Young Engineering, Inc.
9928 Raddington Lane
Charlotte, NC, 28269
(704) 549-9987

Mr. Andy Hansen
Insulated Component Structures, Inc.
323 Farmington Road
Mocksville, NC 27028

July 22, 2002

Dear Andy,

Attached is the report, "Results of Load Testing on Insulated Wall Panels Having OSB or Galvanized Steel Outer Skins." The report summarizes research and testing conducted at UNC Charlotte in March, 2002 under the supervision of Young Engineering, Inc. on insulated wall panel samples provided by Insulated Component Structures (ICS). Research and testing was conducted to evaluate panel behavior under transverse loading, compressive loading, and racking loading. This evaluation is required to satisfy requests for information from ICS clients and from building officials.

All work was performed in accordance to ASTM E72-98 "Standard Methods of Conducting Strength Tests of Panels for Building Construction." Testing was conducted on two sets of panels: one set having both skins of oriented strand board (OSB) and one set having both skins of 24 gauge galvanized steel (GGS).

I have enclosed 1 bound copy of the report for ICS and an unbound set of originals in case you want to make other copies.

It has been a pleasure working with you, and please let me know if you have questions or comments.

Sincerely,

David T. Young

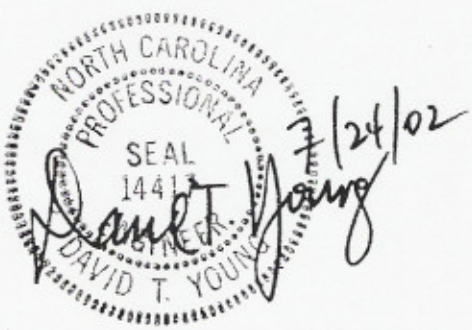
David T. Young, Ph.D., P.E.

Results of Load Testing
on
Insulated Wall Panels
Having OSB or Galvanized Steel Outer Skins

tested for
Insulated Component Structures, Inc.
Mocksville, NC

tested at
The Structures Materials Laboratory
The William States Lee College of Engineering
The University of North Carolina at Charlotte

directed by
David T. Young, Ph.D., P.E.
Young Engineering, Inc.
Charlotte, NC



July 22, 2002

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PART I - TRANSVERSE LOAD TESTING

Test Procedure

The two-point (quarter span) loading method as described in Section 11.3.1 of ASTM E 72-98 (see Figure No. I-1) was used to conduct transverse (bending) loading tests. A 50,000 lb. hydraulic jack and 50,000 lb. load cell were used to load a longitudinal steel beam supported by two transverse beams (with rollers) placed at quarter spans of the panels. Each panel was evaluated for one test, to panel failure. On all panels, two displacement transducers (DT) were used to measure midspan panel deflections. The DT's were attached to the supporting (stationary) load frame with each DT located approximately 5" from each edge of the panel.

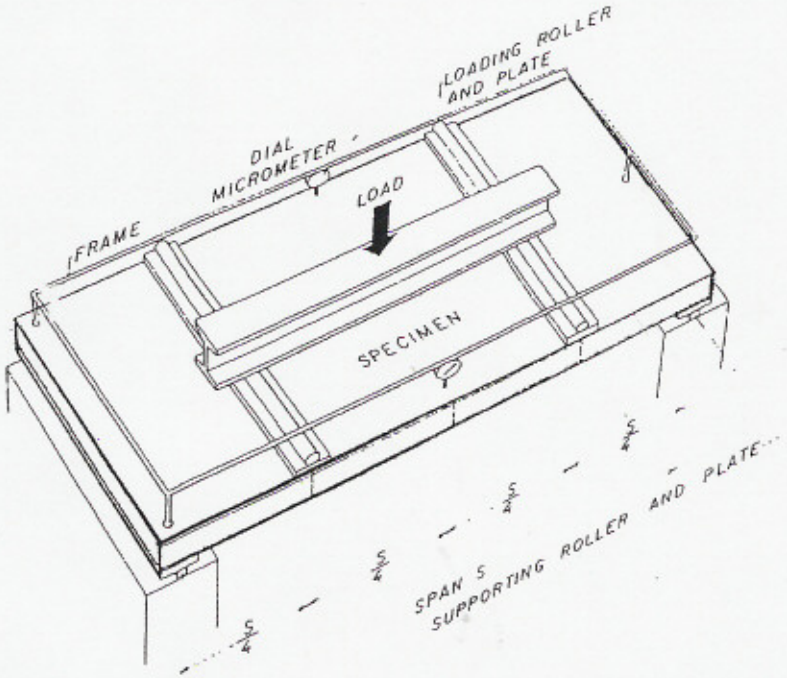

Figure No. I-1: Test Setup for Transverse (Flexural) Loading (from "ASTM E72-98, Fig. 3")

Transverse load testing was performed on the following panels:

Panel Skins		Panel Size	Number of Samples	Sample Designations
Type	Orientation			
OSB-OSB	OSB both	4' x 8'	3	OO1, OO2, OO3
GGS-GGS	GGS both	4' x 8'	3	GG1, GG2, GG3

OSB = 7/16" oriented strand board
GGS = 24 gauge galvanized steel

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

Test results for transverse loading are presented as described below:

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

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

Table No. I-1: Results for Load vs. Deflection for 8' OSB-OSB Panels

OSB-OSB Panel OO1 8'-0	
Transverse Load (lbs.)	Average Displacement (in.)
10	0.0009
531	0.1624
698	0.2143
895	0.2675
1410	0.4015
2711	0.7189
4512	1.2333
4457	1.2767
4382	1.2791
4334	1.2806
4581	1.3437
4912	1.4481
5091	1.5197
5193	1.5757
5269	1.6204
5565	1.7210
5811	1.8361
6131	1.9840
6314	2.1365
6336	2.2254

OSB-OSB Panel OO2 8'-0"	
Transverse Load (lbs.)	Average Displacement (in.)
12	0.0026
505	0.1569
876	0.2614
1646	0.4582
2605	0.7033
2556	0.7070
2539	0.7078
2653	0.7335
3166	0.8689
3613	0.9855
4131	1.1464
4253	1.2008
4312	1.2336
4334	1.2527
4688	1.3392
5705	1.6725
5904	1.8066
6067	1.9564
6610	2.1566
6174	2.3012

