MPI CONCEPTS INC.
6548 Center Industrial Dr.
Jenison, MI 49428
616.669.9300
mpiconcepts.com

ISTAIR Product Evaluation Report and Test Data

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BUILDING CODE COMPLIANCE

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Please contact Progressive Engineering Inc.
@ 574.533.0337 directly for additional
engineering support.

INTERNATIONAL ACCREDITATION SERVICE®

MPI CONCEPTS INC.

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6548 Center Industrial Dr.
Jenison, MI 49428
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Product Evaluation Report - 13062
4 pages total

MPI
CONCEPTS INC.

Pei Evaluation Service®

PER-13062

Pei **Evaluation Service** is an accredited **ISO Standard 17065** Product Certifier, accredited by the IAS. This **Product Evaluation Report** represents a product that *Pei* **ES** has Evaluated and this product has a Follow-up Service / Inspection Agreement. This **Product Evaluation Report** in no way implies warranty for this product or relieves **MPI Concepts, Inc.** of their liabilities for this product. This **PER** is an official document if it is within one year of the initial or re-approval date.

Initial Approval
Febuary, 2019

Re-Approved

See all Pei **ES** *Listings at: www.p-e-i.com*

Report Owner
MPI Concepts, Inc.
6548 Center Industrial Dr.
Jenison, MI 49428

Product
ISTAIR™ System

Approved Manufacturing Locations
MPI Concepts, Inc.
6548 Center Industrial Dr.
Jenison, MI 49428

Evaluation Report Information
MPI Concepts, Inc. Contact: Mike Prins
Phone: 616-669-9300

General Details

This report covers the **ISTAIR™ System**. This product is manufactured by **MPI Concepts, Inc.** and is intended for residential stairways in a non-fire rated assembly. This evaluation report covers structural strength properties only. The manufacturing location has an approved Quality Control Program to manufacture the products. **MPI Concepts, Inc.** has an Product Evaluation Service Agreement with *Pei* **Evaluation Service** (*Pei* **ES**) and an Inspection Agreement with *Progressive Engineering Inc.* (*Pei*). The manufacturing location(s) for the bracket and gussets will be audited quarterly by *Pei*.

Product Description

The **ISTAIR™ System** is a stair assembly kit using 18 ga. steel (.048" nominal) and/or 20 ga. (.036" nominal) triangular shaped ASTM A653 33-ksi steel stringer brackets with a G60 galvanized coating, 2x4 #2 SPF lumber minimum stringers, and 3/4" APA, Structural 1 rated OSB treads/risers. Each bracket is fastened to the 2x4 stringer with four (4)#10 x 1-1/2 Strong Point Screws, to the 3/4" OSB treads with three (3) #6 x 3/4" zinc plated pan head screws or better, and to the 3/4" APA or Structural 1 rated OSB risers with two (2) #6 x 3/4" zinc plated pan head screw. On the underside of each tread to riser connection is a Tread-Riser-Gusset 20 ga. (.036") nominal galvanized steel hinge-gusset for support. See Figure 1 and Figure 2 for system details. The **ISTAIR™** stringer brackets, gussets and screws are not approved to be used in contact with pressure treated lumber. The **ISTAIR™ System** should be protected from exposure to the elements.

Building Code Compliance

2012 International Residential Code		2015 International Residential Code		2018 International Residential Code	
ISTAIR™ System		ISTAIR™ System		ISTAIR™ System	
R104.11	R302.7	R104.11	R302.7	R104.11	R302.7
R301.5	R311.7	R301.5	R311.7	R301.5	R311.7
R302.11	R505.23	R302.11	R505.2.2	R302.11	R505.2.2
R317.1		R317.1		R317.1	

Notes:

1. Meets the loading requirements of the 2015 Michigan Residential Code - Table R301.5 (Stairs) including Note C
2. Concentrated load tested in accordance with the loading required by 2012/2015/2018 IRC Table R301.5 - Note C
3. Stairs have been evaluated for use in One and Two-Family Dwellings only in accordance with the 2012/2015/2018 IRC.
4. Enclosed space under stairs that is accessed by a door or access panel shall have walls, under-stair surface and any soffits protected on the enclosed side with 1/2" (12.7mm) gypsum board as required in the 2012/2015/2018 IRC Section R302.7. Additional horizontal framing may be required for applying gypsum to the under-stair surface.
5. Under-stair protection and Fireblocking shall be In accordance with 2012/2015/2018 IRC.
6. Meets or exceed the Building Code sections as noted above.

General Product Use

ISTAIR™

1. The **ISTAIR™ System** shall be assembled and installed in accordance with the manufacturer's installation instructions and is subject to the conditions of this **PER**. A copy of the **ISTAIR™** Installation Instructions shall be made easily available to the installer.

2. All construction, wood or steel framing, beams, joist, stringers and associated connections needed to support the **ISTAIR™ System** are outside the scope of this evaluation report. All construction shall follow applicable building.

3. Subfloor shall be cut leaving a 1-3/4" overhang or at least a 1-1/2" minimum.

4. The 2x4 lumber stringers are not designed to support the full code prescribed design loading on the **ISTAIR™ System**. Instead, the **ISTAIR™** is designed to be attached to adjacent wall studs per Table 1 of this **PER**. Alternative construction and connection methods are outside the scope of this **PER** and shall follow applicable codes.

5. The **ISTAIR™ System** is limited to a maximum width of 48-inches and shall not be less than 36-inches. This system is limited to use in One and Two-Family Dwellings only.

6. The **ISTAIR™ System** must have the impervious moisture barrier attached to stringer feet on any system that will come in contact with a concrete or masonry slab. Where any wood-based component of the **IStair™ System** (including structural framing) is in direct contact with concrete or a masonry slab in direct contact with the ground, protection from decay shall be provided by the use of naturally durable wood or wood that is preservative-treated in accordance with AWPA U1. Fasteners for preservative treated wood shall comply with the requirements of the IRC.Please note that the fastener application will need to meet the corrosion requirements under the 2012/2015/2018 IRC Section R505.23 and R505.2.2. when any treated lumber is introduced to this system.

7. The underside of the **ISTAIR™ System** shall be protected with a minimum of 1/2" tk. gypsum in all uses/locations for this product.

Product Documentation

An Approved QC Manual - Dated January 13, 2019
An Evaluation and Follow-up Service Agreement between *Pei* **Evaluation Service** and MPI Concepts, Inc.
An Inspection Agreement between *Progressive Engineering Inc.* and **MPI Concepts, Inc.**
ISTAIR™ System Installation Instructions
A *Pei* test report No. 2011-0404 - i18gs, i20gs and trg45 i-Stair Bracket Concentrated Load Testing, **IStair Systems**, Inc. Dated: March 11, 2011
An engineering calculation project no. 2016-1445 - i-Stair 2x4 Lumber Stringer to Wall Stud Connection - Dated: 12/11/2018.

Product Labeling

Each **ISTAIR™ System** assembly kit that is covered by this **Product Evaluation Report**, must have a label attached with at least the following information:

1. MPI Concepts, Inc. Name and Address
2. Product name
3. Plant identifier & date code
4. Product code
5. The **PER** number and
6. *Pei* **Evaluation Service** Name or Evaluation Mark

Acceptable Evaluation Marks

Table 1. Screw and Nail Fastener Connection

Table 1 - Number of Fasteners Required per Stud for Connection between ISTAIR™ Stringer and Support Wall

Fastener	Stud Spacing (in)	Stair Width (in) (Ref. Figure 2)			
		36	42	45	48
GRK RSS Screw 5/16 x 4" Lg. (7.0x100)	12	1	1	1	1
	16	1	1	1	1
	19.2	1	1	1	1
	24	1	1	1	1
0.131" x 3" Nails	12	2	2	2	2
	16	2	2	2	2
	19.2	2	2	2	2
	24	2	2	2	2

Notes:

1. Number of fasteners determined by engineering analysis assuming a maximum 40 psf live load or 300 lb concentrated load distributed between two studs.
2. Fasteners were analyzed in accordance with the design provisions found in the 2012 and 2015 National Design Specification® (NDS) for Wood Construction.
3. Alternative construction and connection methods are outside the scope of this PER and shall follow applicable codes or be designed by a licensed engineer.
4. The GRK RSS Screw is a speciality screw. See ESR-2442.

