STRUCTURESMITH, LLC
P.O. Box 667824
Miami, FL 33166-9406

Analysis of the Transverse Load Test Results from EMLA Report L-11-1869a per ICC-ES AC191-11

StructureSmith Project 120207A

Report prepared for

EXPANDED LATH MANUFACTURERS ASSOCIATION (EMLA)
A Division of NAAMM
National Association of Architectural Metals Manufacturers

March 27, 2012

Submitted by:
J. Ryan Smith, P.E.
Principal, StructureSmith, LLC

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Report prepared for
EMLA, a Division of NAAMM
c/o NAAMM Headquarters
800 Roosevelt Rd. Bldg. C, Suite 312
Glen Ellyn, IL 60137
Voice: 630-942-6591 / Fax: 630-790-3095

StructureSmith Project 120207A

March 27, 2012

I hereby certify that this engineering report was prepared by me and under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the State of California.

(signature) (date) 3/27/2012

J. Ryan Smith

California License No. 71989

My license renewal date is March 31, 2012

** Other States available upon request*

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Analysis of the Transverse Load Test Results from EMLA Report L-11-1869 per ICC-ES AC191-11

by

J. Ryan Smith, P.E.

1. Introduction

The Expanded Metal Lath Association (EMLA), a Division of the National Association of Architectural Metal Manufacturers seeks to promote the use of Expanded Metal Lath through code advocacy, testing and education. EMLA members produce metal lath in accordance with ASTM standard C847. One of the most common types of lath utilized in the United States today is 2.5 self-furring expanded metal lath. The 2.5 designation represents the standard weight per square yard of lath. Self-furring means the lath features grooves or dimples which offset the center of the expanded steel sheet from the framing member or sheathing into the stucco layer providing adequate cover for the lath as well as locating the reinforcement closer to the centroid of the stucco providing better resistance to positive and negative loading. 2.5 self-furring laths are commonly utilized in exterior wall application where three-coat stucco systems are applied. Stucco systems are often applied over discretely spaced metal or wood framing members, with and without exterior sheathing. These metal lath and stucco systems serve as the cladding for many commercial and residential structures. The exterior cladding, during the life of the structure, may experience transverse loading from wind or seismic events as well as other loading when designed to carry these loads.

With a general lack of industry published data or research for stucco systems, the EMLA conducted testing on common metal lath and stucco assemblies to provide baseline data to designers, end-users, and standards organizations. The objective of this report is to analyze this data and provide allowable loads for the tested assemblies. Allowable load calculations may also serve as a basis for the EMLA to obtain an evaluation service report from a recognized code certification agency on the values for these systems. Design professionals use allowable transverse load data to select their exterior cladding system and to specify elements of the exterior wall assembly such as framing member type, spacing and properties; fastener size and spacing; lath type and properties; and sheathing requirements.

Construction of these assemblies consists of three different types of framing members; 2x6 #2 wood studs, 6” x 16 gauge steel studs, and 3-5/8” x 20 gauge steel studs. The framing members for each test were spaced at 16 inches on center. The steel studs were sheathed with 5/8" exterior gypsum sheathing, while the wood studs were not sheathed. Metal Lath was installed with #8 modified truss screws spaced at 6 inches on center for all assemblies. The following table outlines the 3 types of panels that were constructed.

Table 1 – Sample Construction Details (reproduced from Smith-Emery L-11-1869a)

ID	Lath	Stucco	Frame	Fastener (Lath to frame)	Sheathing	Number of Panels
A	2.5 self-furring, expanded metal lath	3-coat stucco	3-5/8 inch, 20 gauge stud, 16" on center	#8 modified truss screw at 6" on center	5/8" gypsum	6
B	2.5 self-furring, expanded metal lath	3-coat stucco	6 inch, 16 gauge stud, 16" on center	#8 modified truss screw at 6" on center	5/8" gypsum	6
C	2.5 self-furring, expanded metal lath	3-coat stucco	2×6 wood stud (#2 SPF) at 16" on center	#8 modified truss screw at 6" on center	none	6

Smith-Emery Laboratories, International Accreditation Service (IAS) Testing Laboratory TL-191, conducted 18 total wall panel tests to determine the ultimate (nominal) transverse load for the 3 assemblies described above for positive and negative loading conditions. It should be noted that the assemblies were not subjected to cyclic loading and caution should be taken when utilizing the results for seismic loading conditions. The test method is generally described below and presented in detail along with the test results in Smith-Emery Laboratories' report L-11-1869a (enclosed).

2. Stucco Panel Transverse Load Tests

The stucco panels were constructed in 48" by 48" panels in accordance with ICC-ES AC191. The three coats of stucco were applied with 2-days between the scratch coat and the brown coating, and 7-days between the brown coat and finish coat. Six samples were constructed for each of the three assemblies, for three tests in each direction for positive and negative loading. The panels were oriented horizontally in the vacuum test chamber and a uniform load was applied through plastic sheeting and the differential pressure created by the vacuum removing air from the chamber. The pressure levels were incrementally increased in 5-minute intervals and deflection and load measurements were taken at each increment.

3. Allowable Transverse Loads

The EMLA contacted ICC-ES for clarification on Acceptance Criteria AC191-11 to determine an acceptable factor of safety for the tested assemblies. ICC-ES recommended a factor of safety of 3.0 referencing Acceptance Criteria AC11-10 for Cementitious Exterior Wall Coatings, Section 4.3.2.1. The allowable load values are summarized in the following tables.

Table 3-1: ASTM C847 - 2.5 Self-furring Metal Lath with 3-Coat Stucco Allowable Transverse Loads

Framing Member	Stud Spacing (inches)	Sheathing	Allowable Pressure [Average Ultimate Test Load] (Positive, psf)	Allowable Pressure [Average Ultimate Test Load] (Negative, psf)
3-5/8" x 20ga Steel Stud (0.0329" min.)	16"	5/8" Exterior Gypsum Sheathing	87 [262]	50 [149]
3-5/8" x 16ga Steel Stud (0.0538" min.)	16"	5/8" Exterior Gypsum Sheathing	188 [564]	132 [396]
2x6 #2 SPF Wood Stud	16"	None	107 [322]	133 [398]

- All assemblies were constructed with #8 Modified Truss Screws spaced at 6" on center maximum.
- A Factor of Safety of 3.0 was used for all allowable load values per ICC-ES AC11-10.

4. Performance Analysis

The standard deviations for the results of each assembly test are shown in the table below and are expressed in pounds per square foot and as a percentage of average nominal values:

Table 4-1: Statistical Analysis of Test Results

Framing Member	Metal Lath	Positive Load Standard Deviation (lbs) / Mode of Failure	(+) Load Test Stan Dev as a % of Ave. Load	Negative Load Standard Deviation (lbs) / Mode of Failure	(-) Load Test Stan Dev as a % of Ave. Load
3-5/8" x 20ga Steel Stud (0.0329" min.)	2.5 SF	10.0 Flexural	3.8%	9.1 Flexural	6.1%
3-5/8" x 16ga Steel Stud (0.0538" min.)	2.5 SF	23.7 No Failure*	4.2%	26.1 Stucco Crack	6.6%
2x6 #2 SPF Wood Stud	2.5 SF	41.8 Frame Conn, Stucco Crack	12.6%	9.5 Pull-Thru	6.1%

*Assembly reached maximum load capable by test method / apparatus.

