Wind Resistance of Clay and Concrete Roofing Tiles

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Disclaimer

- Results should be considered preliminary
- They are provided for the express purpose of documenting the progress made on the project during FY 2011-12
- The authors anticipate releasing final results and recommendations to the Hurricane Research Advisory Committee or the roofing technical advisory committee in the future as directed by staff

Research Partners & Oversight

TILE ROOFING INSTITUTE

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Any opinion expressed in this presentation are those of the authors and do not necessarily reflect the views of the partners

Research Objectives

1. Develop a wind load model for low-, medium- and high-profile roof tiles to compute pressures and attachment forces
2. Compare/contrast wind resistance of installation options (mech. fastening, foam)
3. Use findings to evaluate FBC 1609.5.3 and TAS 101-95 (mech. uplift), TAS 108-95 (wind tunnel char.), as well as other relevant code provisions

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Connection to Shingle Research

- Roofing tiles (clay, concrete, metal) and asphalt shingles are discontinuous roof systems
- "Discontinuous"
  - Porous; air communication above and below element
  - Large degree of pressure equalization across element
- Different approaches are used
  - Redlands study ➔ Roofing tile load design (TRI manual)
  - ARMA/NRCA/CPP studies ➔ Shingle load design (ASTMs)
- Should one approach be used?

