

PART II – COMPRESSIVE LOADING

Test Procedure

A uniform loading method as described in Section 9.3.1 of ASTM E 72-98 (see Figure II-1) was used to conduct compression loading tests. A hydraulic load cell was used to load a longitudinal steel beam placed at the top of each panel. The loading piston was centered on a line parallel to the panel skins and at one-third the panel thickness from the inside face. Each panel was preloaded by the weight of the top beam 74.6 lbs. Each panel was evaluated for one test, until panel failure occurred.

Four displacement transducers (DT's) were used to measure panel shortening. Wire cables were supported by brackets attached near the top and bottom corners of each panel, and the transducer cable was attached to the wire cables. The transducer gage length as 88" for the 8' panels. Two additional displacement transducers were used to measure lateral deflections at mid-height of the two longitudinal panel edges (in lieu of the deflectometer and mirror indicated in Figure No. II-1). These transducers were unattached to opposite faces of each panel. (See attached Figure No. II-1 and Photo No. II-1 for the test setup).

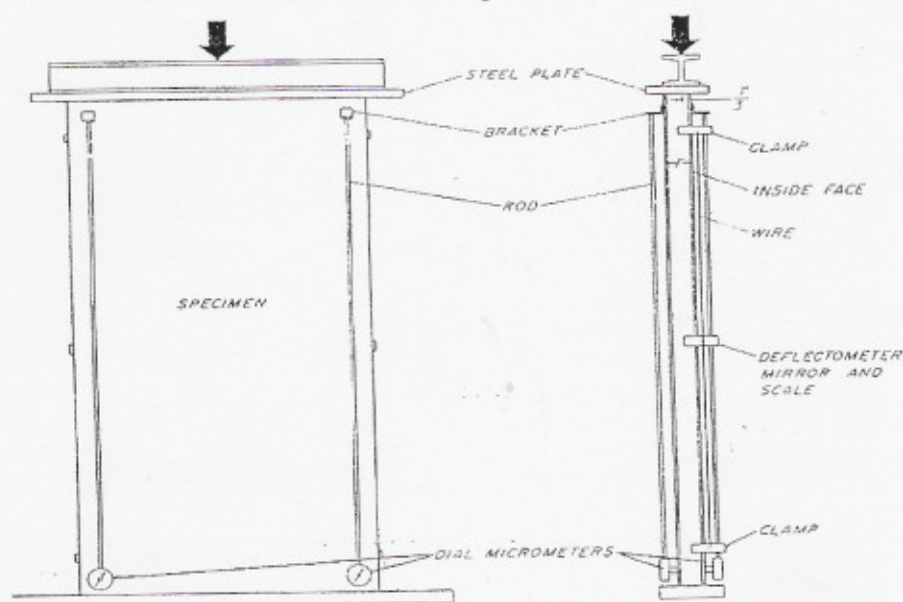


Figure No. II-1: Test Setup for Compressive (Axial) Loading (from "ASTM E72-98, Fig. 2")

Transverse load testing was performed on the following panels:

Panel Skins	Skin Orientation	Panel Size	No. of Samples	Sample Designations
OSB-OSB	OSB both faces	4' x 8'	3	OO1A, OO2A, OO3A
GGG-GGS	GGG both faces	4' x 8'	3	GG1A, GG2A, GG3A

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

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

OSB-OSB Tables No. II-1, II-3, and II-5

Figures No. II-2, II-3, II-4, II-5

GGG-GGS Tables No. II-2, II-4, and II-5

Figures No. II-6, II-7, II-8, II-9

The results include individual panel results indicated above as well as "average" results in Table No. II-5 and Figures No. II-3, II-5, II-7, and II-9. Maximum load and displacement values and descriptions of panels and failure modes are provided in Tables No. II-3 and II-4.

Table No. II-1: Results for Compressive Load vs. Deflections for Individual 8' OSB-OSB Panels

Panel OO1A 8'-0"		
Compr. Load (lbs)	Vert. Displ. Ends (in.)	Lat. Displ. Mid-Ht. (in.)
8	0.0000	-0.0003
1142	0.0021	-0.0015
2797	0.0062	-0.0169
3985	0.0091	-0.0259
6324	0.0167	-0.0417
9372	0.0254	-0.0426
10073	0.0281	-0.0415
11297	0.0321	-0.0416
14080	0.0406	-0.0396
16998	0.0497	-0.0370
21420	0.0633	-0.0343
25662	0.0761	-0.0276
29994	0.0897	-0.0171
34315	0.1045	-0.0068
38470	0.1176	0.0093
42330	0.1271	0.0226
46063	0.1399	0.0446
49525	0.1577	0.0709
52446	0.1788	0.1097
53891	0.2040	0.1623
53237	0.2171	0.1962

Panel OO2A 8'-0"		
Compr. Load (lbs)	Vert. Displ. Ends (in.)	Lat. Displ. Mid-Ht. (in.)
2	0.0002	-0.0003
675	0.0009	-0.0033
1676	0.0042	-0.0133
3021	0.0083	-0.0247
4701	0.0141	-0.0340
7613	0.0233	-0.0332
10968	0.0334	-0.0325
14877	0.0455	-0.0295
18214	0.0549	-0.0246
21214	0.0638	-0.0179
24287	0.0726	-0.0104
27512	0.0824	-0.0008
30827	0.0910	0.0109
34220	0.1020	0.0262
37685	0.1151	0.0431
41077	0.1279	0.0634
44412	0.1395	0.0902
47572	0.1529	0.1202
50421	0.1681	0.1563
52977	0.2030	0.2388
52743	0.2086	0.2585

Panel OO3A 8'-0"		
Compr. Load (lbs)	Vert. Displ. Ends (in.)	Lat. Displ. Mid-Ht. (in.)
18	0.0438	0.0000
600	0.0450	0.0005
1594	0.0468	-0.0086
3492	0.0517	-0.0179
3760	0.0531	-0.0187
3949	0.0545	-0.0190
4746	0.0569	-0.0228
5825	0.0599	-0.0269
7582	0.0631	-0.0333
9566	0.0723	-0.0341
12262	0.0817	-0.0381
15115	0.0898	-0.0341
18427	0.1012	-0.0301
22020	0.0858	-0.0223
25920	0.0923	-0.0119
29749	0.1041	0.0020
33597	0.1227	0.0244
37547	0.1387	0.0508
41709	0.1605	0.0879
45004	0.2051	0.1291
44745	0.2024	0.1311

Note: Compressive load does not include the weight of the load beam or the panels

Table No. II-2: Results for Compressive Load vs. Deflections for Individual 8' GGS-GGS Panels

Panel GG1A 8'-0"		
Compr. Load (lbs)	Vert. Displ. Ends (in.)	Lat. Displ. Mid-Ht. (in.)
1	0.0002	0.0019
3	0.0001	-0.0017
37	0.0004	-0.0005
40	0.0004	0.0004
108	0.0004	0.0005
272	0.0008	0.0012
645	0.0010	0.0029
1696	0.0019	0.0029
3425	0.0038	0.0124
6101	0.0071	0.0300
7237	0.0079	0.0327
7400	0.0079	0.0332
7589	0.0078	0.0342
7782	0.0081	0.0347
7946	0.0092	0.0427
8568	0.0098	0.0442
9376	0.1530	0.0598
7140	0.0738	0.1319
7752	0.1034	0.1632
7608	0.1631	0.2054
5266	0.2941	0.4117