The standard deviations for the test show repeatable values with all assemblies having a standard deviation as a percentage of average values less than 15%. Additionally all test values fell within 15% of the average. (14% maximum for test C2). The results of the tests demonstrate repeatability of these tests and consistent performance of the assemblies. Furthermore the mode of failure was consistent within each assembly and loading condition.

5. Conclusions

Expanded metal lath demonstrated consistent performance in the tested assemblies. The factor of safety provided by the ICC-ES of 3.0, the repeatable modes of failure, and low standard deviations of the results provides validity to these allowable values.

While the allowable transverse load for negative pressure was always lower than the values for positive pressure on the same assembly, the negative values were high enough that the systems should provide adequate performance for most structures in the United States. Indeed the lowest allowable transverse load under negative pressure was 50 pounds per square foot (psf) for a 3-5/8" x 20 gauge steel stud. 50 psf will generally exceed the ASCE 7 calculated interior zone component and cladding wind loads on structures except for very tall buildings or those located in high wind, coastal environments. In practice, most structures with component and cladding loads greater than 50 psf will require heavier framing than a 3-5/8" x 20 gauge steel stud because of other design considerations.

The EMLA tests have generated data for assemblies and systems that did not previously exist. These values, when used within the limitations stated below, can be employed by design professionals allowing them to make informed decisions in the selection of their exterior cladding system. Furthermore these values provide substantiation for decades of performance of C847 Metal Lath and the installation procedures developed by the ASTM C11 committee.

6. Limitations on Application

The results of this work are allowable transverse loads for exterior cladding systems following the construction utilized in the tested assemblies. The lesser of the published allowable loads and code-prescribed calculated values for the specific mode of failure for each assembly should be used in design.

The allowable transverse loads presented in this report are appropriate for the design of exterior cladding systems for assemblies where the specified material properties exceed the physical properties for the materials used in the tested assemblies listed in this report and Smith-Emery's Laboratories' report L-11-1869a (enclosed). Use of the reported results for assemblies with different material properties (steel, wood, or plaster), framing member spacing, fasteners, and fastener spacing should only be done by a licensed professional engineer with a clear understanding of the mode of failure and code-prescribed calculation method for each possible mode of failure. The Designer of Record shall review and approve any plans or specification where a system described herein is specified. The use of this report, findings, or opinion contained herein for any other purpose shall be at the users' own risk.

7. Codes and Referenced Standards

AISI S100-2007, North American Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute, 2007 Edition.

AISI S1-09, Supplement No. 1 to the North American Specification for the Design of Cold-Formed Steel Structural Members, 2007 Edition, American Iron and Steel Institute.

ANSI/AWC NDS-2012, National Design Specification for Wood Construction, American Wood Council, August 2011.

ASTM C 847-10a, Standard Specification Metal Lath, American Society for Testing and Materials International, 2010.

ASTM C 926-11a, Specification for Application of Portland Cement Based Plaster, American Society for Testing and Materials International, 2011.

ASTM C 1063-11b Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement Based Plaster, American Society for Testing and Materials International, 2011.

ICC-ES AC11-10, Acceptance Criteria for Cementitious Exterior Wall Coatings International Code Council Evaluation Service, Whittier, CA, approved March 2010.

ICC-ES AC191-11, Acceptance Criteria for Metal Plaster Bases (Lath), International Code Council Evaluation Service, Whittier, CA, approved May 2008, editorially revised January 2011.

SMITH-EMERY LABORATORIES
An Independent Commercial Testing Laboratory, Established 1904
781 East Washington Boulevard – 2nd Floor Los Angeles, California 90021 ♦ Phone (213) 745-5333♦ Fax (213) 741-8626

Project No.: 40205-1

March 6, 2012

Jeff Church
Expanded Metal Lath Association c/o
National Association of Architectural Metal Manufacturers
800 Roosevelt Rd.
Building C, Suite 312
Glen Ellyn, IL 60137

Subject: Transverse Load Test on Stucco Panels

Dear Mr. Church:

At your request, transverse load tests were performed on 18 stucco wall assemblies with 2.5 self-furring expanded metal lath in October, 2011 in general accordance with ICC-ES AC191, *Acceptance Criteria for Metal Plaster Bases (Lath),* effective June, 2009. The attached Report Number L-11-1869a R1 presents the description of the tests performed, the results of our testing, and our findings.

We appreciate this opportunity to be of service to you. If you have any questions regarding this report, please do not hesitate to contact us at your earliest convenience.

Respectfully submitted,
SMITH EMERY LABORATORIES, INC.

Pingsheng Zhu
Registered Civil Engineer No. C72482
Registration Expires 6-30-12
Staff Engineer

Attachment: Report No. L-11-1869a R1

SMITH EMERY LABORATORIES

791 E. WASHINGTON BLVD. • LOS ANGELES, CA 90021
PHONE (213) 745-5333 • FAX (213) 741-8626

SUBJECT REPORT: **TRANSVERSE LOAD TEST ON STUCCO PANELS**

PREPARED FOR:

Expanded Metal Lath Association c/o
National Association of Architectural Metal Manufacturers
800 Roosevelt Rd.
Building C, Suite 312
Glen Ellyn, IL 60137

Date: **March 6, 2012**

Project No.: **40205-1**

Report No.: **L-11-1869a R1**

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1. INTRODUCTION

1.1 Purpose

The purpose of the testing was to evaluate the transverse load resisting capacity of stucco wall assemblies incorporating 2.5 self-furring expanded metal lath.

1.2 Scope of Testing

Our general scope of this testing program included the following:

- Perform transverse load testing on 18 wall panels (4′×4′) in general accordance with ICC-ES AC191, *Acceptance Criteria for Metal Plaster Bases (Lath),* effective June, 2009.
- Preparation of this report providing description of the testing, test results, our findings and conclusion.

1.3 Sample Description

Eighteen stucco wall assemblies were fabricated at Smith-Emery facility by the client's contractor. The details of the panels' construction are listed in Table 1 and were verified by Smith-Emery representatives. All samples were 4-feet long by 4-feet wide and constructed with the frames standing vertically. The scratch coat was applied on 9/21/11, the brown coast was applied on 9/23/11, and the finish coat was applied on 9/30/11.

Table 1 – Sample Construction Details

ID	Lath	Stucco	Frame	Fastener (Lath to frame)	Sheathing	Number of Panels
A	2.5 self-furring, expanded metal lath	3-coat stucco	3-5/8 inch, 20 gauge stud, 16" on center	#8 modified truss screw at 6" on center	5/8" gypsum	6
B	2.5 self-furring, expanded metal lath	3-coat stucco	6 inch, 16 gauge stud, 16" on center	#8 modified truss screw at 6" on center	5/8" gypsum	6
C	2.5 self-furring, expanded metal lath	3-coat stucco	2×6 wood stud (#2 SPF) at 16" on center	#8 modified truss screw at 6" on center	none	6

2. TEST SETUP AND LOADING PROCEDURE

Each specimen was subjected to either a positive or negative uniform pressure until failure. The sample was installed horizontally on a vacuum chamber. For a positive pressure test, the sample was placed with the stucco panel facing up and supported continuously under the two outer studs. For a negative pressure test, the sample was installed with the stucco panel facing down. To avoid direct support under the stucco, angle brackets were used to attach the two outer studs. Refer to Figure 1 for clarification.

A plastic sheet (2 mils) was used to cover the top of panel and sealed the chamber. A vacuum pump was used to generate partial vacuum inside the chamber so the plastic sheet will apply a uniform pressure on the whole panel. The loading process was controlled manually.

A differential pressure transducer was used to measure the relative pressure across the chamber. The deflections of each panel were measured at the center of the stucco panel by one displacement transducer.

