PART III – RACKING LOAD TESTING

Test Procedure

Each test consisted of two panels, connected together along their common vertical joint, and standing (96" dimension of each panel was vertical) in the load frame. Thus, the dimensions of each test sample were 96" x 96". To prevent panel rotation (uplift), hold down rods were installed at the edge of the panel to be loaded. One rod was placed on each face of the panel, and each rod was preloaded with a tension force of 20 pounds. Non-binding lateral guides were used along the top edge of each test sample to prevent movement perpendicular to the plane of the panels during loading. OSB panel skins were nailed with 8d nails at 6" o/c into a 2" x 4" sill and cap plates. The cap plate was then bolted to the load beam. GGS panel skins were screwed to a galvanized steel channel sill with sheet metal screws at 6" o/c. The sill channel was bolted to the load frame. See Figure III-1 and Photo III-1 for details of the test setup.

An in-plane concentric load was applied at the top corner of the panel as described in Section 14.3.3 of ASTM E 72-98 and as shown in Figure III-1. A hydraulic jack was used to load a steel plate bearing on a 4" x 6" timber cap plate at the top of the sample. The applied load was transferred from the 4" x 6" cap through lag bolts into the 2" x 4" cap plate embedded in the top of each panel. A pressure transducer was used to record the magnitude of the in-plane load applied to the top corner of each sample. Each sample was loaded as follows:

- loaded to 790 lb. and then load removed
- loaded to 1570 lb. and then load removed
- loaded to 2360 lb. and then load removed
- loaded to failure

During each half-cycle of loading, applied loads and deflections were recorded at approximately 1 second intervals. Each panel was evaluated for one test, until panel failure occurred. On all samples, four displacement transducers (DT) were used to measure three separate displacements (see Figure III-1 for details):

    D1) uplift was measured by 2 DT's placed on opposite faces along the vertical edge where the load was applied;

    D2) slippage was measured by 1 DT placed on the panel centerline at the lower right corner of the sample; and

    D3) total movement was measured by 1 DT placed on the panel centerline at the upper right corner of the sample.

Net panel displacement (deformation) was then calculated to be:
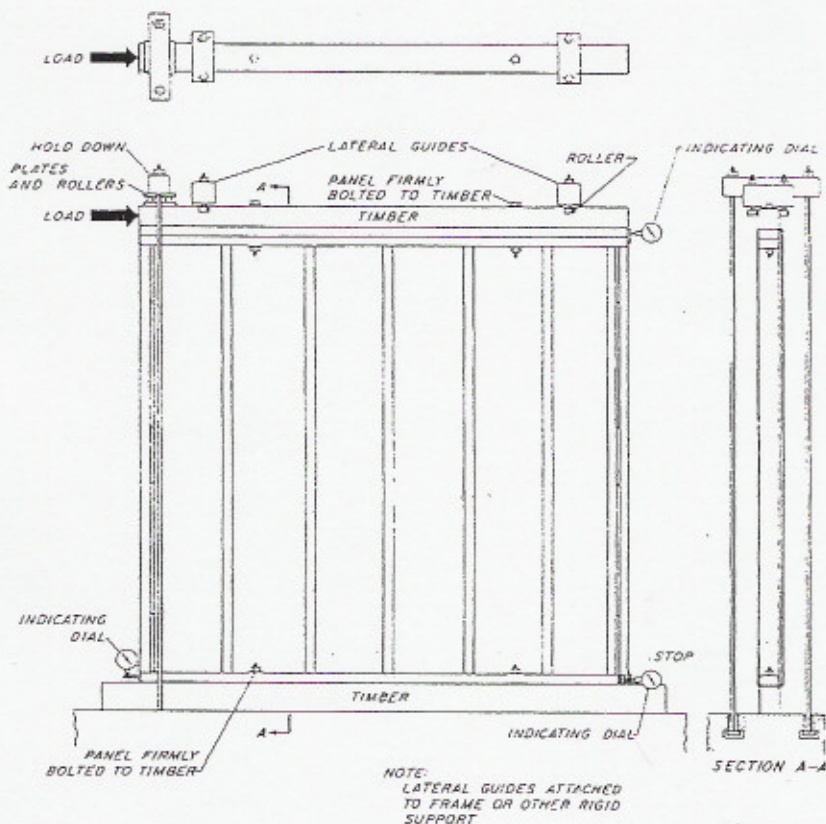
$$D_{net} = D3 - D1 - D2$$

Figure No. III-1: Test Setup for Racking (in-Plane) Loading

Test Results for 8' OSB Panels and 8' Galvanized Steel Panels

Test results for 8' panels are presented as described below:

OSB-OSB	Tables No. III-1, III-3, and III-5	Figures No. III-2 and III-3
GGS-GGS	Tables No. III-2, III-4, and III-5	Figures No. III-4 and III-5

The results include individual panel results indicated above as well as "average" results
(Table No. III-4 and Figures No.III-3 and III-5). Maximum load and displacement values and
descriptions of panels and failure modes are provided in Tables No. III-3 and III-4. Three
OSB-OSB panels and five GGS-GGS panels were tested.

Table No. III-1: Results for Racking Load vs. Net Deflections for 8' OSB-OSB Panels

8' OSB-OSB Panel OO1R				8' OSB-OSB Panel OO2R				8' OSB-OSB Panel OO3R			
Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)
1	-0.0018	218	0.0237	12	-0.0041	916	0.1358	2	0.0001	619	0.0563
16	-0.0015	391	0.0344	35	-0.0041	1284	0.1628	39	0.0005	1232	0.1073
23	-0.0033	634	0.0533	69	-0.0034	1736	0.2001	59	0.0005	1616	0.1870
26	-0.0047	1002	0.0908	100	-0.0023	2076	0.2511	96	0.0017	1964	0.2790
45	-0.0051	1529	0.1260	156	0.0013	2041	0.3015	114	0.0026	2403	0.7080
87	-0.0045	1913	0.1712	228	0.0055	2375	0.6553	167	0.0051	2247	0.7164
136	-0.0003	2369	0.5171	338	0.0117	2226	0.6703	245	0.0089	-93	0.1697
246	0.0056	388	0.4434	470	0.0195	-39	0.1623	353	0.0131	-17	0.1676
447	0.0161	-123	0.0458	636	0.0319	-10	0.3406	498	0.0190	-3	0.3524
814	0.1131	-44	0.0405	814	0.0942	0	0.3402	830	0.0748	1	0.3521
-38	0.0842	-18	0.0408	-24	0.0803	21	0.1714	-26	0.0600	36	0.1625
-99	0.0031	0	0.1272	-92	0.0103	57	0.1709	-35	0.0084	117	0.1624
-33	0.0019	2	0.1273	-45	0.0100	290	0.1799	0	0.0191	331	0.1747
0	0.0321	76	0.0430	0	0.0295	1021	0.2268	1	0.0190	837	0.2160
1	0.0321	273	0.0524	1	0.0293	2108	0.3397	28	0.0089	1692	0.3095
16	0.0033	698	0.0915	7	0.0097	2899	0.4989	53	0.0090	2343	0.4250
53	0.0049	1496	0.1621	19	0.0096	3132	0.6994	100	0.0113	2667	0.5697
117	0.0066	2555	0.2595	53	0.0097	3417	0.9064	166	0.0127	2592	0.7439
174	0.0107	3064	0.3639	126	0.0124	3580	1.0890	279	0.0171	3020	0.9128
276	0.0150	4001	0.4684	252	0.0188	3789	1.2605	462	0.0242	3395	1.0739
458	0.0231	4736	0.5703	453	0.0269	4027	1.4341	781	0.0384	3780	1.2434
762	0.0447	4660	0.7434	828	0.0488	3944	1.6190	1119	0.0715	3809	1.4206
1172	0.0853	4595	0.9308	1142	0.0913	4297	1.8101	1570	0.2759	3798	1.5994
1605	0.2978	4834	1.0950	1697	0.3365	4489	1.9978	71	0.2173	3769	1.7755
151	0.2468	5040	1.2543	1597	0.3486	4501	2.1740	-36	0.0371	3805	1.9524
-81	0.0179	5223	1.4027	-52	0.0682	4804	2.3482	-1	0.0980	4010	2.0453
-33	0.0019	5387	1.5458	-25	0.1754	4959	2.5206	5	0.0980	3809	2.1312
-1	0.0687	5593	1.9117	198	0.1756	5089	2.6479	18	0.0373	3860	2.2896
3	0.0688	4732	2.0559	35	0.0652	4716	2.7300	46	0.0365	3884	2.4675
49	0.0158	4836	2.2395	314	0.1088	4439	2.7999	112	0.0374	3112	2.6533
125	0.0197	4399	2.4254	524	0.1175			267	0.0394		

