PFS Corporation

An Employee-Owned Company

Assurance you can build on™

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PFS TEST REPORT # 03-20
ICBO ES ACCEPTANCE CRITERIA ON
GUARDRAIL SYSTEM
FOR
RAILING DYNAMICS, INC.
EGG HARBOR TOWNSHIP, NEW JERSEY

BY:
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GENERAL

The PFS Corporation, Madison, Wisconsin, performed client requested testing services for Railing Dynamics, Inc., Egg Harbor Township, New Jersey. A PFS representative witnessed the manufacturing and sampled the test materials at the client's facilities on February 13, 2003. The testing was performed in accordance with procedures and methods referenced in ICBO, ES AC 174, *"Acceptance Criteria for Deck Board Span Ratings and Guardrail Systems"* April 2002, Section 4.2. The guardrail system test samples were received in good order at PFS Laboratory on March 4, 2003. The tests were performed from April 15, 2003 through May 20, 2003.

TEST SPECIMENS

A PFS representative performed sampling services by initialing all submitted test specimen components at the client's manufacturing plant.

The test sample was identified by the client as "Endurance" a Structural Vinyl / Aluminum guardrail system, Railing Dynamics Part Number #ENDTL8. The Endurance railing system test specimens consisted of top rail and bottom rail with aluminum inserts, square and turned balusters, and mounting hardware. PFS staff assembled an 8-ft. railing assembly for railing system testing. The top rail was a Extruded Beveled PVC T-rail section 3.2-in wide reinforced with an aluminum member insert 0.077-in thick. The bottom rail had a rectangular shape, measuring 3.5-in deep x 0.75-in wide with 0.115-in thick walls and a P-shaped aluminum insert-reinforcing member measured 0.072-in thick with the leg of the shape facing the exterior side. The top rail and aluminum reinforcing sections are held in place by 0.187-in diameter aluminum pins. Rail ends were connected to receiving brackets that were mounted on test-fixture-simulated-walls with (2) #10 x 2-in long wood screws. The baluster member were spaced 5-in o.c. and fit securely into top and bottom rail cut-outs. The samples were reported to be representing the standard manufactured product for which recognition is being sought.

CONDITIONING

All specimens were condition prior to testing in an environment of 70° ± 5°F for 48 hours. Testing was conducted in the standard laboratory atmosphere of 72°F and 40% relative humidity.

GUARDRAIL PERFORMANCE TESTS

The guardrail structural performance tests were performed on the Endurance guardrail assemblies manufactured by Railing Dynamics, Inc. The test specimen was defined as an 8-ft guardrail system attached between two simulated end walls. All guardrail components, and all connections are described in the manufacturer's installation instructions. Note – testing was conducted with the turned balusters only. The turned baluster flexural strength was found to be less than the square baluster flexural strength. The test specimen was subjected to the in-fill load test (Section 4.2.2), the uniform load test (Section 4.2.3), and the concentrated-load test (Section 4.2.4), in that order. The specimen was loaded at a rate to achieve the specified loads between 10 seconds and 5 minutes. The specified test load was held for one minute before the load was released.

One design of guardrail system was evaluated for the design load requirements.

Flexural Strength - End Use Adjustments

Testing was conducted to verify the flexural strength of each guardrail component for the range of temperatures that are expected during the service life of the guardrail system. For the purposes of this criterion, the lower and upper temperatures were -20°F and +130°F respectively. Quarter-point load flexure tests were performed on the individual guardrail components at ambient, low, and high temperatures. The flexural strength and stiffness were determined in accordance with Section 4.1.1 and the average change in properties between the baseline specimens and the specimen tested at the low and high temperatures were calculated as a percentage and reported. The model code prescribed guardrail test loads were increased proportionately to the flexural strength loss test results data.