Figure 1 - ISTAIR™ Bracket and Gusset Installation Details

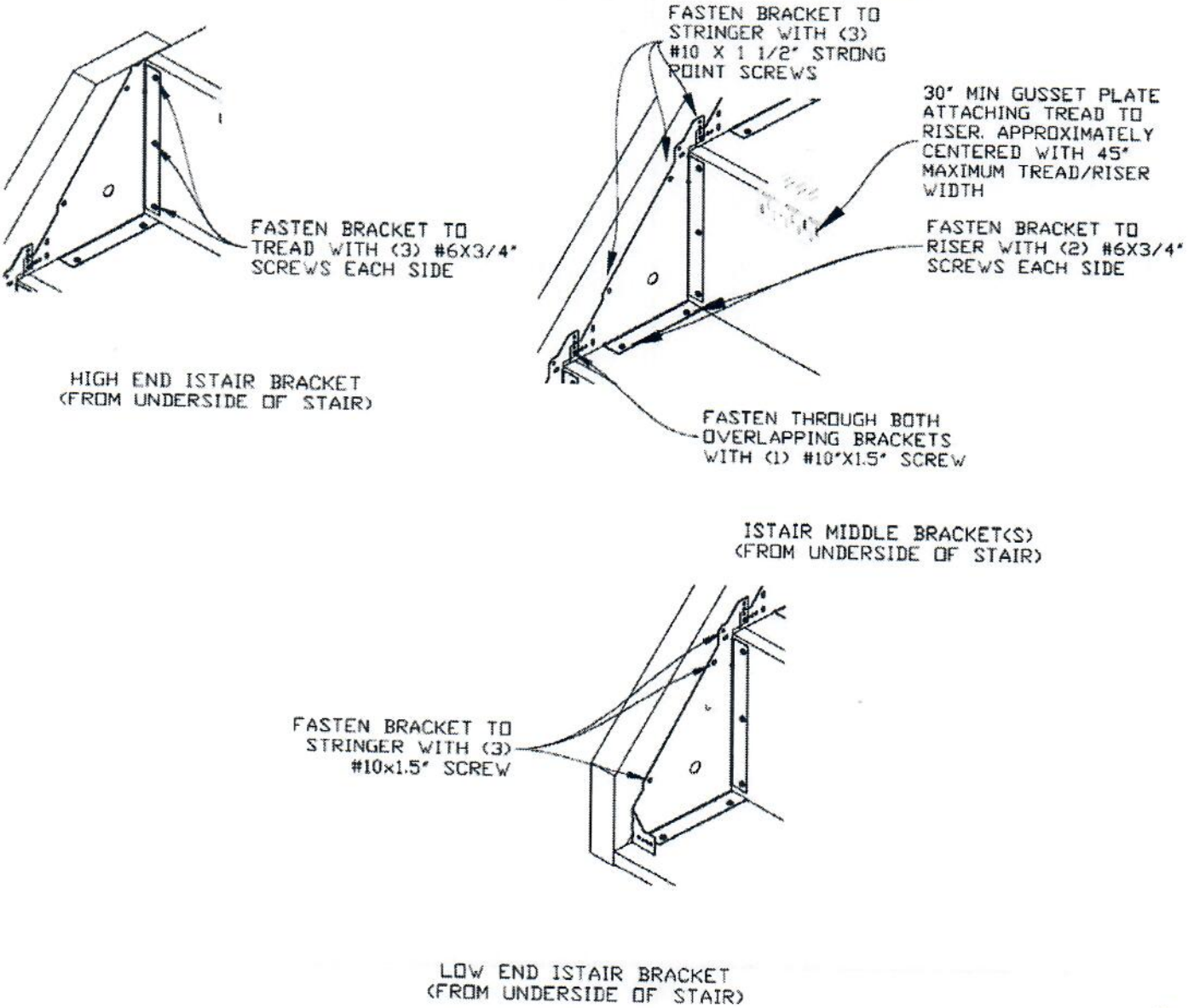
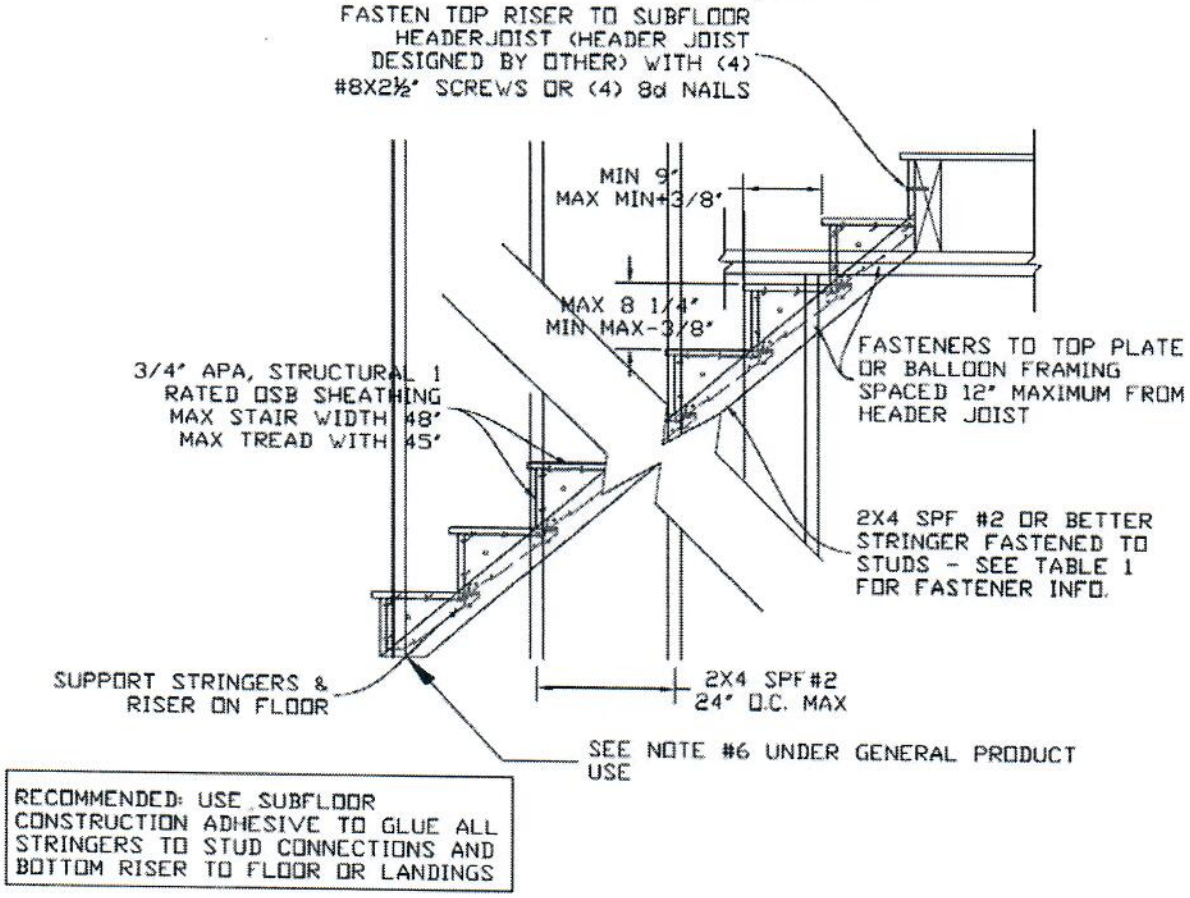
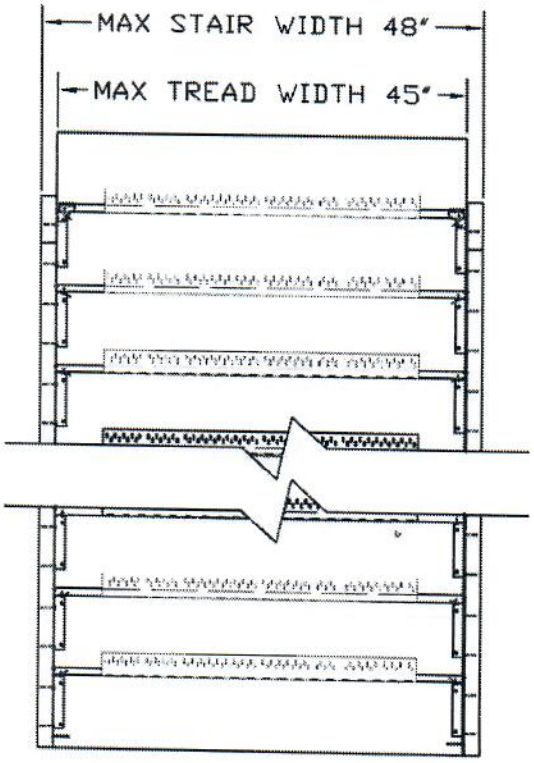


Figure 2 - ISTAIR™ Bracket and Gusset Installation Details





MPI CONCEPTS INC.
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ISTAIR Bracket Concentrated Load Testing Data
17 pages total

MPI
CONCEPTS INC.

Progressive Engineering Inc.

I-STAIR SYSTEMS, INC.

i18gs, i20gs and trg45 I-Stair Bracket
Concentrated Load Testing

3/11/2011

Revised on
5/6/2011

3/12/2013 - Added Michigan Residential Code reference to Section 2
6/2/2016 - Revised page 2 section 2 - code revision dates.
Revised page 2 section 3 - address change.

STATE OF MICHIGAN
TIMOTHY A. BALDRIDGE
ENGINEER
No. 54863
LICENSED PROFESSIONAL ENGINEER

Date Signed: Jun 09,2016

This test report contains Seventeen (17) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

2011-404

58640 State Road 15 - Goshen, IN 46528
Phone: 574-533-0337 - Fax: 574-533-9736
www.p-e-i.com

1. TITLE

i18gs, i20gs and trg45 I-Stair Bracket Concentrated Load Testing

2. OBJECTIVE

To verify the step brackets and the tread riser gusset can withstand the force required by the codes listed below. Secondly, to verify the use of tread and riser materials.

1. 2012 IBC, Table 1607.1, Note F
2. 2015 Michigan Residential Code, Table R301.5 (Stairs), Note c
3. ICC-ES AC174 §4.1

This test report pertains only to the specimens tested. It remains the sole responsibility of the manufacturer to provide a product consistent to that which was tested.

3. TESTED FOR

I-Stair Systems, Inc.
6548 Center Industrial Dr.
Jenison, MI 49428

4. TESTING ORGANIZATION

Progressive Engineering Inc.
58640 State Road 15
Goshen, IN 46528
www.p-e-i.com

See IAS Evaluation Report No. TL-178 for ISO 17025 Accreditation.

5. TESTING PERSONNEL

Laboratory Manager - Jason R. Holdeman
Project Manager - Jacob Bontrager

All of the tests were witnessed by Mike Prins of I-Stair Systems, Inc.

6. TESTING EQUIPMENT

- Load Cell (***PEI*** No. 465)
- Linear Transducers (***PEI*** No. 648, 653, 731)
- Data Acquisition System (***PEI*** No. 566)

7. TEST SPECIMEN

The test specimen was built by I-Stair Systems Inc,, and was verified by ***PEI*** *personnel to the attached drawings.*

The i18gs I-Stair Brackets consisted of triangular shaped galvanized steel with a triangular shaped cut-out in the center. The average measured thickness was .046". Two (2) 1" wide tabs, one (1) located on each side of the triangle, were folded at a 90° angle and fastened to the stair tread and the other to the stair riser. See attached drawing B2 for details.

The i20gs I-Stair Brackets consisted of triangular shaped galvanized steel with a triangular shaped cut-out in the center. The average measured thickness was .036". Two (2) 1" wide tabs, one (1) located on each side of the triangle, were folded at a 90° angle and fastened to the stair tread and the other to the stair riser. See attached drawing B3 for details.

The trg45 consisted of a gang nail plate 30 inches long, with 3/4" slots at the bend point. The average measured thickness is .033". The gusset is intended for use with stair systems 45" wide.

The brackets were attached to a 2x4 stringer, which were attached to the base and back piece which was comprised of 3/4" OSB. The brackets were fastened to the stringer with 1-1/2" long Galvanized Joist Hanger Nails. The treads and the riser were fastened with 3/4" long Drywall Screws.

The steps were comprised of 3/4" OSB material for the tread as well as the riser support underneath the tread. Each tread to riser connection was supported with the trg45. The tread and riser material measured 45 inches wide.

8. TEST SET-UP

A hydraulic cylinder was positioned above the test specimen, in the desired location, with a load cell, and a 2.000" x 2.000" loading block inline. A linear transducer was set to measure the deflection of the hydraulic cylinder at the load point, and two other were used to subtract out the system deflection. The system deflection was defined as movement not directly related to the loaded parts, such as the test specimen support at the base and the stringer deflection. The Data Acquisition System was set to record the Load and Deflection throughout the tests. See attached fixture Drawing No. F1765 for details.

9. TEST PROCEDURE

The load was applied to 850 lbf, which is more than 2.5 times the 300 lbf requirement. Load was applied at a uniform rate through the 2" by 2" loading block until the desired load was reached. The load was increased until a failure was attained at the final test location, at the direction of the client.

10. TEST RESULTS

See the attached data pages for details.

Progressive Engineering Inc.

Stair Tread Concentrated Load Test

Date: 3/11/2011 **Project No.:** 2011-404

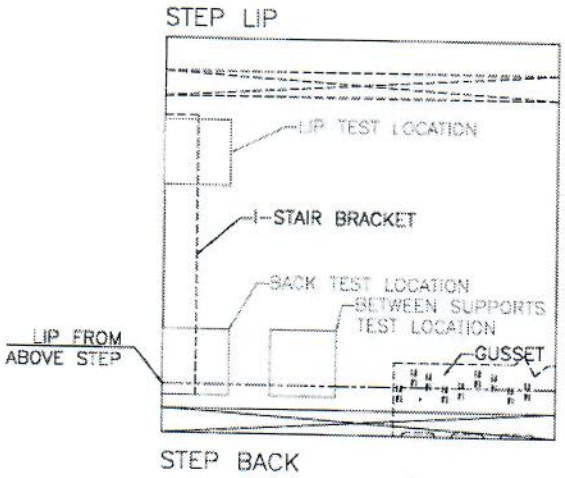
Client: I-Stair Systems, Inc. **Temp.:** 62.7° F

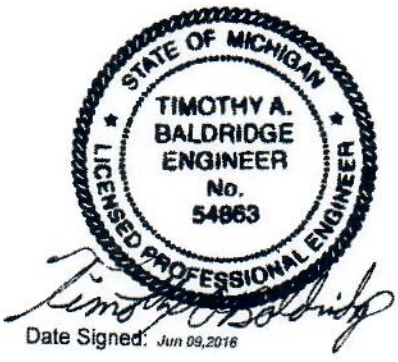
Specimen: i18gs I-Stair Bracket, trg45 **Humidity:** 39.4% R.H.

Test: 2" x 2" Concentrated Load **Deflection Limit @ 300 lbf*:** .125"

Load (lbf)	Test Location / Deflection[1] (in)		
	Step Lip	Step Back	Between supports
200	.086	.078	.071
300	.103	.100	.107
400	.117	.119	.144
500	.133	.136	.185
600	.149	.155	.232
700	.166	.177	.303
800	.184	.200	.401

Note: Each location was loaded separately.





* Based on ICC-ES AC174 §4.1

[1] The deflection is measured at the loading nose. The system deflection was removed.

Progressive Engineering Inc.

Stair Tread Concentrated Load Test

Date: 3/11/2011 **Project No.:** 2011-404

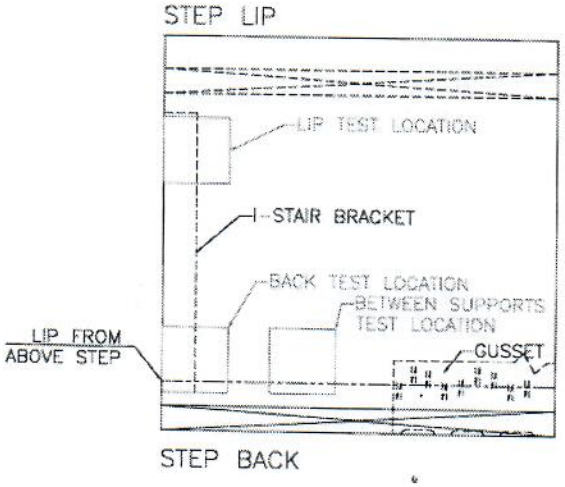
Client: I-Stair Systems, Inc. **Temp.:** 62.7° F

Specimen: i20gs I-Stair Bracket, trg45 **Humidity:** 39.4% R.H.