The load was applied continuously in increments. At each load increment, the load was maintained for 5 minutes.

The following instrumentations were used in the test:

- One differential pressure transducer (Omega PX654-100D5V).
- One displacement transducers (UniMeasure PA-5-DS)
- One Vishay® Scanner 5100 for data acquisition of all other instrumentation.

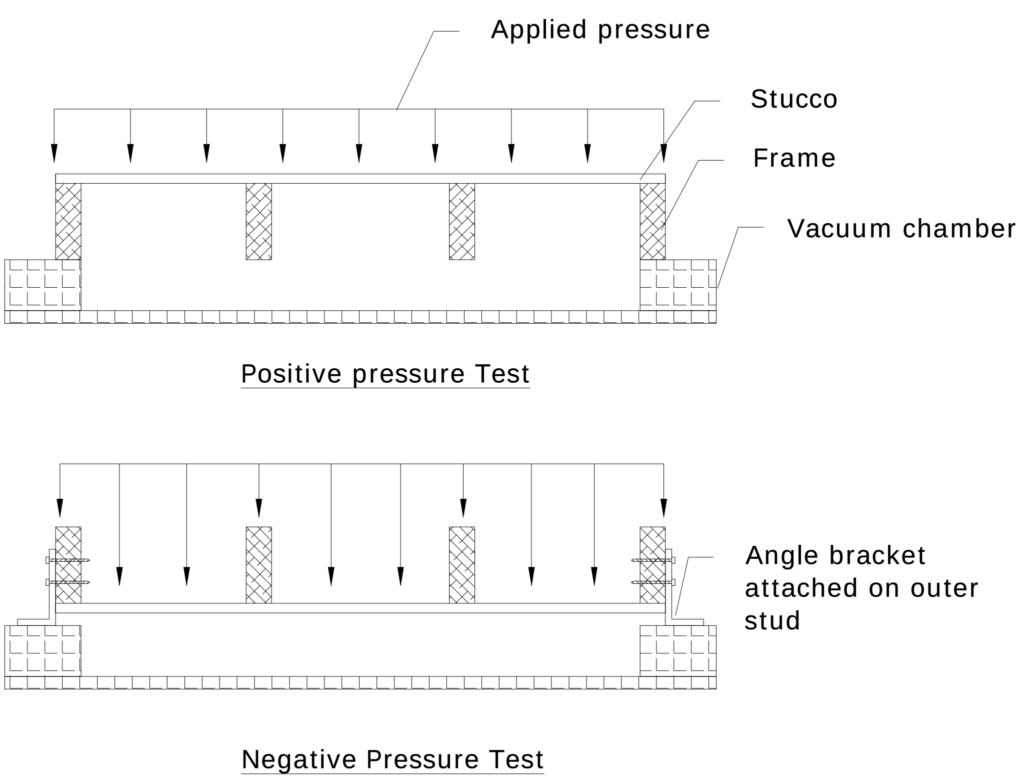

Figure 1 – Test Setup

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An Independent Commercial Testing Laboratory, Established 1904
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3. TEST RESULTS

3.1 Plaster Mix Compressive Strength

Three 2-inch cubes for each plaster mix of the scratch coat and brown coat were tested for compressive strength at the age of 28-days and the results are summarized in Table 2.

Table 2 – Compressive Strength for Plaster

Specimen ID	28-day Compressive Strength (psi)	Average (psi)
Scratch coat	2,830	2,950
	2,980	
	3,040	
Brown coat	2,240	2,200
	2,100	
	2,250	

3.2 Transverse Load Test Results

Eighteen stucco wall panels were tested for transverse loading. The results are summarized in Table 3. The load-deformation charts are included in Appendix B.

Table 3 – Summary of Transverse Load Test Result

Loading Type	Sample ID	Test Date	Maximum Load (psf)	Average Load (psf)	Failure Mode*
Positive	A1	10/6/11	258	262	2
	A2	10/6/11	273		2
	A3	10/7/11	254		2
	B1	10/11/11	544	564	1
	B2	10/12/11	590		1
	B3	10/12/11	557		1
	C1	10/7/11	302	332	3, 5
	C2	10/10/11	380		3, 5
	C3	10/10/11	315		3, 5
Negative	A4	10/6/11	145	149	2
	A5	10/6/11	142		2
	A6	10/7/11	159		2
	B4	10/11/11	369	396	5
	B5	10/12/11	398		5
	B6	10/12/11	421		5
	C4	10/7/11	167	157	4
	C5	10/10/11	148		4
	C6	10/10/11	156		4

* Failure mode:

1. No failure;
2. Global flexural failure at the mid-span of the panel;
3. Frame members connection failure;
4. Metal lath pulling through fasteners;
5. Stucco panel crack;

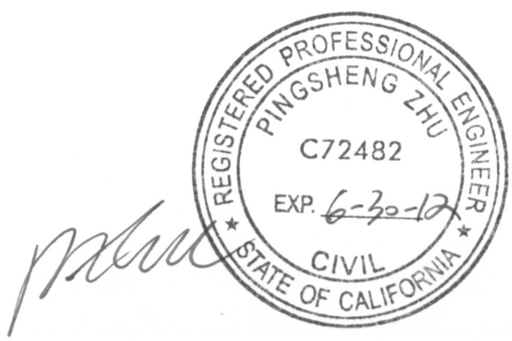
4. FINDINGS AND CLOSURE

4.1 Findings

Based on the information given and results presented in this report, we make no statement of compliance or noncompliance to any standard or specification for the product tested.

4.2 Closure

Any findings noted in this report were prepared in accordance with generally accepted material engineering and testing principles and practices. No other warranty, either expressed or implied, is made. This report has been prepared for **Expanded Metal Lath Association** to be used for product evaluation and/or design purposes only. The use of this report for any other purpose shall be at the users' own discretion, based on their own interpretation of the results contained within.



APPENDIX A

TESTING PHOTOS

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Project No: 40205-1
Report No: L-11-1869a R1