OSB-OSB Panel OO3 8'-0"	
Transverse Load (lbs.)	Average Displacement (in.)
5	0.0001
884	0.2506
1138	0.3198
1177	0.3334
2384	0.6125
2793	0.7166
2846	0.7389
3798	0.9611
4070	1.0480
4129	1.0776
4499	1.1664
4792	1.2539
4926	1.3029
5499	1.4577
5722	1.5456
6840	1.8777
7257	2.2139
6714	2.3794
6835	2.6478
6800	2.9638

Note: The transverse load does not include the weight of the load beams and panels

Table No. I-2: Results for Load vs. Deflection for 8' GGS-GGS Panels

GGS-GGS Panel GG1 8'-0	
Transverse Load (lbs.)	Average Displacement (in.)
4	0.0001
377	0.0940
892	0.2022
1297	0.2879
1381	0.3056
2508	0.5036
2393	0.5041
2622	0.5380
2768	0.5642
2794	0.5724
2801	0.5765
2833	0.5838
3533	0.6985
3788	0.7488
3901	0.7748
4068	0.8059
4528	0.8948
4709	0.9417
4799	0.9708
5048	1.0309

GGS-GGS Panel GG2 8'-0"	
Transverse Load (lbs.)	Average Displacement (in.)
7	0.0001
517	0.1161
794	0.1713
815	0.1771
808	0.1771
1886	0.3665
2086	0.4061
3060	0.5679
3448	0.6454
3506	0.6627
4658	0.8680
4901	0.9598
4869	0.9786
4850	0.9927
4834	1.0013
4793	1.0022
4760	1.0028
4732	1.0034
4710	1.0040
5340	1.1464

GGS-GGS Panel GG3 8'-0"	
Transverse Load (lbs.)	Average Displacement (in.)
9	0.0000
918	0.2053
1223	0.2727
1216	0.2740
1228	0.2777
1308	0.2929
1434	0.3157
1522	0.3322
1820	0.3846
2407	0.4940
2606	0.5343
2970	0.5992
3463	0.7022
3298	0.8499
3578	0.9584
3713	1.0145
3769	1.0502
3796	1.0749
4171	1.2039
4310	1.3331

Note: The transverse load does not include the weight of the load beams and panels

TABLE No. I-3: TRANSVERSE TEST RESULTS FOR 8' OSB-OSB PANELS
(does not include weight of load beams or panel itself)

SAMPLE NO.	MAX. LOAD (lbs.)	MAX. LOAD (psf)	MAX DEFL (in.)	PANEL SIZE (w x l)	UNSUP SPAN (in.)	FAILURE CHARACTERISTICS
OO1	6336	207	2.23	48" x 96"	92	Panels failed by some combination of foam shearing near panel ends; 24 ga. steel spline buckling near load beam; and/or OSB skin cracking near load beam.
OO2	6610	216	2.15	48" x 96"	92	
OO3	7257	237	2.21	48" x 96"	92	
Average	6734	220	2.20	Load Beams Weight = 157.7 lbs. (or 5.14 psf)		
defl of L/180 occurs at ~61 psf defl of L/240 occurs at ~44 psf defl of L/360 occurs at ~29 psf				Average Panel Weight =113.6 lbs. (range =112.4 to 114.7 lbs.) Average Panel Weight = 3.55 psf		

TABLE No. I-4: TRANSVERSE TEST RESULTS FOR 8' GGS-GGS PANELS
(does not include weight of load beams or panel itself)

SAMPLE NO.	MAX. LOAD (lbs.)	MAX. LOAD (psf)	MAX. DEFL (in.)	PANEL SIZE (w x l)	UNSUP SPAN (in.)	FAILURE CHARACTERISTICS
GG1	5048	165	1.03	48" x 96"	92	Panels failed by some combination of foam shearing near panel ends and 24 ga. steel spline buckling and/or pulling from foam near the ends.
GG2	5340	174	1.15	48" x 96"	92	
GG3	4310	141	1.33	48" x 96"	92	
Average (- GG3)	4900	160	1.17	Load Beams Weight = 157.7 lbs. (5.14 psf)		
defl of L/180 occurs at ~78 psf defl of L/240 occurs at ~59 psf defl of L/360 occurs at ~35 psf				Average Panel Weight =113.6 lbs. (range =112.4 to 114.7 lbs.) Average Panel Weight = 3.71 psf		

Note: Effective load carrying area of each panel = 48" x 92" = 30.67 sf

Table No. I-5: Average Results for Transverse Load vs. Deflection for 8' Panels

OSB-OSB Panels OO1, OO2, and OO3	
Transverse Load (lbs.)	Average Displacement (in.)
9	0.0012
885	0.2598
1138	0.3198
1411	0.3977
2495	0.6579
2687	0.7142
2692	0.7233
3705	0.9733
4226	1.1635
4198	1.1682
4404	1.2188
4653	1.3009
4902	1.3873
5346	1.5167
5495	1.5830
6037	1.7571
6312	1.9283
6263	2.0809
6405	2.2469
6433	2.4968

GGS-GGS Panels GG1, GG2, and GG3	
Transverse Load (lbs.)	Average Displacement (in.)
7	0.0000
604	0.1385
969	0.2154
1110	0.2463
1139	0.2534
1901	0.3877
1971	0.4086
2401	0.4794
2679	0.5314
2902	0.5764
3355	0.6596
3568	0.7143
3955	0.7931
3979	0.8638
4104	0.9115
4191	0.9408
4352	0.9826
4412	1.0067
4560	1.0596
4900	1.1701

Note: The transverse load does not include the weight of the load cell, load beams, and panel

