ECTEK INTERNATIONAL / AMERIFORM LLC

ASTM E455 Floor Diaphragm Test on a
10' x 20' Floor using 3/4" Armoroc®
Panels (6”-12”) and 16 ga. Steel Joists Spaced 24” o.c.

8/1/2013

This test report contains thirty-one (31) pages, including the cover sheet. Any
additions to, alterations of, or unauthorized use of excerpts form this report are
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2012-1806
1. TITLE

ASTM E455 Floor Diaphragm Test on a 10’ x 20’ Floor using 3/4” Armoroc® Panels (6”-12”) and 16 ga. Steel Joists Spaced 24” o.c.

2. OBJECTIVE

The objective of this test was to determine the horizontal diaphragm strength of a floor diaphragm constructed per the enclosed details using Armoroc® Panels.

*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

Ameriform LLC
36A Pope Rd
Holliston, MA 01746

Ectek International
49 Mossgrove Trail
North York, ON, Canada
M2L2W2

4. TESTING ORGANIZATION

*Progressive Engineering Inc.*
58640 State Road 15
Goshen, IN 46528
[www.p-e-i.com](http://www.p-e-i.com)


5. TESTING PERSONNEL

Test Engineer - Timothy A. Baldridge, P.E.
Director of Testing - Jason R. Holdeman
Technician - Chris Stutzman
Technician - Justin Witmer
6. REFERENCE STANDARDS

ASTM E 455-11 - Standard Test Method for Static Load Testing of Framed Floor or Roof Diaphragm Constructions for Buildings

7. TEST EQUIPMENT

A. Four (4) Lynair hydraulic cylinders, Model No. LH-D401, Bone 3-1/4" and 12" stroke.
B. Five (5) Linear Transducers (PEI No. 653, 739, 849, 850 & 858).
   - .001" increments (4" travel)
C. One (1) Omega pressure transducer (PEI No. 633).
D. Data Acquisition System (PEI No. 566)
E. Panel Scale Load Cell (PEI No. 414)
F. Disk Micrometer (PEI No. 626)

8. TEST SPECIMEN

A. Floor Sheathing

   1. 3/4" Armoroc® - Armoroc® Panels are a structural cement bonded partical board - CBPB, composed of cement and mineralized wood fibers. A square-edge tongue and groove is located along the 8' dimension of the 4' x 8' sheets. The average measured thickness was, .751". The Armoroc® Panels used for the tests in this report had no stamped production dates or any markings, however the skid label read; "Production Lot No: 20130409-C-6, Skid Series: 413-7, Inspection Date: 2013.4.10".

      See attached drawings, photographs, and Appendix for more details.

B. Floor Framing

   1. Joists - 16 ga. x 10" deep x 10' long joists, Part No. ST1016CSW10', manufactured by MarinoWare. The joists were stamped "MW .0538 50 KSI G90 ICC ES ESR3016".

   2. Track - 16 ga. x 10" deep x 22' long tracks, Part No. TR1016TSB22', manufactured by MarinoWare. The track was stamped "MW .0538 50 KSI G60".
C. Hardware

1. Utility Angle for Joist to Track - 16 ga. x 2" x 2" x 10" steel angle, Part No. ANGLE216-10', manufactured by MarinoWare.

2. Utility Angle for blocking to Joists - 16 ga. x 2" x 3" x 10" steel angle, Part No. ANGLE2316-10', manufactured by MarinoWare.

3. Strapping - 20 ga. x 1-1/4" wide flat strapping, Part No. STFS1142050.

D. Fasteners

1. Sheathing to Frame - #10-16 x 1-5/8" long ceramic coated screws, winged driller, self countersinking head, manufactured by Grabber, Item No. PFH-PT#3. The screws had an average measured head diameter of .369" and thread diameter of .185". See ICC-ES Legacy Report No. ER-5280.


3. Track Leg to Joist - #8-16 x 1/2" long phillips drive, wafer head drill-point screw, part no. VB34Z, manufactured by Grabber. See ICC-ES Legacy Report No. ER-5280.

9. TEST SPECIMEN CONSTRUCTION

Two (2) test samples were constructed to an overall dimension of 10'-0" x 20'-0" by PEI personnel. The steel framework was assembled in accordance with installation guidelines set by Ameriform LLC.