Photo 1 – Sample Fabrication

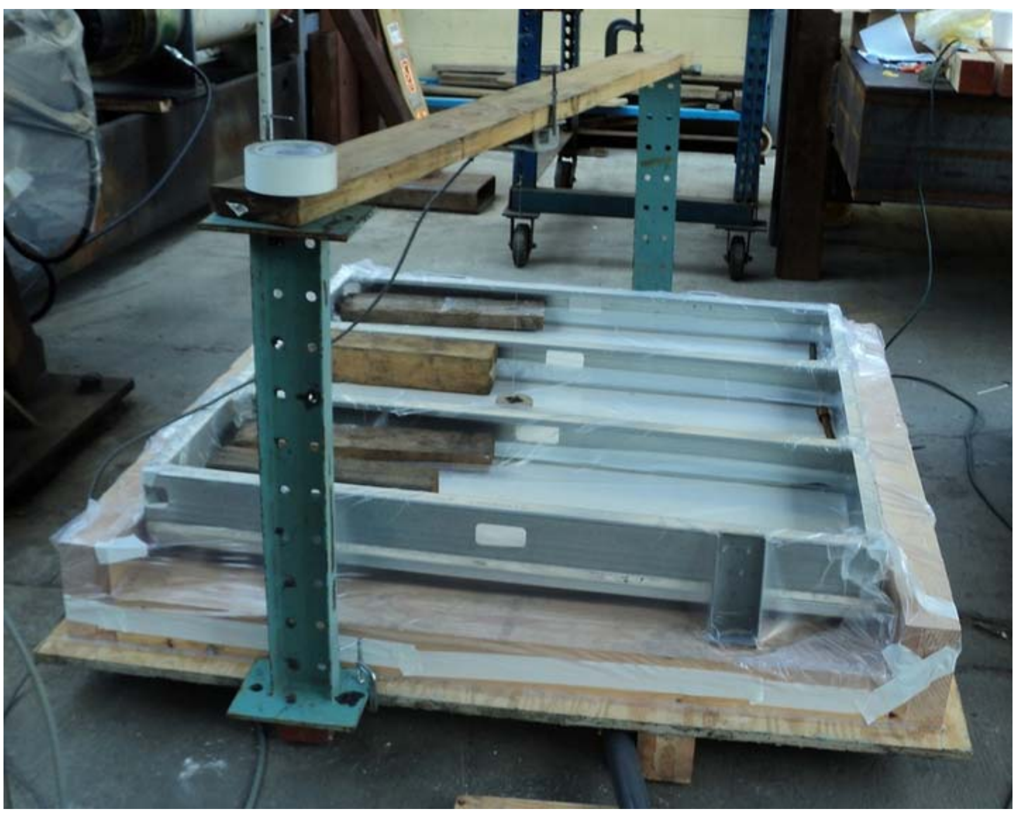


Photo 2 - Test Setup

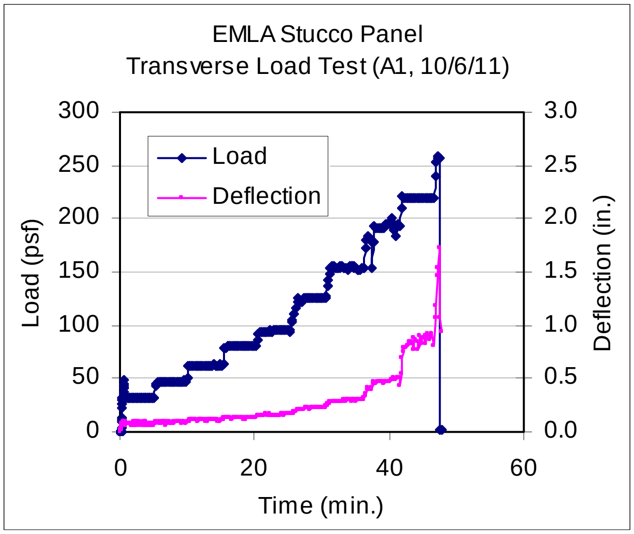
Photo 3 – Typical Failure (B4)

Photo 4 – Typical Failure (C5)

Photo 5 – Typical Failure (A3)