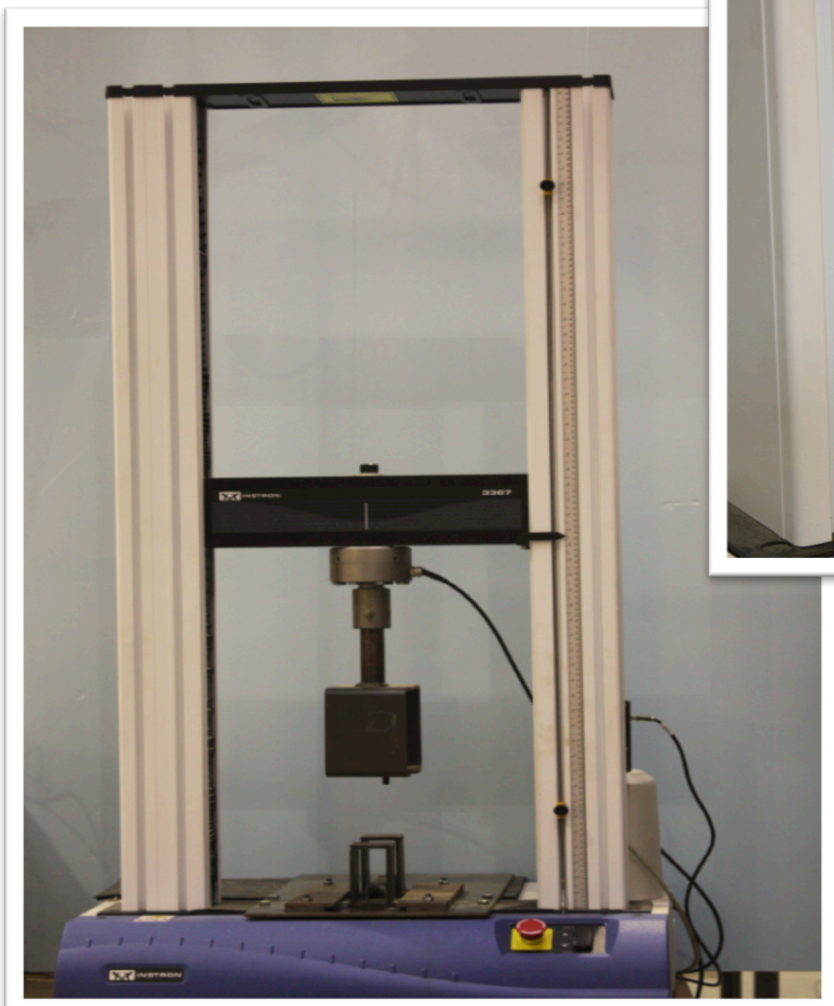
Research not addressed today

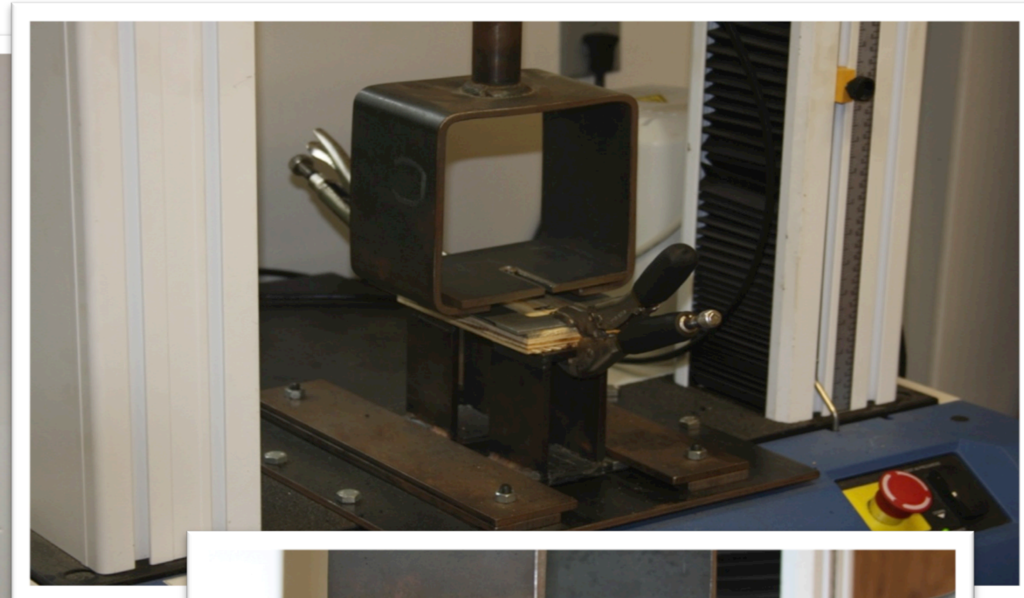
- Assessment of wind-borne tile impact on approved missile impact resistant products
- Presentation given 12/11/2004 to HRAC
- Paper under peer review in *Wind and Structures*
- Key findings re: likelihood of shutter puncture
  - 100-120 mph BSW: minimal risk except for long flight distances (> 45 m) in Exposure C and D
  - 130-140 mph BSW: moderate risk for short flight distances; more significant for longer distances
  - > 140 mph BWS: significant risk for all exposures

Activities

1. Nail/Screw Withdrawal Testing Using Plywood/OSB (completed)
2. Quantify the Uplift Resistance of Roof Tile Attachment Configurations (partially completed)
3. Characterize Wind-Induced Pressures on Roof Tiles (in progress)
4. Quantify Wind-Induced Reaction Forces on Roof Tiles (in progress)

Fastener Withdrawal Testing: Plywood vs. OSB





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Fastener Withdrawal Testing: Plywood vs. OSB

- 240 ASTM D 1761 withdrawal tests were performed on four combinations:
  - Nails or screws
  - Plywood and oriented strand board (OSB)
- Universal testing machine loaded at rate of 0.1 in/min until failure
- Reported failure values correspond to the largest recorded force applied to the fastener
- Testing took place over the course of four non-consecutive days
- Moisture content tests were conducted at the same time that each specimen type was tested.