Note: racking loads does not include weight of top beam and panel self weight

Table No. III-2: Representative Results, Racking Load vs. Net Deflections, 8'GGS-GGS Panels
(GG1R and GG5R are not shown)

8' GGS-GGS Panel GG4R				8' GGS-GGS Panel GG2R				8' GGS-GGS Panel GG3R			
Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)	Avg. Racking Load (lbs.)	Avg. Net Displ. (in.)
7	0.0002	792	0.1544	1	-0.0017	539	0.0605	0	-0.0003	541	0.0497
34	0.0024	1271	0.2008	17	-0.0017	981	0.0988	13	0.0018	986	0.0846
126	0.0114	1704	0.2613	214	0.0135	2497	0.2308	78	-0.0023	2494	0.2005
200	0.0209	2216	0.3247	266	0.0140	-82	0.1258	171	0.0021	15	0.1109
298	0.0322	2752	0.3985	563	0.0323	-54	0.0591	460	0.0137	-13	0.0412
431	0.0466	2601	0.4082	842	0.0552	-52	0.0594	828	0.0435	-4	0.0405
596	0.0672	-150	0.1644	-56	0.0401	65	0.0591	111	0.0367	0	0.0405
802	0.0959	-5	0.1595	-107	0.0113	319	0.0773	-11	0.0095	45	0.0411
-4	0.0805	1	0.1592	-125	0.0040	610	0.0965	-13	0.0051	108	0.0416
-19	0.0374	169	0.1721	-125	0.0042	1043	0.1467	-14	0.0025	197	0.0442
2	0.0364	921	0.2701	-123	0.0047	1878	0.2026	0	0.0081	386	0.0600
37	0.0368	2740	0.4392	99	0.0135	3395	0.3717	27	0.0064	1915	0.1816
94	0.0414	3927	0.6357	153	0.0154	3941	0.4718	59	0.0066	3227	0.2838
285	0.0558	4952	0.8412	325	0.0243	4522	0.5666	157	0.0057	3479	0.4280
422	0.0662	5118	1.0694	702	0.0421	5085	0.6684	356	0.0162	4068	0.5747
928	0.1077	5931	1.3075	973	0.0628	5450	0.7838	592	0.0330	4545	0.7286
1083	0.1460	6246	1.5258	1321	0.0920	5813	0.8978	998	0.0592	5260	0.8753
1626	0.2166	6770	1.7625	1555	0.1363	5945	1.0153	1591	0.1224	5305	1.0502
225	0.1951	7062	1.9999	516	0.1377	5672	1.1496	265	0.1012	5571	1.2266
-154	0.0895	7353	2.2336	-108	0.0364	5617	1.2610	-3	0.0322	5764	1.4001
4	0.0885	6659	2.4805	-115	0.0341	5877	1.3766	-2	0.0285	6000	1.5885
30	0.0876	6875	2.9816	66	0.0342	5939	1.5111	2	0.0277	6172	1.7823
97	0.0924	6634	3.2183	78	0.0358	6372	1.8247	79	0.0283	6465	2.0824
222	0.1026	6456	3.4597	170	0.0413	4910	1.8995	174	0.0304	4520	2.2580
448	0.1204	6254	3.7109	273	0.0509			302	0.0320		
		6358	3.9648								
		6082	4.2935								

Note: racking loads does not include weight of top beam and panel self weight

TABLE No. III-3: RACKING TEST RESULTS FOR 8' OSB-OSB PANELS

SAMPLE NO.	MAX. LD. (LBS)	DEFL. (IN) AT MAX. LOAD				FAILURE CHARACTERISTICS
		UPLIFT D1	SLIDE D2	DRIFT D3	NET D3-D1-D2	
OO1R	5593	0.20	0.22	2.33	1.91	Panels failed by some combination of tearing of the OSB around the nails at the sill and top plates and bending and shearing of the nails; crushing of the foam; lifting/tearing of the sill plate; and separation of the skins from the foam.
OO2R	5089	0.19	0.24	2.90	2.47	
OO3R	4010	0.16	0.16	2.36	2.04	
AVERAGE	4897	0.18	0.19	2.53	2.14	Avg. Panel Wt. = 135.9 lbs. (range = 133.4 to 138.9 lbs.)

TABLE No. III-4: RACKING TEST RESULTS FOR 8' GGS-GGS PANELS

SAMPLE NO.	MAX. LD. (LBS)	DEFL. (IN) AT MAX. LOAD				FAILURE CHARACTERISTICS
		UPLIFT D1	SLIDE D2	DRIFT D3	NET D3-D1-D2	
GG1R	Omitted due to premature lifting of sill channel				-----	Panels failed by some combination of tearing of the galvanized steel around the nails and screws at the sill and top plates and bending and shearing of the nails/crews; crushing of the foam; lifting/tearing of the sill plate; and separation of the skins from the foam.
GG2R	6372	0.12	0.05	1.99	1.82	
GG3R	6465	0.14	0.05	2.27	2.08	
GG4R	7353	0.08	0.18	2.38	2.12	
GG5R	6700	0.07	0.15	2.44	2.22	
AVERAGE	6723	0.10	0.11	2.27	2.06	Avg. Panel Wt. = 114.6 lbs. (range = 112.4 to 115.8 lbs.)