In-fill Load

The test specimen must be capable of satisfactorily resisting a load of 169 lbf applied over a one square foot area normal to the in-fill. The in-fill was considered to be the load resisting elements between posts (vertical supports), such as balusters or panel fillers. The load was applied at a position on the in-fill that represented the "worst case" loading and deflection scenarios.

The guardrail system (guard and handrail) is considered to satisfactorily pass if there is no failure, nor evidence of disengagement of any component, nor visible cracks in any component.

Uniform Load Test

The top rail of the guardrail system (guard and handrail) test specimen was subjected to two separate tests where a maximum uniform load of 1060 lbf was applied vertically and horizontally. For the purposes of this test, quarter-point loading was deemed to be equivalent to uniform loading.

Uniform Load Test (Cont.)

The guardrail system (guard and handrail) is considered to satisfactorily pass if there is no failure, nor evidence of disengagement of any component, nor visible cracks in any component.

Concentrated Load Test

One test was conducted, where a test load of 530 pounds was applied at the top rail. The load was continuously applied normal to the top rail (top of guard) at the maximum guardrail system height. When the applied load reaches 200 pounds the deflection at the point of loading was recorded.

The test specimens were inspected prior to testing to verify size and general condition of the materials.
(See Appendix for Detail Test Results)

RESULTS

End Use Adjustments

The end use factor testing determined the component strength loss to be 35% for the spindles and 6% for the top rail when compared to the ambient strength results.

Guardrail Performance Tests

The guardrail assemblies as described herein achieved a test load equal to at least 2.0 times the design load and recovered over 75% of the deflection. This guardrail meets the requirements of ICBO, ES, AC 174.

REPORT REPRODUCTION

Tests Performed by:	Report Reviewed by:	Tests Witnessed and Report Prepared by:	Report Reviewed by:
Allan Adams Lead Lab Technician	James Van Schoyck Lab Administrator	Dwight E. McDonald Lab Testing Manager	Larry Turner, P.E. Staff Engineer

RAILING DYNAMICS, INC.
Guardrail Performance

Guardrail Performance Test	Service Temperature Adjusted Test Loads (lbf)	*after 1 min.* Load Applied Net Deflection (in.)	*1 min. after load release* Residual Deflection (in.)	Deflection Percent Recovery	AC 174 Requirement	AC 174 Compliance
Baluster (In-Fill) Load Test	169	1.823	0.138	92	No failure, nor evidence of disengagement of any component, nor visible cracks in any component.	Yes
Uniform Load Horizontal - Top Rail Test	1060	3.577	0.471	87	No failure, nor evidence of disengagement of any component, nor visible cracks in any component.	Yes
Vertical - Top Rail Test	1060	N/A	N/A	N/A		
Concentrated Load - Top Rail	200	0.727	N/A	N/A	**Ref. 1. below**	Yes
	530	2.91	0.458	84		

AC174 Section 4.2.4.1, 200 lbf maximum net deflection requirements:

1. Rail Height is 36 inches / 24 = 1.5 plus Rail Length is 96.0 inches / 96 = 1. Therefore 1.5 plus 1.0 = maximum net deflection with load applied is 2.5 inches

TABLE 1

RAILING DYNAMICS, INC

ASTM D 6109

Top Rail Flexures (with inserts)