Panel GG2A 8'-0"		
Compr. Load (lbs)	Vert. Displ. Ends (in.)	Lat. Displ. Mid-Ht. (in.)
0	0.0000	0.0003
38	0.0002	-0.0007
631	-0.0006	-0.0003
2302	-0.0023	0.0030
3819	-0.0033	0.0089
5698	-0.0053	0.0148
7198	-0.0045	0.0210
7537	-0.0011	0.0242
7646	0.0024	0.0256
7782	0.0020	0.0260
8681	0.0033	0.0265
9444	0.0051	0.0294
10152	0.0046	0.0315
11047	0.0102	0.0346
11942	0.0155	0.0359
12769	0.0272	0.0322
13380	0.0431	0.0280
12595	0.0726	0.0227
11496	0.1581	0.0099
10285	0.2097	0.0075
10215	0.2114	0.0091

Panel GG3A 8'-0"		
Compr. Load (lbs)	Vert. Displ. Ends (in.)	Lat. Displ. Mid-Ht. (in.)
3	-0.0001	-0.0001
1427	-0.0025	0.0008
2375	-0.0059	-0.0002
3196	-0.0074	0.0047
3309	-0.0076	0.0048
3441	-0.0075	0.0058
4427	-0.0082	0.0082
5552	-0.0085	0.0102
6846	-0.0093	0.0131
7396	-0.0089	0.0131
7646	-0.0090	0.0137
8168	-0.0089	0.0130
9238	-0.0063	0.0126
9979	0.0017	0.0063
9815	0.0365	0.0054
10929	0.0502	0.0052
12662	0.0626	0.0090
14511	0.0757	0.0106
16346	0.0849	0.0108
17343	0.0904	0.0074
16589	0.0732	-0.0066

Note: Compressive load does not include the weight of the load beam or the panels

TABLE No. II-3: COMPRESSION TEST RESULTS FOR 8' OSB-OSB PANELS

(does not include the weight of the load beam or the self-weight of the panels)

SAMPLE NO.	PANEL SIZE	GAUGE LN (IN.)	MAX LD. (LBS.)	DEFL. AT MAX. LOAD.		FAILURE CHARACTERISTICS
				VERT (IN.)	HORZ (IN.)	
OO1A	48" x 96"	88	53891	0.2040	0.1623	Panels failed by some combination of OSB buckling, galvanized steel spine buckling, and/or foam crushing near top of panel.
OO2A	48" x 96"	88	52977	0.2030	0.2388	
OO3A	48" x 96"	88	45004	0.2051	0.1291	
AVERAGE			50624	0.2040	0.1767	Load Beam Wt. = 119.8 lbs. Avg. Panel Wt. = 135.1 lbs. (range = 134.5 to 135.7 lbs.)

TABLE No. II-4: COMPRESSION TEST RESULTS FOR 8' GGS-GGS PANELS

(does not include the weight of the load beam or the self-weight of the panels)

SAMPLE NO.	PANEL SIZE	GAUGE LN (IN.)	MAX LD. (LBS.)	DEFL. AT MAX. LOAD.		FAILURE CHARACTERISTICS
				VERT (IN.)	HORZ (IN.)	
GG1A	48" x 96"	88	9376	0.1530	0.0598	Panels failed by some combination of FCB buckling, OSB cracking, skins pulling away from foam, galvanized steel spine buckling, and/or foam crushing near top of panel.
GG2A	48" x 96"	88	13380	0.0431	0.0280	
GG3A	48" x 96"	88	17343	0.0904	0.0074	
AVERAGE			13366	0.0956	0.0317	Load Beam Wt. = 119.8 lbs. Avg. Panel Wt. = 114.8 lbs (range = 114.5 to 115.1 lbs.)

Table No. II-5: Average Results for Compressive Load vs. Deflections for 8' Panel

8' OSB-OSB Panels OO1A, OO2A, OO3A		
Avg. Compr. Load (lbs.)	Avg Vert. Displ. Ends (in.)	Avg. Lat. Displ. Mid-Ht. (in.)
10	0.0146	-0.0002
806	0.0160	-0.0014
2022	0.0191	-0.0129
3499	0.0230	-0.0228
4928	0.0280	-0.0314
6978	0.0344	-0.0316
8596	0.0395	-0.0323
10666	0.0458	-0.0327
13292	0.0529	-0.0325
15926	0.0619	-0.0297
19323	0.0725	-0.0276
22763	0.0828	-0.0208
26416	0.0940	-0.0121
30185	0.0974	-0.0010
34025	0.1083	0.0135
37718	0.1197	0.0293
41358	0.1340	0.0531
44881	0.1497	0.0806
48192	0.1691	0.1180
50242	0.2094	0.1952

8' GGS-GGS Panels GG1A, GG2A, GG3A		
Avg. Compr. Load (lbs.)	Avg Vert. Displ. Ends (in.)	Avg. Lat. Displ. Mid-Ht. (in.)
1	0.0000	0.0007
489	-0.0007	-0.0005
1014	-0.0021	-0.0004
1846	-0.0031	0.0027
2412	-0.0035	0.0047
3137	-0.0040	0.0072
4090	-0.0039	0.0107
4928	-0.0026	0.0125
5972	-0.0010	0.0170
7093	0.0000	0.0230
7855	0.0007	0.0243
8337	0.0013	0.0252
8993	0.0020	0.0261
9603	0.0067	0.0252
9901	0.0204	0.0280
10755	0.0290	0.0272
11061	0.0598	0.0563
11619	0.0839	0.0655
11817	0.1354	0.0754
10690	0.1929	0.1381

Note: Compressive load does not include the weight of the load beam or the panels