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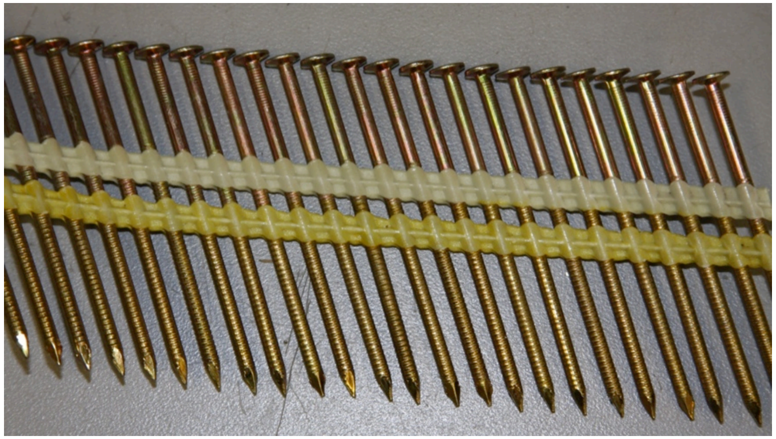
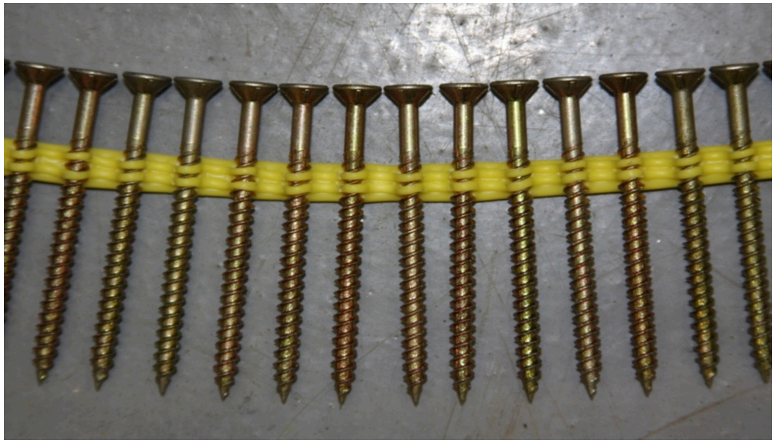
Materials

- Oriented Strand Board (OSB)
  - 15/32 Performance Category, APA Rated Sheathing, 32/16 (Span Rating), Exposure 1 (Bond Classification), 0.451 in Thickness
  - 19/32 Performance Category, APA Rated Sheathing, 40/20 (Span Rating), Exposure 1 (Bond Classification), 0.578 in Thickness
- Plywood
  - 15/32 Performance Category, APA Rated Sheathing, 32/16 (Span Rating), Exposure 1 (Bond Classification), 0.451 in Thickness
  - 19/32 Performance Category, APA Rated Sheathing, 40/20 (Span Rating), Exposure 1 (Bond Classification), 0.578 in Thickness

Materials

- Fasteners
  - Continental Materials Inc. 10D (3 in x 0.121in) coated galvanized ring shank nails
  - Quik Drive #8 x 2.5 in WSCT Series tile roofing screws (ASTM A641 Class 1)





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Withdrawal Testing Results

Nails

Specimen Type	Average Resistance (lbs)	Standard Deviation (lbs)	CoV	% Difference
15/32 OSB	125	35	0.28	38.8%
15/32 Plywood	173	41	0.24	
19/32 OSB	172	53	0.31	1.3%
19/32 Plywood	174	56	0.32	

Screws

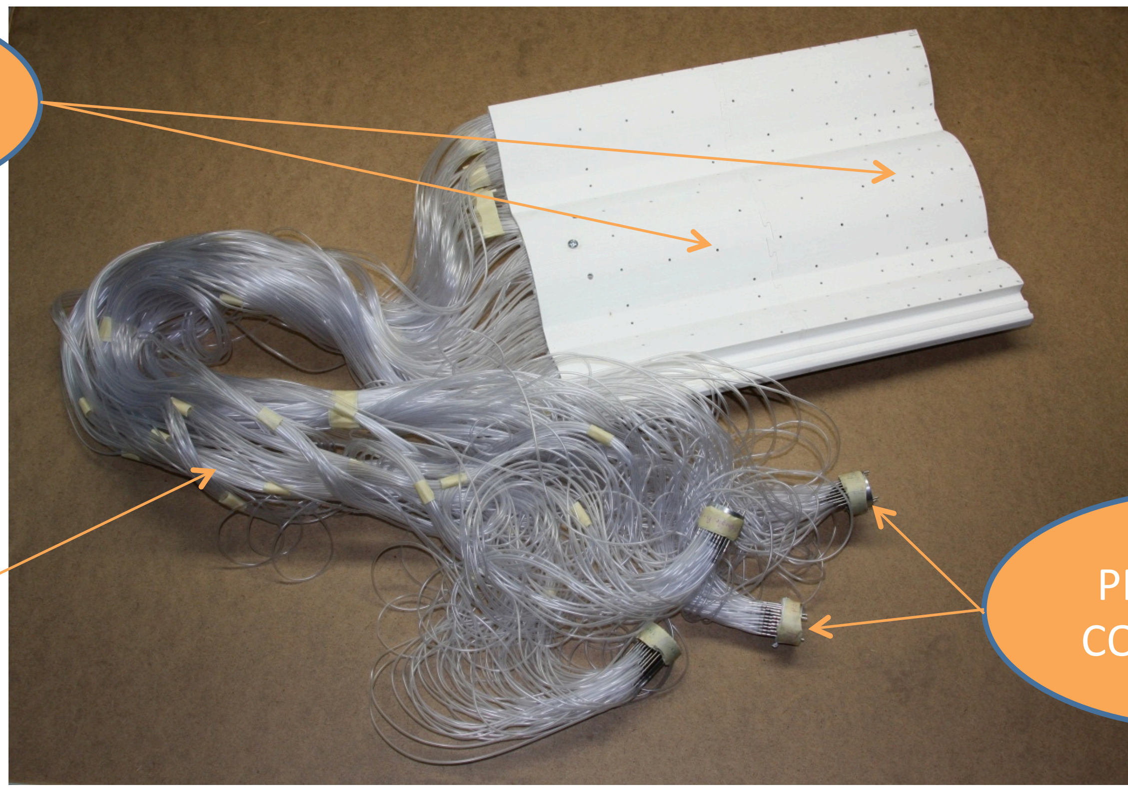
Specimen Type	Average Resistance (lbs)	Standard Deviation (lbs)	CoV	% Difference
15/32 OSB	238	58	0.24	53.2%
15/32 Plywood	365	49	0.13	
19/32 OSB	371	51	0.14	19.7%
19/32 Plywood	444	45	0.10	