Table No. III-5: Average Results for Racking Load vs. Net Deflection for 8' Panels

8' OSB-OSB Panels OO1R, OO2R, and OO3R				8' GGS-GGS Panels GG2R, GG3R, GG4R, GG5R			
Racking Load (lbs.)	Average Displacement (in.)	Racking Load (Cont'd) (lbs.)	Average Displacement (in.)	Racking Load (lbs.)	Average Displacement (in.)	Racking Load (Cont'd) (lbs.)	Average Displacement (in.)
5	-0.0019	1741	0.1880	4	-0.0004	357	0.0742
30	-0.0017	1973	0.2506	33	0.0018	603	0.0907
51	-0.0021	2382	0.6268	68	0.0038	936	0.1154
74	-0.0018	1620	0.6100	139	0.0079	1396	0.1569
105	-0.0004	-85	0.1259	199	0.0121	1984	0.2066
161	0.0021	-24	0.1214	240	0.0168	2526	0.2717
240	0.0067	-5	0.2734	314	0.0229	1239	0.2263
356	0.0127	1	0.2732	418	0.0321	-176	0.0843
527	0.0223	45	0.1256	576	0.0435	-138	0.0822
819	0.0940	149	0.1285	825	0.0665	-53	0.0795
-30	0.0748	440	0.1487	217	0.0575	-89	0.0798
-75	0.0074	1118	0.2016	-129	0.0147	-18	0.0860
-38	0.0067	2118	0.3029	-133	0.0136	17	0.0863
0	0.0269	2769	0.4293	-94	0.0114	402	0.1229
1	0.0268	3266	0.5792	-72	0.0129	959	0.1663
17	0.0073	3581	0.7402	-34	0.0172	1669	0.2391
42	0.0078	3753	0.9151	20	0.0165	2336	0.3245
90	0.0092	3926	1.0884	65	0.0202	3040	0.4293
155	0.0120	4214	1.2575	128	0.0240	3594	0.5555
269	0.0170	4264	1.4313	208	0.0288	4352	0.6906
458	0.0248	4439	1.6041	311	0.0360	4706	0.8289
790	0.0440	4549	1.7730	465	0.0441	5229	0.9742
1144	0.0827	4580	1.9424	658	0.0575	5587	1.1259
1624	0.3034	4723	2.1136	925	0.0783	5979	1.2759
606	0.2709	4517	2.2887	1195	0.1082	5934	1.4342
-58	0.0420	4479	2.4790	1607	0.1572	5977	1.6028
-9	0.1140	3983	2.6262	642	0.1474	6078	1.7749
69	0.1141			-136	0.0467	6219	1.9511
34	0.0395			-74	0.0452	6282	2.1326
162	0.0550			-34	0.0490	6295	2.3184
285	0.0595			18	0.0490	6417	2.5022
525	0.0699			55	0.0520	5490	2.6908
846	0.0908			123	0.0574		
1323	0.1327			211	0.0641		

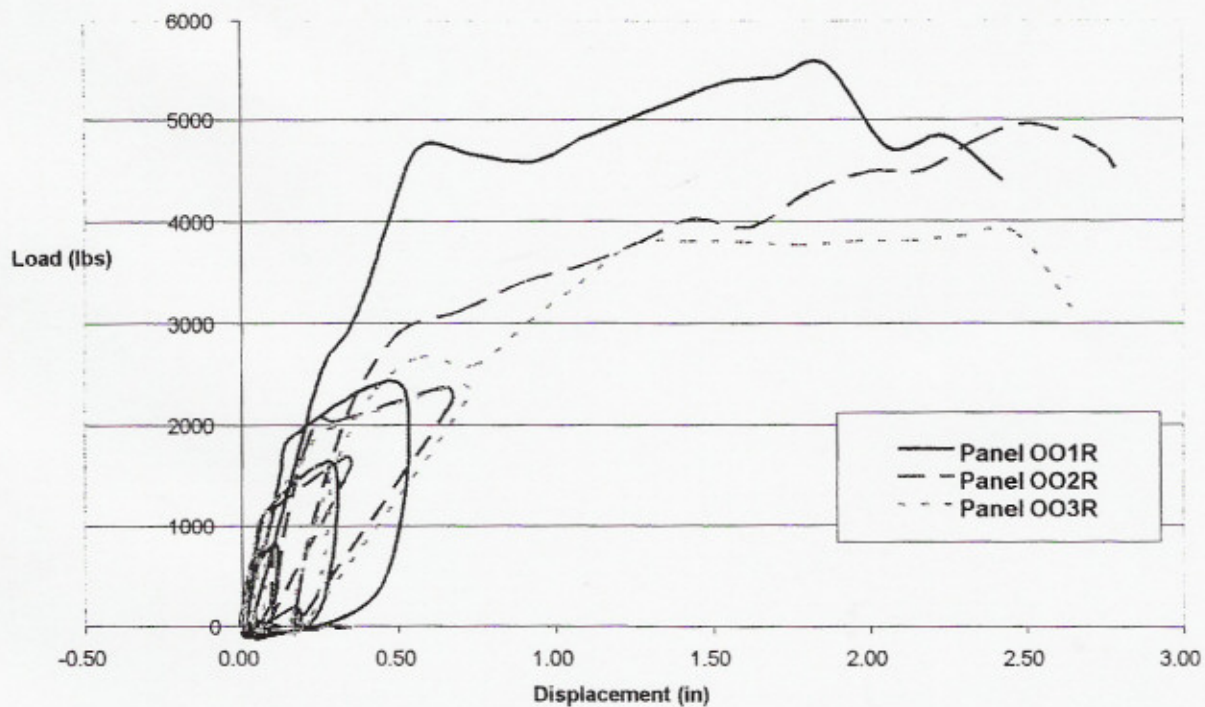Note: racking loads does not include weight of top beam and panel self weight