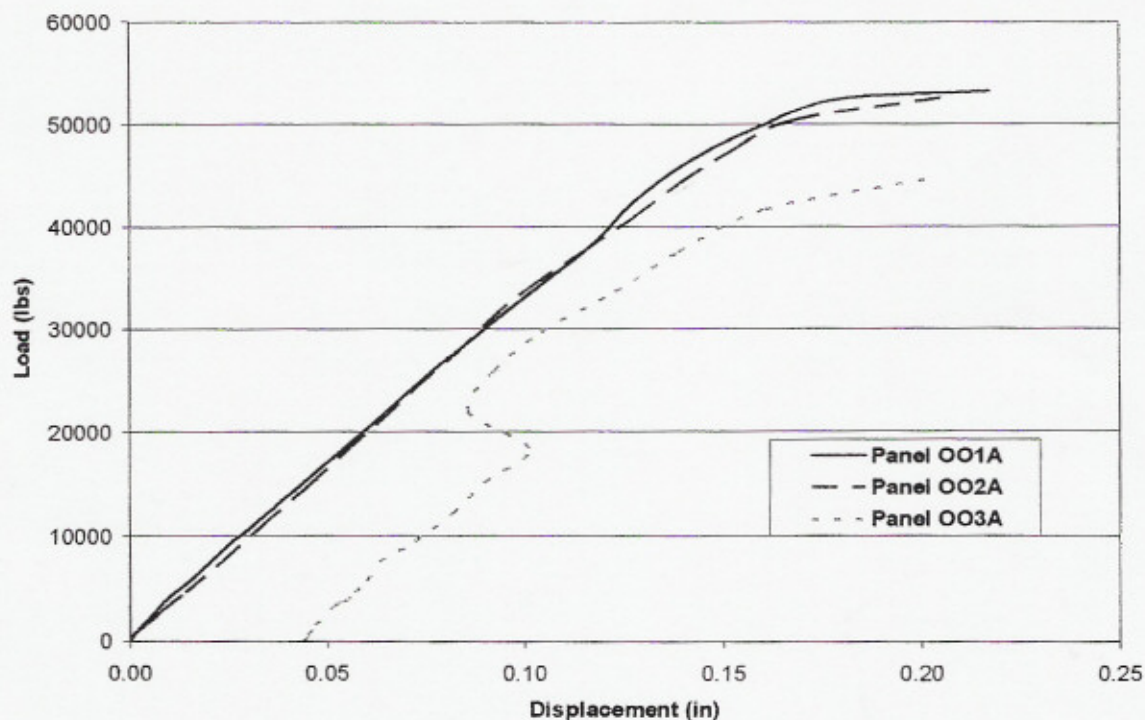


Figure No. II-2: Results for Compressive Load vs. End Deflection for 8' OSB-OSB Panels

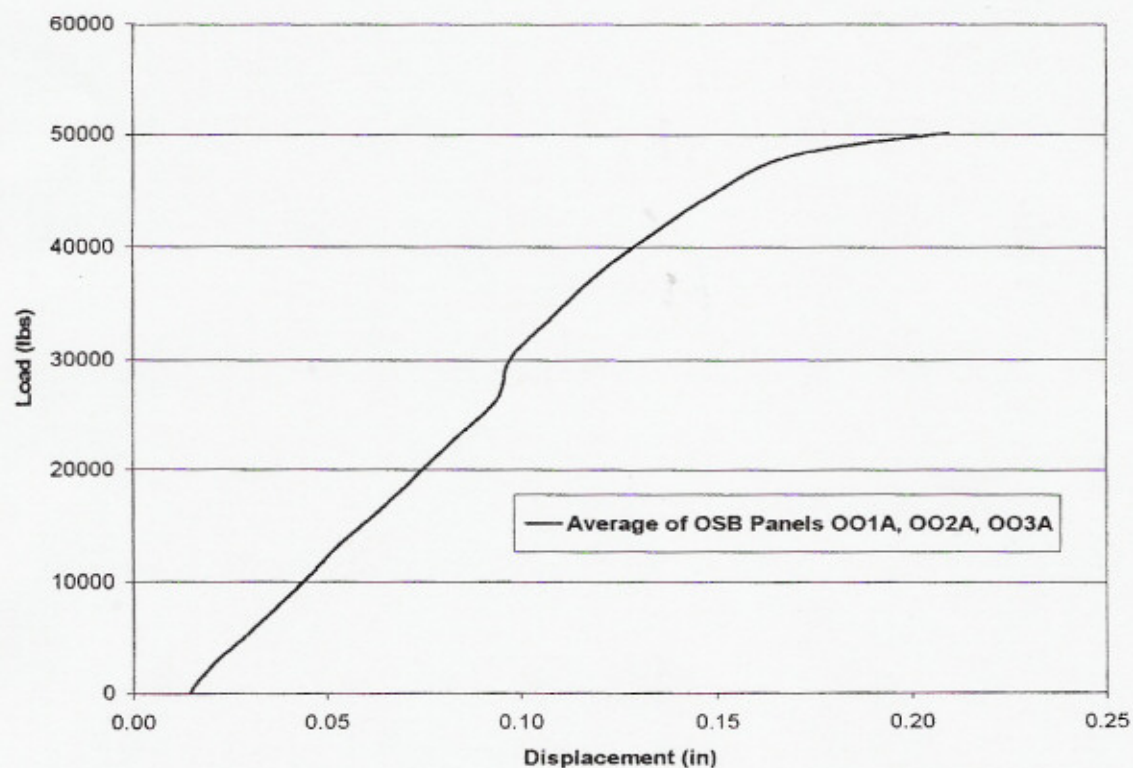


Figure No. II-3: Average Results for Compressive Load vs. End Deflection. 8' OSB-OSB Panels

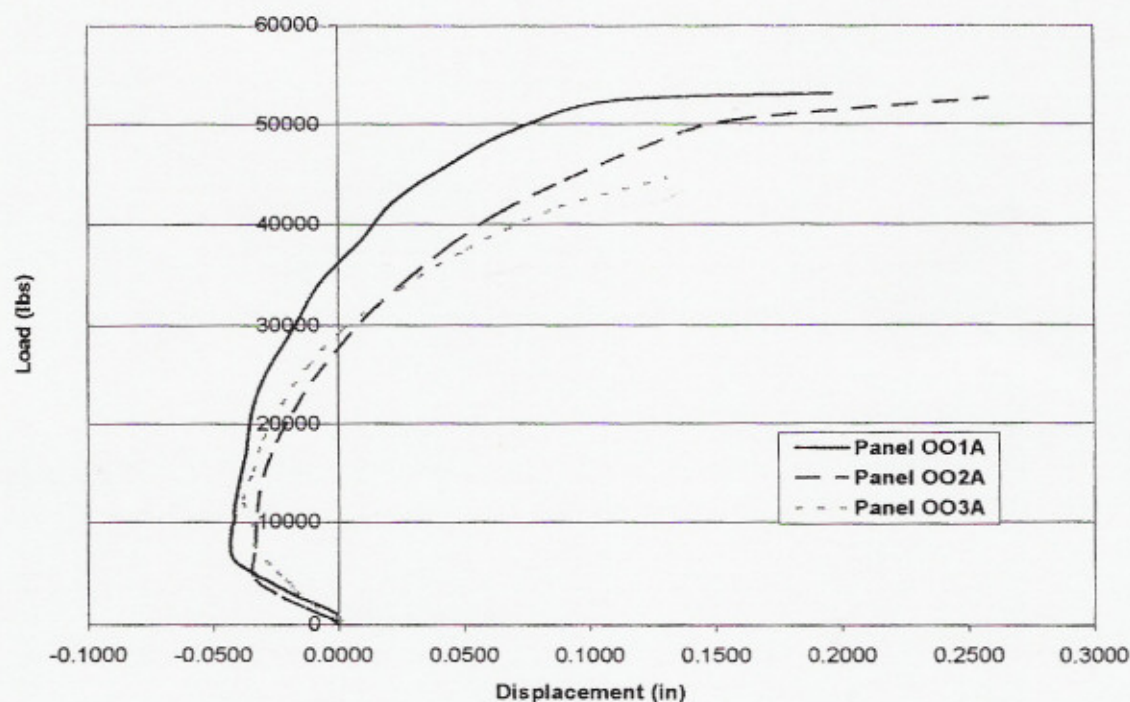


Figure No. II-4: Results for Compressive Load vs. Mid-Ht. Deflection for 8' OSB-OSB Panels