I (in^4) = 0.094 Span (in.) = 28 Neutral Axis (in.) = 0.979

Sample #	Slope	Depth (in)	Base (in)	Load at P'	Deflection at P'	MOE (psi)	Ult. Load (lbf)	MOR (psi)
Ambient								
1	2466.48	1.475	1.736	817	0.322	8486798	1323	48226
2	2243.80	1.475	1.736	813	0.424	6413608	1311	47789
3	2215.02	1.475	1.736	818	0.418	6545679	1287	46914
4	2468.35	1.475	1.736	797	0.318	8383182	1306	47606
5	2240.41	1.475	1.736	815	0.451	6044478	1300	47388
6	2387.28	1.475	1.736	780	0.355	7349266	1291	47060
7	2520.63	1.475	1.736	820	0.351	7814199	1294	47169
8	2483.64	1.475	1.736	811	0.322	8424472	1310	47752
9	2543.09	1.475	1.736	789	0.396	6664376	1336	48700
10	2505.44	1.475	1.736	782	0.377	6938141	1292	47096
					Min	**6044478**	**1287**	**46914**
					Mean	**7306420**	**1305**	**47570**
					Max	**8486798**	**1336**	**48700**
					Std. Dev.	**917643**	**16**	**568**
					COV%	**12.6**	**1.2**	**1.2**
Low Temp. (-20°F)								
1	2486.87	1.475	1.736	840	0.406	6920396	1369	49903
2	2655.00	1.475	1.736	844	0.275	10265674	1402	51106
3	2617.82	1.475	1.736	809	0.309	8757250	1362	49648
4	2866.37	1.475	1.736	848	0.283	10022755	1328	48408
5	2505.07	1.475	1.736	825	0.424	6508274	1314	47898
6	2218.93	1.475	1.736	797	0.290	9192593	1382	50377
7	2449.90	1.475	1.736	792	0.360	7358688	1368	49867
8	2661.36	1.475	1.736	842	0.337	8357183	1317	48007
9	2516.16	1.475	1.736	842	0.423	6658086	1354	49356
10	2889.66	1.475	1.736	834	0.284	9822576	1340	48846
					Min	**6508274**	**1314**	**47898**
					Mean	**8386348**	**1354**	**49342**
					Max	**10265674**	**1402**	**51106**
					Std. Dev.	**1444532**	**29**	**1046**
					COV%	**17.2**	**2.1**	**2.1**
High Temp. (+130°F)								
1	2388.69	1.475	1.736	737	0.325	7585109	1260	45930
2	2385.37	1.475	1.736	732	0.396	6182920	1279	46622
3	2494.79	1.475	1.736	740	0.294	8419031	1222	44545
4	2306.36	1.475	1.736	723	0.394	6137900	1282	46732
5	2386.96	1.475	1.736	718	0.277	8670066	1257	45820
6	2353.57	1.475	1.736	715	0.318	7520672	1262	46003
7	2576.89	1.475	1.736	747	0.277	9020249	1264	46075
8	2333.52	1.475	1.736	739	0.389	6354371	1255	45747
9	2352.84	1.475	1.736	749	0.368	6807877	1262	46003
10	2375.67	1.475	1.736	750	0.332	7556155	1208	44034
					Min	**6137900**	**1208**	**44034**
					Mean	**7425435**	**1255**	**45751**
					Max	**9020249**	**1282**	**46732**
					Std. Dev.	**1046771**	**23**	**843**
					COV%	**14.1**	**1.8**	**1.8**

TABLE 2

RAILING DYNAMICS, INC

ASTM D 6109

Bottom Rail Flexures (with inserts)