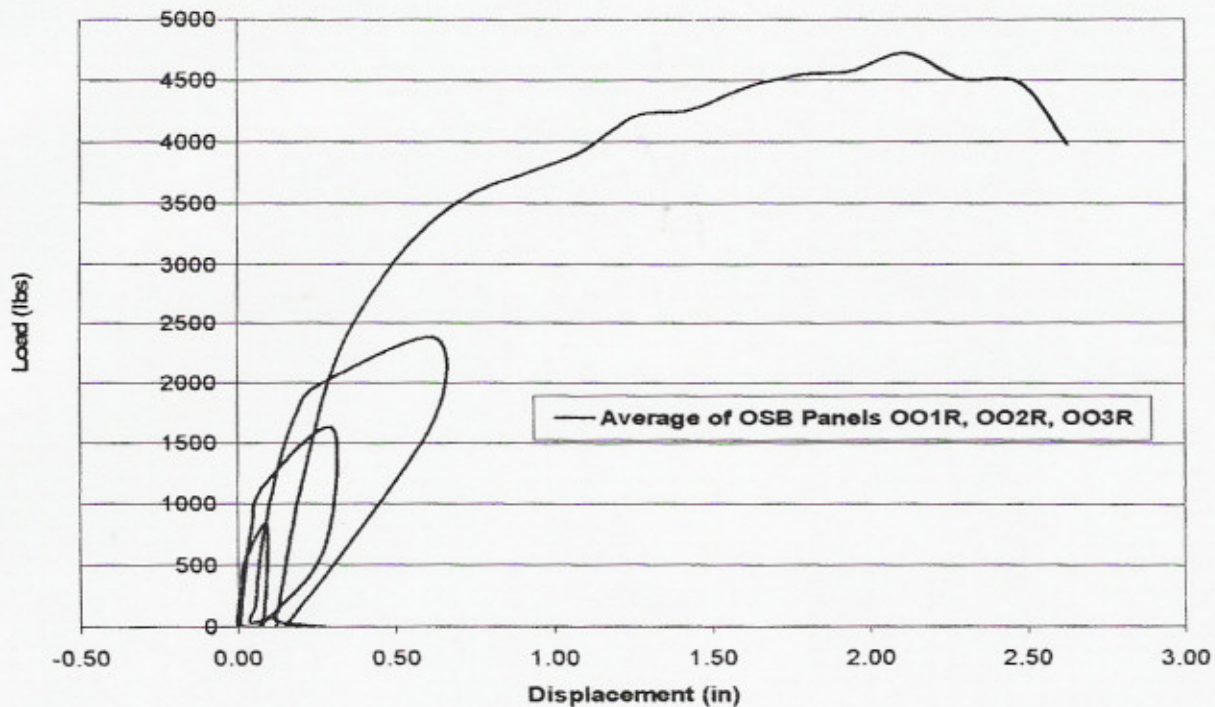Figure No. III-2: Results for Racking Load vs. Net Deflection for 8' OSB-OSB Panels

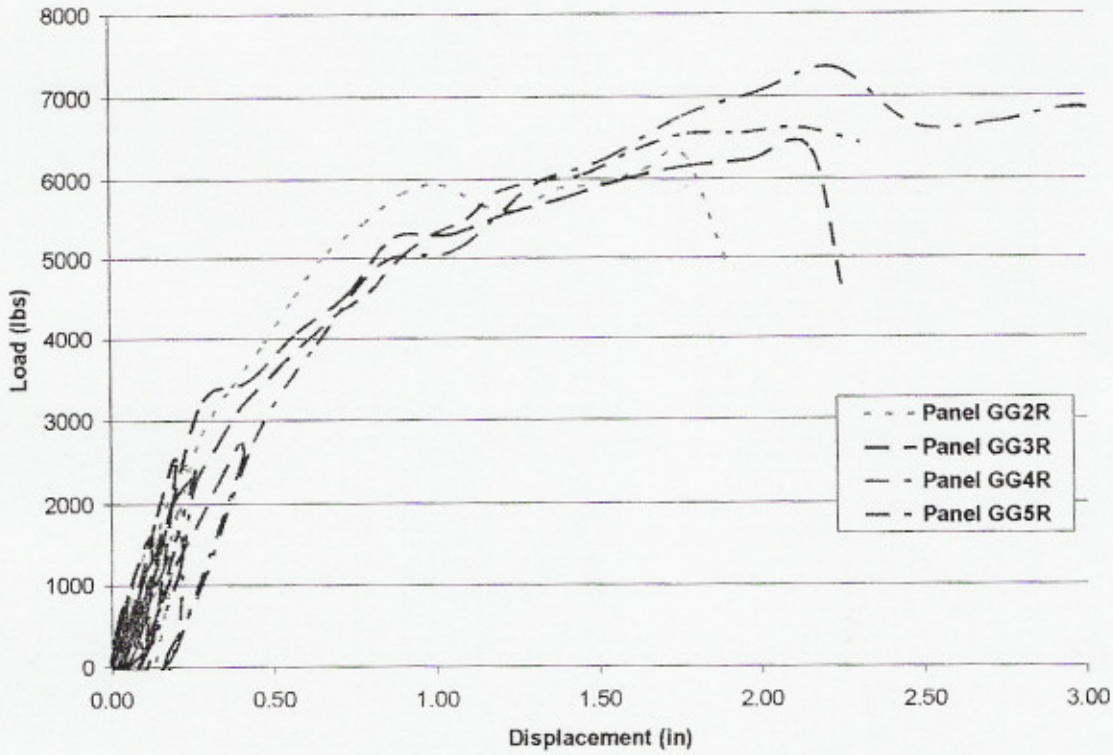Figure No. III-3: Average Results for Racking Load vs. Net Deflection for 8' OSB-OSB Panels

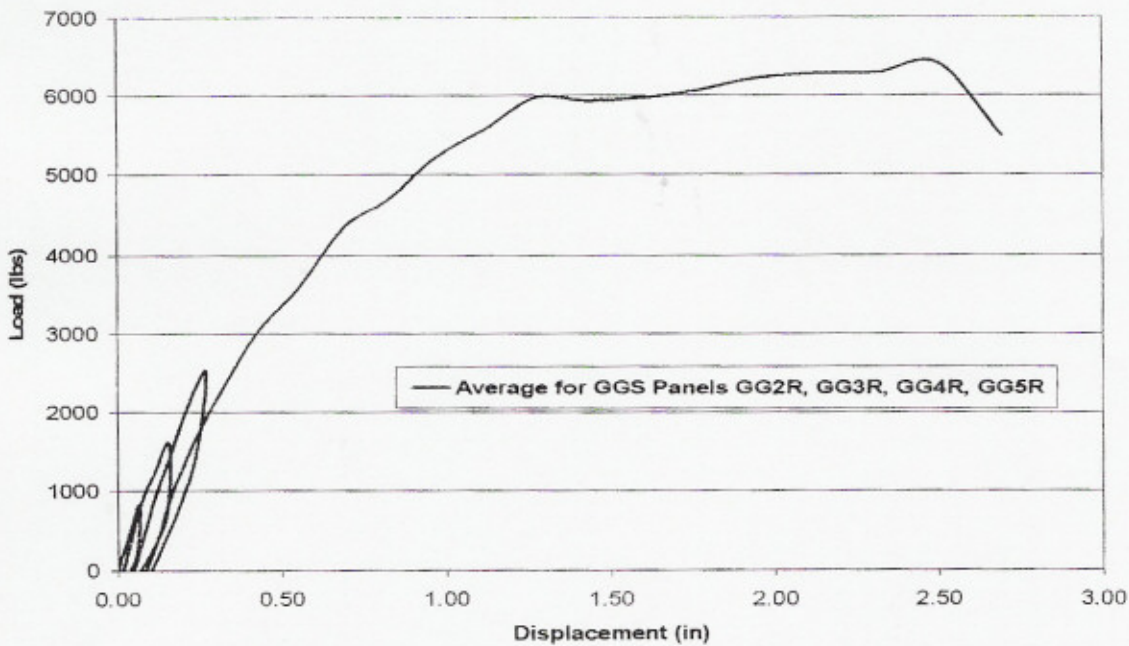Figure No. III-4: Results for Racking Load vs. Net Deflection for 8' GGS-GGS Panels

Figure No. III-5: Average Results for Racking Load vs. Net Deflection for 8' GGS-GGS Panels

Discussion of Results

Representative results for individual panels and for averages for skin sets subjected to racking loading are given in tables and figures referenced earlier. In these tables and figures, all panels in each skin set reveal similar load-deflection characteristics. That is, the in-plane shearing "stiffness" values (load/net deflection) are in the range of 2,000-3,500 lb./in. for these 8' panels.