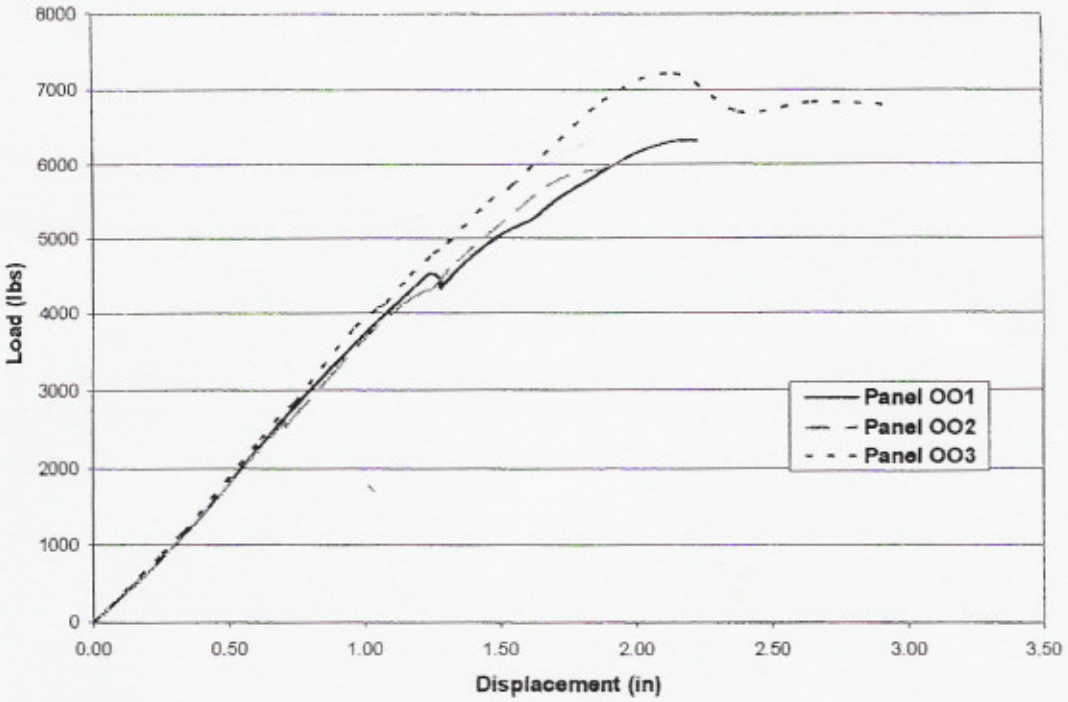

Figure No. I-2: Results for Transverse Load vs. Deflection for 8' OSB-OSB Panels

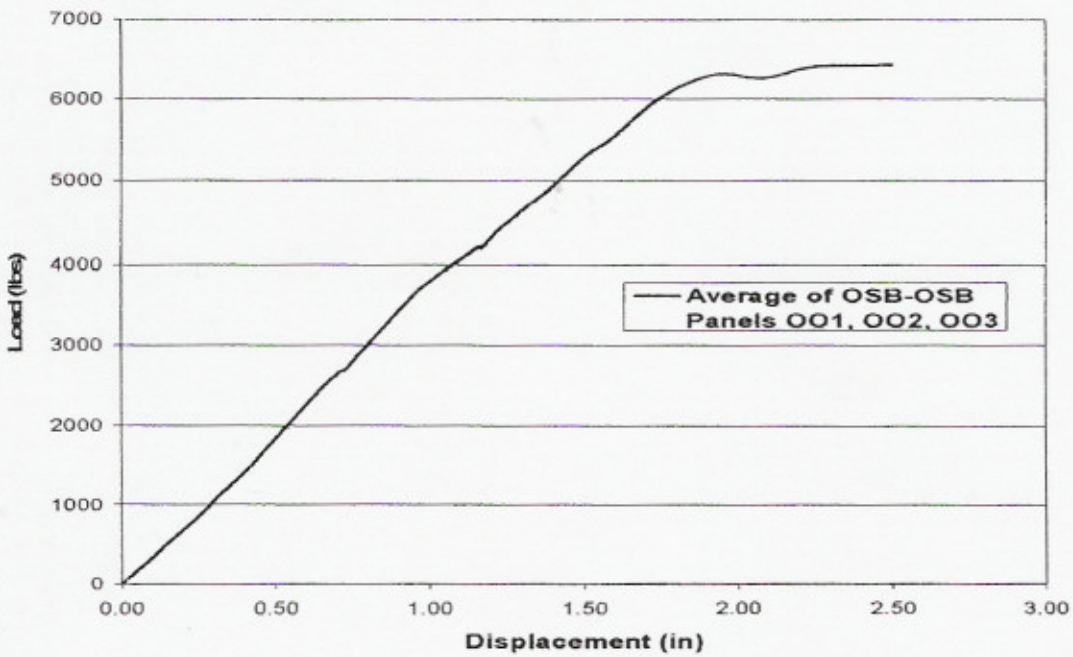

Figure No. I-3:Average Results for Transverse Load vs. Deflection, 8' OSB-OSB Panels