Active Research Plan

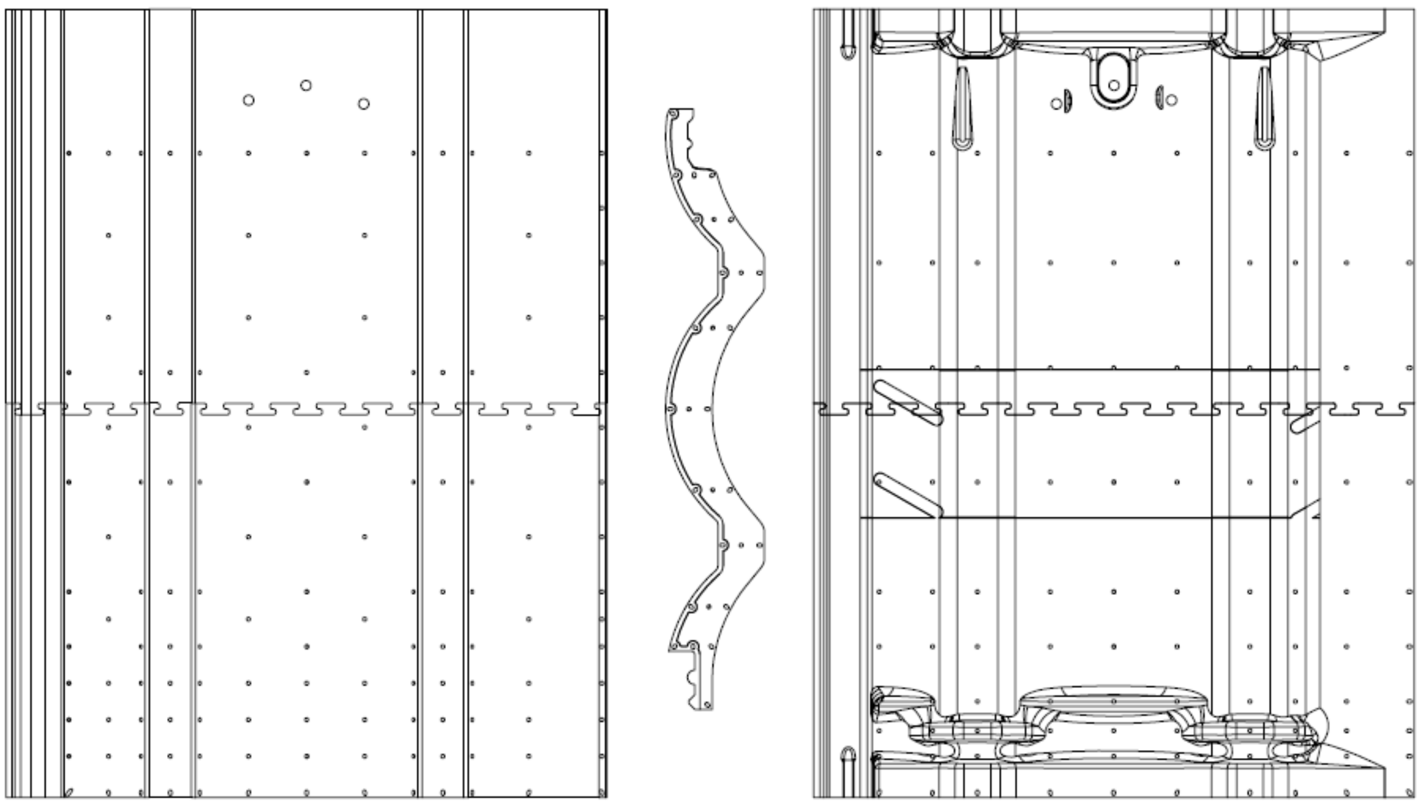
1. Adapt Peterka quasi-steady shingle wind load model to determine uplift forces on tiles (differs from the Redland approach, but ensures consistency between load characterization)
2. Conduct experiments to quantify peak loads on three tile shapes (low, mid, high)
3. Perform rational engineering analysis to determine force requirements for common attachments
4. Perform validation studies on real tile systems
5. Conduct mechanical uplift tests to determine resistance of the options from #3. Compare with existing test data
6. Develop recommendations to FBC based on findings