I (in^4) = 0.165 Span (in.) = 28 Neutral Axis (in.) = 0.877

Sample #	Slope	Depth (in)	Base (in)	Load at P'	Deflection at P'	MOE (psi)	Ult. Load (lbf)	MOR (psi)
Ambient								
1	3212.55	1.771	3.476	1437	0.523	5235723	2460	45763
2	3203.53	1.752	3.480	1400	0.488	5466758	2472	45987
3	2971.01	1.753	3.479	1488	0.493	5751454	2453	45633
4	3020.56	1.751	3.478	1414	0.528	5103136	2566	47735
5	2909.01	1.750	3.482	1472	0.546	5137322	2540	47252
6	3100.76	1.752	3.480	1471	0.518	5411336	2460	45763
7	3072.33	1.757	3.475	1429	0.487	5591456	2546	47363
8	3181.33	1.750	3.481	1422	0.519	5221002	2643	49168
9	3245.82	1.752	3.476	1473	0.519	5408253	2561	47642
10	3138.18	1.754	3.482	1434	0.521	5244850	2430	45205
					Min	**5103136**	**2430**	**45205**
					Mean	**5357129**	**2513**	**46751**
					Max	**5751454**	**2643**	**49168**
					Std. Dev.	**207278**	**68**	**1265**
					COV%	**3.9**	**2.7**	**2.7**
Low Temp. (-20°F)								
1	3264.81	1.750	3.481	1524	0.539	5387879	2653	49354
2	3200.41	1.752	3.478	1598	0.570	5342242	2825	52554
3	3202.88	1.753	3.479	1541	0.551	5329331	2742	51010
4	3164.89	1.750	3.482	1533	0.559	5225790	2665	49577
5	3331.30	1.752	3.480	1589	0.531	5702312	2876	53502
6	2901.63	1.753	3.475	1539	0.595	4928824	2499	46489
7	2844.81	1.757	3.476	1525	0.612	4748321	2487	46266
8	4336.81	1.757	3.481	1516	0.400	7222056	2680	49856
9	3008.46	1.752	3.479	1592	0.586	5176868	2675	49763
10	4301.45	1.750	3.481	1589	0.428	7074598	2506	46619
					Min	**4748321**	**2487**	**46266**
					Mean	**5613822**	**2661**	**49499**
					Max	**7222056**	**2876**	**53502**
					Std. Dev.	**849422**	**134**	**2487**
					COV%	**15.1**	**5.0**	**5.0**
High Temp. (+130°F)								
1	3761.10	1.703	3.481	1353	0.432	5968094	2323	43215
2	3518.85	1.750	3.475	1324	0.282	8946651	2059	38304
3	2519.24	1.749	3.479	1319	0.490	5129444	2269	42210
4	2854.24	1.754	3.480	1372	0.479	5458084	2245	41764
5	3450.74	1.757	3.482	1388	0.440	6011162	2434	45280
6	2976.51	1.753	3.481	1362	0.446	5819208	2375	44182
7	3198.13	1.750	3.475	1364	0.432	6016615	2287	42545
8	2782.27	1.752	3.476	1377	0.521	5036372	2163	40238
9	2867.41	1.757	3.478	1345	0.474	5407114	2375	44182
10	2866.99	1.750	3.481	1370	0.487	5360598	2166	40294
					Min	**5036372**	**2059**	**38304**
					Mean	**5915334**	**2270**	**42221**
					Max	**8946651**	**2434**	**45280**
					Std. Dev.	**1124754**	**115**	**2143**
					COV%	**19.0**	**5.1**	**5.1**