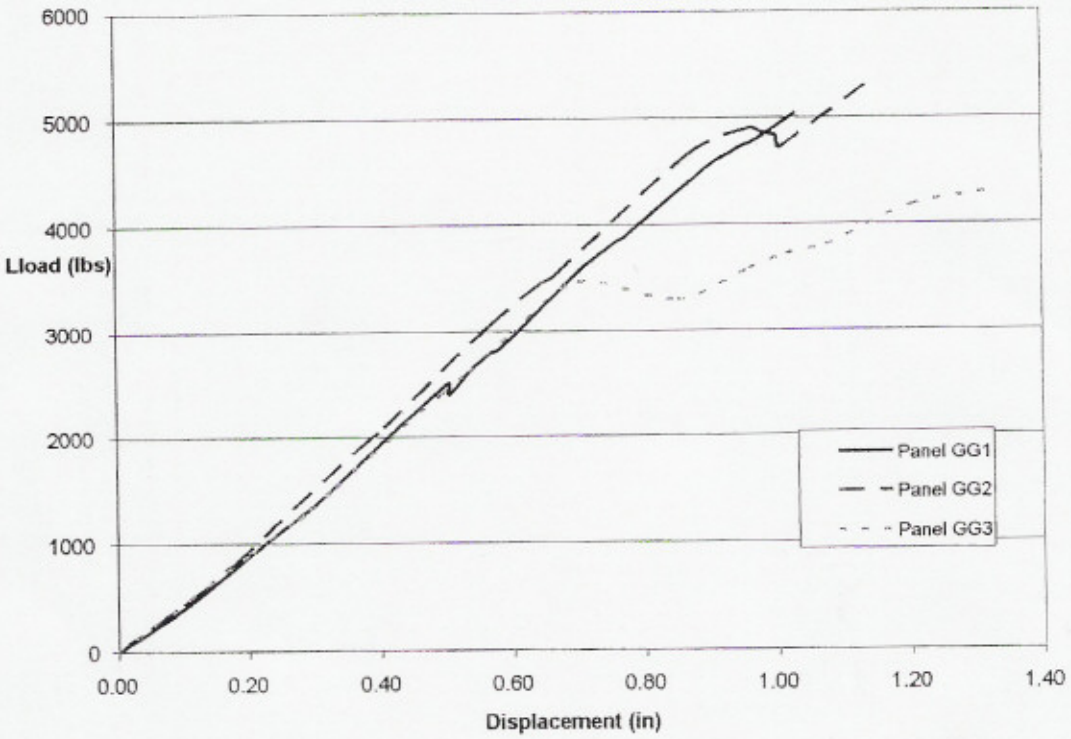

Figure No. I-4 Results for Transverse Load vs. Deflection for 8' GGS-GGS Panels

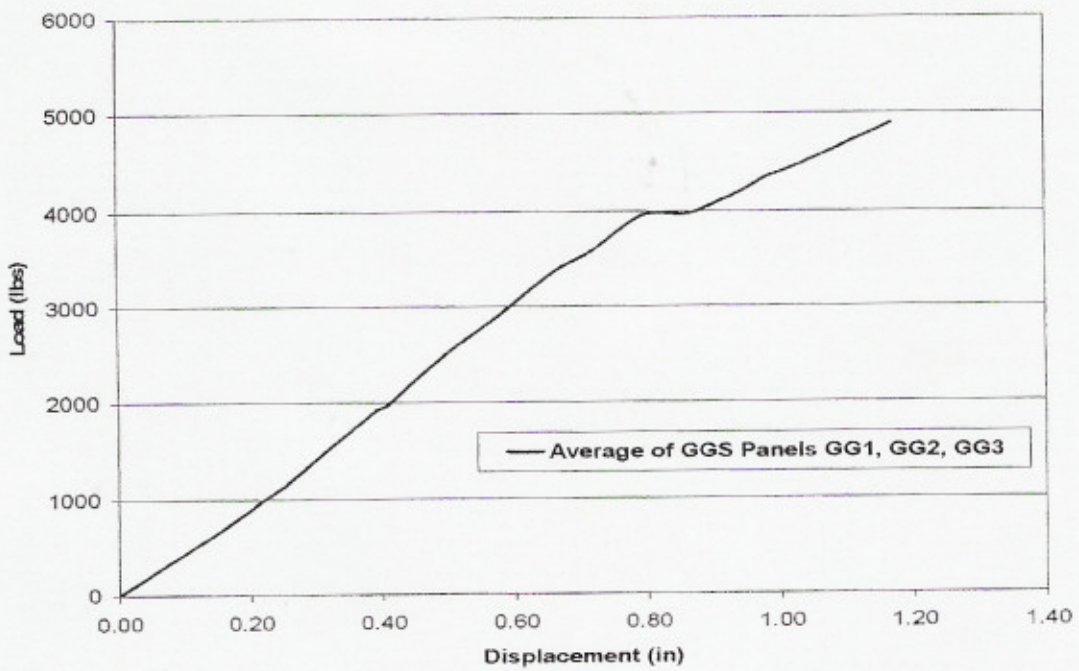

Figure No. I-5: Average Results for Transverse Load vs. Deflection for 8' GGS-GGS Panels

Discussion of Results

Representative results for individual panels and for averages for skin sets subjected to transverse 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 flexural "stiffness" values (load/deflection) are in the range of 3500 to 4800 lb./in. for these 8'panels. Calculations for these stiffness-type terms are presented below by choosing average load, P, and deflection, d, values from Table No. I-5 approximately half-way to the ultimate load value. These values are presented below In Table No. I-6.

Table No. I-6: Average Flexural "Stiffness" Values for Panel Sets (values taken from Table No. I-5)

Panel Type	Skin Orientation	Load, P (lbs.)	Deflection, d (in.)	"Stiffness", k=P/d (lb/in)
8' OSB-OSB	OSB both faces	3705	0.9733	3807
8' GGS-GGS	GGS both faces	2415	0.5221	4626

For each length panel, the "k" values for the GGS panels are greater than those of the OSB panels. These terms represent the average load required to generate 1" of deflection and can be seen as the slopes of the load-deflection curves. The greater flexural stiffness in the GGS panels is the result of the stiffer GGS skins being on of the panels. This greater stiffness is the result of a much higher modulus of elasticity for the steel (GGS) skins than for the OSB skins.

As shown below in Table No. I-7, the OSB panels failed at higher ultimate loads than did the GGS panels. The lower ultimate (failure) loads in the GGS panels often resulted from the sudden failure (buckling) of the aluminum spline along the panel edge. Generally, failure of all panels occurred from a combination of events but often occurred from crushing of the top skin in flexural compression, buckling of the aluminum spline, or tearing in the foam core. .

Table No. I-7: Average Failure Loads

Panel Type	Skin Orientation	Load, P (lbs.)
8' OSB-OSB	OSB both faces	6734
8' GGS-GGS	GGS both faces	4900

Conclusions

Considering the maximum uniform load for each panel and a safety factor (failure load/allowable load) of 4.0, both the OSB panels and the GGS panels area able to safely sustain typical transverse wind loads. As shown in Table No. I-8 below, restricting deflections to L/360 permits a transverse wind load of 29 psf for the OSB panels and a wind load of 35 psf for the GGS panels. Both loadings exceed typical wind loads on low-rise structures.

Table No. I-8: Results at Key Deflection Limits

Initial Deflection (in.)	OSB-OSB Panels				GGS-GGS Panels			
	Load (psf)		Deflection (in.)		Load (psf)		Deflection (in.)	
L/180	61		0.51		78		0.51	
L/240	44		0.38		59		0.38	
L/360	29		0.26		35		0.26	
Loads (S.F. = 4.0)	Failure Load		Allowable Load		Failure Load		Allowable Load	
	(lbs.)	(psf)	(lbs.)	(psf)	(lbs.)	(psf)	(lbs.)	(psf)
	6734	220	6734	220	4900	160	1225	40

Based on the results presented in Table No. I-8 above, a deflection of L/180 would not be permitted for either panel because the load causing the deflection exceeds the allowable load for each panel. For the same reason, a deflection of L/240 would not be permitted for the GGS panels. To maintain a safety factor of 4.0 against failure load, deflections should be restricted to L/200 for OSB panels and L/315 for GGS panels.