Characterize Wind-Induced Pressures

Low, medium, and high profile tile models have been rapid prototyped. Each model has 256 pressure taps.



Pressure "Taps"



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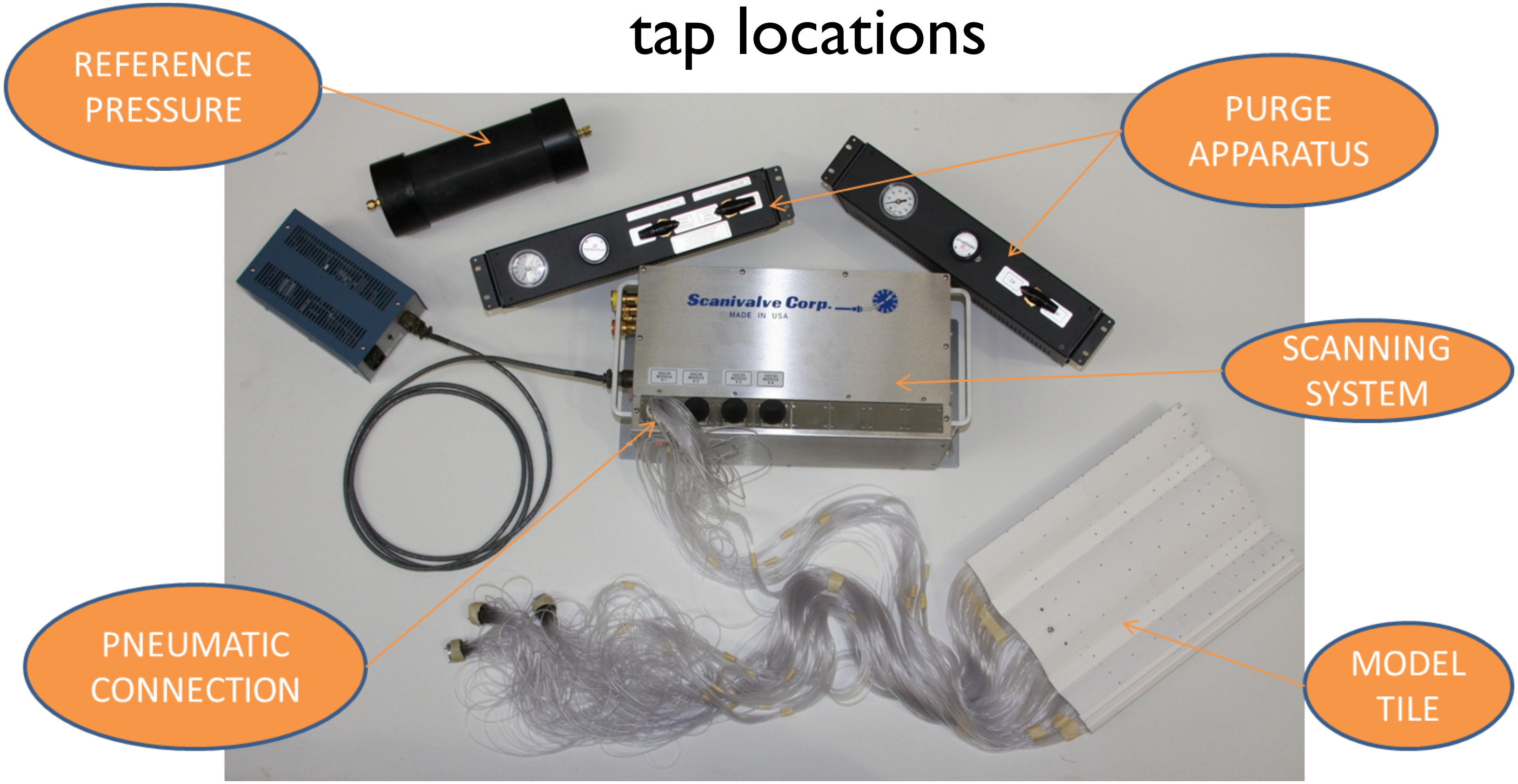
Characterize Wind-Induced Pressures