A. The joists were attached to the track using a 2" x 2" x 10" utility angle at each end of the joists with two (2) #10 screws into the joist and two (2) #10 screws into the the track. One (1) #8 screw was placed thru the top and bottom leg of the rim track into each joist.

B. Metal strapping was fastened to the bottom of the joists across the center line of the floor. The strapping was attached with one (1) #10 screw into each joist.
C. Solid blocking was added to the midspan of the outside two (2) bays at each end of the test sample. A piece of the joist was used along with utility angles for the solid blocking. Two (2) #10 screws were used to secure each leg of the angles.

D. The frame was squared and then the Armoroc® panels were fastened to it. The Armoroc® panels were fastened at 6" o.c. around the entire perimeter, inset 2" from the corners, and 12" o.c. in the field with #10-16 x 1-5/8" lg. Grabber screws. Care was taken to insure that the fasteners were kept flush or slightly below the surface of the Armoroc® panels and also did not strip out in the steel framing.

E. 1/2" x 4" x 4" angle iron was then fastened to the end joists flush to the bottom of the joists to minimize crumpling of the joists at the bearings and to represent the top plate member.

10. TEST SET-UP

The test sample was supported by appliance rollers at 24" o.c. around the perimeter of the test sample on a concrete floor. A bearing support was placed at both ends of the test sample. A 1" thick x 10" tall x 14" wide reaction plate was set against the rim track at each bearing to minimize local deformation. The reaction plates were spaced from the bearing with a 1" x 1" steel bar on one end and with a 1" dia. rod on the other end. Four (4) loading cylinders were located on the opposite side of the test sample. The load was applied from the cylinders through steel I-beams, to eight (8) 18" bearing blocks to uniformly apply the load to the floor. Five (5) linear transducers, were placed along the bearing side of the test sample to measure deflection. See attached fixture drawing no. F1907 and F1908 for details.

11. TEST PROCEDURE

A. The data acquisition system was initiated and all of the displacement gauges and the load cell were checked to insure the signal was active. The preload file was opened and the program was initiated. A preload of approximately 10% of the expected ultimate load.

B. The preload was applied at approximately the same rate as is required to attain the anticipated maximum load in not less than ten (10) minutes. The preload was held for approximately 5 seconds and then was released. The data file was saved and then closed. The load was removed for a minimum of one (1) minute.
C. The "test file" was then opened and then the program was initiated with all measurement devices set to zero. The load was applied using the hydraulic cylinders and manually regulated using flow control valves to maintain a load rate of not less than ten (10) minutes to the maximum load. Observations were recorded throughout the test.

D. The loads were released at the point where no further gain could be attained. The file was saved and then the maximum load and displacement at the maximum load was recorded by the technician, along with a detailed description of the failure.

E. The data acquisition system was set to record in one (1) second increments until a failure was attained. The data pages found in this report display only ten (10) readings between zero and the maximum load. However, the chart reflects the data as recorded by the acquisition system.

12. TEST RESULTS

See the attached data pages and charts for test results.

13. CONCLUSION

Based on the testing described in this report, when tested per ASTM E455 Simple Beam Test Method, an average ultimate shear strength of 1,000 PLF for a 6-12 fastener spacing can be attained when using the following:

A. 3/4" Armoroc® panels fastened in accordance with drawing no. B3 report.

B. 3/4" Armoroc® panels fastened using #10-16 x 1-5/8" long winged driller screws manufactured by Grabber.

C. 16ga. x 10" joists spaced 24" o.c. and 16ga. x 10" track attached in accordance with drawing no.'s B1 and B2 of this report.
Progressive Engineering Inc.

ASTM E 455 Simple Beam Diaphragm Test

Date: 7/10/2013
Client: Ameriform, LLC / Ectek

Specimen: 3/4" Armoroc (T&G) fastened to 16 ga. Steel joists, set 24" o.c., with #10 x 1-5/8" screws spaced 6" o.c. around the perimeter and 12" o.c. in the field. See drawing no. B4 for details.

Test No. 12-1806-FD-6x12@24oc-1

<table>
<thead>
<tr>
<th>Load (lbf)</th>
<th>Location 1</th>
<th>Location 2</th>
<th>Location 3</th>
<th>Location 4</th>
<th>Location 5</th>
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Ultimate Load (R_u) = 20,706 lbf
Shear Strength (S_u) = 1,035 plf

Design Load (Ru/3) = 6,902 lbf
Design Shear Strength = 345 plf

Failure:
Row #2, Joist #3 - The board cracked/split across the 48" width. The butt-joints had significant separation on Rows #1 and #2 due to board break out around the fasteners. Board break out around the fasteners also occurred along both end joists. The board cracked/split in Row #3 between Joists #8 and #9. Shifting along T&G edges noted on both joints with fastener rotation and surface spalling at some intermediate joist fasteners. See Failure Detail drawing and photographs for more details.