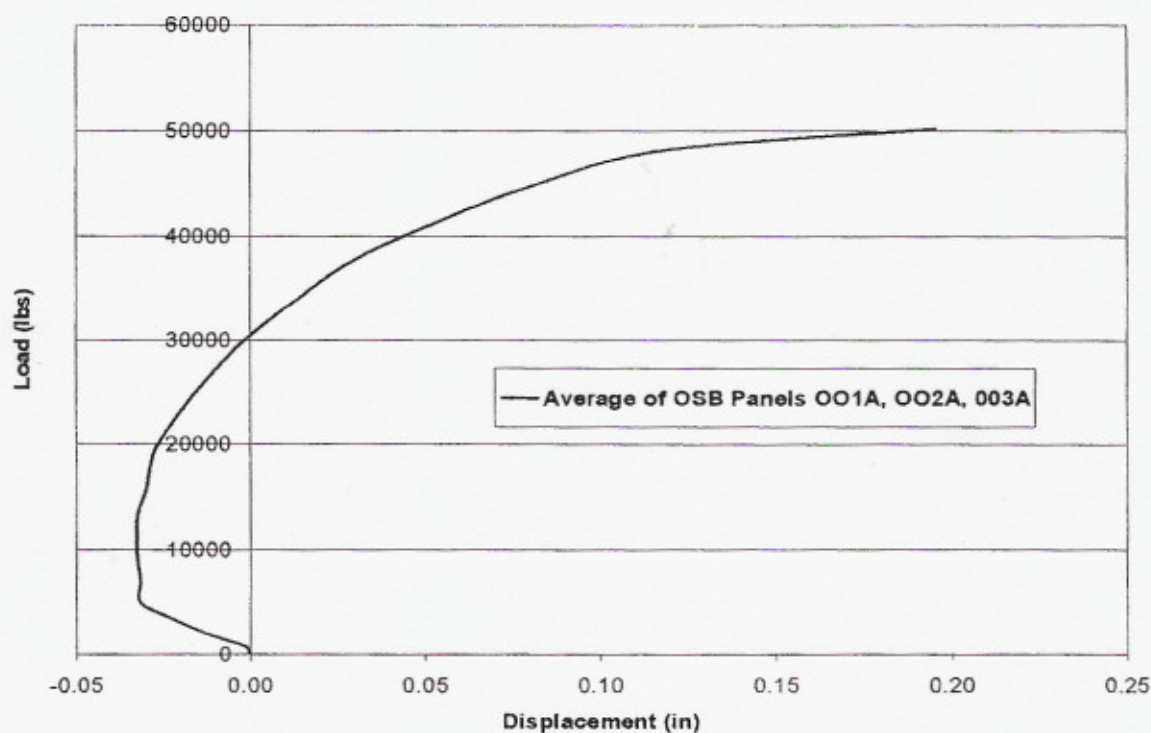


Figure No. II-5: Average Results, Compressive Load vs. Mid-Ht. Deflection, 8' OSB-OSB Panel

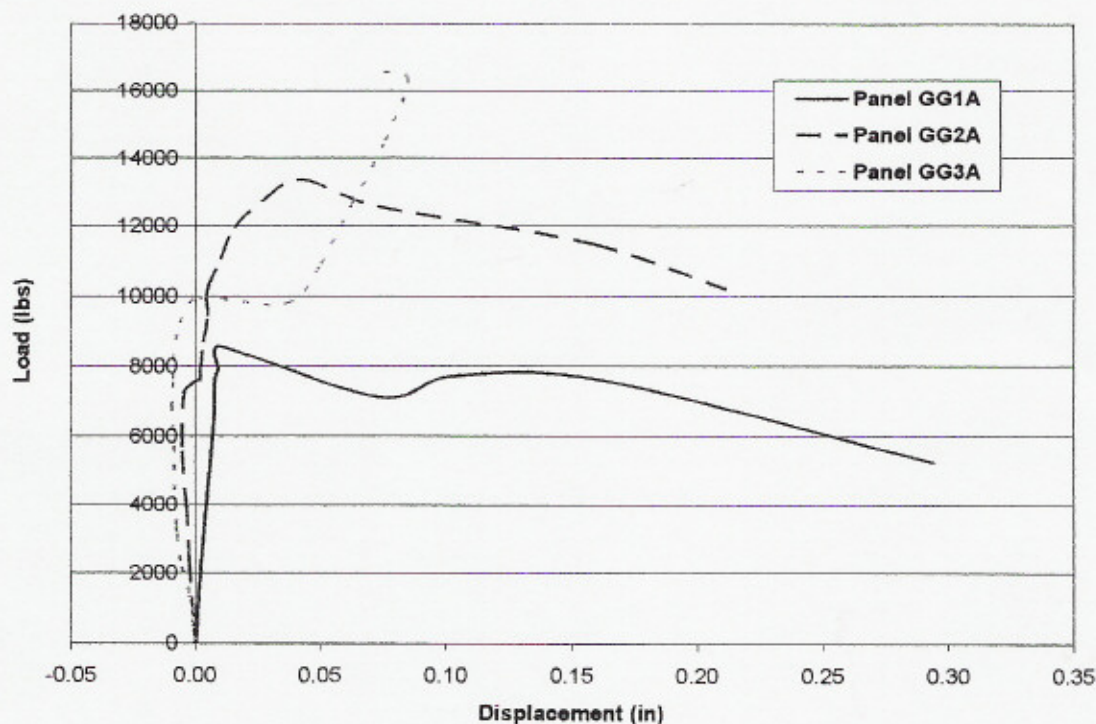


Figure No. II-6: Results for Compressive Load vs. End Deflection for 8' GGS-GGS Panels

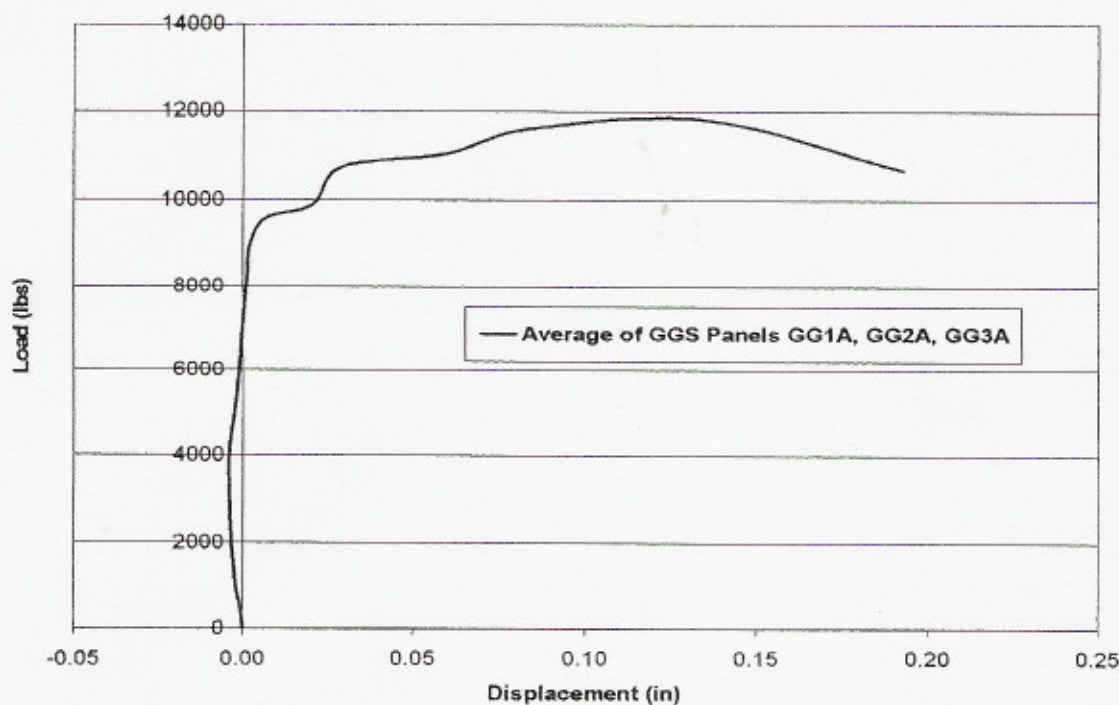


Figure No. II-7: Average Results for Compressive Load vs. End Deflection, 8' GGS-GGS Panels