The tile models are designed for use with a pressure scanning system capable of recording pressure at all 256 tap locations



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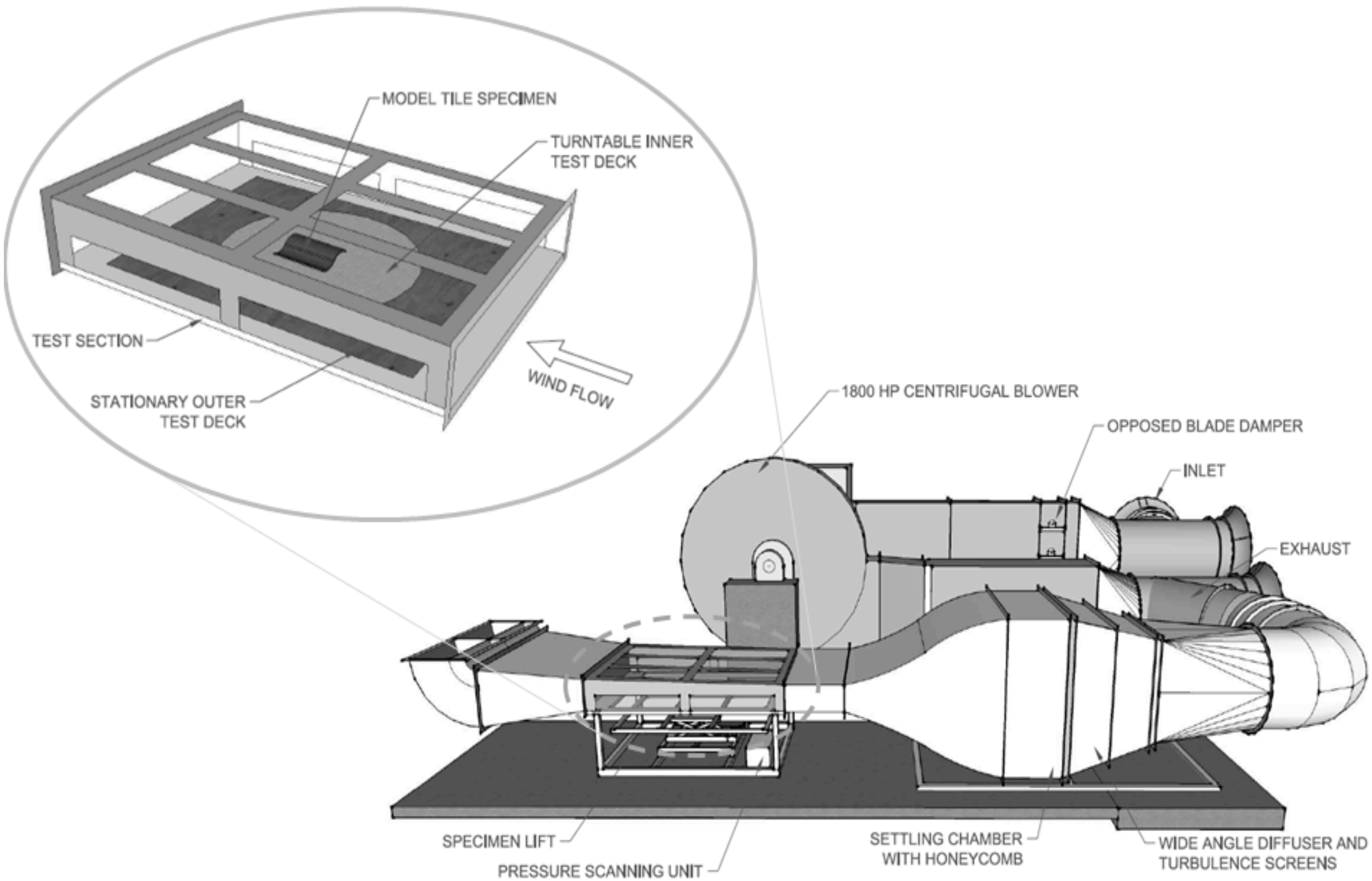
Dynamic Flow Simulator