The OSB panels were weaker than the GGS panels in terms of in-plane shearing stiffness. Calculations for these stiffness-type terms are presented below by choosing maximum load, P, and deflection, d, values from Table No.III-3. These stiffness-type numbers represent the average load required to generate 1" of deflection and can be seen as the slopes of the load-deflection curves.

Table No. III-6: Average In-Plane Shearing "Stiffness"				
Panel Type	Skin Orientation	Max. Load, P (lbs.)	Net Defl. d(in)	"Stiffness" k=P/d (lb/in)
8' OSB-OSB	OSB both faces	4897	2.14	2288
8' GGS-GGS	GGS both faces	6723	2.06	3263

Table No. III-7: Deflections at Key Loads						
	Load = 790 lbs.			Load = 1570 lbs.		
Panel Type	Avg. Max. Deflection (in.)	Avg. Set Deflection (in.)	Set Defl. as % of Max. Defl.	Avg. Max. Deflection (in.)	Avg. Set Deflection (in.)	Set Defl. as % of Max. Defl.
8' OSB-OSB	0.094	0.007	7%	0.300	0.042	14%
8' GGS-GGS	0.066	0.013	20%	0.150	0.050	33%

For the both sets, failure modes were similar. The GGS panels did not appear to tear as easily or bend the screws at easily as did the GGS panels at the nails. Thus, the GGS panels were able to carry load with slightly less deflection as compared to the OSB panels. Average set deflections after releasing 790 lbs. varied from 0.007" to 0.013". These average set deflections represent 7% to 20% of the actual deflections at 790 lbs. Average set deflections after releasing 1570 lbs. varied from 0.042" to 0.05". These average set deflections represent 14% to 33% of the actual deflections at 1570 lbs. For all panels, failure occurred most often because of tearing of the skins around the nails/screws, bending/shearing of the nails/screws, and/or crushing of the foam.

Conclusions

Considering the maximum load for the panel and a safety factor (failure load/allowable load) of 4.0, both the OSB and GGS panels can safely sustain typical in-plane shear loads applied to shear walls in low-rise buildings. As shown in Table No. III-8 below, loads causing net panel deflections of L/400, L/600, and L/800 are within the range of typical shear wall (due to wind) loads. The deflection (drift) limits shown are those commonly applied to buildings. caused by loads less than allowable racking loads for the OSB panels. GGS panels, however, must be limited to a drift of L/240.

Table No. III-8: Results at Key Deflections (Drift)				
Deflection (Drift) Limit (in.)	OSB-OSB Panels		GGS-GGS Panels	
	Load, P (lbs.)	Set Deflection (in.)	Load, P (lbs.)	Set Defection (in.)
H/400 = 0.240"	1500	~0.04	2200	~0.08
H/600 = 0.160"	1300	~0.03	1600	~0.05
H/800 = 0.120"	1200	~0.03	1300	~0.05

Note: "H" = the panel height, which is the same as the panel length, L = 8'-0"

Table No. III-9: Deflection Results at Allowable Loads				
Panel Type	Ultimate Load, P (lbs.)	Allowable Load, P/4 (lbs)	Deflection (in.) at Allowable Load	Set Defection (in.) After Allowable Load
8' OSB-OSB	4897	1224	0.120	~0.03
8' GGS-GGS	6723	1681	0.160	~0.05