TABLE 3

RAILING DYNAMICS, INC

ASTM D 6109

Turned Baluster Flexures

I (in^4) = 0.0815 Span (in.) = 20 Neutral Axis (in.) = 0.389

Sample #	Slope	Depth (in)	Base (in)	Load at P'	Deflection at P'	MOE (psi)	Ult. Load (lbf)	MOR (psi)
Ambient								
1	188.68	0.776	1.008	117	0.578	284591	197	2351
2	186.60	0.776	1.009	116	0.601	271361	194	2315
3	191.68	0.777	1.017	103	0.537	269666	167	1993
4	188.61	0.778	1.007	117	0.600	274156	196	2339
5	194.15	0.781	1.016	118	0.582	285051	190	2267
6	190.66	0.776	1.018	116	0.586	278307	187	2231
7	191.00	0.787	1.014	105	0.506	291744	167	1993
8	192.55	0.777	1.013	112	0.562	280185	176	2100
9	188.63	0.777	1.005	119	0.619	270284	203	2422
10	194.17	0.776	1.011	117	0.555	296385	193	2303
					Min	**269666**	**167**	**1993**
					Mean	**280173**	**187**	**2231**
					Max	**296385**	**203**	**2422**
					Std. Dev.	**9223**	**13**	**152**
					COV%	**3.3**	**6.8**	**6.8**
Low Temp. (-20°F)								
1	212.80	0.779	1.012	160	0.657	342388	268	3198
2	205.92	0.781	1.006	163	0.696	329262	279	3329
3	229.61	0.778	1.009	164	0.668	345169	286	3413
4	210.52	0.777	1.011	160	0.646	348218	242	2888
5	211.50	0.788	1.006	162	0.596	382149	271	3234
6	211.56	0.776	1.014	164	0.701	328920	283	3377
7	212.75	0.781	1.005	161	0.676	334844	283	3377
8	222.08	0.775	1.018	163	0.697	328790	262	3126
9	210.76	0.782	1.007	160	0.707	318174	265	3162
10	210.97	0.777	1.011	162	0.710	320790	263	3138
					Min	**318174**	**242**	**2888**
					Mean	**337870**	**270**	**3224**
					Max	**382149**	**286**	**3413**
					Std. Dev.	**18460**	**13**	**159**
					COV%	**5.5**	**4.9**	**4.9**
High Temp. (+130°F)								
1	131.34	0.776	1.018	74	0.559	186116	123	1468
2	126.82	0.781	1.003	73	0.572	179428	121	1444
3	125.06	0.777	1.013	72	0.568	178217	120	1432
4	126.62	0.776	1.009	70	0.548	179590	120	1432
5	128.04	0.787	1.005	74	0.556	187120	124	1480
6	125.50	0.777	1.011	74	0.590	176337	126	1503
7	128.04	0.782	1.009	73	0.558	183930	113	1348
8	131.67	0.776	1.016	75	0.566	186298	121	1444
9	128.89	0.777	1.011	73	0.559	183601	125	1492
10	124.89	0.778	1.007	73	0.572	179428	117	1396
					Min	**176337**	**113**	**1348**
					Mean	**182006**	**121**	**1444**
					Max	**187120**	**126**	**1503**
					Std. Dev.	**3849**	**4**	**46**
					COV%	**2.1**	**3.2**	**3.2**

TABLE 4

RAILING DYNAMICS, INC

ASTM D 6109

Square Baluster Flexures

I (in^4) = 0.0815 Span (in.) = 20 Neutral Axis (in.) = 0.624

Sample #	Slope	Depth (in)	Base (in)	Load at P'	Deflection at P'	MOE (psi)	Ult. Load (lbf)	MOR (psi)
Ambient								
1	201.15	1.250	1.245	130	0.558	327547	232	4441
2	203.21	1.250	1.243	130	0.546	334745	262	5015
3	210.92	1.249	1.244	130	0.531	344201	254	4862
4	216.04	1.250	1.243	131	0.507	363268	229	4383
5	224.50	1.250	1.242	131	0.531	346849	227	4345
6	212.83	1.243	1.250	130	0.527	346814	244	4670
7	222.33	1.252	1.245	131	0.547	336704	222	4249
8	222.62	1.253	1.246	132	0.553	335593	221	4230
9	220.93	1.247	1.255	130	0.544	335976	238	4556
10	221.24	1.248	1.256	131	0.555	331850	231	4422
					Min	**327547**	**221**	**4230**
					Mean	**340355**	**236**	**4517**
					Max	**363268**	**262**	**5015**
					Std. Dev.	**10256**	**14**	**260**
					COV%	**3.0**	**5.8**	**5.8**
Low Temp. (-20°F)								
1	236.04	1.244	1.255	143	0.567	354582	247	4728
2	232.43	1.247	1.258	142	0.536	372467	272	5206
3	239.53	1.254	1.247	141	0.550	360429	240	4594
4	232.84	1.246	1.257	140	0.530	371378	288	5513
5	241.67	1.257	1.248	141	0.511	387938	272	5206
6	236.18	1.246	1.257	140	0.530	371378	274	5245
7	241.01	1.246	1.259	140	0.511	385186	272	5206
8	236.87	1.249	1.255	140	0.536	367221	269	5149
9	242.52	1.252	1.255	143	0.521	385889	263	5034
10	269.48	1.250	1.252	141	0.466	425400	267	5111
					Min	**354582**	**240**	**4594**
					Mean	**378187**	**266**	**5099**
					Max	**425400**	**288**	**5513**
					Std. Dev.	**19862**	**14**	**264**
					COV%	**5.3**	**5.2**	**5.2**
High Temp. (+130°F)								
1	199.50	1.247	1.259	190	0.876	304939	318	6087
2	183.93	1.259	1.248	155	0.780	279384	260	4977
3	193.06	1.247	1.259	150	0.754	279694	242	4632
4	191.59	1.248	1.259	142	0.709	281583	234	4479
5	186.78	1.246	1.259	140	0.704	279588	228	4364
6	200.09	1.254	1.251	179	0.803	313402	299	5723
7	184.63	1.246	1.256	140	0.725	271490	230	4402
8	184.75	1.247	1.254	141	0.714	277642	226	4326
9	176.34	1.261	1.247	142	0.744	268336	239	4575
10	203.76	1.249	1.257	192	0.865	312068	328	6278
					Min	**268336**	**226**	**4326**
					Mean	**286813**	**260**	**4984**
					Max	**313402**	**328**	**6278**
					Std. Dev.	**16730**	**39**	**756**
					COV%	**5.8**	**15.2**	**15.2**