Test: 2" x 2" Concentrated Load **Deflection Limit @ 300 lbf*:** .125"

Load (lbf)	Test Location / Deflection[1] (in) Step Lip	Step Back	Between supports
200	.040	.048	.069
300	.055	.068	.099
400	.068	.089	.130
500	.084	.108	.163
600	.100	.129	.198
700	.120	.149	.235
800	.141	.171	.280

Note: Each location was loaded separately.



* Based on ICC-ES AC174 §4.1

[1] The deflection is measured at the loading nose. The system deflection was removed.

Progressive Engineering Inc.

Stair Tread Concentrated Load Test

Date: 3/11/2011
Client: I-Stair Systems, Inc.
Specimen: i20gs I-Stair Bracket, trg45
Test: 2" x 2" Concentrated Load

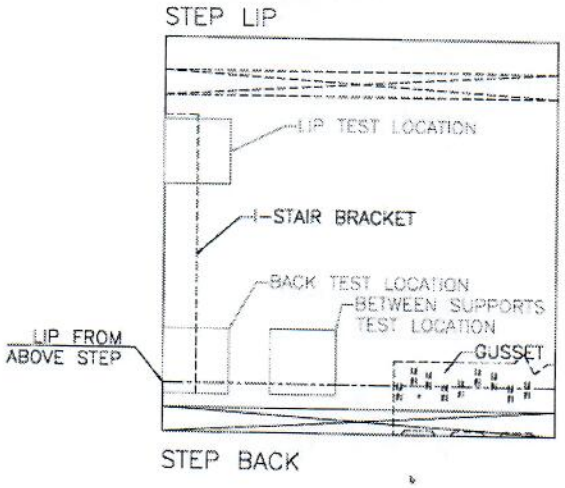
Project No.: 2011-404
Temp.: 62.7° F
Humidity: 39.4% R.H.
Deflection Limit @ 300 lbf*: .125"

Load (lbf)	Deflection[1] (in) Step Lip to Failure
200	.067
300	.085
400	.103
500	.119
600	.135
700	.151
800	.167
900	.186
1000	.205
1100	.245
1200	.304
1300	.436
1400	.762

Failure Mode:

During loading, the bracket directly under the loading nose started to deform at the lower portion of the bracket. Load was applied until a loss of load, and no subsequent load gains were noted. See failure pictures for further details.

Maximum Load: **1,424 lbf**



* Based on ICC-ES AC174 §4.1
[1] The deflection is measured at the loading nose. The system deflection was removed.

Progressive Engineering Inc.

Stair Tread Concentrated Load Test

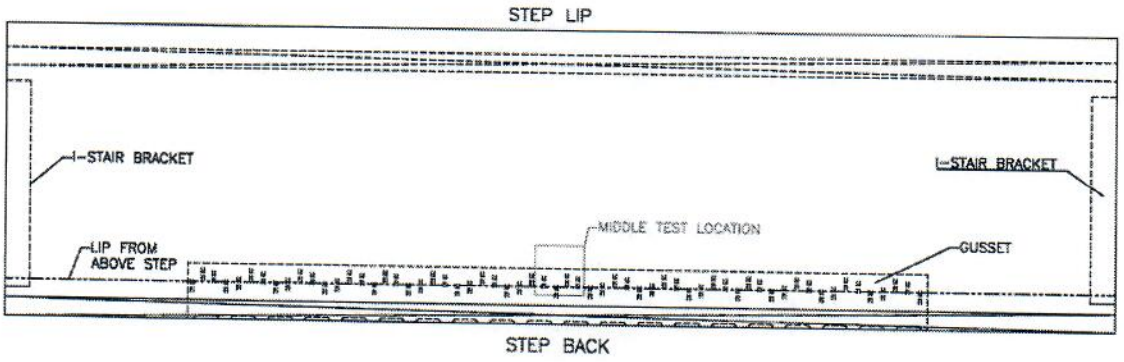
Date: 3/11/2011
Client: I-Stair Systems, Inc.
Specimen: trg45 [1]
Test: 2" x 2" Concentrated Load

Project No.: 2011-404
Temp.: 62.7° F
Humidity: 39.4% R.H.
Deflection Limit @ 300 lbf*: .125"

Load (lbf)	Deflection[2] (in) Midspan - trg45
200	.041
300	.059
400	.077
500	.094
600	.111
700	.130
800	.150

STATE OF MICHIGAN
TIMOTHY A. BALDRIDGE
ENGINEER
No. 54863
LICENSED PROFESSIONAL ENGINEER

Date Signed: Jun 09,2016



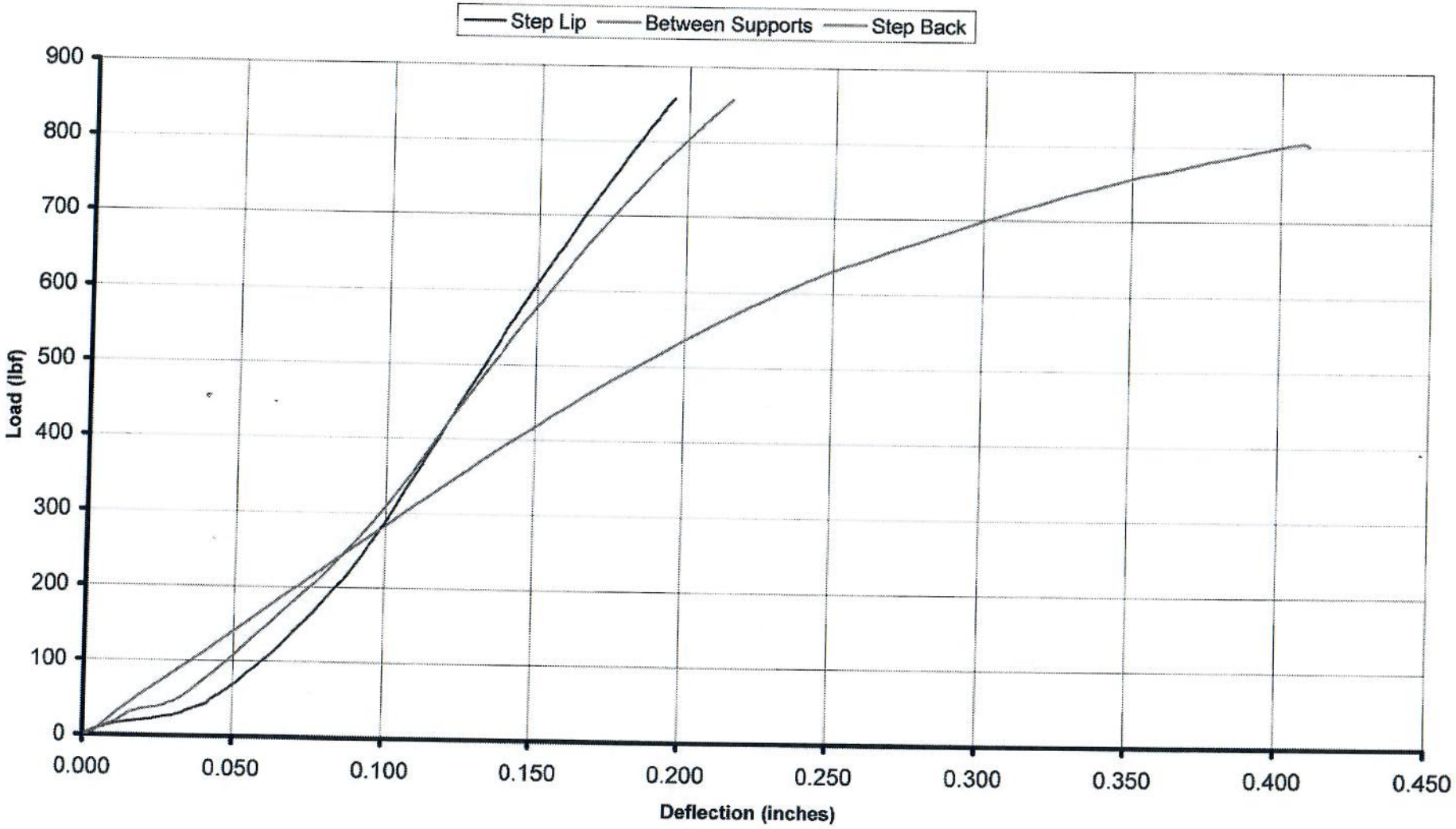
* Based on ICC-ES AC174 §4.1

[1] tread-riser-gusset, 45"

[2] The deflection is measured at the loading nose. The system deflection was removed.

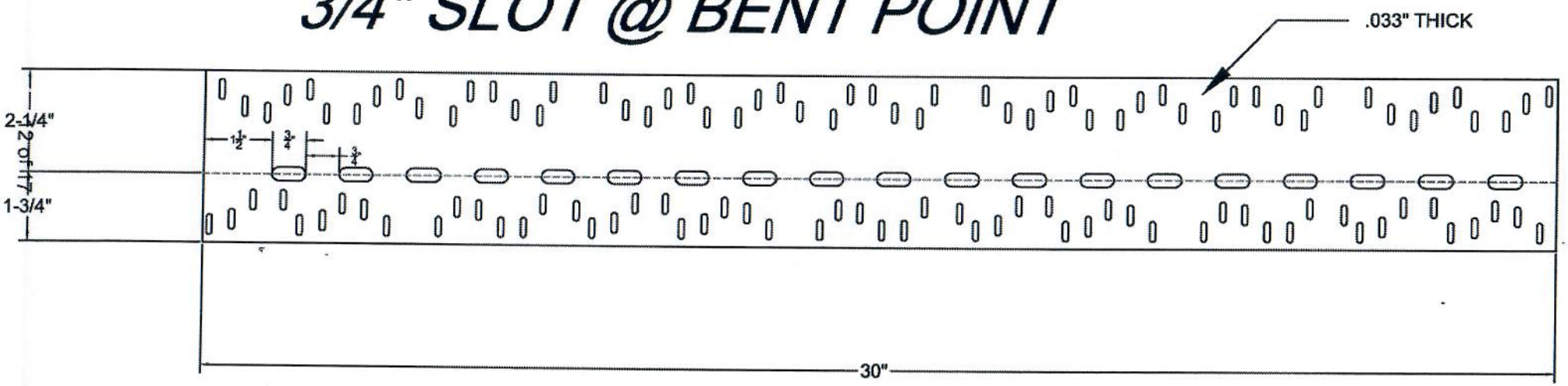
Progressive Engineering Inc.

I-Stair Systems
2x2" Concentrated Load
Load versus Deflection
i18GS I-Stair Bracket and trg45



Rev. 6/2/2016

3/4" SLOT @ BENT POINT



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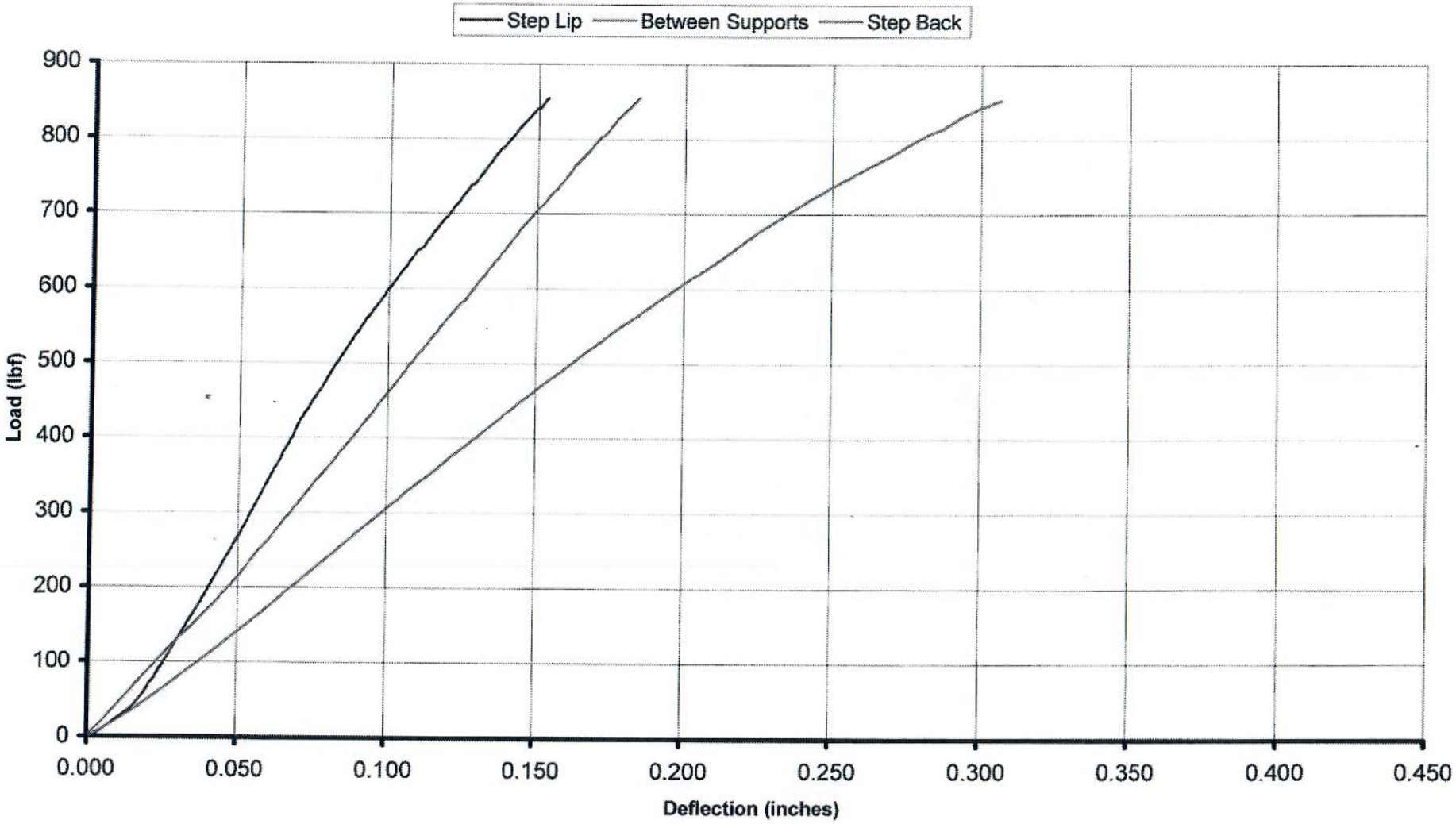
DATE: 04/01/11				
SCALE:				
JOB NO. 2011-404		TITLE: trg45 - TREAD RISER GUSSET		
DWG. NO. B1				