Notes:
At 11,700 lbf the butt-joints in Rows #1 and #2 started to open. There were gaps between the track and bearing plates at each end due to a slight twist in the track and may account for some of the extra movement seen on Indicators #1 and #5. Not many noises during the loading and the failure was a quiet soft sound.

* Δ is derived by subtracting the average bearing movement from the maximum point of deflection.
ASTM E 455 Simple Beam Diaphragm Test

Test Conditions
- Temperature (°F): 73
- Relative Humidity (%): 52
- Preload (lbf): 1,287
- Diaphragm Length a (in): 240
- Diaphragm Depth b (in): 120

Load Duration to Rₜ(min:sec): 32:46

Deflection (in)

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<tr>
<th>Load (lbf)</th>
<th>Location 1</th>
<th>Location 2</th>
<th>Location 3</th>
<th>Location 4</th>
<th>Location 5</th>
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<td>0.681°</td>
<td>0.807°</td>
<td>0.710°</td>
<td>0.148°</td>
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Ultimate Load (Rₜ) = 19,324 lbf
Shear Strength (Sₜ) = 966 plf

Design Load (Rₜ/3) = 6,441 lbf
Design Shear Strength = 322 plf

Failure:
- Joist #1 rolled with board break out around all of the fasteners in Row #2 and #3 and some board pull-over at the corner.
- Row #1, Joist #3 - butt-joint separation with board break out around fasteners resulting in shifting of the T&G joint with board pull-over at the fasteners in Joist #2.
- Row #1, Joist #7 - butt-joint separation with T&G shift to Row #2, Joist #9 which also had butt-joint separation with board break out around the fasteners. A small crack/split occurred in Row #3 between Joist #9 and #10. See Failure Drawing and photographs for more details.

Notes:
- At 5,200 lbf butt-joints started separating on Row #1 and #2. Row #1, Joist #3 - At 14,000 lbf the butt-joint started to separate due to board break out around fasteners.

* Δ is derived by subtracting the average bearing movement from the maximum point of deflection
SAMPLE NO. 12-1806-FD-6x12@24"O.C.-2

MISSING FASTENER

1 1/4" SHIFT

JOIST ROLLED

LOAD SIDE

BEARING SIDE

PANEL GROOVE EDGE

= SHEATHING FRACTURES @ FASTENER
= SURFACE SPALLING
= BOARD SURFACE FAILURE AT ADHESIVE BOND REGION
= FASTENER ROTATION
= SHEATHING PULL-OVER
= FASTENER SHEAR
--- = SEPARATION OR SHIFTING (>1/4")
---- = SEPARATION OR SHIFTING (<1/4")
----- = BOARD BREAKAGE

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Ameriform LLC / Ectek
ASTM E455 Simple Beam Floor Diaphragm Test
16 Ga. Steel Framing Spaced at 24" o.c.
using 3/4" ARMOROC® with a 6"-12" Fastening Schedule
# Board Weight and Thickness

**Date:** 7/10/2013  
**Project No.:** 2012-1806  
**Client:** Ameriform, LLC  
**Specimen:** 3/4" Armoroc  
**Temp.:** 73°F  
**Humidity:** 52%

<table>
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<th>Sample No.</th>
<th>Weight (lbs)</th>
<th>Thickness (in)</th>
<th>Board Code</th>
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<td>.751</td>
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<td>.751</td>
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<td>12-1806-034AR-3</td>
<td>151.8</td>
<td>.749</td>
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<td>12-1806-034AR-6</td>
<td>152.7</td>
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</table>

| Min:                | 151.3        | .749           |
| Max:                | 152.7        | .751           |
| Average:            | 152.0        | .751           |
NOTE:
1) SEE DWG. B5 FOR DETAILS ON RIM TRACK
2) SEE DWG. B6 FOR DETAILS ON JOIST
3) SOLID BLOCKING IS ATTACHED TO JOISTS
   BY A UTILITY ANGLE WITH FOUR (4) #10 WAFER HEAD
   SCREWS PER BLOCKING