TABLE 5

RAILING DYNAMICS GUARDRAIL SYSTEM TESTING
(AC 174)
INCREASE LOAD ON ONE 8' RAIL SYSTEM

1 **IN-FILL LOAD TEST** *SECTION 4.2.2*

125 LB LOAD ON 1 SQ. FT. OF IN-FILL AREA

TURNED 125 LB x 1.35 (*TEMP LOSS INCREASE*) = **169 LBS**

SQUARE 125 LB x 1.16 (*TEMP LOSS INCREASE*) = **145 LBS**

2 **UNIFORM LOAD TEST** *SECTION 4.2.3*

125 PLF x 8 FT = 1000 LBS
(***APPLIED VERTICALLY & HORIZONTALLY***)
1000 LB x 1.06 (*TOP RAIL TEMP LOSS INCREASE*) = **1060 LBS**
1000 LB x 1.15 (*BOTTOM RAIL TEMP LOSS INCREASE*) = **1150 LBS**

3 **CONCENTRATED LOAD TEST** *SECTION 4.2.4*

500 LB APPLIED AT TOP OF RAIL
500 LB x 1.06 (*TOP RAIL TEMP LOSS INCREASE*) = **530 LBS**
500 LB x 1.15 (*BOTTOM RAIL TEMP LOSS INCREASE*) = **575 LBS**