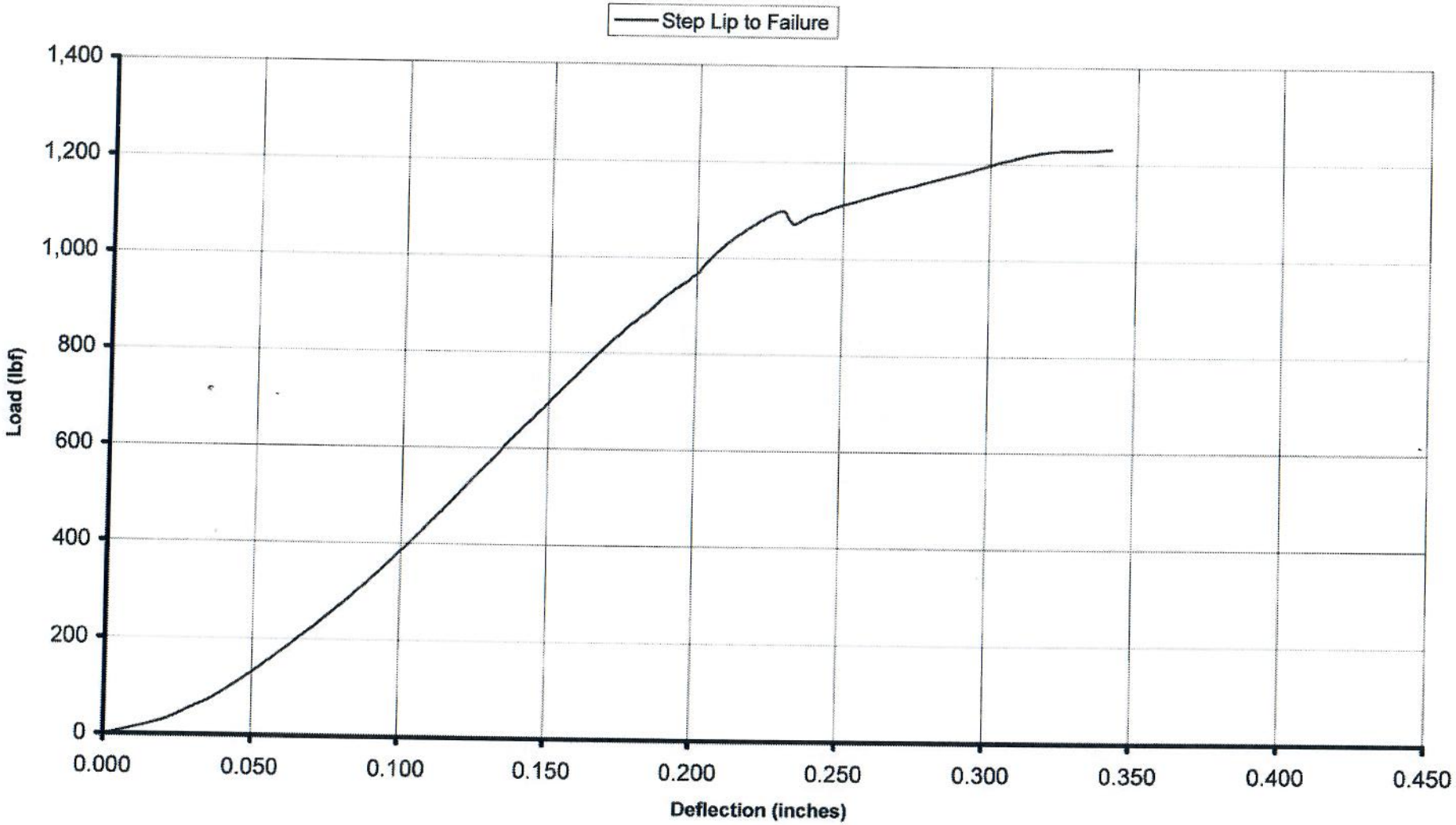
Progressive Engineering Inc.

I-Stair Systems
2x2" Concentrated Load
Load versus Deflection
i20GS I-Stair Bracket and trg45



Progressive Engineering Inc.

I-Stair Systems
2x2" Concentrated Load
Load versus Deflection
i20GS I-Stair Bracket and trg45



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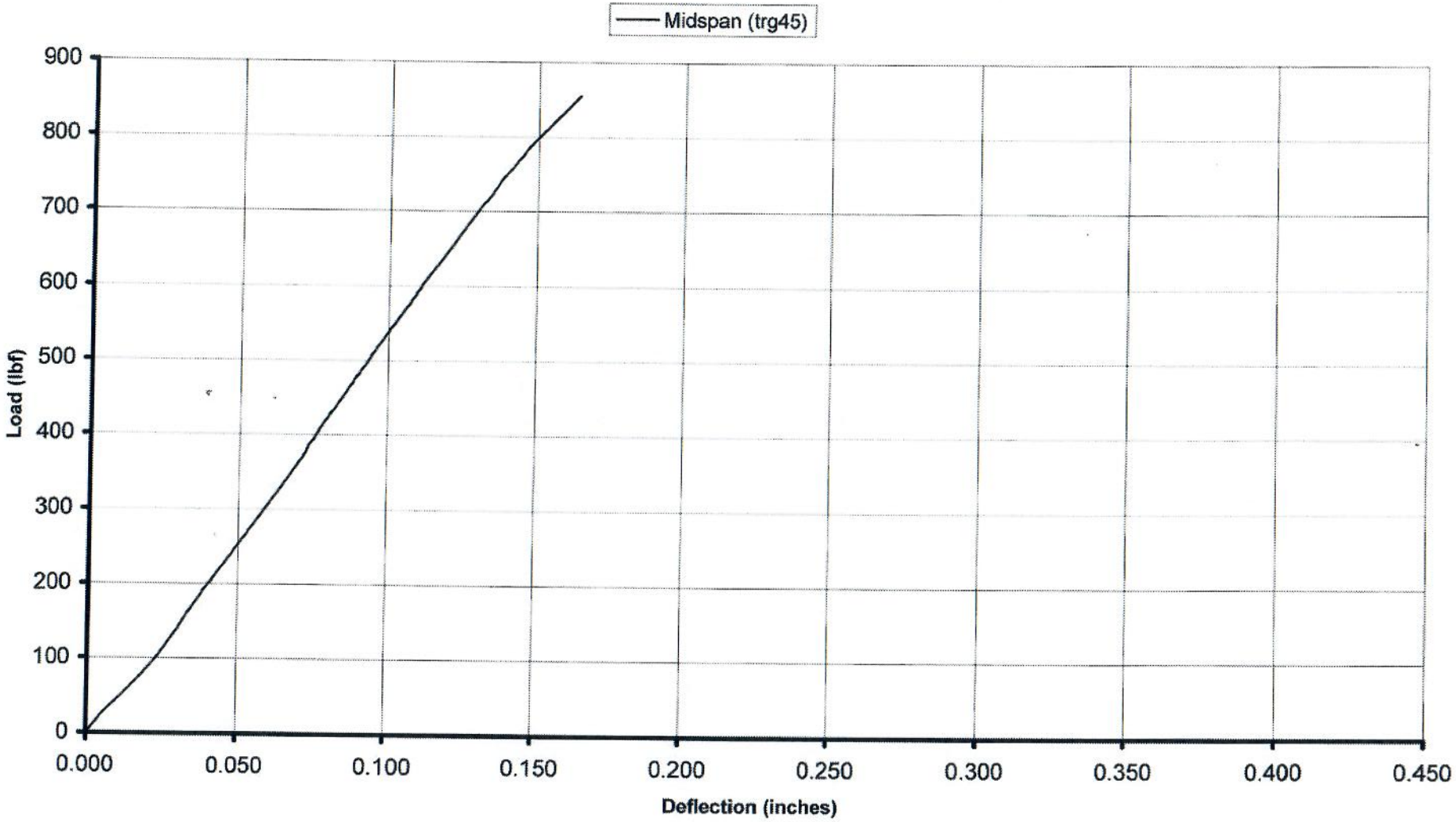
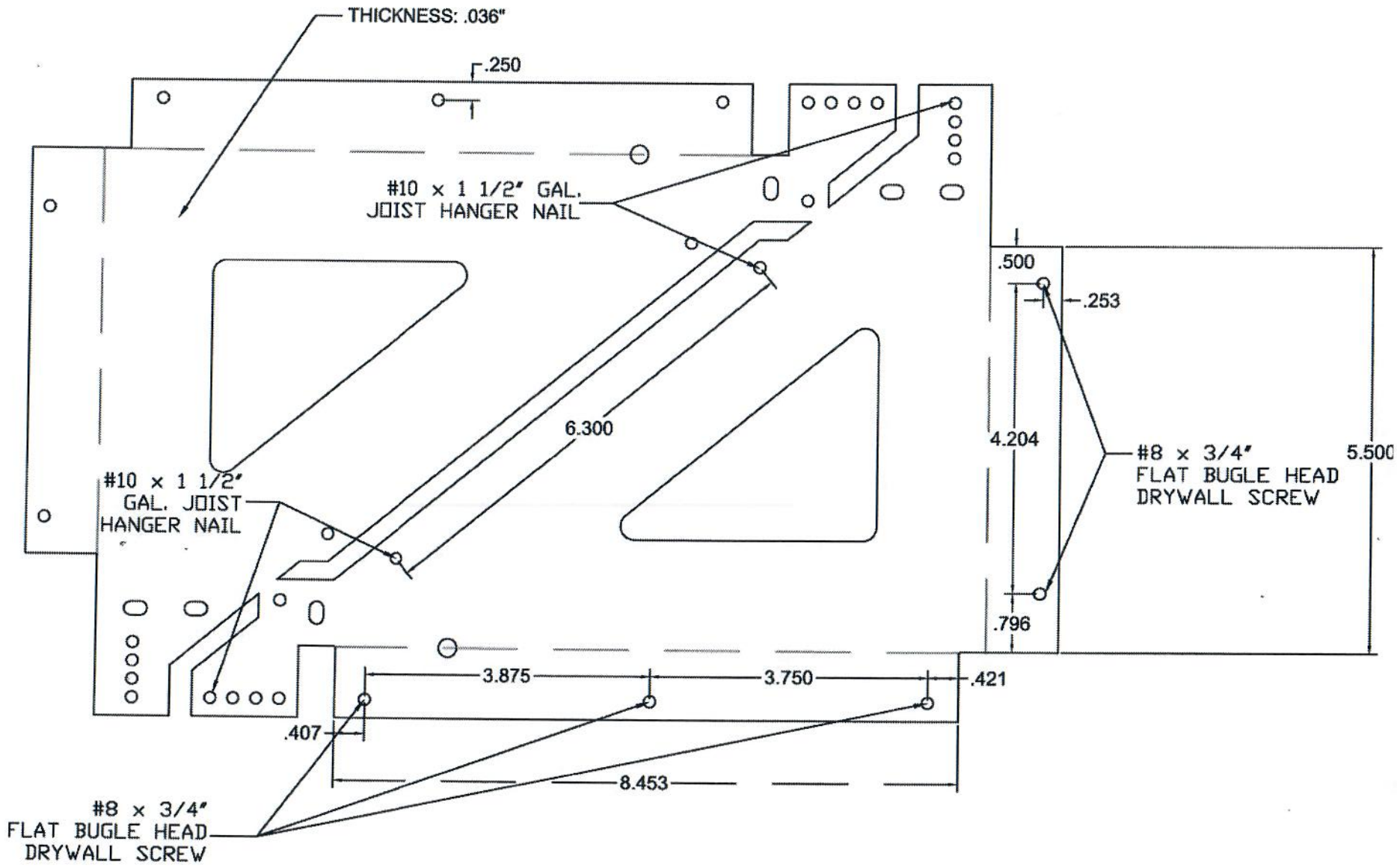
I-Stair Systems
2x2" Concentrated Load
Load versus Deflection
trg45" I-Stair Bracket