ONE (1) #8-16x3/4" LONG WAFER HEAD SELF
   DRILLING SCREWS; ONLY AT ARMOROC
   BUTT-JOINT LOCATIONS

TWO (2) #10-16x3/4" HEX HEAD
   SCREWS ON EACH SIDE OF
   UTILITY ANGLE

ONE (1) #10-16x3/4" LONG HEX HEAD
   SCREW THROUGH BOTTOM OF
   RIM TRACK INTO EACH JOIST

.5" THK. X 4" X 4" STEEL ANGLE, 10' LONG
   ATTACHED WITH #10 X1" LONG DRIVALL
   SCREWS @ 6" O.C.

ELEVEN (11) JOISTS,
   SEE DRAWING B6 FOR DETAILS

2" x 2" UTILITY ANGLE

2" x 3" UTILITY ANGLE
   INSIDE JOIST

12 1/4"x.0356" THK. METAL STRAPPING
   FASTENED WITH ONE #10 WAFER
   HEAD SCREW INTO EACH JOIST

THIS DRAWING IS A PART OF TEST REPORT NO. 2012-1806
SHEATHING:
3/4" x 4'-0" x 8'-0" ARMOROC CAL SEAL TG2

FASTENERS:
#10-16 x 1-5/8" LG, CERAMIC COATED WINGED DRILLER BY GRABBER
SCREWS SET 6" O.C.
AROUND THE OUTERMOST EDGE AND ON
BOTH SIDES OF THE BUTT JOINTS, AND AT 12" O.C. IN THE FIELD
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End No. 2

Rigid Bearing No. 1

1" x 10" x 14" Reaction Plate (2 Plcs.)

Hold Downs (4 Plcs.)

1" x 10" x 14" Linear Transducer

No. 2

No. 3

No. 4

No. 5

1" x 10" Long Steel Rod

1" x 1" Steel Bar 10" Long

60" 60" 60" 60" 60"

End No. 1

Reaction Plate (2 Plcs.)

Data Acquisition System

Hydraulic Cylinder #1

Hydraulic Cylinder #2

Hydraulic Cylinder #3

Hydraulic Cylinder #4

DENOTES LINEAR TRANSDUCER LOCATIONS

2 x 4 x 1/4" Plate

TEST SET-UP
TEST SET-UP

18" LOAD BLOCK

4" x 4" x \(\frac{3}{4}\)" THICK ANGLE FASTENED TO SPECIMEN 6" O.C. WITH #12 x 1" LONG SELF-DRILLING HEX HEAD SCREWS

2 x 4 x \(\frac{1}{4}\) STEEL PLATE

CENTER LINE OF LOAD

LOADING DETAIL

RIGID BEARING

HYDRAULIC CYLINDER

ROLLERS AROUND TEST SAMPLE APPX 4' O.C.

RIGID I-BEAM FIXTURE

TEST SAMPLE SHEATHING

2" ROLLERS

HOLD DOWN LOCATIONS

18" LOAD BLOCK

STEEL PLATE

2" x 2" STEEL TUBE

2 x 4 x 1/4" STEEL PLATE

18" LOAD BLOCK

1/4" PLATE

11" ROLLER

HOLD DOWN DETAIL

21 of 31

PEI Report No. 2012-1806
Joist #1 - Board breakout around fasteners

Joist #2 - Board shift and fastener rotation

Joist #3 - Board cracked thru Row #2 and #3

Joist #3 - Board crack

Joist #8/9 - Crack thru board

Joist #9 - Butt-joint separation due to board breakout
Sample No. 12-1806-FD-6x12@24oc-2

Progressive Engineering Inc.

Joist #1 - Board break out around fasteners

Joist #1 - Board break out around fasteners

Joist #1/2 - T&G shift and board pull-over at fasteners

Joist #3 - Butt-joint separation

Joist #9 - Board cracked in Row #3

Joist #11 - Board break out around fasteners
ADDENDUM

A

Ameriform LLC

ASTM E455 Floor Diaphragm Test on a 10' x 20' Floor using 3/4" Armoroc® Panels Adhered to 16 Ga. Steel Framing Spaced 24" o.c. with Loctite® PL Premium Construction Adhesive

2012-1806
August 21, 2013

**Client:** Ameriform LLC / Ectek  
**Specimen:** 3/4" Armoroc mechanically fastened and adhered to 16 Ga. steel framing

**PEI Project No.:** 2012-1806

**Subject:** To evaluate the increased diaphragm strength of the Armoroc sheathing using adhesive as compared to a mechanically fastened design.