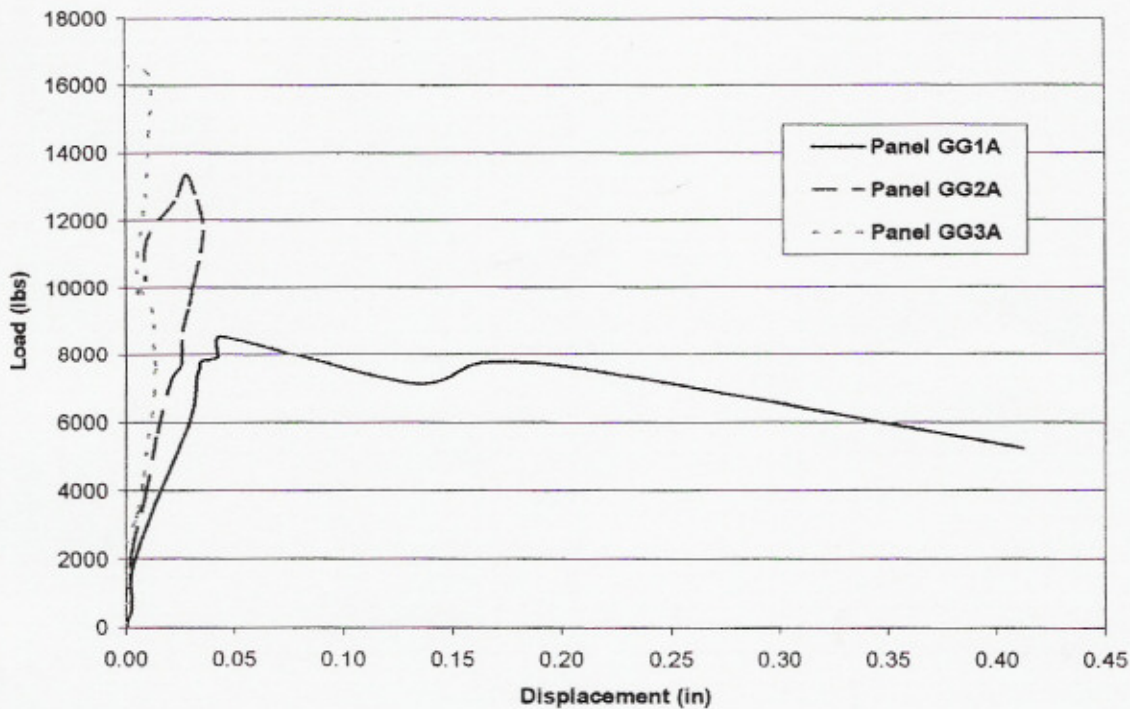


Figure No. II-8: Results for Compressive Load vs. Mid-Ht. Deflection for 8' GGS-GGS Panels\

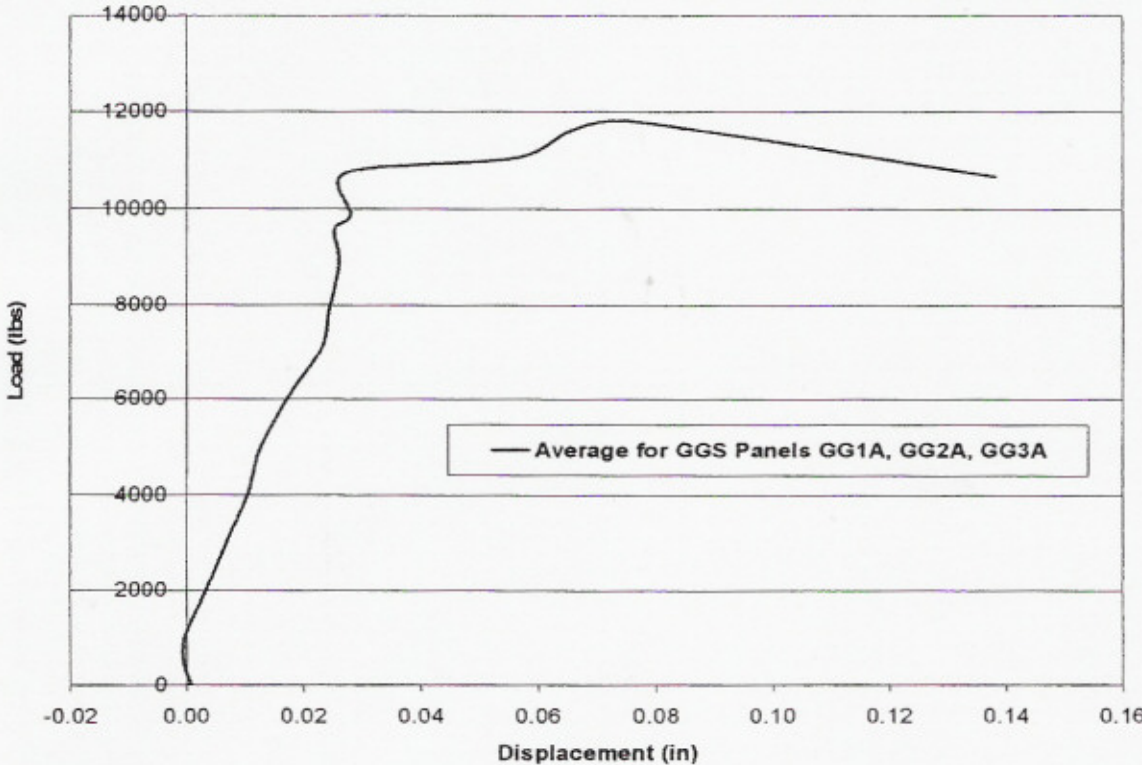


Figure No.II-9: Average Results, Compressive Load vs. Mid-Ht. Deflection, 8' GGS-GGS Panel

Discussion of Results

Representative results for individual panels and for averages for skin sets subjected to compressive loading are given in tables and figures referenced earlier. Of particular interest are the compressive "stiffness" values (load/vertical deflection). For example, for OSB-OSB panels #1A and #2A, stiffness values are in the vicinity of 300,000 lb./in., as shown in Table No. II-5. In Figure No. II-2, OSB-OSB panel #3A has a sudden change in the load-deflection curve around 20,000 lbs. that could be the result of the panel "seating" under load. Outside of this abnormal portion of the curve, the slope (stiffness) is similar to panels #1A and #2A.

GGS panels #2 and #3 exhibit zero or slightly negative vertical displacements under low loading. Thus, using only GGS panel #1A, stiffness can be calculated as shown in Table No. II-5 to be ~ 900,000 lb./in. or three times that of the OSB panels. This result is not surprising due to the stiffer steel skins on the GGS panels.