As seen in Table Nos. III-8 and III-9, the OSB panels will limit building drift to approximately H/800 and the GGS panels will limit drift to approximately H/600 at their respective allowable loads, on an 8' high wall. For example, consider a 40'-0" square, 10'-0" high building subjected to a 20 psf wind loading. The wind load on any shear wall is 20 psf x 40'/2 x 10'/2 = 2000 lbs. Assuming half of any wall length (40'/2 = 20') is active as a shear wall, the shear load is resisted by 20' of a wall giving a shear load (per foot of length) on the wall of 2000 lbs / 20' = 100 plf . This load equates to 800 lbs. on a double panel (2 panels = 8' wide), well below the allowable loads shown above (1224 lbs. and 1681 lbs for OSB and GGS, respectively).
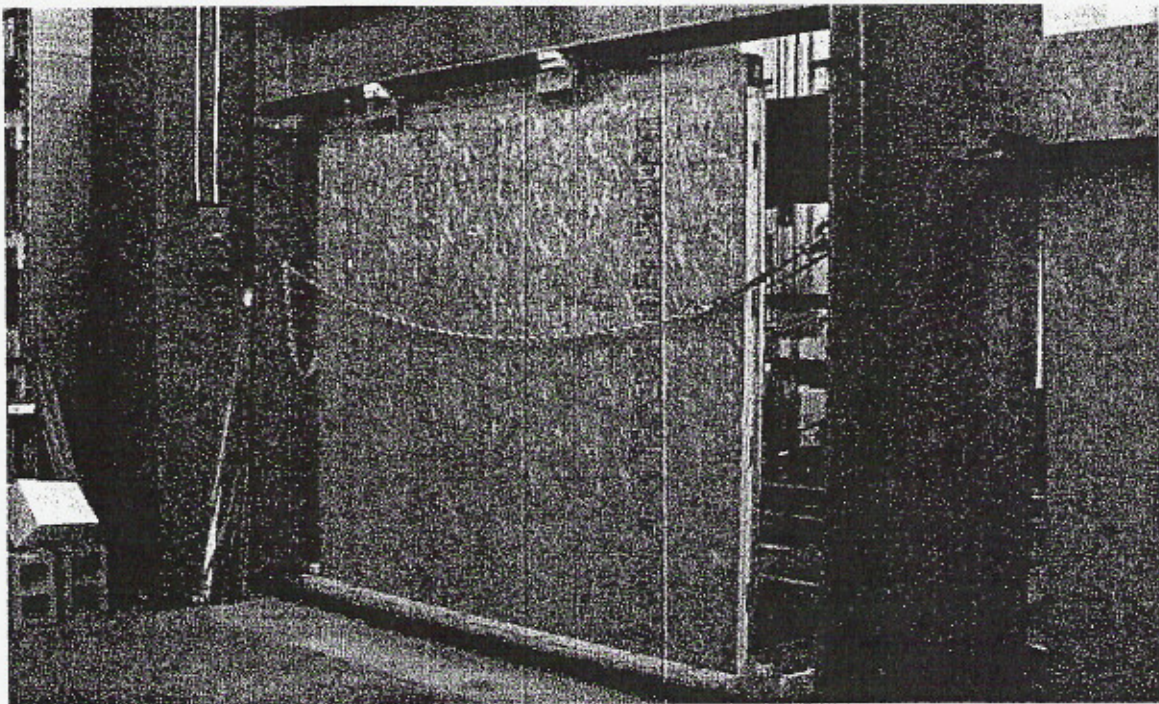
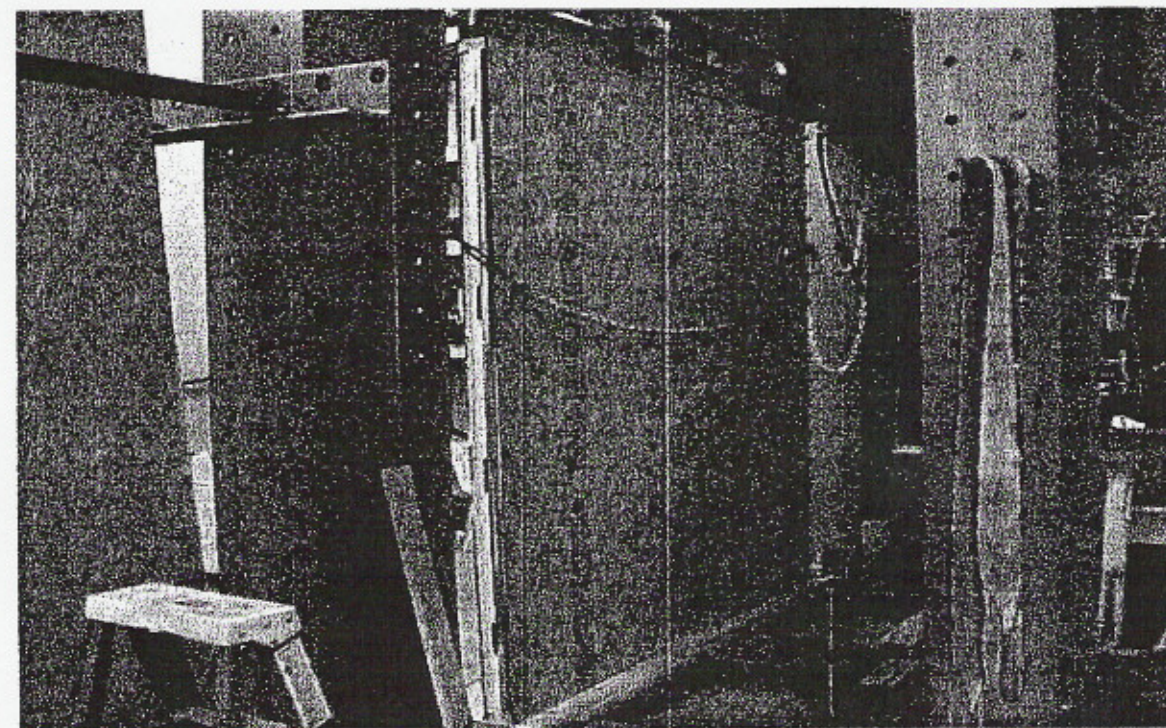Photo No. I-1: Test Setup for Racking Loading on 8' OSB-OSB Panel

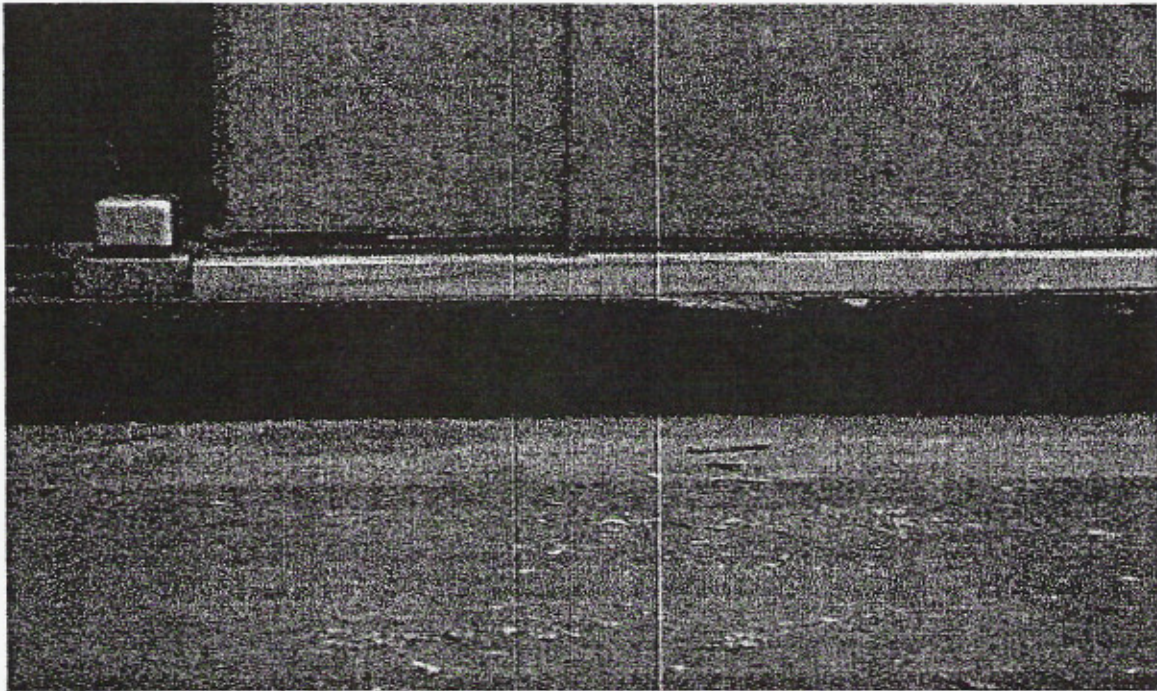Photo No. I-2: Response of 8' OSB-OSB Panel to Racking Loading

