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ERD LABORATORY REPORT #3903.12.02
Impact Resistance of Flex Membrane International
Roofing Systems
State of Florida Public Shelter Design Criteria for
Enhanced Hurricane Protection Areas (EHPAs)

SSTD 12-99, Standard for Determining
Impact Resistance from Windborne Debris

Prepared for: Flex Membrane International
Attention: John Doyle
Date of Issuance: December 16, 2002

Client Information: Flex Membrane International, Inc.
200 Bethlehem Drive,
Morgantown, PA 19543

Client Reference: Impact Resistance, Flex Membrane Systems

ERD Reference: Project #3903.02LAB

Scope: To test and document the performance of Flex Membrane International roofing products per Subsection 5.4(d)(2) of the State of Florida Public Shelter Design Criteria for Enhanced Hurricane Protection Areas (EHPAs), which states: *“The building enclosure, including walls, roofs, glazed openings, . . . , shall not be perforated or penetrated by a flying object. For walls and roofs, the missile criteria is a 2 x 4 timber plank weight nine (9) pounds traveling thirty-four (34) mph (50 ft/sec) and striking normal to walls and roofs on end.”*

Samples: Test specimens were prepared using membrane and adhesive supplied by Flex Membrane International, Inc. including Flex Tripolymer FB (45 mil) membrane and Flex Rubber Emulsion Adhesive.



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Sample Delivery: Membrane samples were shipped by the named client to the ERD Laboratory, received on September 20, 2002. Decking and insulation materials were procured by ERD Lab from local roofing distribution houses. ERD cast LWC specimens in accordance with the cellular foam manufacturer's instructions with a target 200 psi compressive strength.

Test Date(s): October 10, 2002 & November 25, 2002

ERD Technicians: Charles Phillips, David Smith, Nelson Morez, Wei Lam

Properties: Large Missile Impact, as set forth in SSTD 12-99

Standards: SBCCI Test Standard for Determining Impact Resistance from Windborne Debris, SSTD 12-99, ©1999, SBCCI, Inc.

Specimens: As described in Table I, below, and compliance with Section 302 of SSTD 12-99

Specimen #	Deck	Insulation	Roof Cover
1	Steel ¹	1.5" polyisocyanurate (ASTM C1289, Type II), mechanically attached	Tripolymer FB fully adhered in Flex Rubber Emulsion Adhesive @ 60 ft ² per gallon
2	Steel ¹	200 psi cellular lightweight concrete cast with a minimum 2" thick top coat.	Tripolymer FB fully adhered in Flex Rubber Emulsion Adhesive @ 60 ft ² per gallon

¹ Steel decking consists of 22 ga., type B; Grade 33 profiled steel over supports spaced 5 ft o.c.



Test Apparatus: Pendulum Impact Apparatus per Table I of SSTD 12-99 for wind speed \geq 110 mph consisting of a parallel link, four-bar linkage pendulum. The weight of the pendulum, with a 9 lb., 2"x4" impactor, is 47 pounds. See Figure 1, below.