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SCALE:			
JOB NO. 2011-404		TITLE: 118gs I-STAIR BRACKET	
DWG. NO. B2			

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Goshen, IN 46528
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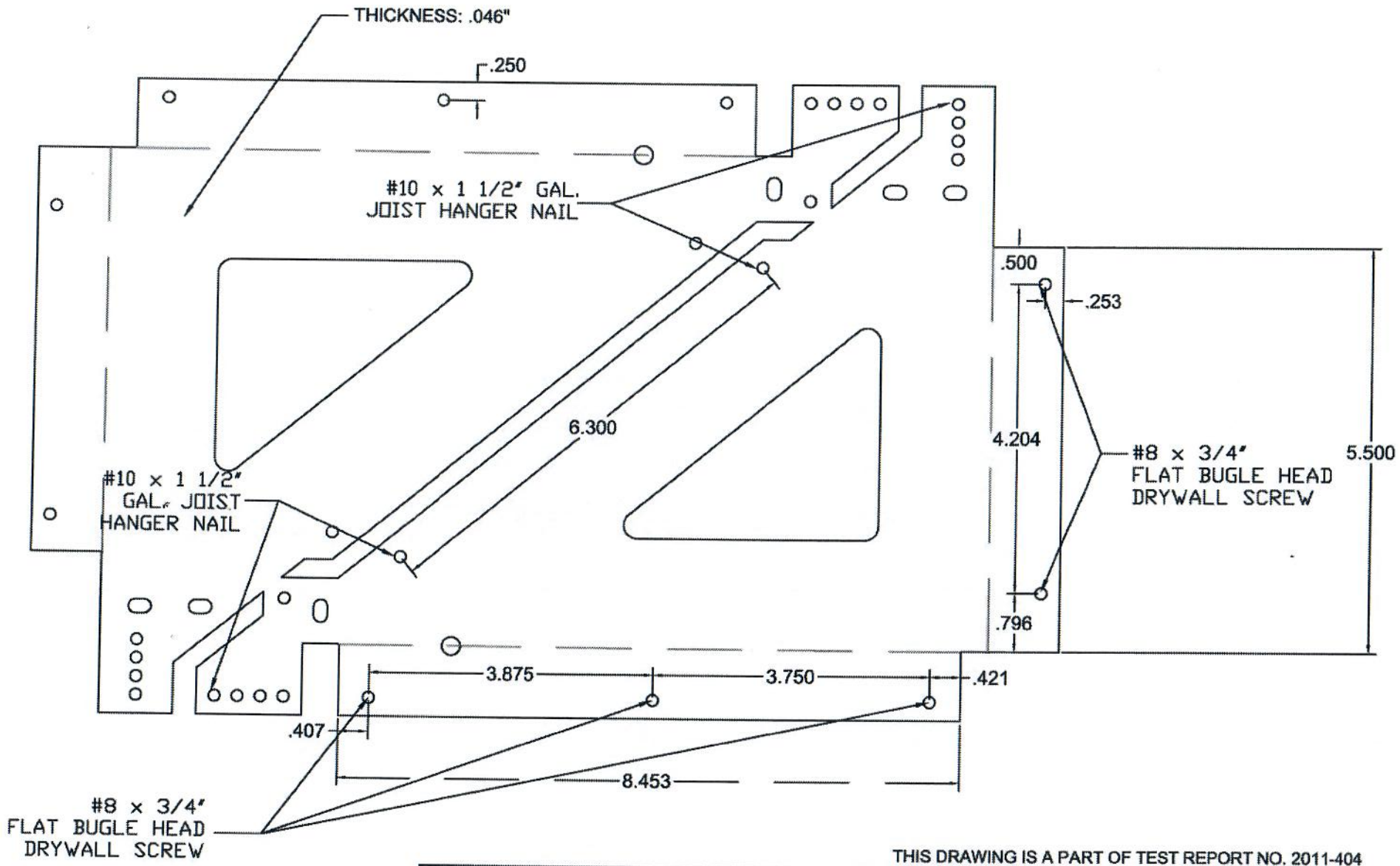

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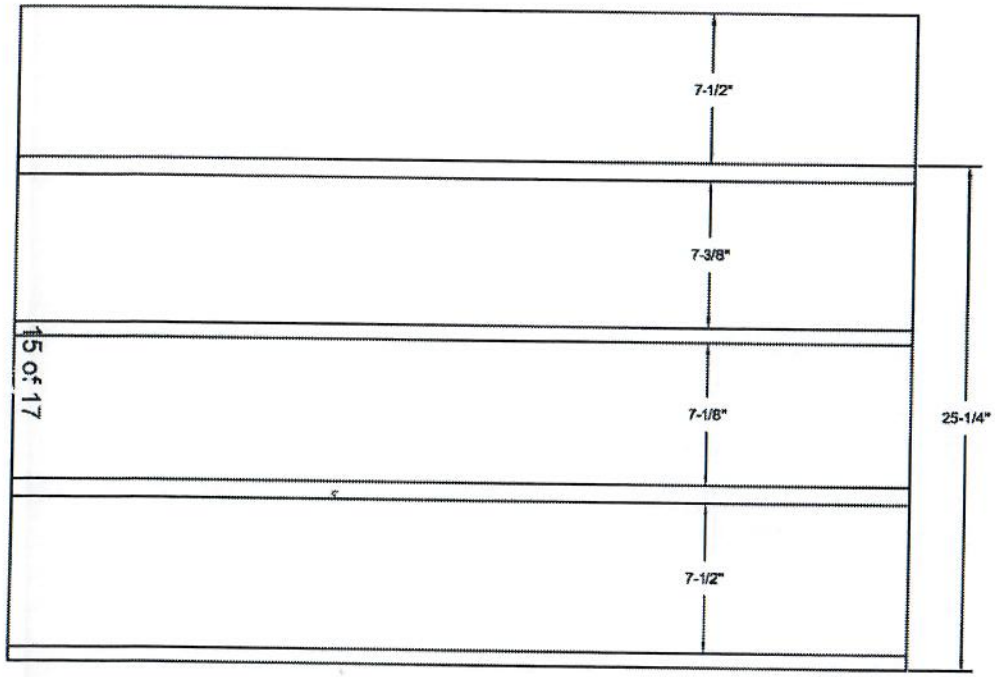
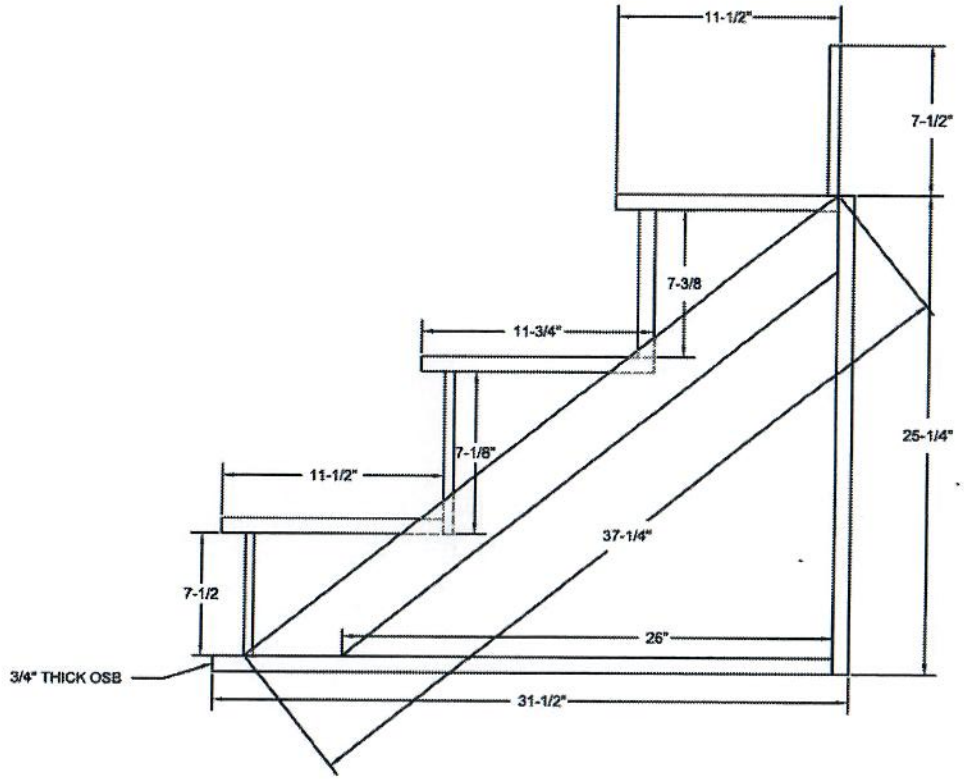
SCALE:				www.p-e-i.com
JOB NO. 2011-404		TITLE: 120gs I-STAIR BRACKET		
DWG. NO. B3				

Rev. 6/2/2016





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SCALE:				Goshen, IN 46528
JOB NO. 2011-404		TITLE: FRONT AND SIDE ELEVATION		Phone (574) 533-0337
DWG. NO. B4				Fax (574) 533-9736