APPENDIX B

LOAD- DEFORMATION CHARTS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Transverse Load Test (A1, 10/6/11)
Load
Deflection
Load (psf)
Deflection (in.)
Time (min.)
300
250
200
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2.0
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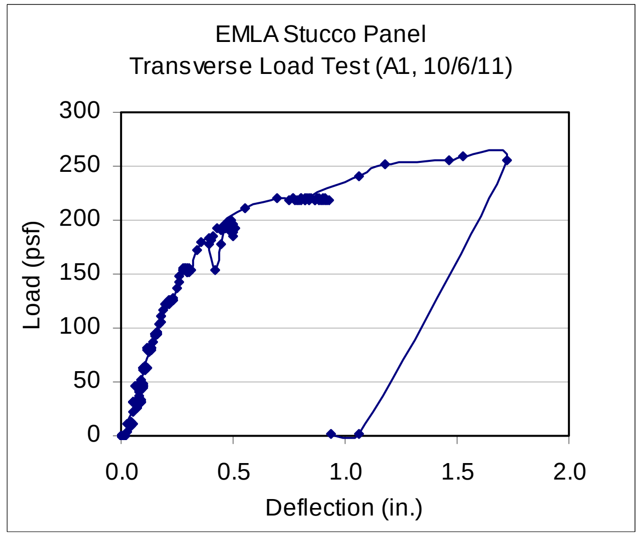
40
60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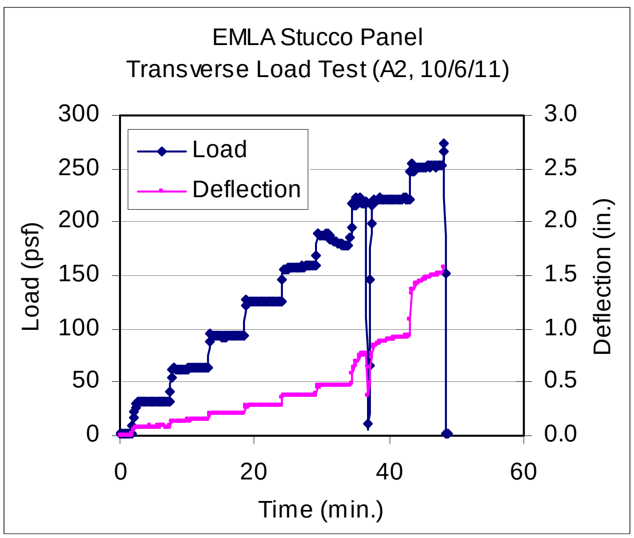
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Deflection
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Deflection (in.)
Time (min.)
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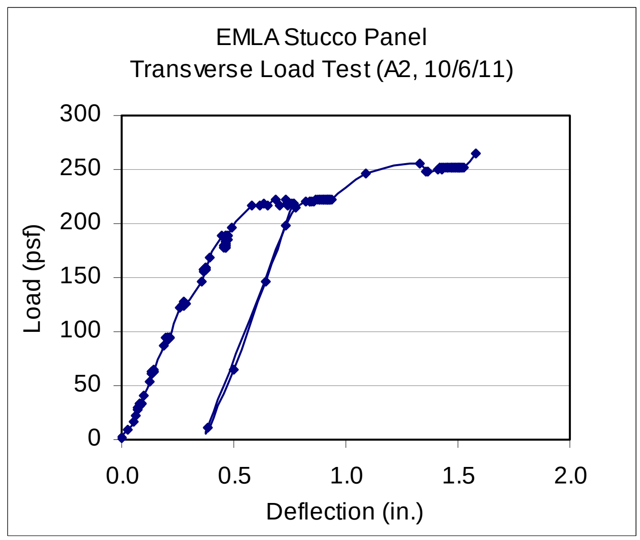
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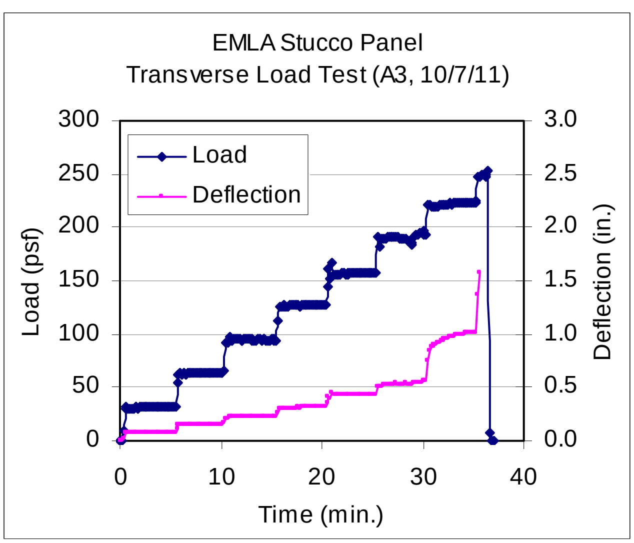
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Deflection
Load (psf)
Deflection (in.)
Time (min.)
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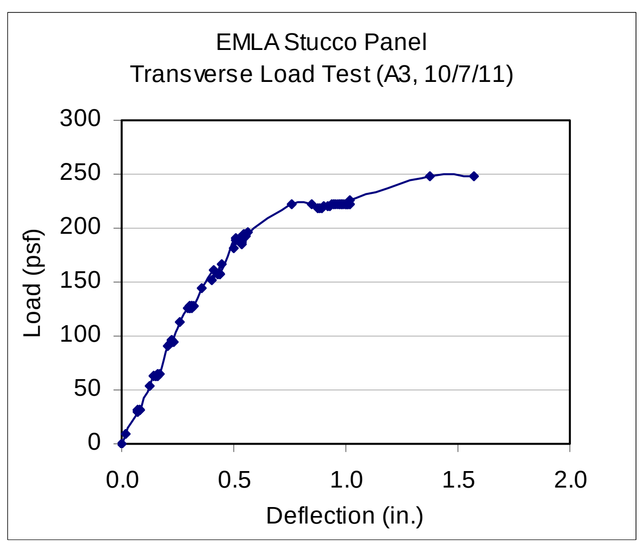
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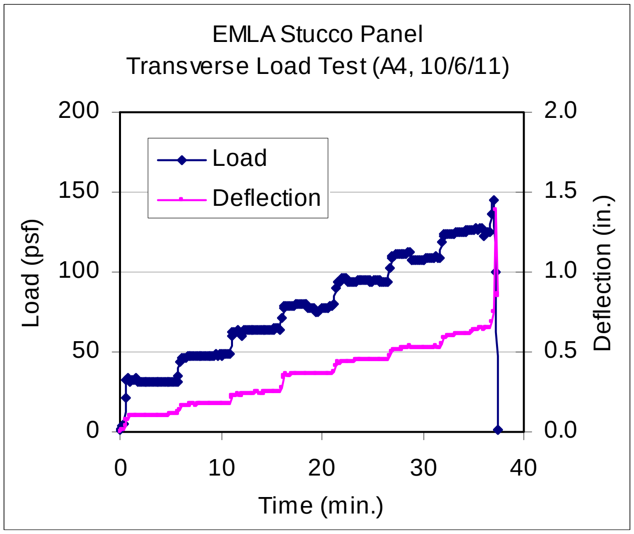
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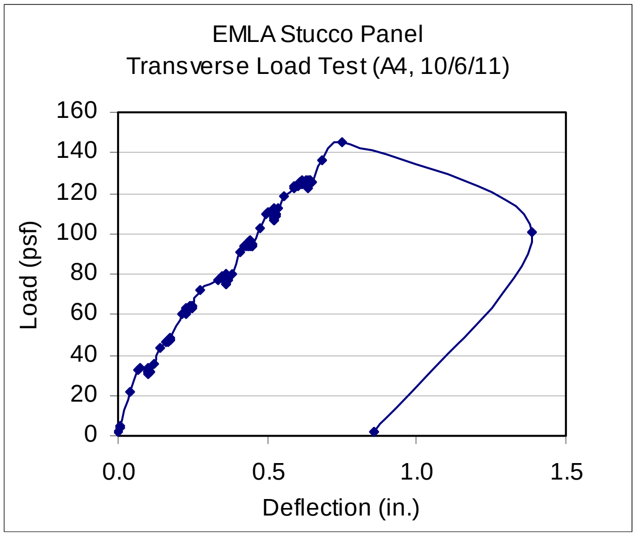
Deflection
Load (psf)
Deflection (in.)
Time (min.)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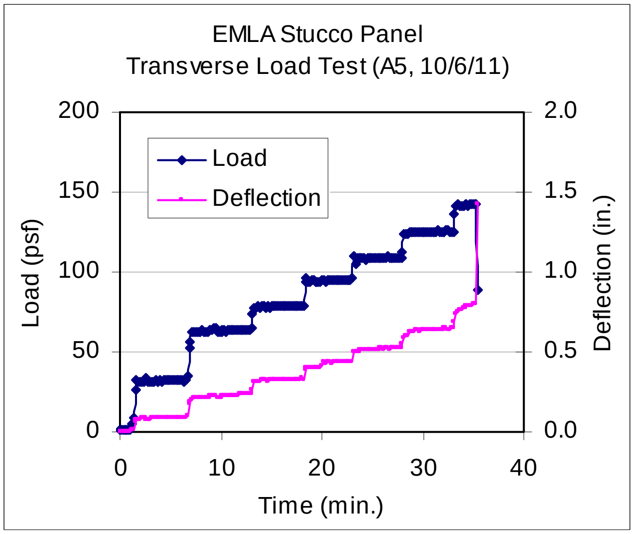