APPENDIX

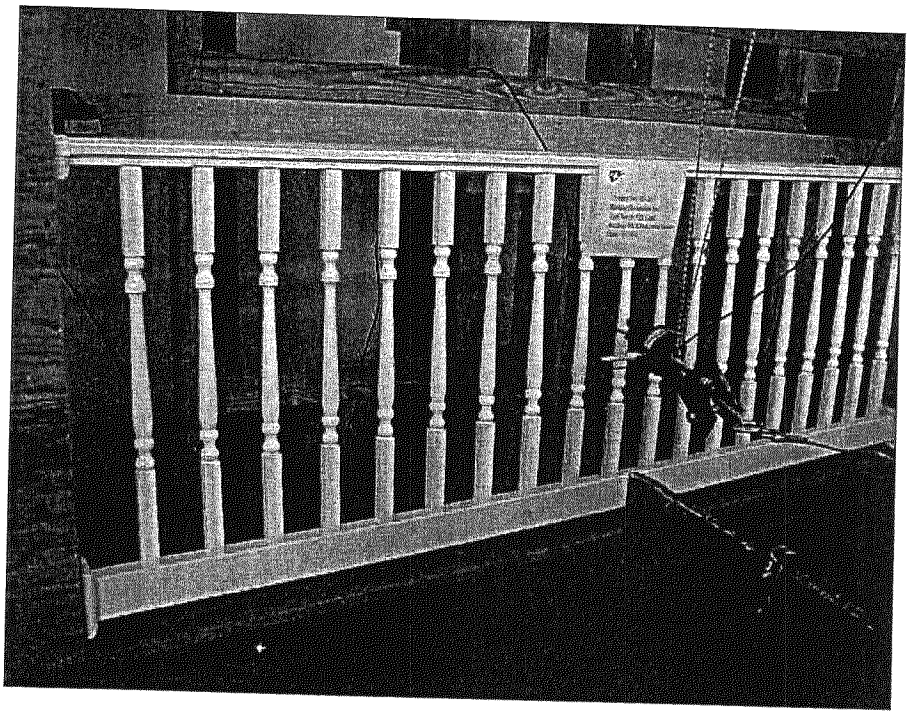

PHOTO 1: In-Fill Load Test Set-up

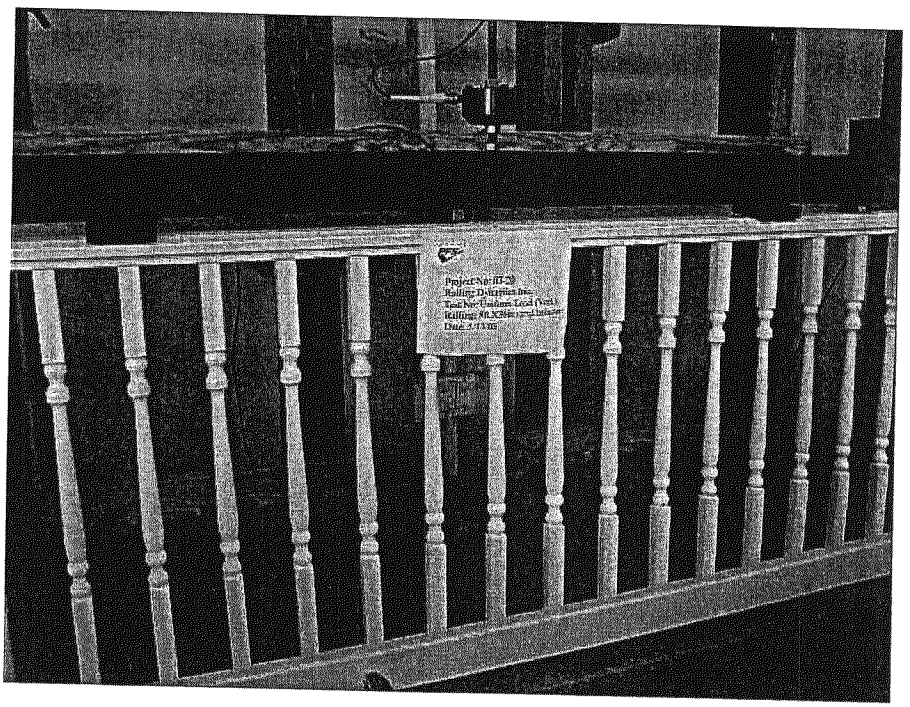

PHOTO 2: Uniform Load applied vertically at Top Rail