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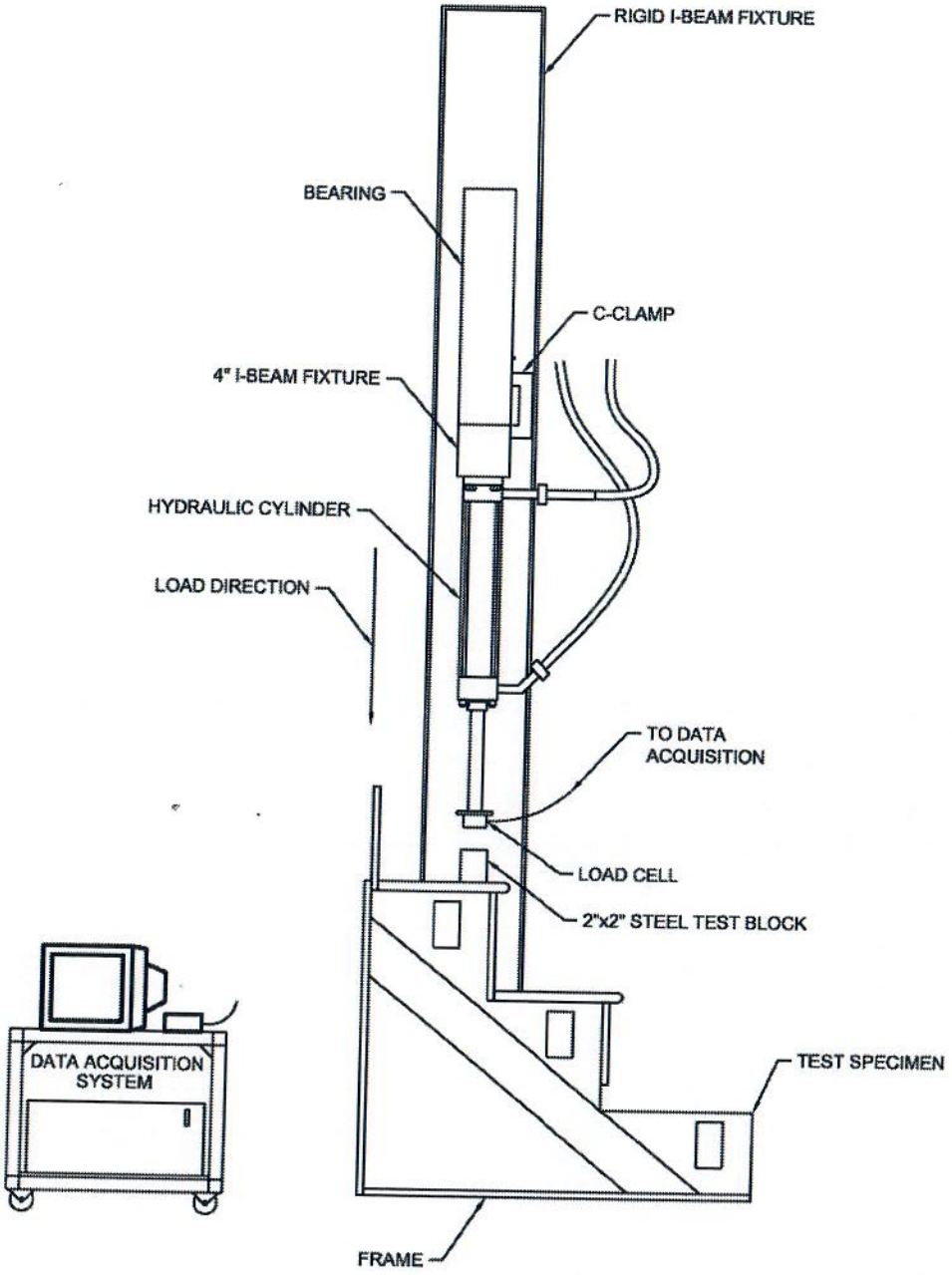
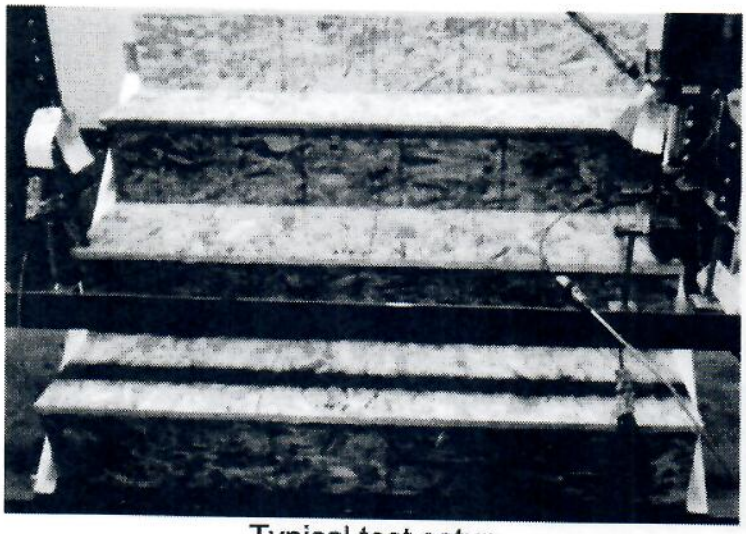
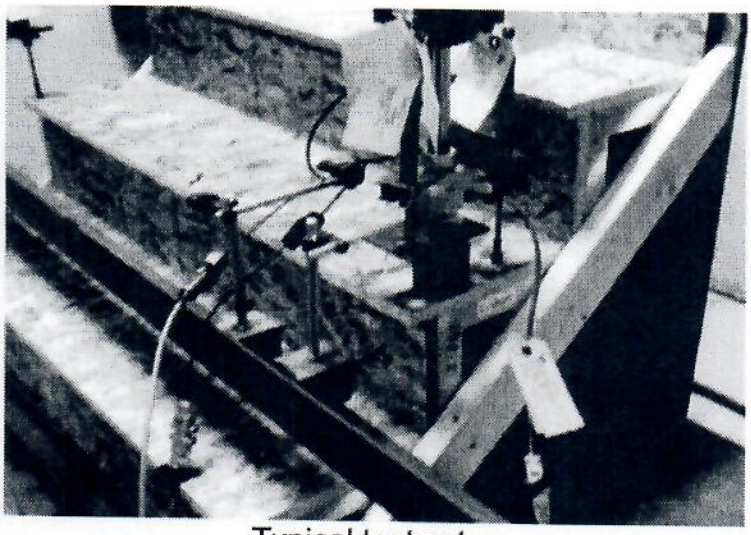


SIDE VIEW

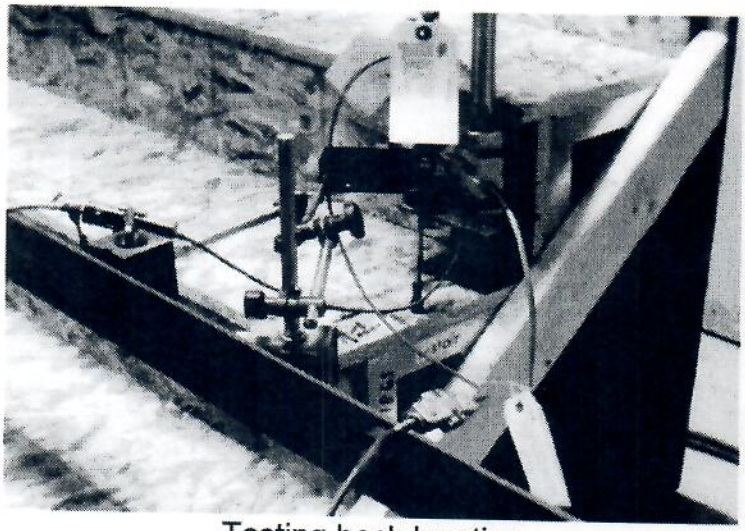
DWN. BY: N. AMSTUTZ	This drawing and all information contained herein is the property of PROGRESSIVE ENGINEERING, INC. and is not to be reproduced without the written permission of Pei. Pei assumes no responsibility for unauthorized use of this drawing.	Progressive Engineering Inc
DATE: 03/30/10		58640 State Road 1[illegible] Goshen, IN 4652[illegible] Phone (574) 533-6637 Fax (574) 533-9756
SCALE:		
DRAWING NUMBER: F1765	TITLE: TEST SET-UP	www.p-e-i.com



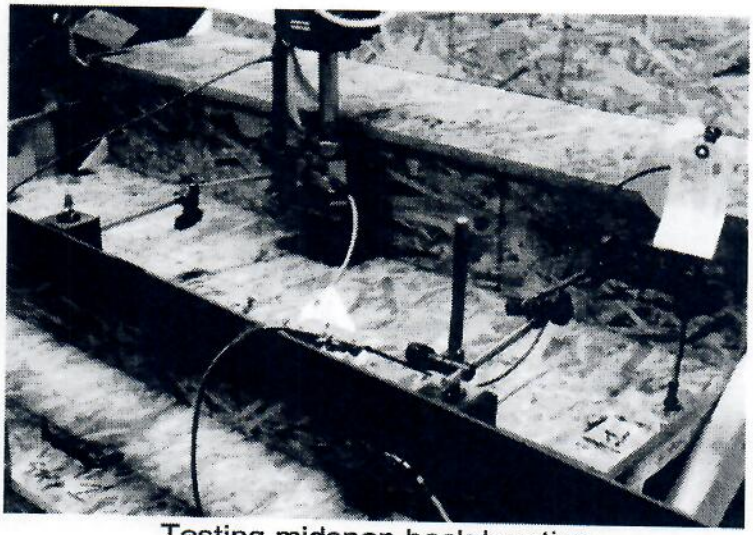
Typical test setup



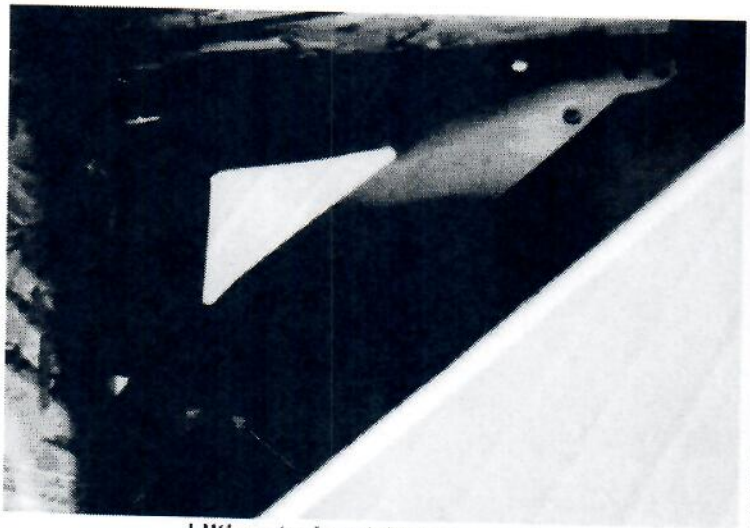
Typical test setup



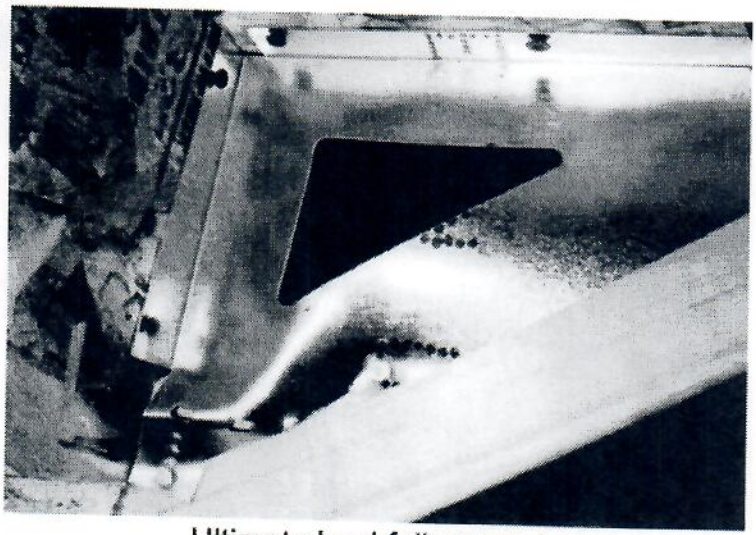
Testing back location



Testing midspan back location



Ultimate load failure mode



Ultimate load failure mode

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Step Load Cycle Test
5 total pages

MPI
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Progressive Engineering Inc.

Step Load Cycle Test

Client: I-Stair Systems, Inc.

Test Specimen: 44" wide steps using 10" Treads and 7-1/2" Risers, cut from 23/32" OSB, with I-Stair brackets fastened at each end to sections of OSB. Adhesive was applied between the I-Stair brackets at the contact areas with the tread and risers, as well as, between the tread and top of the riser. An "L" shaped gang nail reinforcement was used on the underside of the tread-to-riser intersection. *The steps were provided to PEI assembled with the pneumatic load cycling equipment installed.*

Test Details: A concentrated load of 300 lbf was applied to the center of the tread depth and width using a 2" x 2" loading nose. The cycling was intended to evaluate the connection of the tread-to-riser gang nail brace. Each cycle consisted of: (1) 3 second of load application and (2) 3 second with the load removed. Deflection readings were taken from two dial indicators that were placed on the underside of the step, one (1) under the load point and the other approximately six inches in from the end and centered on the tread depth. Deflection was recorded with the full load applied and with the load removed, to monitor changes in the step performance. Notes and readings were recorded at the beginning and end of each weekday, unless an issue occurred in which data was recorded upon notice of issue. See notes below for deflection and cycle information.

Date	Time	Cycle Count	Temp	Hum	Center Defl	End Defl	Comments / Observations
5/6/2016	8:10 AM	1	66	47	0.000	0.000	Started step cycling test.
					0.053	0.006	
5/6/2016	10:40 AM	650	-	-	0.003	0.001	Installed new loading plate w/ welded nut onto cylinder to keep cycle counter in contact.
					0.053	0.006	
5/6/2016	11:15 AM	788	71	46	0.003	0.001	Stopped cycling over weekend.
					0.053	0.006	
5/9/2016	6:50 AM	788	67	48	0.002	0.002	Start of weekly progress readings.
5/13/2016	10:45 AM	50,417	68	59	0.010	0.000	Stopped cycling over weekend.
					0.062	0.005	
5/14/2016	2:00 PM	67,117	-	-	-	-	Start of weekly progress readings, readings not recorded.
					-	-	
5/20/2016	11:35 AM	152,305	69	38	0.020	0.005	End of weekly progress readings.
					0.073	0.009	
5/23/2016	7:00 AM	192,762	70	47	0.023	0.005	Start of weekly progress readings.
					0.076	0.012	
5/27/2016	1:40 PM	253,842	-	-	-	-	End of weekly progress readings.
					-	-	
5/31/2016	7:45 AM	253,842	70	56	0.020	0.001	Start of weekly progress readings.
					-	-	
6/3/2016	12:05 PM	263,929	-	-	0.022	0.003	End of weekly progress readings.
					0.076	0.008	

Progressive Engineering Inc.