Ultimate compressive strains are in the range of 0.001 to 0.002 for these panels. Calculations for these strains are presented below based on the ultimate (failure) deflections given in Table Nos. II-3 and II-4 and gauge lengths of 88" for these 8' panels. Once again, the OSB panels are not as stiff as panels containing GGS skins, and, thus, they exhibit more strain.

Lateral "stiffness" values for these panels are more difficult to determine because of the load-deflection curves possess a high degree of non-linearity. However, selecting values at similar load points offers an indication of lateral stiffness. Stiffness terms calculated near the 6000 lb. load point are shown in Table No. II-6. The OSB-panels are once again weaker, this time in terms of lateral stiffness. These stiffness-type numbers represent the average load required to generate 1" of deflection and also represent the slopes of the load-deflection curves.

Table No. II-5: Average Compressive "Stiffness" and Strain Values for Panel Sets					
Panel Type	Skin Orientation	Load, P (lbs.)	Vertical Defl., d (in)	"Stiffness" $k=P/d$ (lb/in)	Ultimate Normal Strain (in/in)
8' OSB-OSB	OSB both faces	26,587	0.0793	335,271	0.0023
8' GGS-GGS	GGS both faces	3425	0.0038	901,316	0.0011

Table No. II-6: Average Lateral "Stiffness" for Panel Sets				
Panel Type	Skin Orientation	Load P (lbs.)	Lateral Defl. d(in)	"Stiffness" $k=P/d$ (lb/in)
8' OSB-OSB	OSB both faces	6978	0.0316	220,823
8' GGS-GGS	GGS both faces	7093	0.0230	308,391

Table No. II-7: Average Failure Loads		
Panel Type	Skin Orientation	Load, P_u (lbs.)
8' OSB-OSB	OSB both faces	50,624
8' GGS-GGS	GGS both faces	13,366

Although the panels having galvanized skins were stiffer than those having OSB skins, the OSB skin panels carried more load to failure. That is, more axial load was required to cause a certain amount of vertical and lateral deflection in the steel panels, but, even though they deflected more, the OSB panels carried more load before failing. For all panels, failure occurred most often because of crushing of the foam, buckling of the compression ("e" side) skin, pulling away of the skins from the foam, and/or buckling of the aluminum spline along the panel edge.

It is unclear why panel #GG1A produced a failure load significantly less than the other two galvanized steel panels. Nevertheless, until other GGS panels are tested in compression, the results of this panel must be included in the averaging of results.

Conclusions

Table No. II-8 below summarizes load, deflection, and strain results at calculated maximum allowable loads. Calculating the maximum axial load for each panel using a safety factor (failure load/allowable load) of 4.0, both the OSB panels and the GGS panels are able to safely carry typical axial loads resulting from roof gravity loads. For example, a 40' wide, roof-trussed building carrying a total roof load of 30 psf would apply 600 plf axial load to the wall panels. This value is less than the calculated maximum allowable values of 3164 plf for OSB panels and 836 plf for GGS (galvanized steel) panels. Also, lateral deflections in the panels (due to the load eccentricity) of L/2945 for OSB panels and L/12200 for GGS panels at allowable loads are well within recommended deflection limits (L/360, for example).

Table No. II-8: Strains and Deflections at Allowable Loads						
Allowable Line Load, P_a (plf)	OSB-OSB Panels			GGS-GGS Panels		
	Vertical Deflection (in.) and [Strain] (in./in.)	Lateral Defl. (in.)	Lat. Defl. as L/xxx	Line Load (plf = $P/4'$)	Lateral Defl. (in.)	Lat. Defl. as L/xxx
3164	0.0512 [0.058%]	0.0326	L/2945	N/A	N/A	N/A
836	N/A	N/A	N/A	0.0040 [0.004%]	0.0079	L/12200
Average Loads (S.F. = 4.0)	Failure Load, P_f (plf)	Allowable Load, $P_a = P_f/4$ (plf)		Failure Load (plf)	Allowable Load (plf)	
	12,656	3164		3342	836	