Deflection (in.)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Deflection
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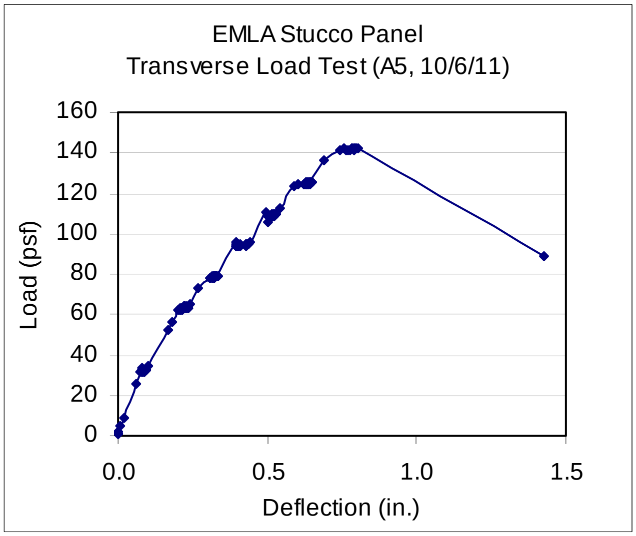
Time (min.)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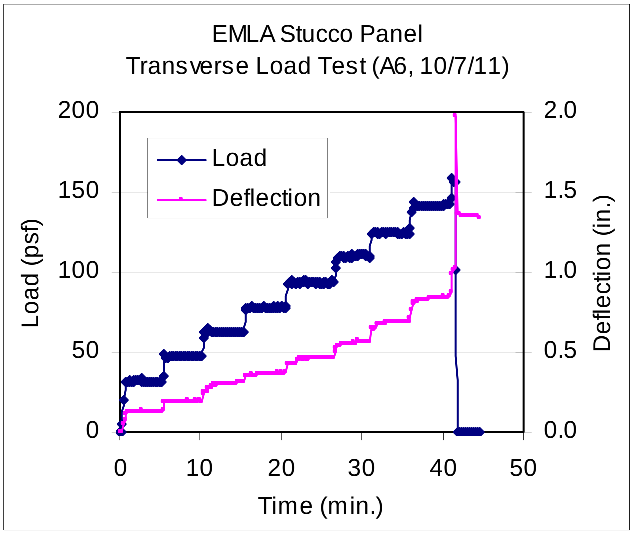
Deflection (in.)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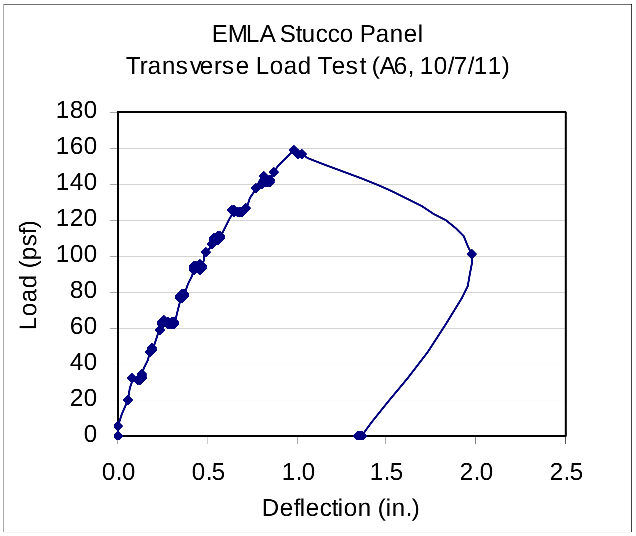
Time (min.)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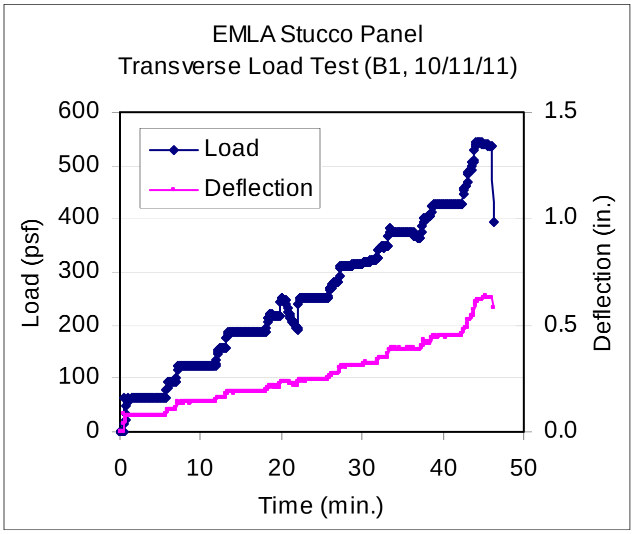
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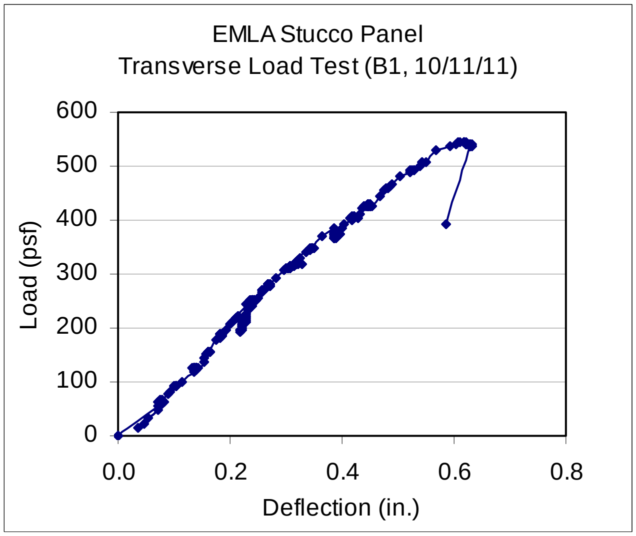
Deflection
Load (psf)
Deflection (in.)
Time (min.)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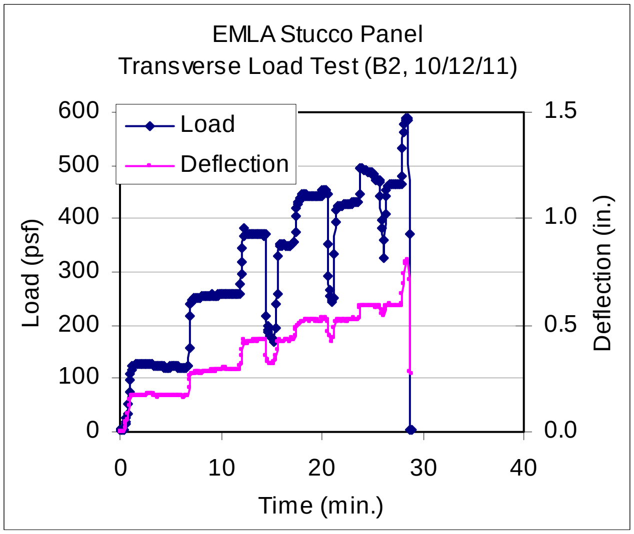
Load (psf)
Deflection (in.)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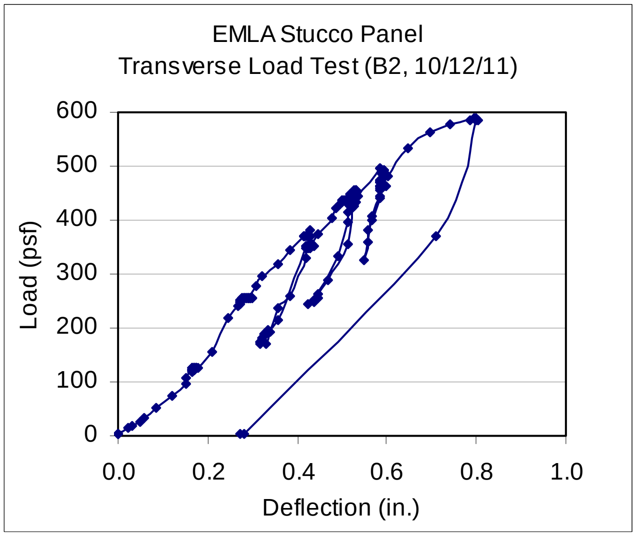
Transverse Load Test (B2, 10/12/11)
Load
Deflection
Load (psf)
Deflection (in.)
Time (min.)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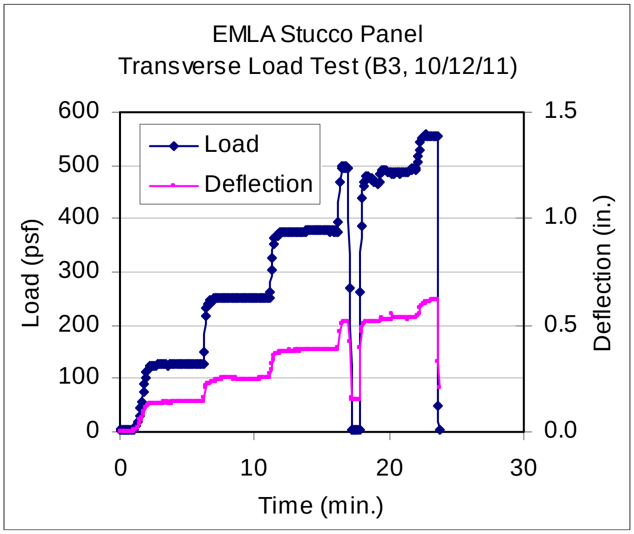
Transverse Load Test (B2, 10/12/11)
Load (psf)
Deflection (in.)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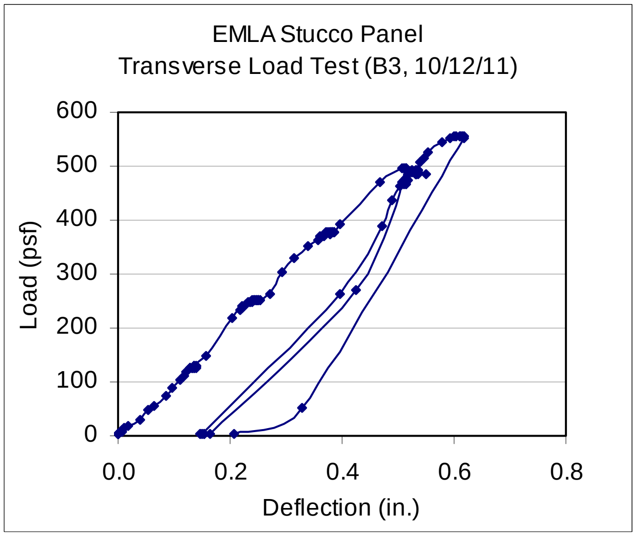
Transverse Load Test (B3, 10/12/11)
Load
Deflection
Load (psf)
Deflection (in.)
Time (min.)