Step Load Cycle Test

Client: I-Stair Systems, Inc.

Test Specimen: 44" wide steps using 10" Treads and 7-1/2" Risers, cut from 23/32" OSB, with I-Stair brackets fastened at each end to sections of OSB. Adhesive was applied between the I-Stair brackets at the contact areas with the tread and risers, as well as, between the tread and top of the riser. An "L" shaped gang nail reinforcement was used on the underside of the tread-to-riser intersection. *The steps were provided to PEI assembled with the pneumatic load cycling equipment installed.*

Test Details: A concentrated load of 300 lbf was applied to the center of the tread depth and width using a 2" x 2" loading nose. The cycling was intended to evaluate the connection of the tread-to-riser gang nail brace. Each cycle consisted of: (1) 3 second of load application and (2) 3 second with the load removed. Deflection readings were taken from two dial indicators that were placed on the underside of the step, one (1) under the load point and the other approximately six inches in from the end and centered on the tread depth. Deflection was recorded with the full load applied and with the load removed, to monitor changes in the step performance. Notes and readings were recorded at the beginning and end of each weekday, unless an issue occurred in which data was recorded upon notice of issue. See notes below for deflection and cycle information.

Date	Time	Cycle Count	Temp	Hum	Center Defl	End Defl	Comments / Observations
6/6/2016	8:45 AM	305,208	68	68	0.020	0.002	Start of weekly progress readings.
					0.073	0.006	
6/10/2016	11:25 AM	400,700	75	67	0.024	0.002	End of weekly progress readings.
					0.079	0.007	
6/13/2016	7:15 AM	441,416	72	44	0.026	0.005	Start of weekly progress readings.
					0.079	0.009	
6/17/2016	8:30 AM	499,582	70	60	-	-	End of weekly progress readings.
					-	-	
6/20/2016	1:50 PM	543,114	83	57	-	-	Start of weekly progress readings.
					-	-	
6/23/2016	2:50 PM	586,914	79	68	-	-	Stopped cycling over weekend.
					-	-	
6/27/2016	6:45 AM	586,914	72	66	-	-	Started step cycling test.
					-	-	
6/30/2016	11:15 AM	633,414	72	40	-	-	Adjusted 2x2 loading plate
					-	-	
7/1/2016	10:10 AM	647,164	71	60	-	-	Stopped cycling over weekend.
					-	-	
7/5/2016	6:50 AM	647,164	72	63	-	-	Started step cycling test.
					-	-	

Progressive Engineering Inc.

Step Load Cycle Test

Client: I-Stair Systems, Inc.

Test Specimen: 44" wide steps using 10" Treads and 7-1/2" Risers, cut from 23/32" OSB, with I-Stair brackets fastened at each end to sections of OSB. Adhesive was applied between the I-Stair brackets at the contact areas with the tread and risers, as well as, between the tread and top of the riser. An "L" shaped gang nail reinforcement was used on the underside of the tread-to-riser intersection. *The steps were provided to PEI assembled with the pneumatic load cycling equipment installed.*

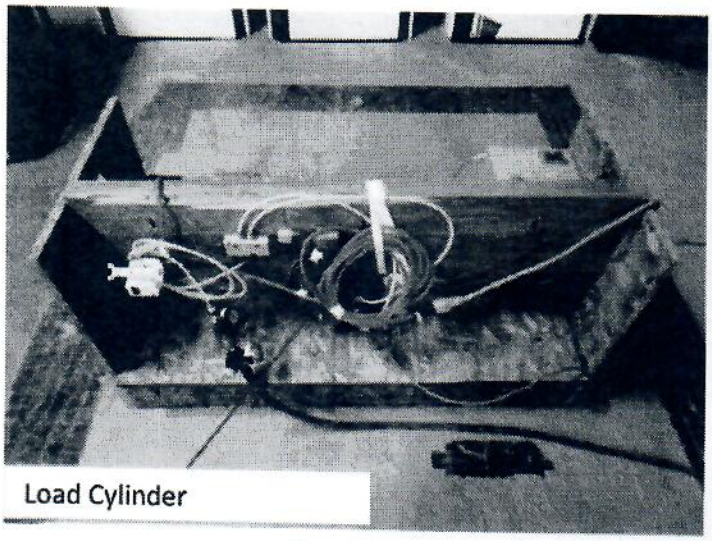
Test Details: A concentrated load of 300 lbf was applied to the center of the tread depth and width using a 2" x 2" loading nose. The cycling was intended to evaluate the connection of the tread-to-riser gang nail brace. Each cycle consisted of: (1) 3 second of load application and (2) 3 second with the load removed. Deflection readings were taken from two dial indicators that were placed on the underside of the step, one (1) under the load point and the other approximately six inches in from the end and centered on the tread depth. Deflection was recorded with the full load applied and with the load removed, to monitor changes in the step performance. Notes and readings were recorded at the beginning and end of each weekday, unless an issue occurred in which data was recorded upon notice of issue. See notes below for deflection and cycle information.

Date	Time	Cycle Count	Temp	Hum	Center Defl	End Defl	Comments / Observations
7/11/2016	10:30 AM	733,658	74	74	0.026	0.005	Discovered the setup had shifted on 6/17/16, so deflection gauges were reset. The permanent set deflection was set equal to the 6/13/16 values.
					0.072	0.010	
7/15/2016	11:30 AM	792,002	75	59	0.028	0.005	End of weekly progress readings.
					0.072	0.010	
7/22/2016	12:30 PM	893,408	76	48	0.031	0.005	End of weekly progress readings.
					0.075	0.011	
7/25/2016	7:30 AM	933,658	72	49	0.032	0.005	Start of weekly progress readings.
					0.076	0.011	
8/1/2016	7:00 AM	1,033,430	73	48	0.034	0.006	Stopped testing, cycling complete.
					0.080	0.013	

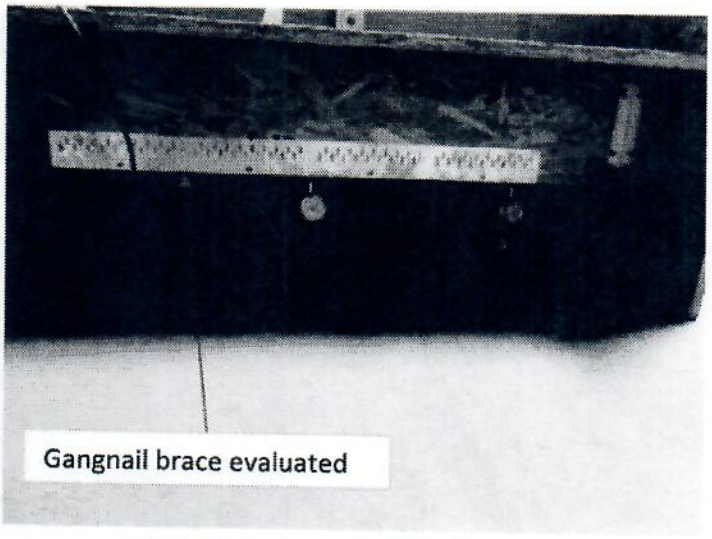
Shaded cell indicates deflection with 300 lbf applied

Shaded cell indicates deflection with no load applied

Conclusion: The stair-cycle test was a success, with no failures occurring, as well as no visual damage to the I-Stair brackets or gang nail brace. The tread surface in contact with the loading nose was slightly indented by 2x2 loading plate and had a few loose or frayed strands around the perimeter of the loading plate. The actual permanent set and deflection under load may vary from that shown at the completion of the test, due to the shifting in the sample on 6/17/16, however it was included to show that there was no significant material breakdown.

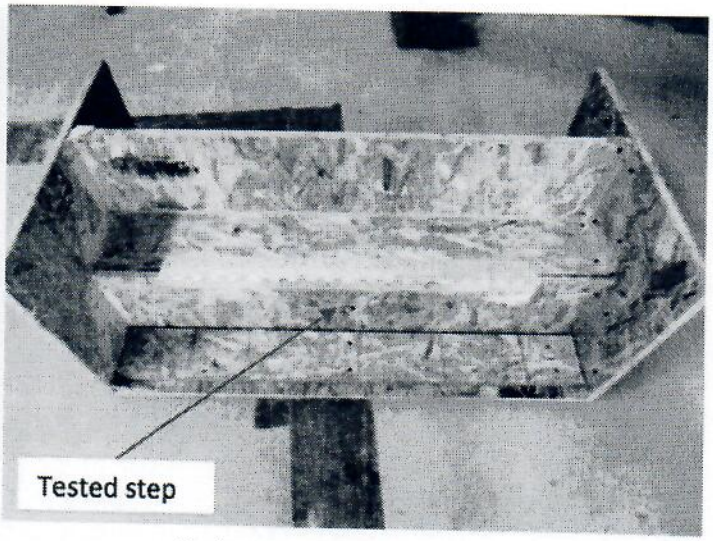


Test Setup



Test Setup - Dial Indicator Placement

2" x 2" loading nose



Underside view of test sample

Gangnail brace after 1,000,000+ cycles

I-Stair Brackets after 1,000,000+ cycles

Tread surface after 1,000,000 cycles

ISTAIR manufactured stair systems TM

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Calculations, Loads, Designs, Codes
8 total pages

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Progressive Engineering Inc.

I-Stair Systems, Inc.

Calculations

Lag Screw & Nail Quantity Check (MI)

Fastener Check

Design Loads

40 psf Live Load & 300 lb Load - IRC Loading

Applicable Codes

2015 International Residential Code

Analysis Provided by:

Progressive Engineering, Inc.

58640 S.R. 15

Goshen, IN 46542

Phone - (574) 533-0337

Fax - (574) 533-9736

Project No.

2016-1445

Progressive Engineering Inc.

Table of Contents

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Progressive Engineering Inc.
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NDS 11.3 - NAILS 10d x 3.0" Length Round Head Coil Nail

Live Load $LL := 40 \cdot psf$ $C_d := 1.0$ 2015 IRC Table R301.5

Dead Load $DL := 0 \cdot psf$ $C_{d2} := 0.9$

Stud Spacing $s_1 := \begin{pmatrix} 12 \\ 16 \\ 19.2 \\ 24 \end{pmatrix} in$

Width of Stair $w_s := \begin{pmatrix} 32 \\ 36 \\ 42 \\ 45 \\ 48 \end{pmatrix} in$

Total Uniform Load $w := C_d \cdot LL \cdot w_s + C_{d2} \cdot DL \cdot w_s = \begin{pmatrix} 106.67 \\ 120 \\ 140 \\ 150 \\ 160 \end{pmatrix} \cdot plf$

Load at Stud

$P_{i,j} := \max\left(w_j \cdot \frac{s_{1_i}}{2}, 150 \cdot lb\right)$

$P = \begin{pmatrix} 150 & 150 & 150 & 150 & 150 \\ 150 & 150 & 150 & 150 & 150 \\ 150 & 150 & 150 & 150 & 150 \\ 150 & 150 & 150 & 150 & 160 \end{pmatrix} \cdot lb$

300 lb concentrated load, assume distributed to a min of 2 studs, 150 lb each

Fastener Check NDS Table 11.3.1A Yeild Limit Equations

Dowel Diameter $D := 0.131 \cdot in$

Yeild Strength (Dowel) $F_{yb} := 100 \cdot ksi$

Dowel Bearing Strength (Main) $F_{em} := 3350 \cdot psi$ NDS Table 11.3.3 and 11.3.3A

Dowel Bearing Strength (Side) $F_{es} := 3350 \cdot psi$ NDS Table 11.3.3 and 11.3.3A