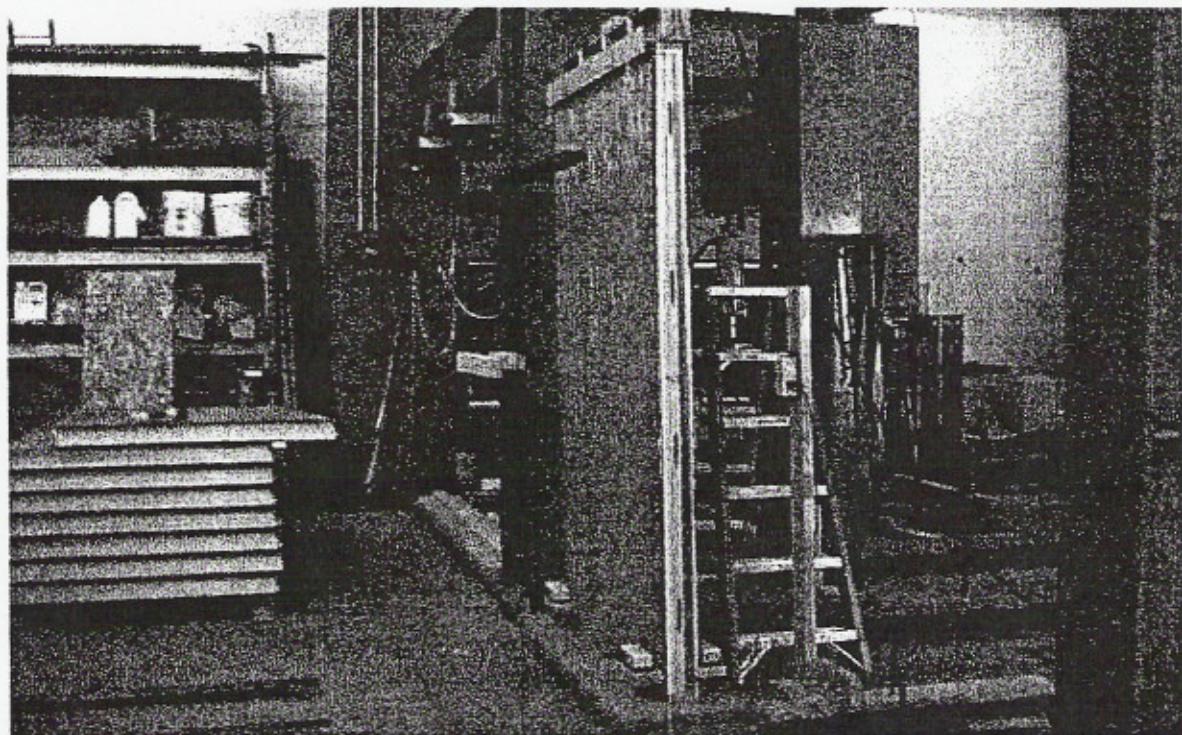


Photo No. I-1: Test Setup for Compressive Loading on 8' OSB-OSB Panel

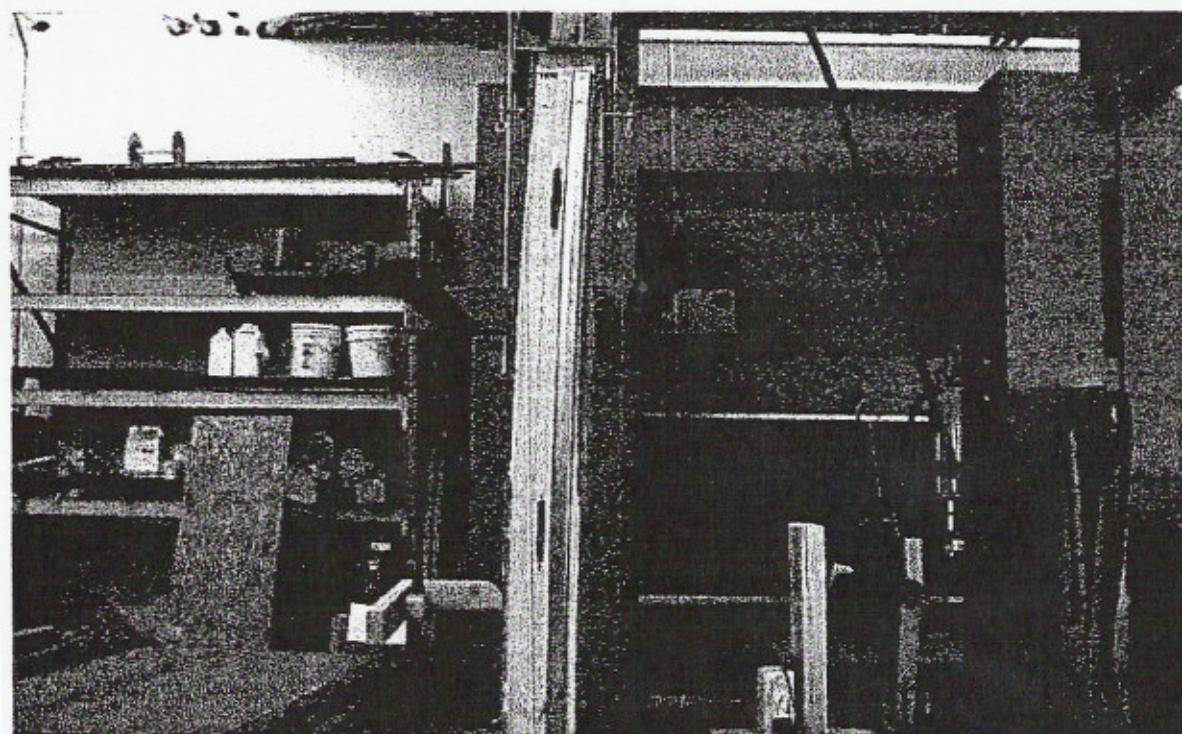


Photo No. I-2: Response of 8' OSB-OSB Panel to Compressive Loading

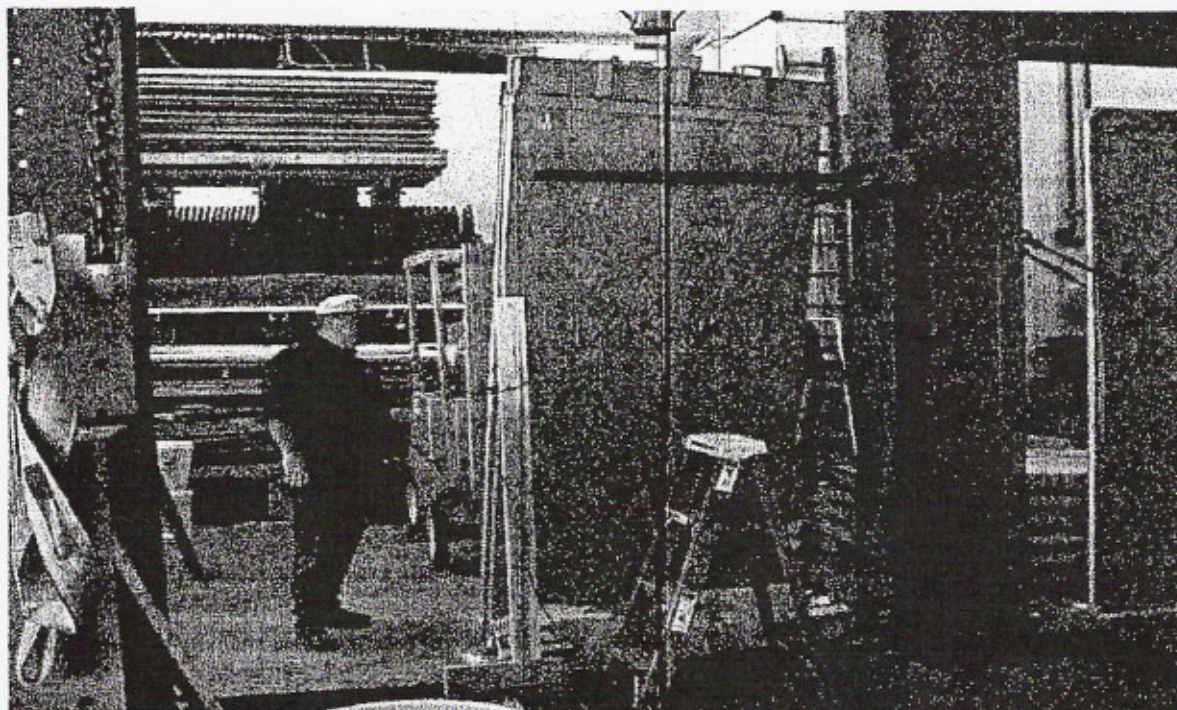


Photo No. I-3: Failure of 8' OSB-OSB Panel Under Compressive Loading



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