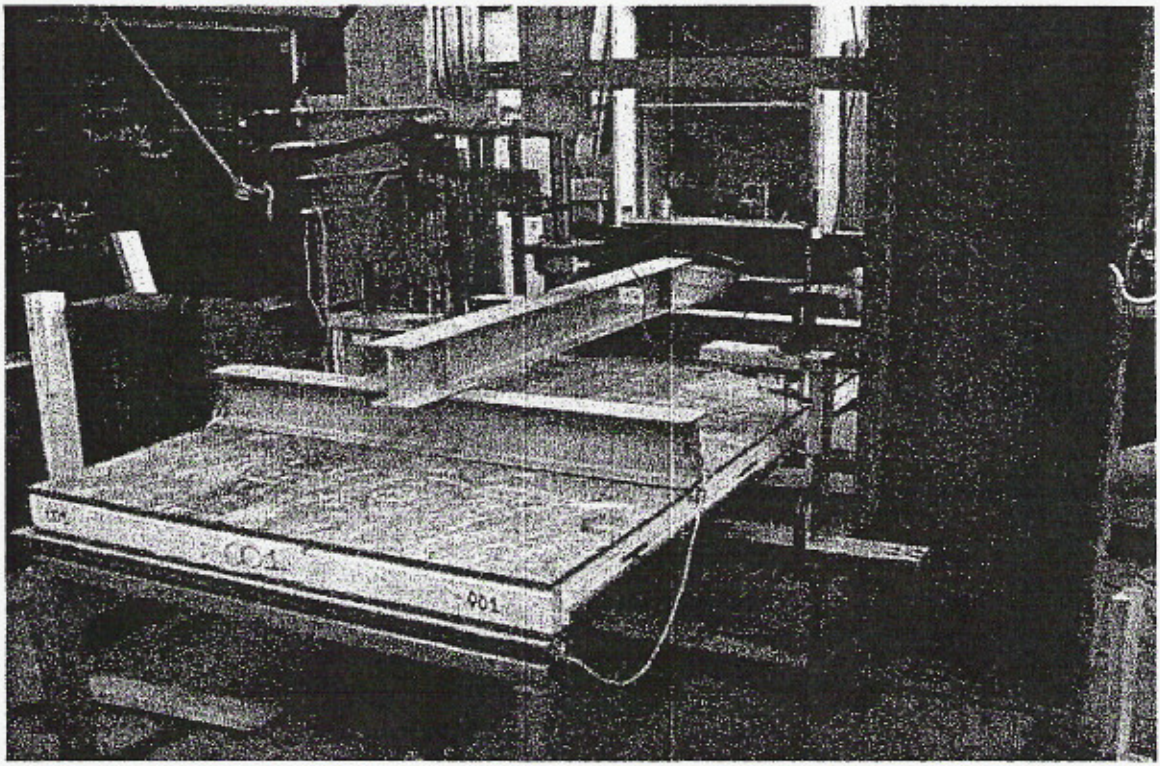

Photo No. I-1: Test Setup for Transverse Loading on 8' OSB-OSB Panel

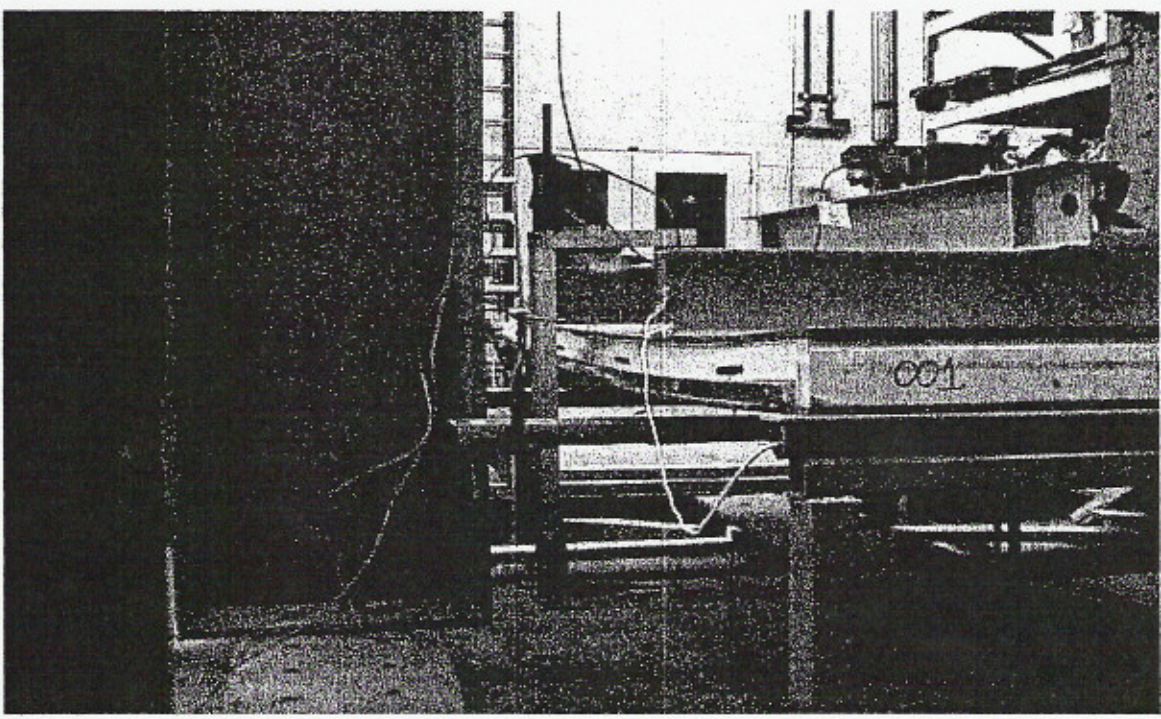

Photo No. I-2: Response of 8' OSB-OSB Panel to Transverse Loading

