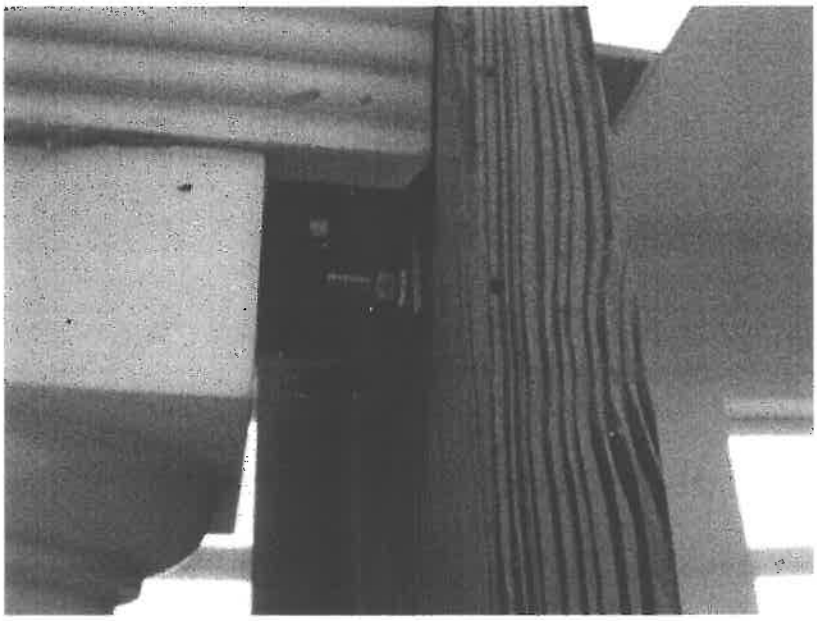
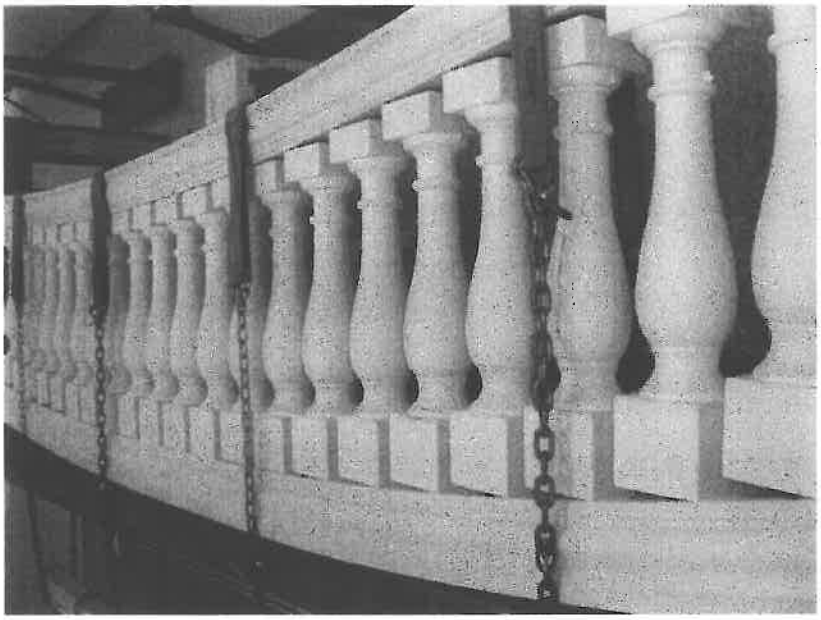


Photo No. 3
1-1/2" by 1-1/2" by 1/8" Thick and 4" Length Angle Brackets



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Vertical Load Test

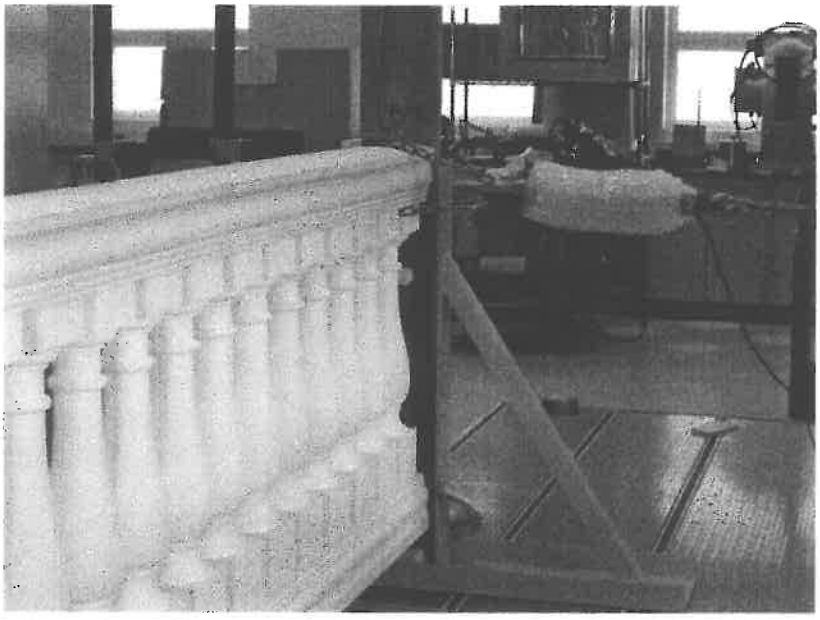

Photo No. 5
Bracket Load Test