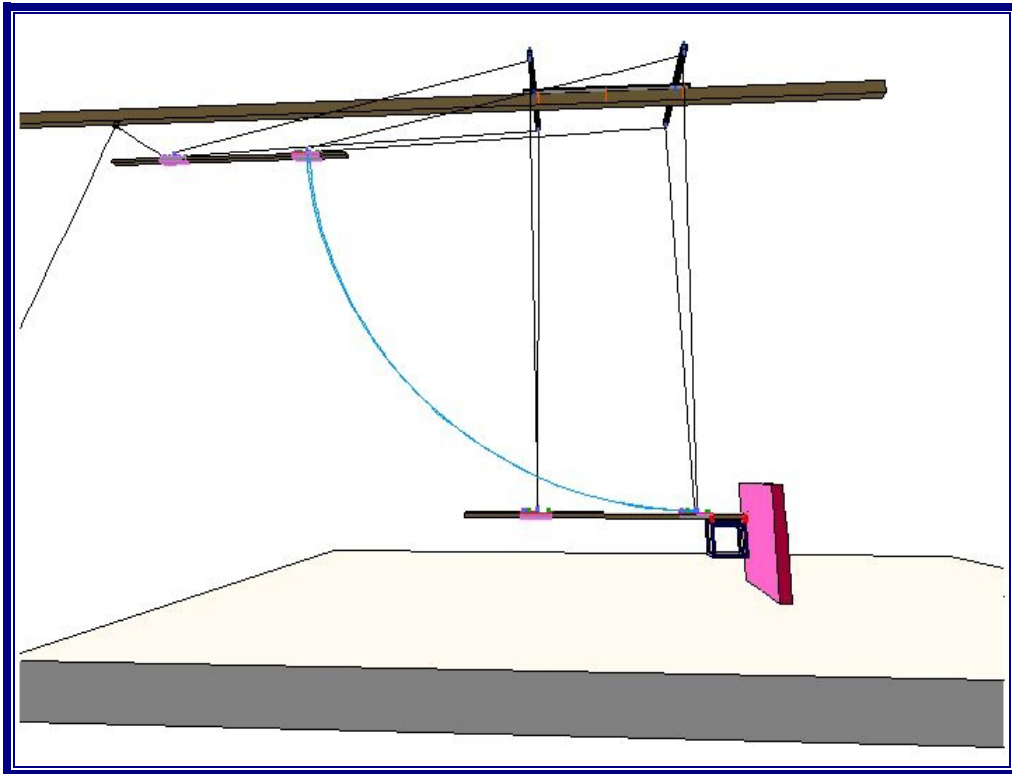


Figure 1: View of ERD Pendulum Impact Apparatus Schematic

Procedure: As set forth in Section 402.1.1 of SBCCI SSTD 12-99 including the following:

- The pendulum is launched from a height to incur 350 ft-lbs of impact energy on the test specimens, as determined from the pendulum weight and velocity at impact. The velocity is measured by through-beam light sensors and a computer data acquisition system. See Photograph 1, below.



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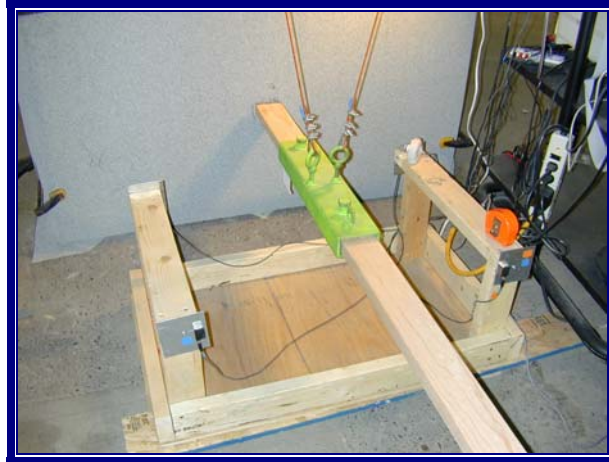


Photo 1: View of Velocity Measurement Apparatus

- Each test specimen receives two impacts: the first within a 5 inch radius circle having its center at the midpoint of the specimen and the second within a 5 inch radius circle in a corner having its center in a location 6 inches away from any supporting member.
- Each impact location is carefully examined for damage defined as compromising the ability of the specimen to perform as a watertight assembly. Impact locations where performance is not visually discernable are subjected to a watertightness test.
- The watertightness test consists of applying a 6 inch head of water over the impact location for a period of 5 minutes followed by membrane removal to examine for water penetration. See Photograph #2, below.

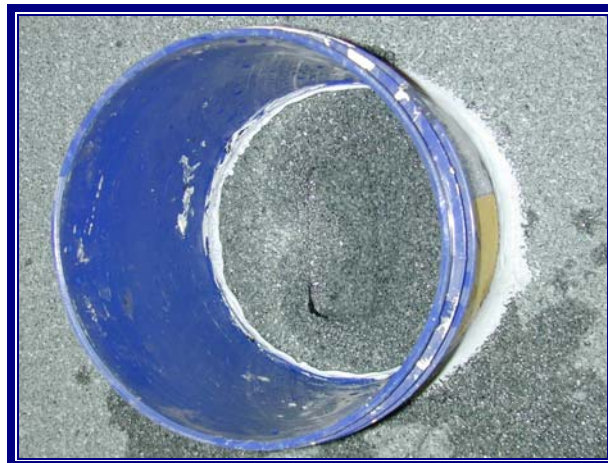


Photo 2: View of Watertightness Apparatus



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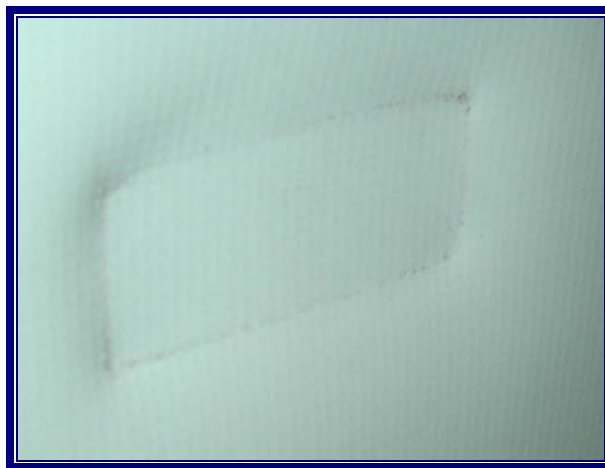


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Results:

Specimen I				
Steel / 1.5" Polyisocyanurate / Flex Tripolymer FB				
Test ID	Impact Location	Visual Observations	Water Test	Pass/Fail
IA	Center	No visible tear or puncture at impact location. See Photo 3.	N/A	Pass
IB	Corner	No visible tear or puncture at impact location. See Photo 4.	N/A	Pass



Photos 3 & 4: Impact locations of Panels IA & IB



Specimen 2 Steel / 200 psi Cellular Lightweight Concrete / Flex Tripolymer FB				
Test ID	Impact Location	Visual Observations	Water Test	Pass/Fail
2A	Center	No visible tear or puncture at impact location. See Photo 5.	N/A	Pass
2B	Corner	No visible tear or puncture at impact location. See Photo 6.	N/A	Pass

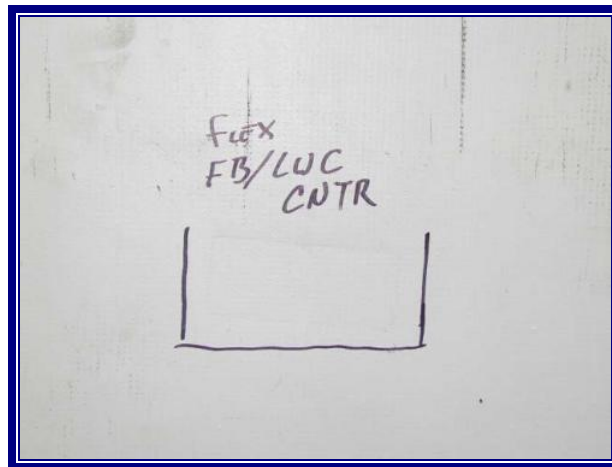
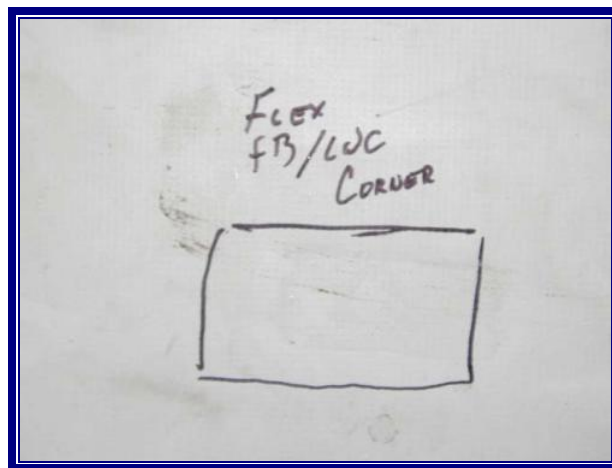


Photo 3: Overview of Impact 1A.



Photos 5 & 6: Impact locations of Panels 2A & 2B



Observations: Review of these results indicates the following:

- Use of an alternate polyisocyanurate insulation material would not adversely affect system performance, provided the insulation is compliant with ASTM C1289, type II.
- Increased compressive strength of underlying materials results in a lesser indent at the point of impact (e.g., 200 psi cellular lwc vs. 16 psi polyisocyanurate).

Conclusions:

Impact resistance testing of the Flex Membrane International roof assemblies set forth in Table I of this report, coupled with the data analysis set forth above, documents the following roof assemblies meet the requirements of Subsection 5.4(d)(2) of the State of Florida Public Shelter Design Criteria for Enhanced Hurricane Protection Areas (EHPAs).

Table 2A: Flex Membrane International Roof Assemblies Meeting Impact Resistance Requirements for Enhanced Hurricane Protection Areas Steel or Concrete Deck		
Deck	Insulation	Roof Cover
Steel ¹ or concrete deck	One or more layers, min. 1.5" thick, ASTM C 1289, type II polyisocyanurate	Flex Tripolymer FB fully adhered in Flex Rubber Emulsion Adhesive @ 60 ft ² per gallon

¹ Steel decking consists of 22 ga., type B, Grade 33 profiled steel over supports spaced 5 ft o.c.

Table 2B: Flex Membrane International Roof Assemblies Meeting Impact Resistance Requirements for Enhanced Hurricane Protection Areas Lightweight Insulating Concrete Deck	
Deck Assembly	Roof Cover
Vented steel or structural concrete deck with cellular LWC cast overtop ²	Flex Tripolymer FB fully adhered in Flex Rubber Emulsion Adhesive @ 60 ft ² per gallon

² LWC consists of minimum 200 psi material cast with 1/4" slurry coat over steel followed by optional 1" thick Apache Holey Board and a minimum 2" thick top coat of LWC.



Please contact our offices with any questions.

Sincerely,
EXTERIOR RESEARCH & DESIGN, LLC.



Wei Lam
Laboratory Manager



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Florida Reg. No. 59166
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