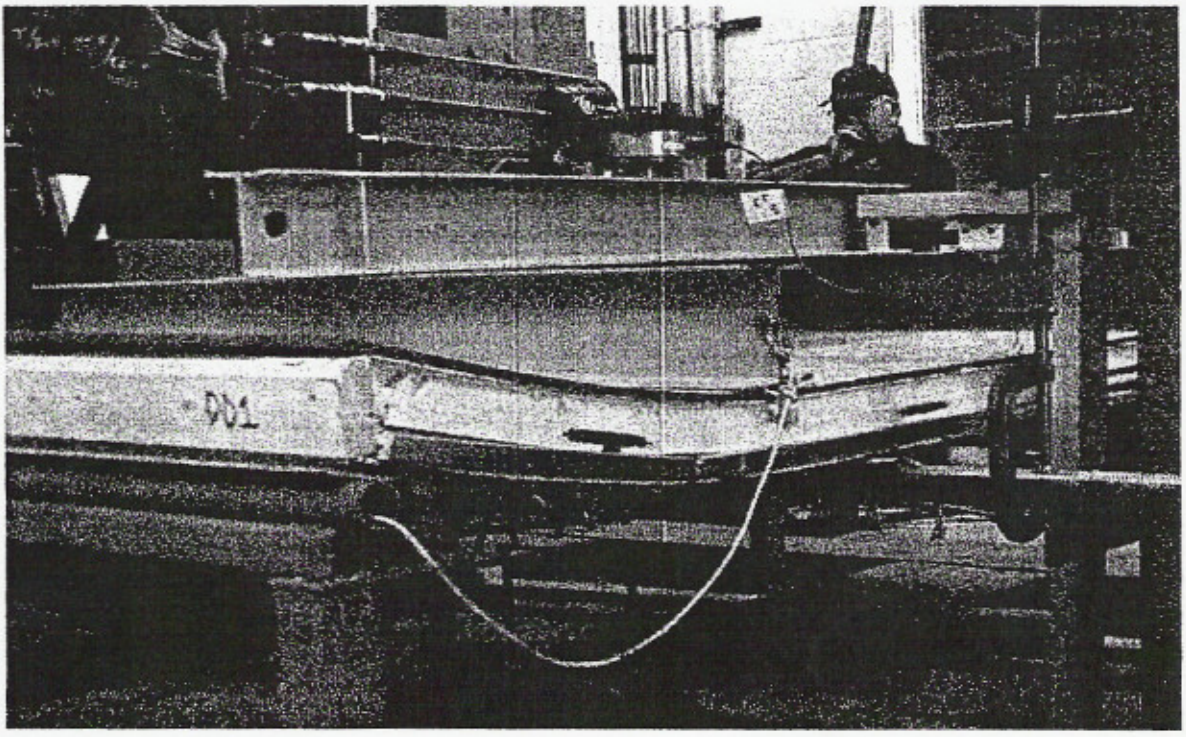

Photo No. I-3: Failure of 8' OSB-OSB Panel Under Transverse Loading

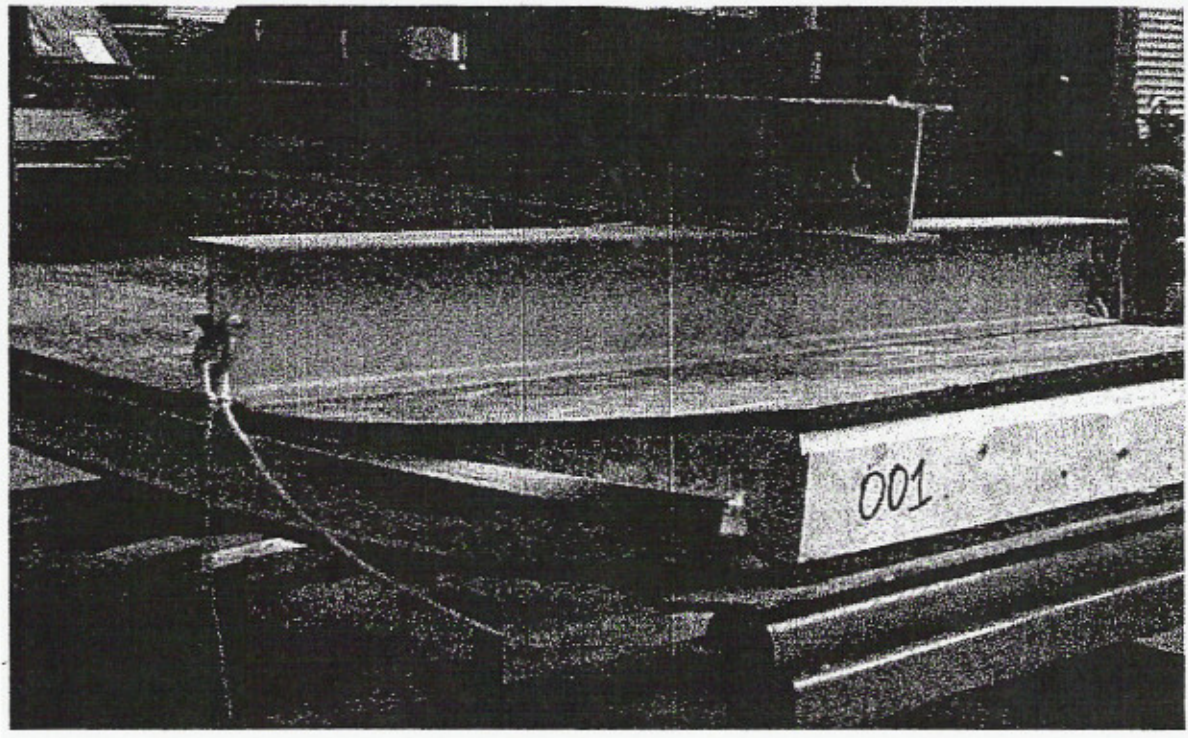

Photo No. I-4: Closeup of Failure of 8' OSB-OSB Panel Under Transverse Loading