Photo No. I-3: Failure of 8' OSB-OSB Panel Under Racking Loading
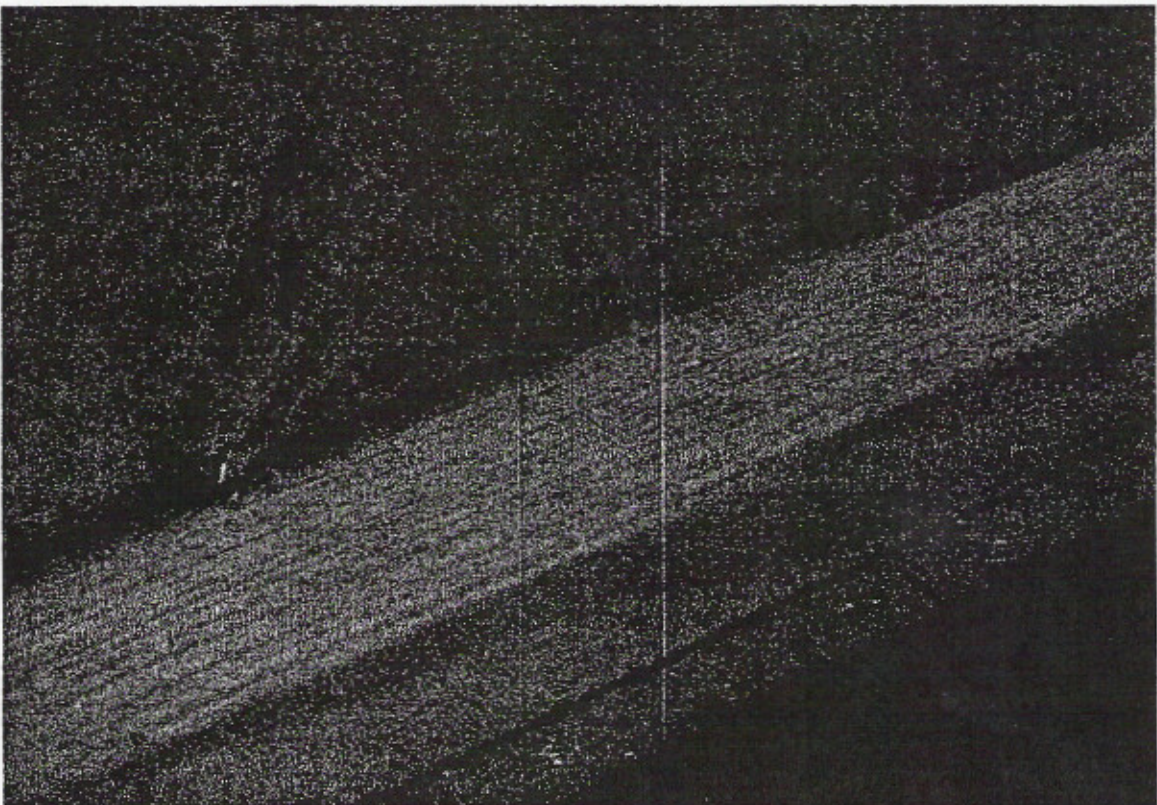

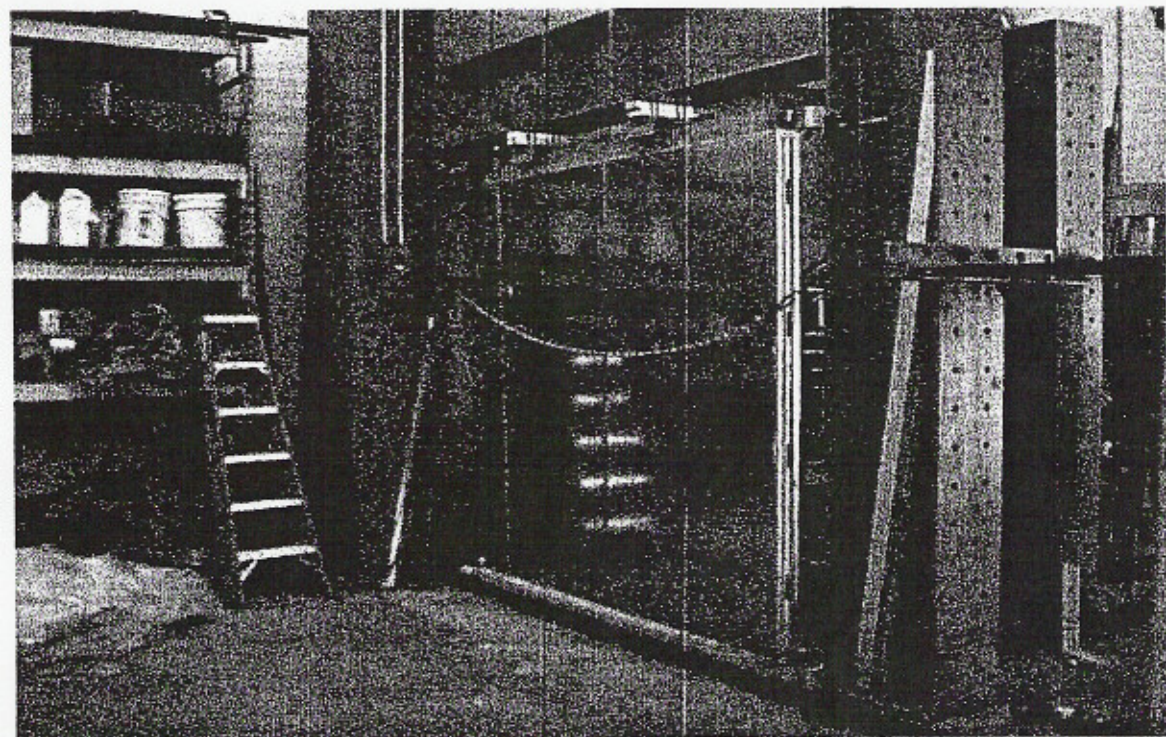Photo No. I-4: Closeup of Failure of 8' OSB-OSB Panel Under Racking Loading

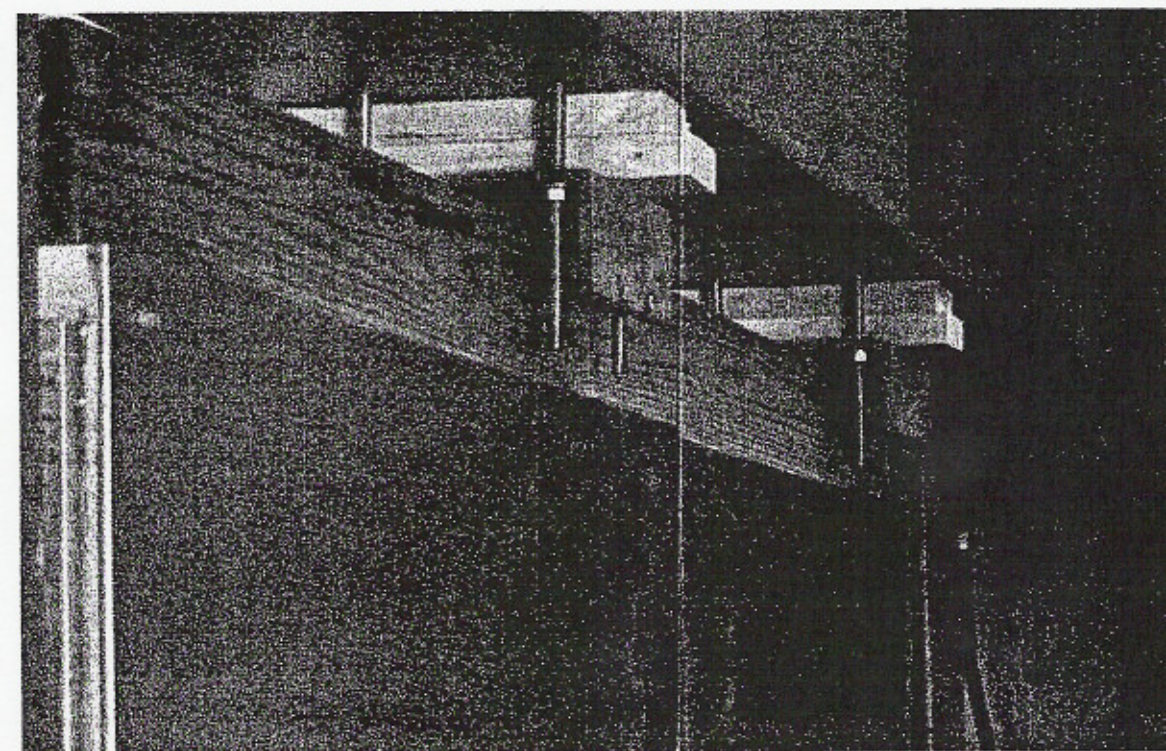Photo No. I-5: Test Setup for Racking Loading 8' Galv.-Galv. Panel