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**Test Sample**

A single test sample was constructed as described in PEI test report no. 2012-1806 with the following exceptions:

- Loctite® PL Premium Construction Adhesive
- 3/8" bead of adhesive applied to all framing members with a double bead at all Armoroc butt-joints.
- A 1/4" to 3/8" bead applied between the butt-joint edges of the Armoroc.
- A 1/4" to 3/8" bead applied inside the groove side of the T&G edge of the Armoroc panel.

*See photographs for adhesive application details.*

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**Test Results**

The mechanically fastened assemblies had an average ultimate shear strength of 1,000 PLF. The adhered assembly had an ultimate shear load of 1,703 PLF. Based on the testing performed using the design configurations shown on the drawings and photographs, the adhered assembly resulted in a 70% increase in shear strength.

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Jason Holdeman  
Director of Testing
Progressive Engineering Inc.

ASTM E 455 Simple Beam Diaphragm Test

Date: 8/1/2013
Client: Ameriform, LLC / Ectek

Specimen: 3/4" Armoroc (T&G) fastened to 16 ga. Steel joists, set 24" o.c., with #10 x 1-5/8" screws spaced 6" o.c. around the perimeter and 12" o.c. in the field. PL Premium adhesive applied to all joists, T&G joints, and butt-joints. See drawing no. B4 for details.

Test No. 12-1806-FD-6x12@24oc-GLUE-1

Test Conditions

Temperature: (°F): 70
Relative Humidity (%): 61
Preload (lbf): 2,300
Diaphragm Length a (in): 240
Diaphragm Depth b (in): 120
Load Duration to Rₚ(min:sec): 38:02

Deflection (in)

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<th>Load (lbf)</th>
<th>Location 1</th>
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<th>Location 3</th>
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<td>.069&quot;</td>
<td>.046&quot;</td>
<td>.029&quot;</td>
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<tr>
<td>.2*Rₚ</td>
<td>6,813</td>
<td>.144&quot;</td>
<td>.170&quot;</td>
<td>.159&quot;</td>
<td>.132&quot;</td>
<td>.069&quot;</td>
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<tr>
<td>Rₚ/3</td>
<td>11,355</td>
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<td>.210&quot;</td>
<td>.210&quot;</td>
<td>.190&quot;</td>
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<td>.4*Rₚ</td>
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<td>.5*Rₚ</td>
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<td>.278&quot;</td>
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<tr>
<td>.6*Rₚ</td>
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<td>.246&quot;</td>
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<td>.512&quot;</td>
<td>.550&quot;</td>
<td>.532&quot;</td>
<td>.252&quot;</td>
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Ultimate Load (Rₚ) = 34,066 lbf  Shear Strength (Sₚ) = 1,703 plf

Design Load (Rₚ/3) = 11,355 lbf  Design Shear Strength = 568 plf

Failure: Armoroc cracked/split across the entire depth (10’ dimension) of the sample starting 12” in from Joist #11 at rim track and proceeded diagonally to the opposite rim track ~6” away from Joist #9. At the Joist #11 bearing corner the board surface was pulled off at the adhesive bond line and then pulled over the fasteners. The board surface also failed along the adhesive bond line along Joist #10. See Failure Drawing and photographs for more details.

Notes: The adhesive was applied on 7/26/2013 at 12:00 and was permitted to cure at lab ambient conditions until the test date.

* Δ is derived by subtracting the average bearing movement from the maximum point of deflection.
Ameriform LLC / Ectek
ASTM E455 Simple Beam Floor Diaphragm Test
16 Ga. Steel Framing Spaced at 24" o.c.
using 3/4" ARMOROC® with a 6"-12" Fastening Schedule
And PL Premium Adhesive
Glue Sample Details

Typical adhesive application

Typical adhesive bead size

Adhesive application at panel butt-joints

Adhesive application in panel groove

Adhesive Used
Sample No. 12-1806-FD-6x12@24oc-GLUE-1

Board Break at Maximum Load

Joist #9, Row #1 - Board break

Joist #10, Row #2 - Board break

Row #3 - Board break

Row #3, Joist #10/11 - Board Pull-over at fasteners

Board surface failure at adhesive bondline