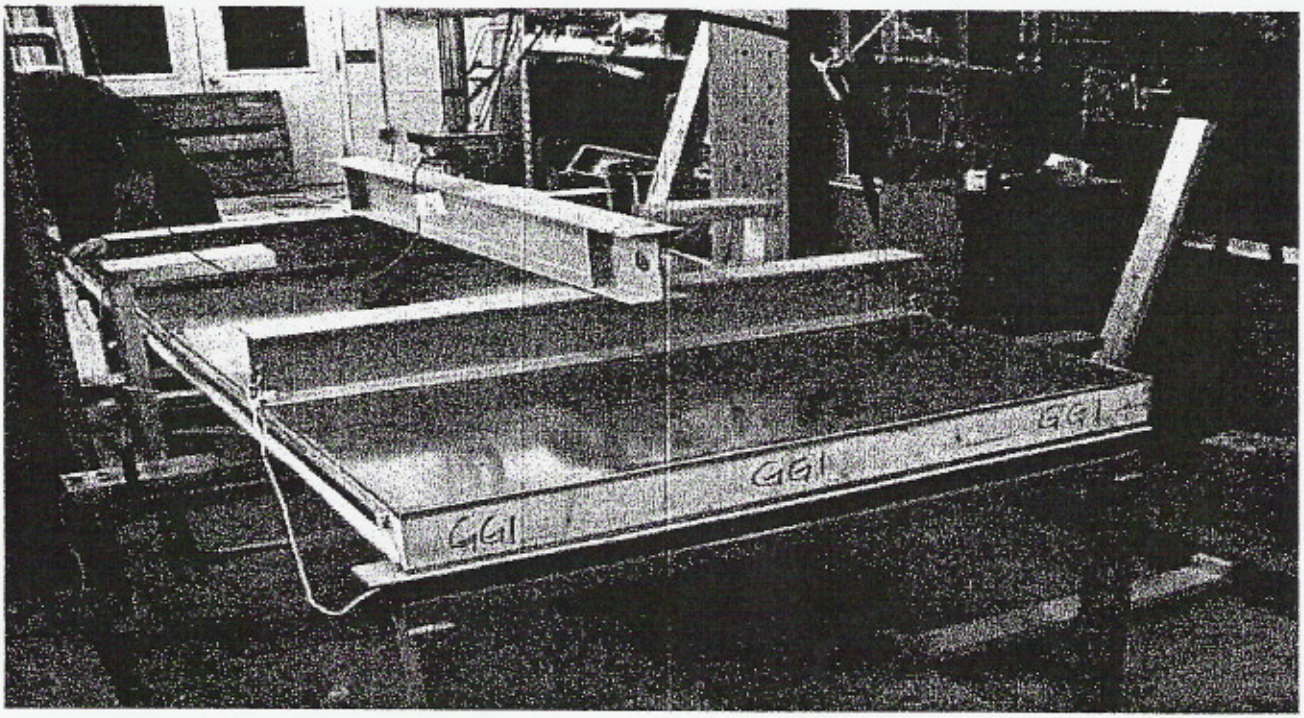

Photo No. I-5: Test Setup for Transverse Loading 8' Galv.-Galv. Panel

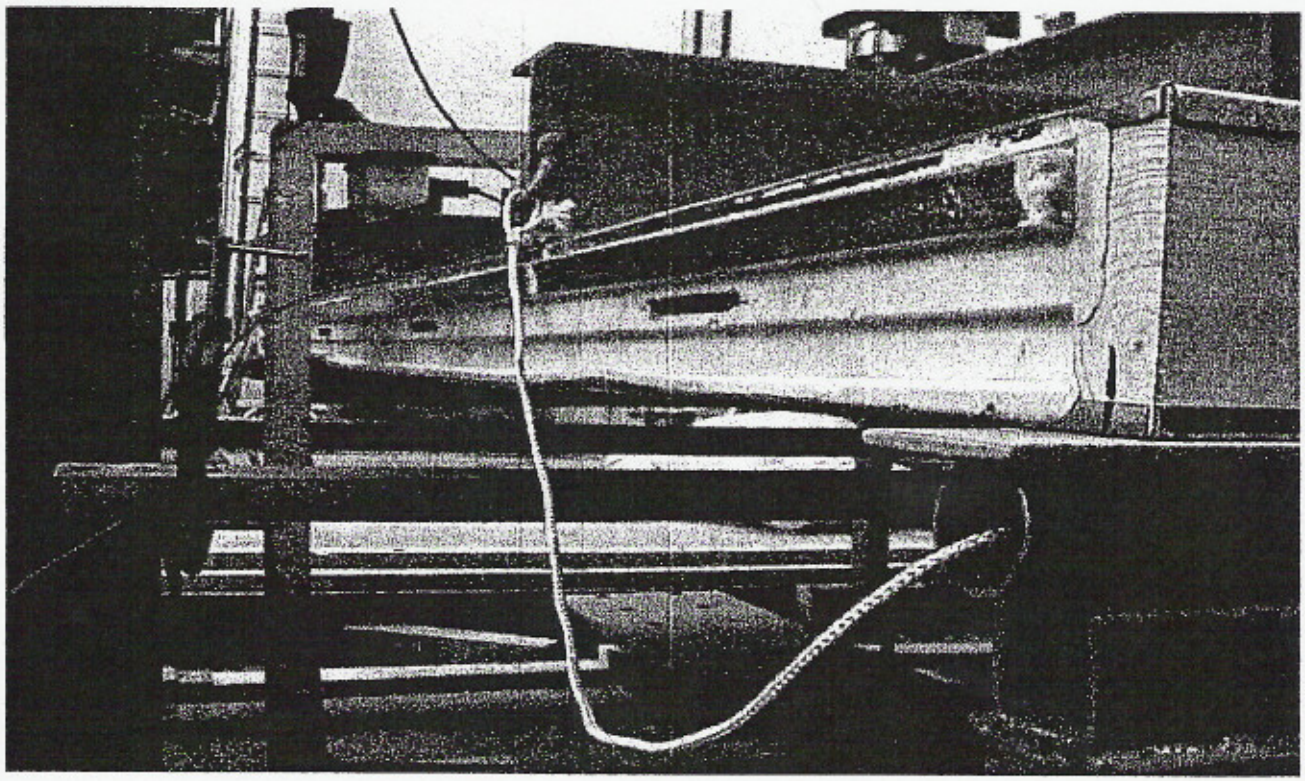

Photo No. I-6: Response of 8' Galv.-Galv. Panel Under Transverse Loading