EMLA Stucco Panel
Transverse Load Test (B3, 10/12/11)
Load (psf)
Deflection (in.)

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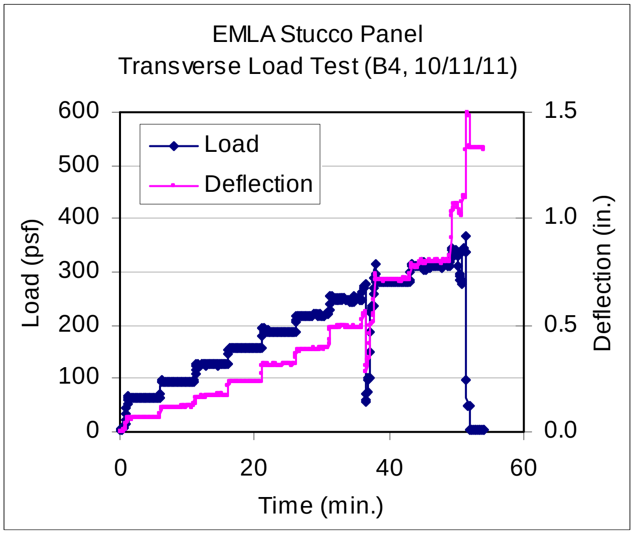