Dowel Bearing Length (Main) $L_m := 2 \cdot in$

Dowel Bearing Length (Side) $L_s := 1.5 \cdot in$

Angle btwn load and grain (Main) $\theta_m := 0$

Angle btwn load and grain (Side) $\theta_s := 37.78$

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Fastener Check NDS Table 11.3.1A Yeild Limit Equations - Continued

$$R_e := \frac{F_{em}}{F_{es}} = 1 \qquad R_t := \frac{L_m}{L_s} = 1.333 \qquad K_\theta := 1 + 0.25 \cdot \left(\frac{\max(\theta_s, \theta_m)}{90}\right) = 1.105 \qquad K_D := 2.2$$

$$k_1 := \frac{\left[\sqrt{R_e + 2 \cdot R_e^{\,2}\left(1 + R_t + R_t^{\,2}\right) + R_t^{\,2} \cdot R_e^{\,3}} - R_e \cdot \left(1 + R_t\right)\right]}{\left(1 + R_e\right)} = 0.492$$

$$k_2 := \left[-1 + \sqrt{2 \cdot \left(1 + R_e\right) + \frac{\left[2F_{yb} \cdot \left(1 + 2 \cdot R_e\right) \cdot D^2\right]}{3 \cdot F_{em} \cdot L_m^{\,2}}}\right] = 1.063$$

$$k_3 := \left[-1 + \sqrt{\frac{\left[2 \cdot \left(1 + R_e\right)\right]}{R_e} + \frac{\left[2F_{yb} \cdot \left(2 + R_e\right) \cdot D^2\right]}{3 \cdot F_{em} \cdot L_s^{\,2}}}\right] = 1.111$$

Yeild Mode

I_m $\quad Z_{Im} := \frac{\left(D \cdot L_m \cdot F_{em}\right)}{K_D} = 398.955 \cdot lb$ EQ 11.3-1

I_s $\quad Z_{Is} := \frac{\left(D \cdot L_s \cdot F_{es}\right)}{K_D} = 299.216 \cdot lb$ EQ 11.3-2

II $\quad Z_{II} := \frac{\left(k_1 \cdot D \cdot L_s \cdot F_{es}\right)}{K_D} = 147.108 \cdot lb$ EQ 11.3-3

III_m $\quad Z_{IIIm} := \frac{\left(k_2 \cdot D \cdot L_m \cdot F_{em}\right)}{\left(1 + 2 \cdot R_e\right) \cdot K_D} = 141.368 \cdot lb$ EQ 11.3-4

III_s $\quad Z_{IIIs} := \frac{\left(k_3 \cdot D \cdot L_s \cdot F_{em}\right)}{\left(1 + 2 \cdot R_e\right) \cdot K_D} = 110.787 \cdot lb$ EQ 11.3-5

IV $\quad Z_{IV} := \frac{D^2}{K_D} \cdot \sqrt{\frac{\left(2 \cdot F_{em} \cdot F_{yb}\right)}{\left[3 \cdot \left(1 + R_e\right)\right]}} = 82.429 \cdot lb$ EQ 11.3-6

$$Z := \min\left(Z_{Im}, Z_{Is}, Z_{II}, Z_{IIIm}, Z_{IIIs}, Z_{IV}\right) = 82.429 \cdot lb$$

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Results

Number of Nails Required

$$w_s^{T} = (32 \quad 36 \quad 42 \quad 45 \quad 48) \cdot \text{in}$$

$$N_{r_{i,j}} := \text{ceil}\left(\frac{P_{i,j}}{Z}\right) \qquad N_r = \begin{pmatrix} 2 & 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 & 2 \end{pmatrix}$$

12" Spacing
16" Spacing
19.2" Spacing
24" Spacing

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NDS 11.3 - GRK RSS LAG SCREWS 5/16"-9 x 3.5" Length

Live Load $LL := 40 \cdot psf$ $C_d := 1.0$ 2015 IRC Table R301.5

Dead Load $DL := 0 \cdot psf$ $C_{d2} := 0.9$

Stud Spacing $s_1 := \begin{pmatrix} 12 \\ 16 \\ 19.2 \\ 24 \end{pmatrix} in$

Width of Stair $w_s := \begin{pmatrix} 32 \\ 36 \\ 42 \\ 45 \\ 48 \end{pmatrix} in$

Total Uniform Load
Load at Stud $w := C_d \cdot LL \cdot w_s + C_{d2} \cdot DL \cdot w_s = \begin{pmatrix} 106.67 \\ 120 \\ 140 \\ 150 \\ 160 \end{pmatrix} \cdot plf$

$P_{i,j} := \max\left(w_j \cdot \frac{s_{1_i}}{2}, 150 \cdot lb\right)$ $P = \begin{pmatrix} 150 & 150 & 150 & 150 & 150 \\ 150 & 150 & 150 & 150 & 150 \\ 150 & 150 & 150 & 150 & 150 \\ 150 & 150 & 150 & 150 & 160 \end{pmatrix} \cdot lb$

300 lb concentrated load, assume distributed to a min of 2 screws, 150 lb each

Fastener Check NDS Table 11.3.1A Yeild Limit Equations

Reduced Dowel Diameter $D_r := 0.199 \cdot in$

Yeild Strength (Dowel) $F_{yb} := 191 \cdot ksi$

Dowel Bearing Strength (Main) $F_{em} := 3100 \cdot psi$ NDS Table 11.3.3 and 11.3.3A

Dowel Bearing Strength (Side) $F_{es} := 3100 \cdot psi$ NDS Table 11.3.3 and 11.3.3A

Dowel Bearing Length (Main) $L_m := 2.5 \cdot in$

Dowel Bearing Length (Side) $L_s := 1.5 \cdot in$

Angle btwn load and grain (Main) $\theta_m := 0$

Angle btwn load and grain (Side) $\theta_s := 37.78$

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Fastener Check NDS Table 11.3.1A Yeild Limit Equations - Continued

$$R_e := \frac{F_{em}}{F_{es}} = 1 \qquad R_t := \frac{L_m}{L_s} = 1.667 \qquad K_\theta := 1 + 0.25 \cdot \left(\frac{\max(\theta_s, \theta_m)}{90}\right) = 1.105 \qquad K_D := 2.2$$

$$k_1 := \frac{\left[\sqrt{R_e + 2 \cdot R_e^{\,2}\left(1 + R_t + R_t^{\,2}\right) + R_t^{\,2} \cdot R_e^{\,3}} - R_e \cdot \left(1 + R_t\right)\right]}{\left(1 + R_e\right)} = 0.582$$

$$k_2 := \left[-1 + \sqrt{2 \cdot \left(1 + R_e\right) + \frac{\left[2F_{yb} \cdot \left(1 + 2 \cdot R_e\right) \cdot D_r^{\,2}\right]}{3 \cdot F_{em} \cdot L_m^{\,2}}}\right] = 1.186$$

$$k_3 := \left[-1 + \sqrt{\frac{\left[2 \cdot \left(1 + R_e\right)\right]}{R_e} + \frac{\left[2F_{yb} \cdot \left(2 + R_e\right) \cdot D_r^{\,2}\right]}{3 \cdot F_{em} \cdot L_s^{\,2}}}\right] = 1.484$$

Yeild Mode

I_m $\quad Z_{Im} := \frac{\left(D_r \cdot L_m \cdot F_{em}\right)}{K_D} = 701.023 \cdot lb$ EQ 11.3-1

I_s $\quad Z_{Is} := \frac{\left(D_r \cdot L_s \cdot F_{es}\right)}{K_D} = 420.614 \cdot lb$ EQ 11.3-2

II $\quad Z_{II} := \frac{\left(k_1 \cdot D_r \cdot L_s \cdot F_{es}\right)}{K_D} = 244.596 \cdot lb$ EQ 11.3-3

III_m $\quad Z_{IIIm} := \frac{\left(k_2 \cdot D_r \cdot L_m \cdot F_{em}\right)}{\left(1 + 2 \cdot R_e\right) \cdot K_D} = 277.254 \cdot lb$ EQ 11.3-4

III_s $\quad Z_{IIIs} := \frac{\left(k_3 \cdot D_r \cdot L_s \cdot F_{em}\right)}{\left(1 + 2 \cdot R_e\right) \cdot K_D} = 208.023 \cdot lb$ EQ 11.3-5

IV $\quad Z_{IV} := \frac{D_r^{\,2}}{K_D} \cdot \sqrt{\frac{\left(2 \cdot F_{em} \cdot F_{yb}\right)}{\left[3 \cdot \left(1 + R_e\right)\right]}} = 252.883 \cdot lb$ EQ 11.3-6

$$Z := \min\left(Z_{Im}, Z_{Is}, Z_{II}, Z_{IIIm}, Z_{IIIs}, Z_{IV}\right) = 208.023 \cdot lb$$

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Results

Number of Screws Required

$$w_s^T = (32 \quad 36 \quad 42 \quad 45 \quad 48) \cdot \text{in}$$

$$N_{r_{i,j}} := \text{ceil}\left(\frac{P_{i,j}}{Z}\right) \qquad N_r = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{pmatrix}$$

12" Spacing
16" Spacing
19.2" Spacing
24" Spacing

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Certificates Of Accreditation
3 total pages

MPI
CONCEPTS INC.

International Accreditation Service

CERTIFICATE OF ACCREDITATION

This is to signify that

PROGRESSIVE ENGINEERING, INC.
58640 STATE ROAD 15
GOSHEN, INDIANA 46528

Testing Laboratory TL-178
(Revised February 10, 2011)

has met the requirements of the IAS Accreditation Criteria for Testing Laboratories (AC89), has demonstrated compliance with ANS/ISO/IEC Standard 17025:2005, *General criteria for the competence of testing and calibration laboratories*, and has been accredited, commencing July 20, 2009, for the test methods listed in the approved scope of accreditation.

Patrick V. McCullen
Vice President

C. P. Ramani, P.E.
President

ACCREDITED

(see attached scope of accreditation for fields of testing and accredited test methods)

Print Date: 03/22/2011

This accreditation certificate supersedes any IAS accreditation certificate bearing an earlier date. The certificate becomes invalid upon suspension, cancellation or revocation of accreditation. See the IAS Accreditation Listings on the web at www.iasonline.org for current accreditation information or contact IAS directly at (562) 699-0541.

IAS is a subsidiary of the International Code Council

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International Accreditation Service

SCOPE OF ACCREDITATION

Progressive Engineering, Inc. TL-178
(Revised February 10, 2011)

Progressive Engineering, Inc.
58640 State Road 15
Goshen, IN 46528

Jason Holdeman
Laboratory Manager
(574) 533-0337

FIELDS OF TESTING	ACCREDITED TEST METHODS
Glued lumber	SPIB Glued Lumber Standard
Gypsum wallboard	ASTM Standards C 36, C 473, C 1177, C 1396 and C 1658
Adhesives	ASTM Standards C 557, C 1442, C 1501, D 903, D 904, D 905, D 1002, D 1084, D 1101, D 1876, D 2559, D 3024, D 3498, D 3930 and D 4317; APA Specification AFG-01
Sandwich panels	ASTM Standards C 271, C 272, C 273, C 297, C 365, C 393, D 1037, D 3043, D 6464, E 564 and E 72; Test methods referenced in Section 4.0 of ICC-ES Acceptance Criteria AC269
Mechanical fasteners	ASTM Standards D 1761 and E 8
Framed floor and roof diaphragms	ASTM Standards D 5206, E 96, E 330, E 455, E 661 and E 1592; AISI Standards TS-5 and TS-7; Test methods referenced in Section 3.0 of ICC-ES Acceptance Criteria AC262, AC318 and AC319
Determine limiting heights of composite walls	Test methods referenced in Section 4.0 of ICC-ES Acceptance Criteria AC86

July 20, 2009
Commencement Date

ACCREDITED

C. P. Ramani, P.E.
President

Print Date: 03/22/2011

International Accreditation Service

SCOPE OF ACCREDITATION

Progressive Engineering, Inc. TL-178
(Revised February 10, 2011)

FIELDS OF TESTING	ACCREDITED TEST METHODS
Deck board and guard rail systems	ASTM Standards D 638, D 790, D 6109 (Method A only), D 7031, D 7032, G 154 and G 155; AAMA 306 (except Sections 5.2, 5.3 and 5.5); Test methods referenced in Section 3.0 of ICC-ES Acceptance Criteria AC174 (except Sections 3.9 and 3.10), AC273 Section 4.0, AC335 Section 3.0 and AC344 Section 3.0
Furniture testing	ASTM Standard F 1561
Vehicle safety and ambulance testing	49 CFR 571 Federal Motor Vehicle Safety Standards (FMVSS) 206, 207, 210, 216, 217, 220, 221, 222 (limited to Section S5.4, S6.1, S6.2, and S6.3), 302, and 403; Ambulance Manufacturers Division (AMD) Standards No. 001, 002, 003, 004, 005, 006, 007, 008, 009, 010, 011, 012, 013 (Limitation: Maximum of 10,000 lb per axle), 014, 015, 016, 017, 018, 019, 020, 021, 022, 024, and 025; KKK-A-1822F Inspections
Structural testing	ASTM Standard E 2126

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ACCREDITED

C. P. Ramani, P.E.
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