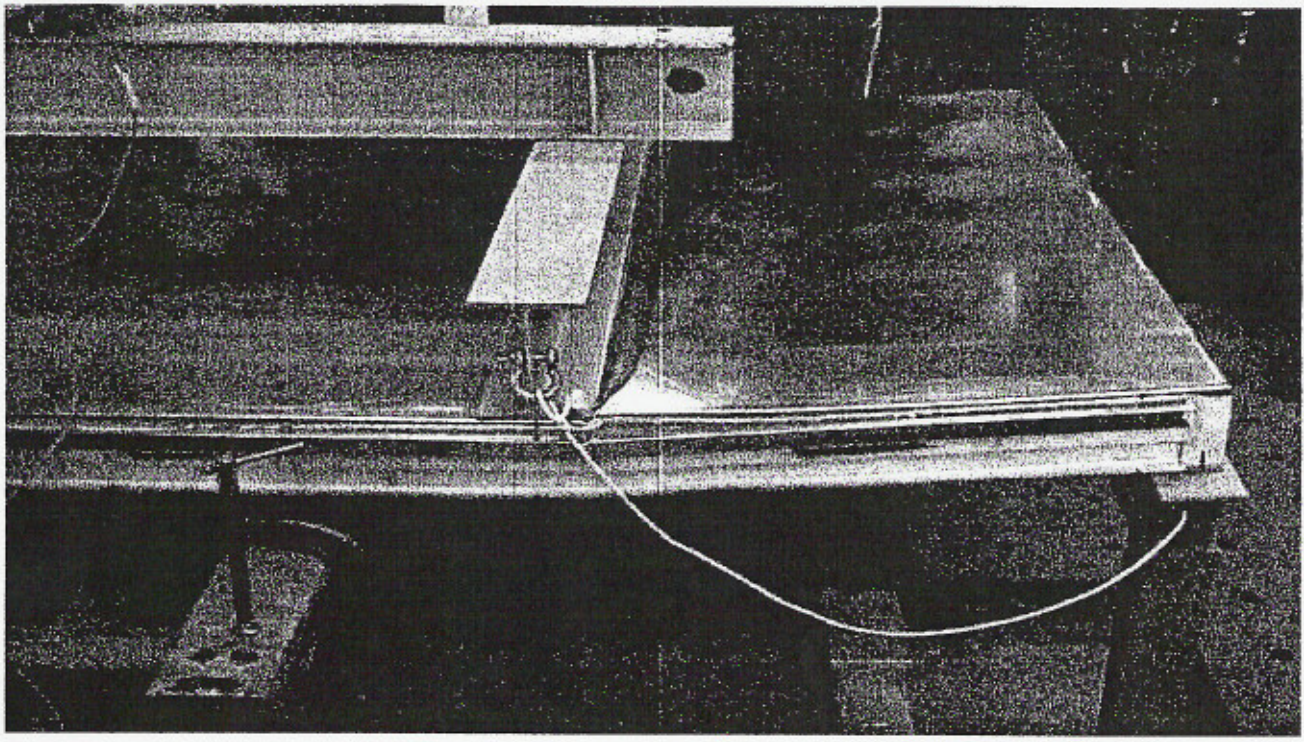

Photo No. I-7: Failure of 8' Galv.-Galv. Panel Under Transverse Loading

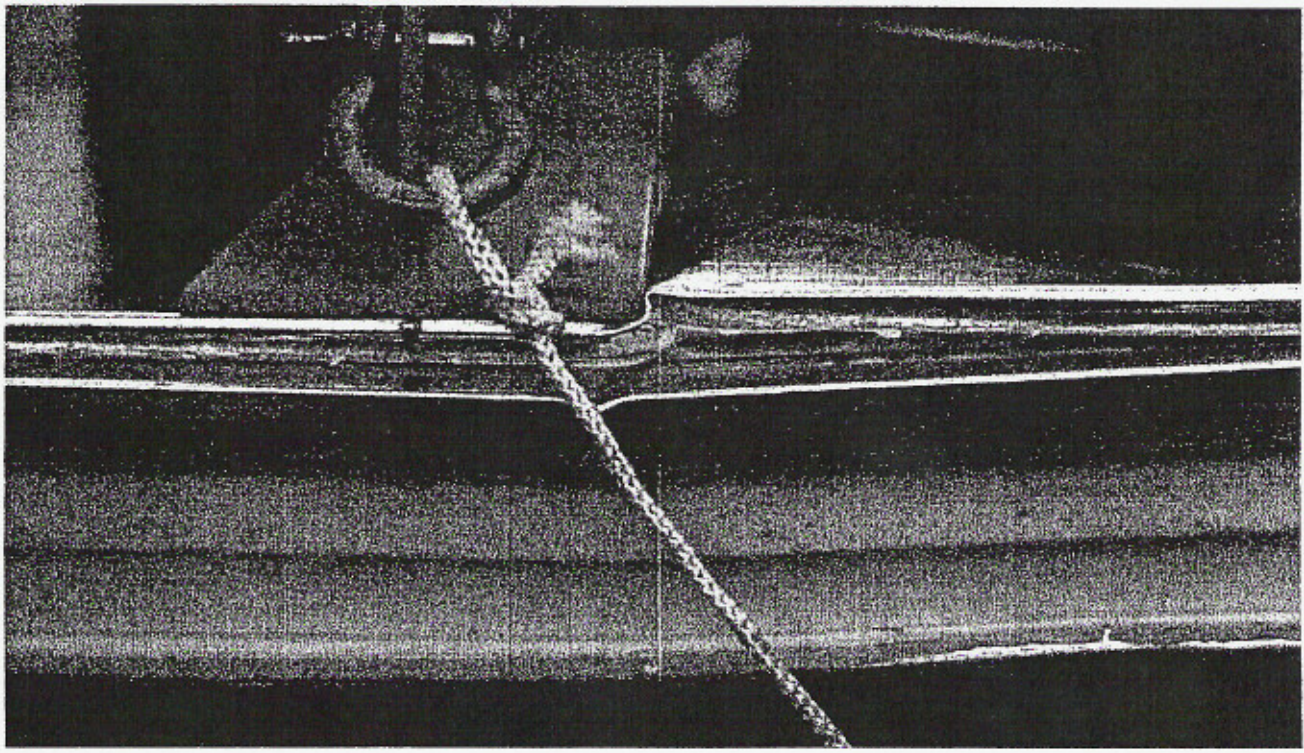

Photo No. I-8: Closeup of Failure of 8' Galv.-Galv. Panel Under Transverse Loading