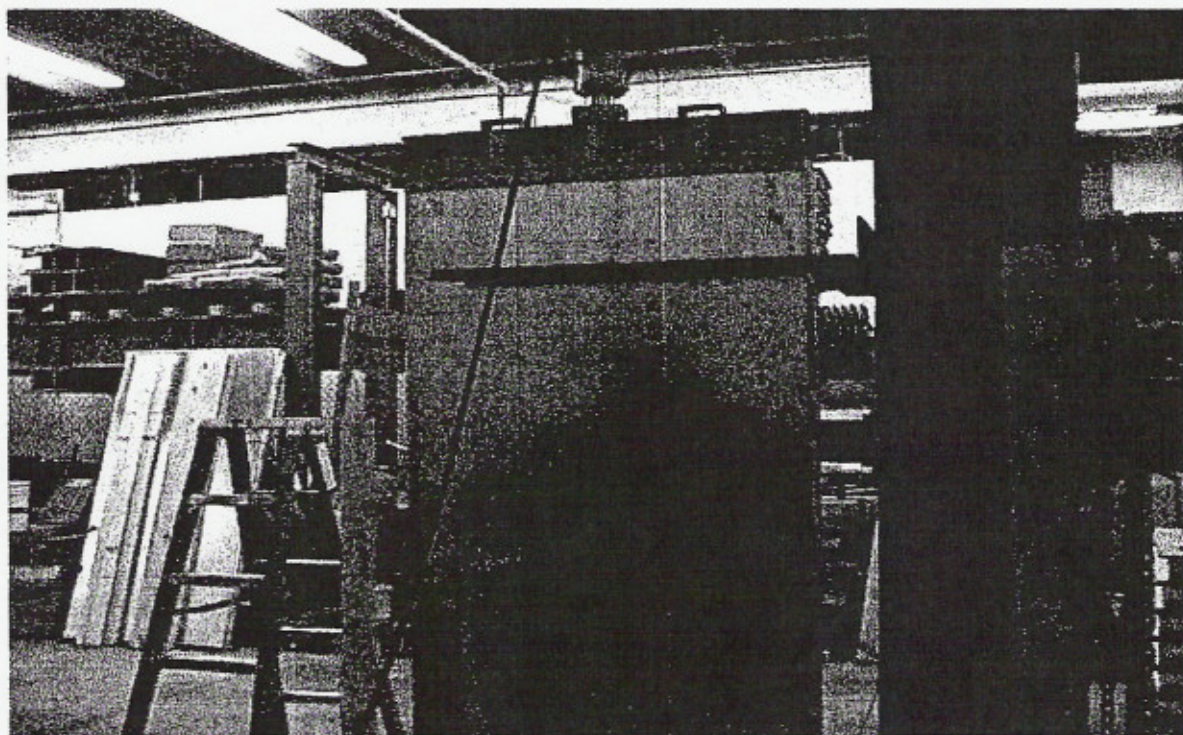


Photo No. I-5: Test Setup for Compressive Loading 8' Galv.-Galv. Panel

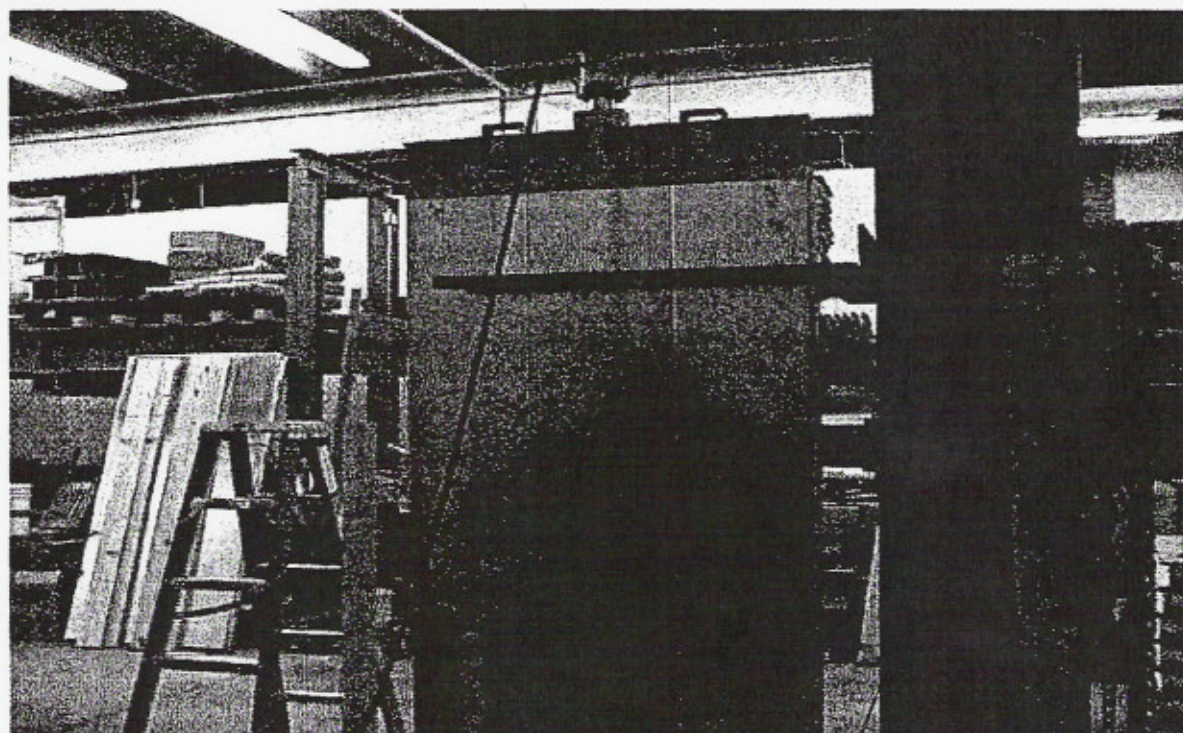


Photo No. I-6: Response of 8' Galv.-Galv. Panel Under Compressive Loading

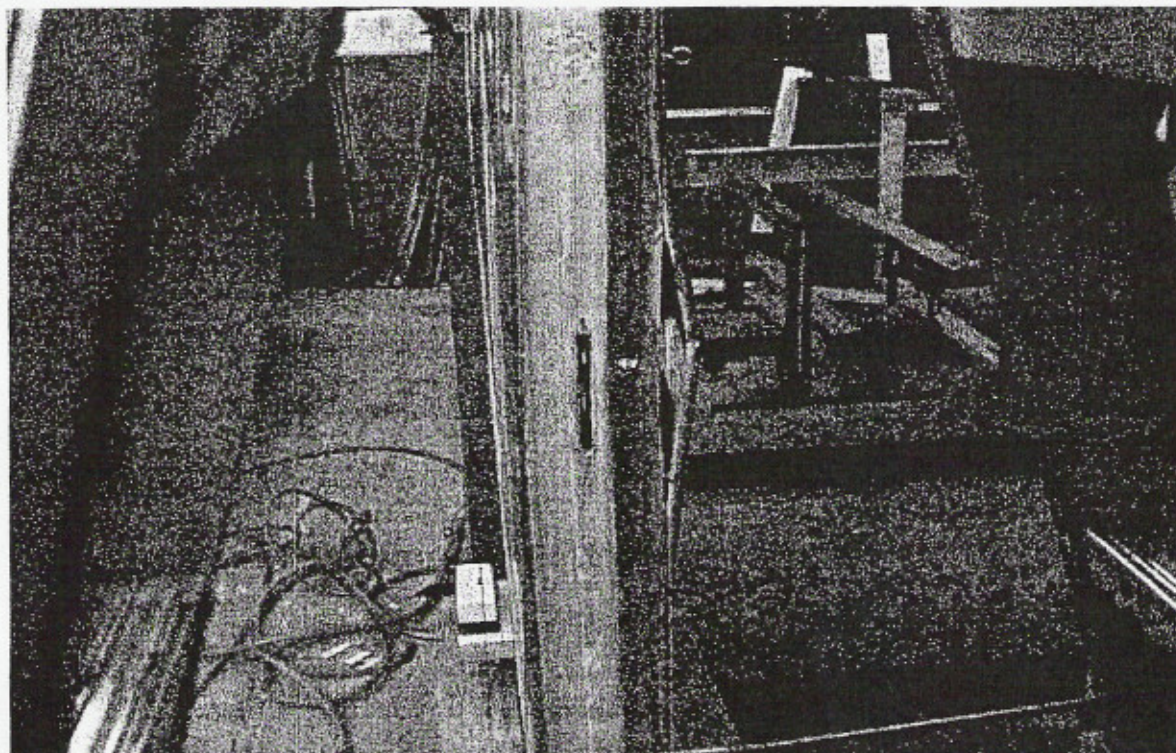


Photo No. I-7: Failure of 8' Galv.-Galv. Panel Under Compressive Loading



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