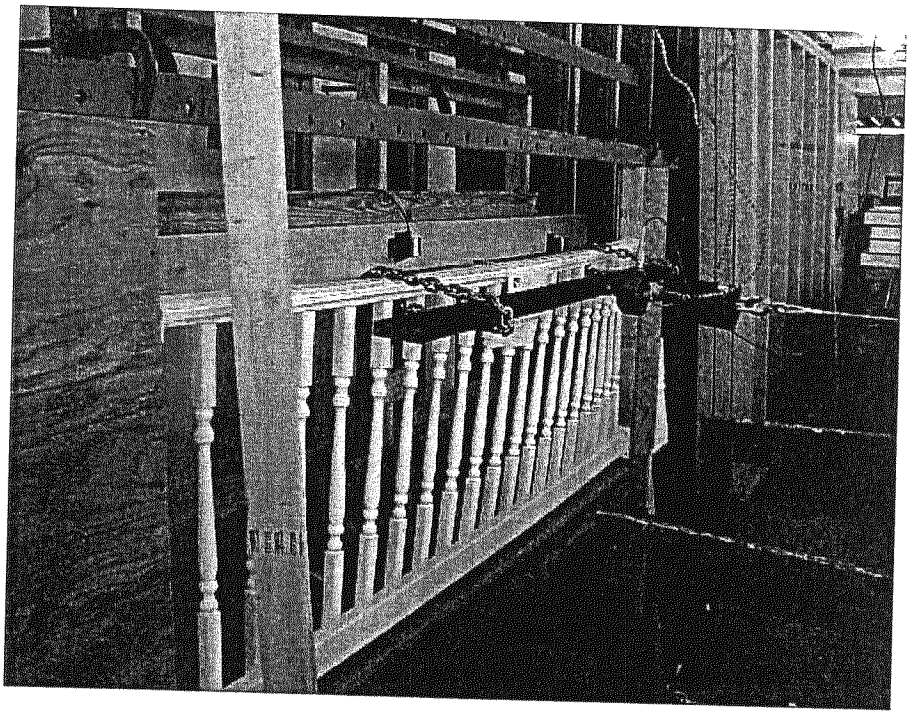

PHOTO 3: Uniform Load applied horizontally at Top Rail

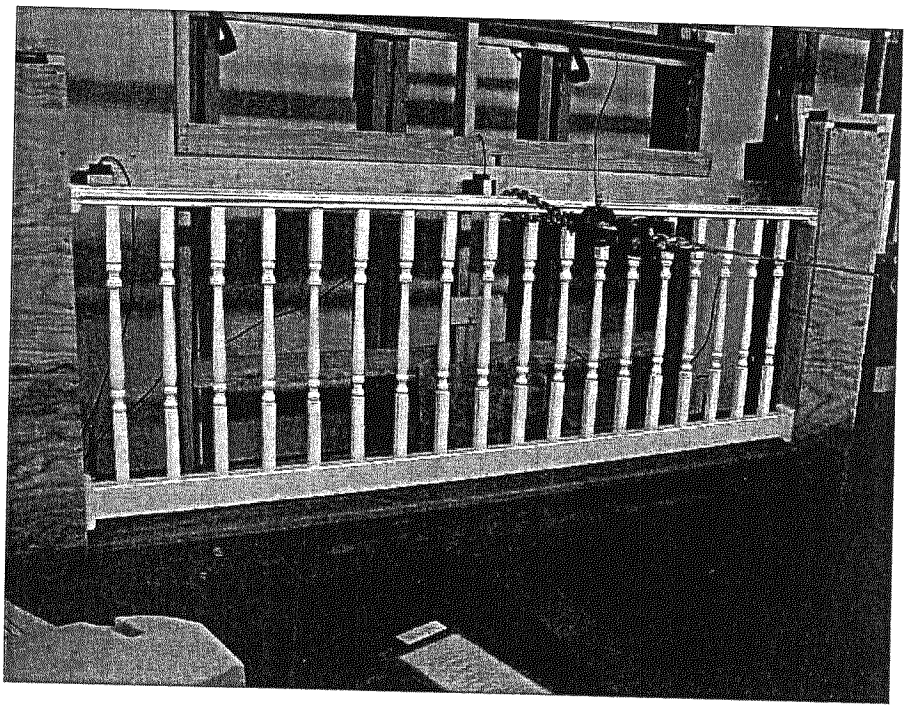

PHOTO 4: Concentrated Load applied mid-span on Top Rail