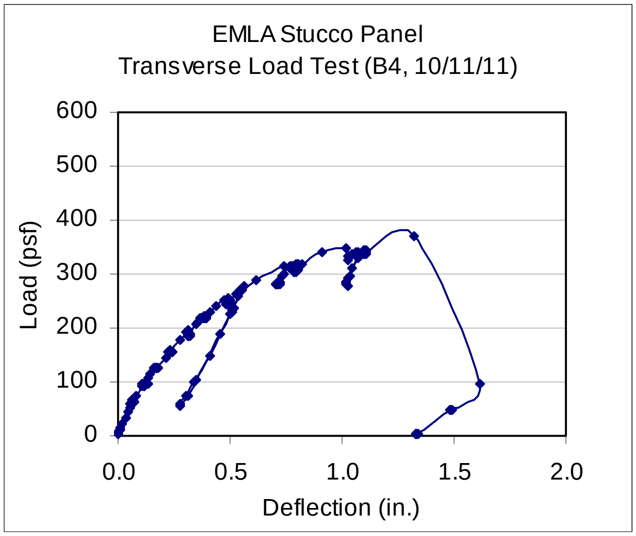

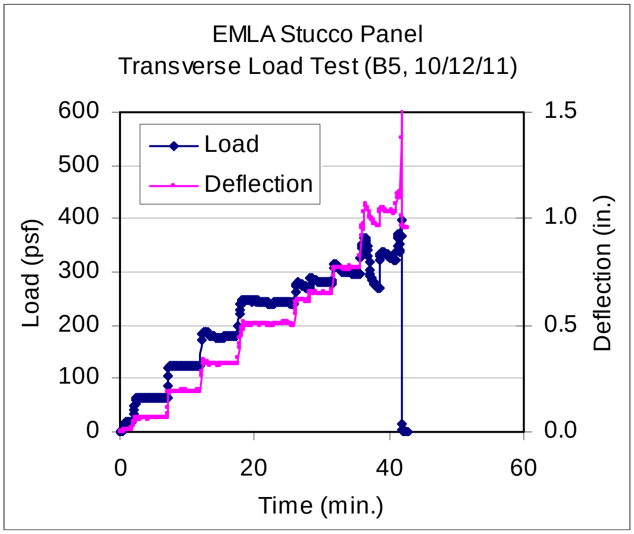

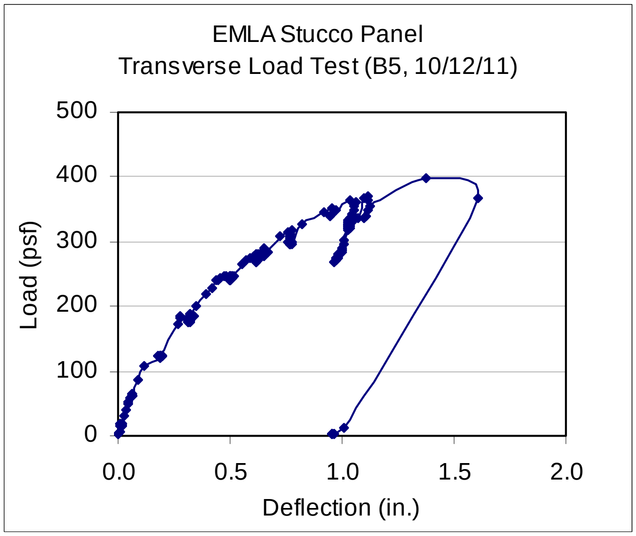

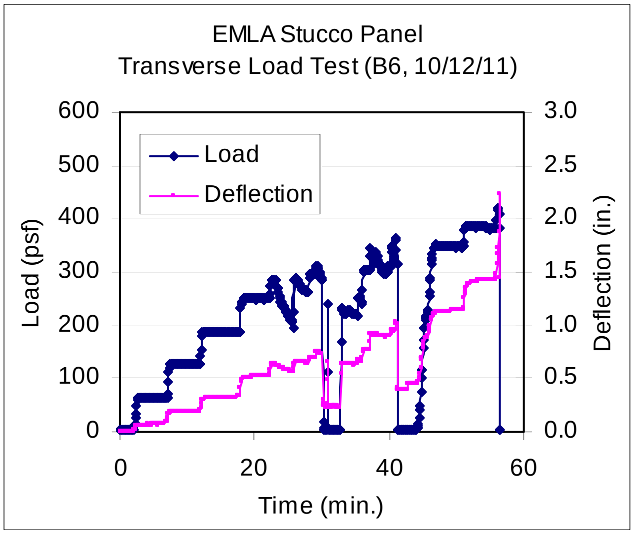

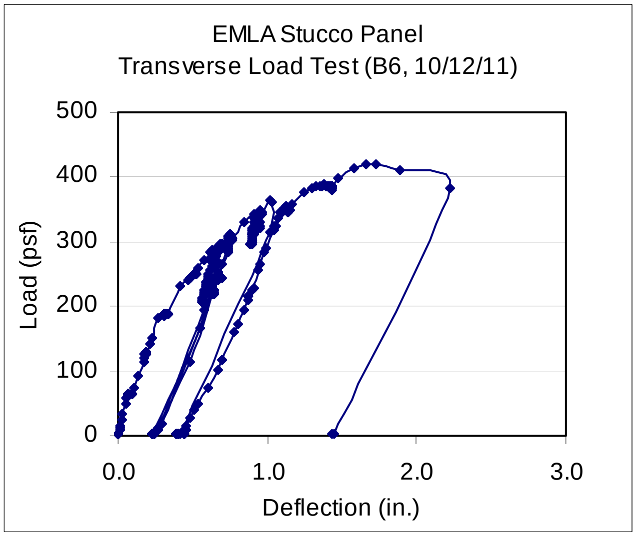

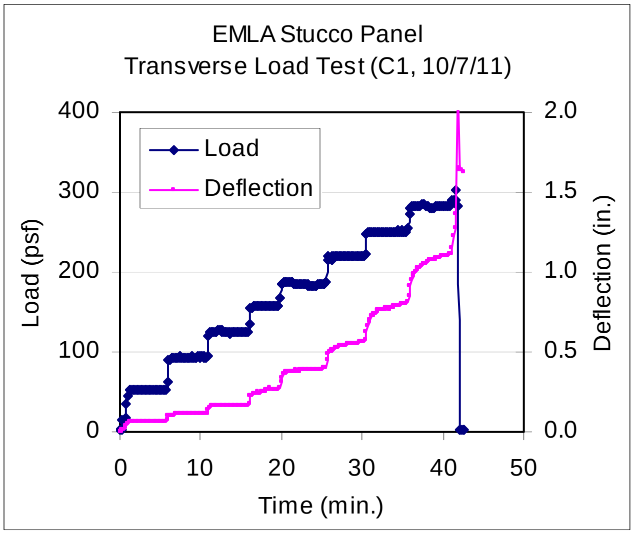
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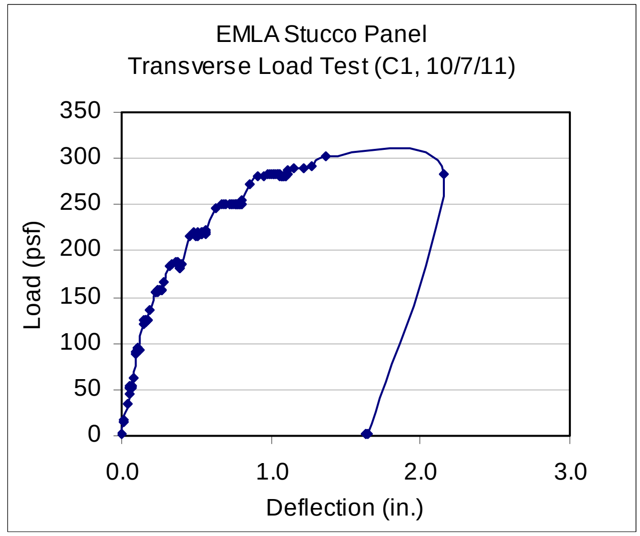
Transverse Load Test (C1, 10/7/11)
Load
Deflection
Load (psf)
Deflection (in.)
Time (min.)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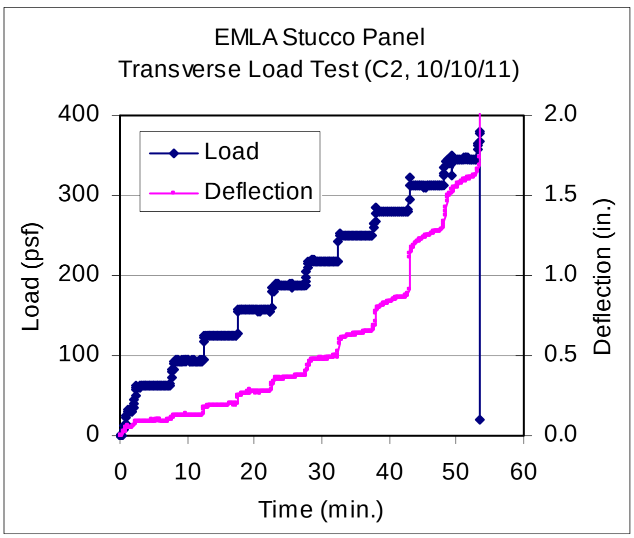
Load (psf)
Deflection (in.)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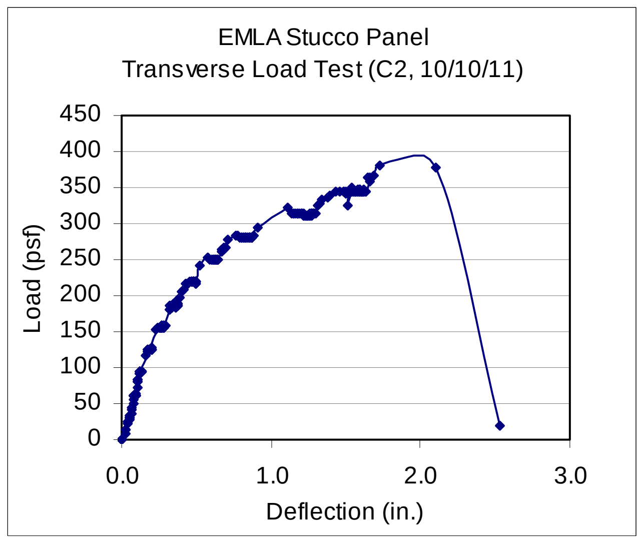
Load
Deflection
Load (psf)
Deflection (in.)
Time (min.)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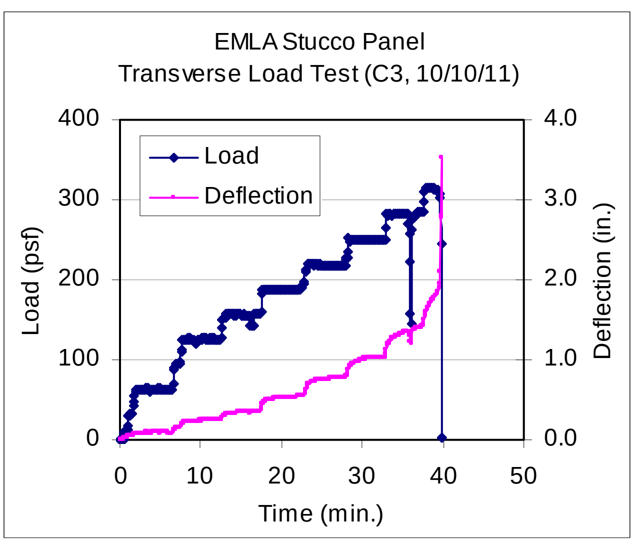
Deflection (in.)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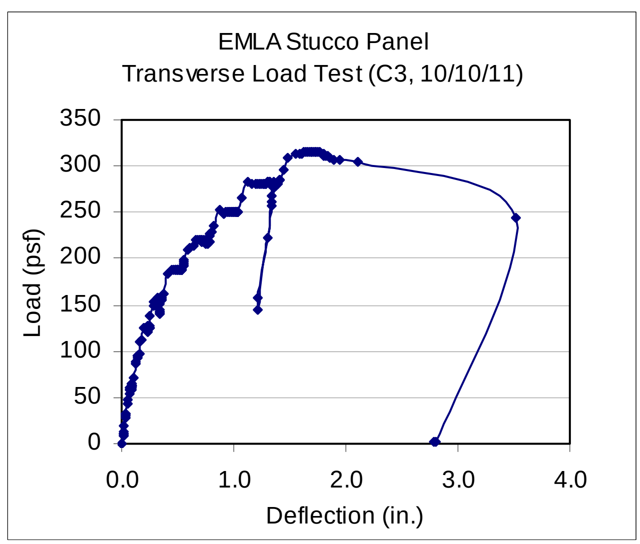
Load
Deflection
Load (psf)
Deflection (in.)
Time (min.)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Transverse Load Test (C3, 10/10/11)
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