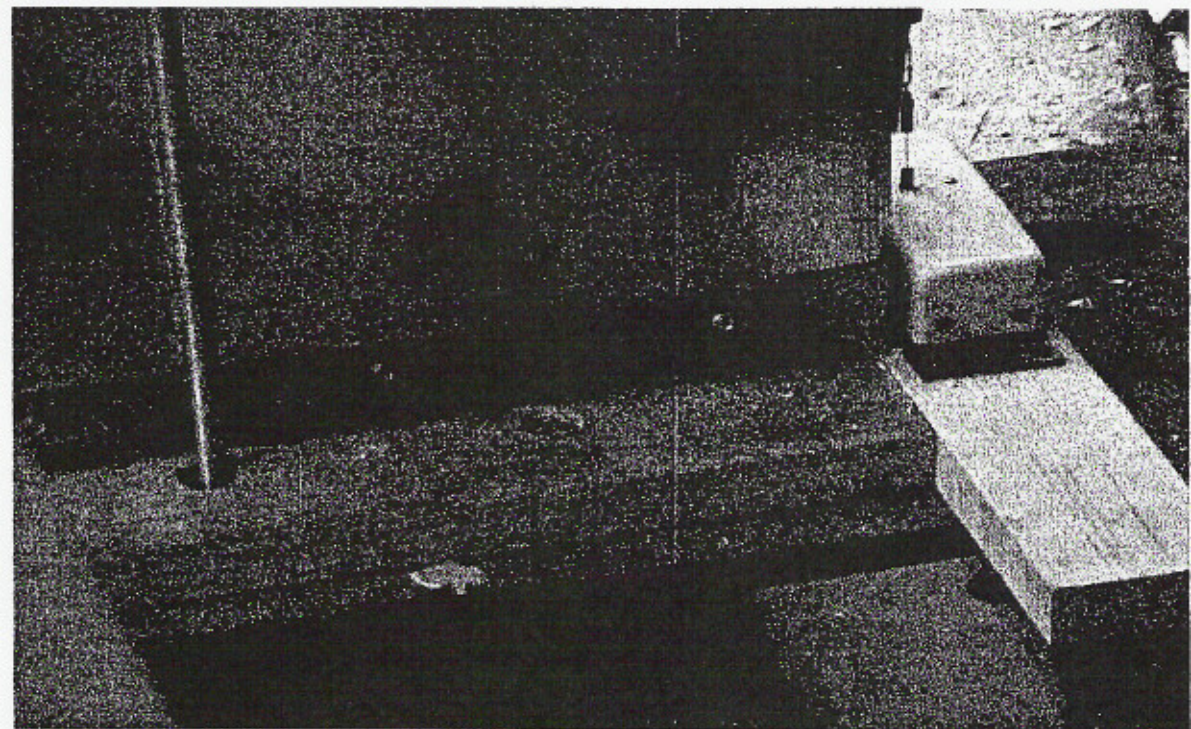Photo No. I-6: Response of 8' Galv.-Galv. Panel Under Racking Loading

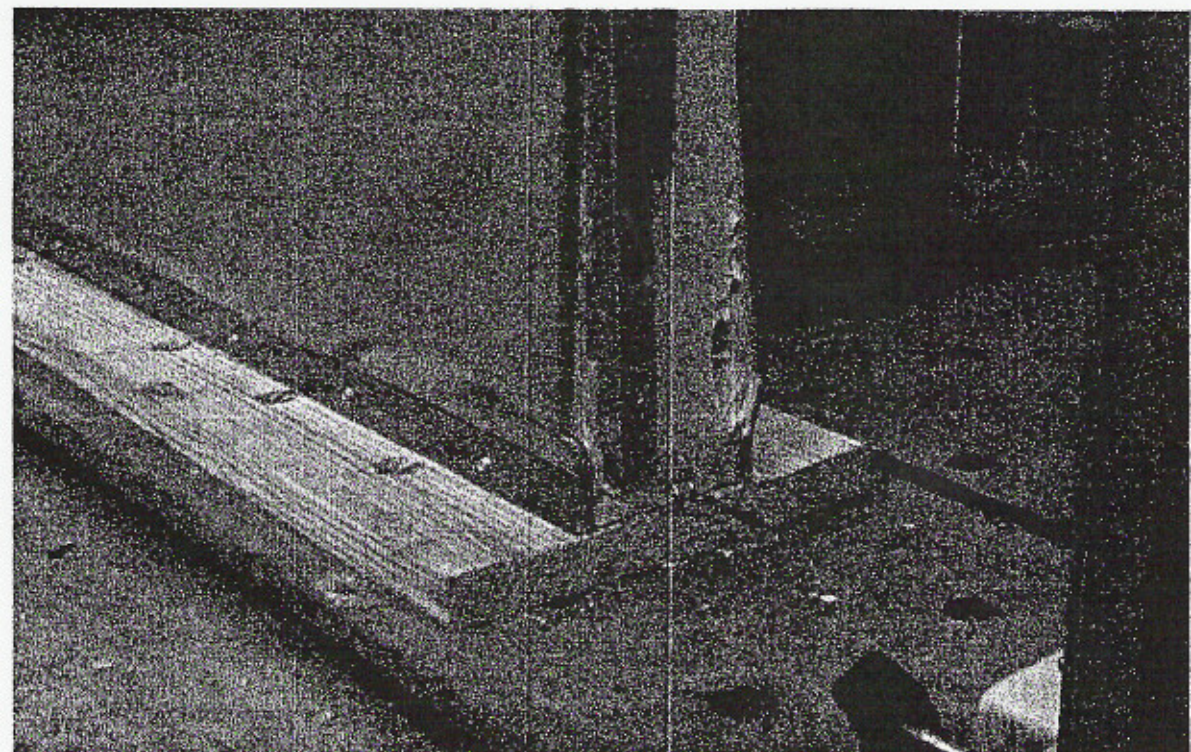Photo No. I-7: Failure of 8' Galv.-Galv. Panel Under Racking Loading

Photo No. I-8: Closeup of Failure of 8' Galv.-Galv. Panel Under Racking Loading