Characterize Wind-Induced Pressures

The DFS test section was configured for the model tile specimens. Calibration phase is currently underway with experimentation to follow.

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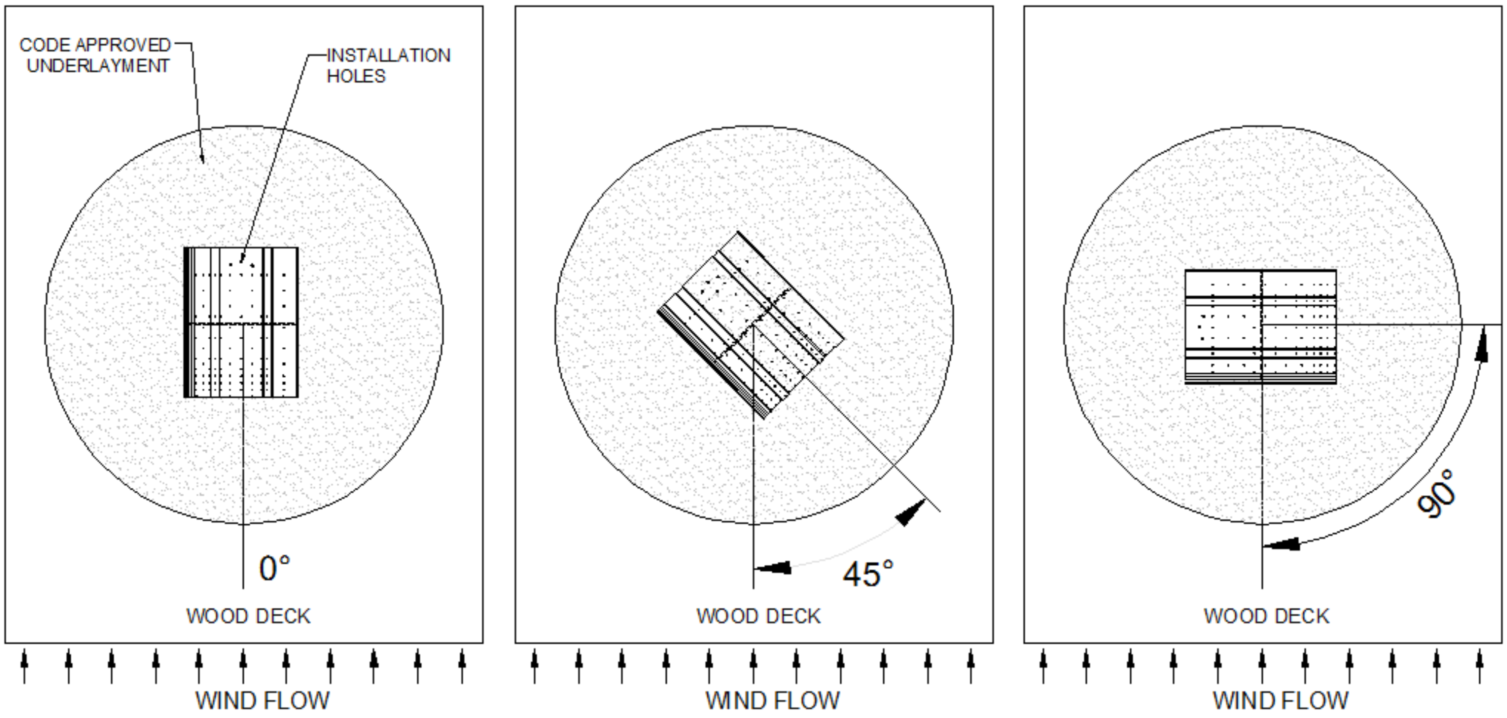
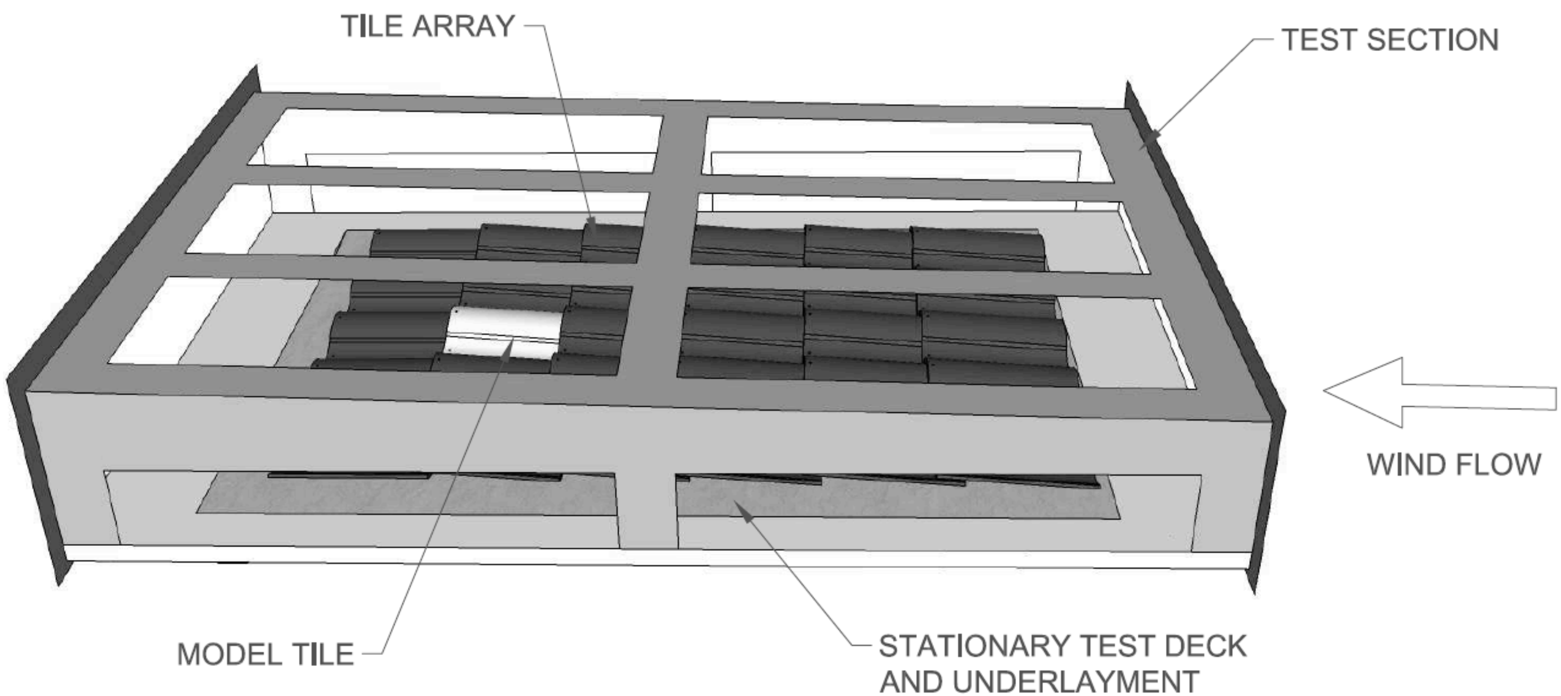
Phase I



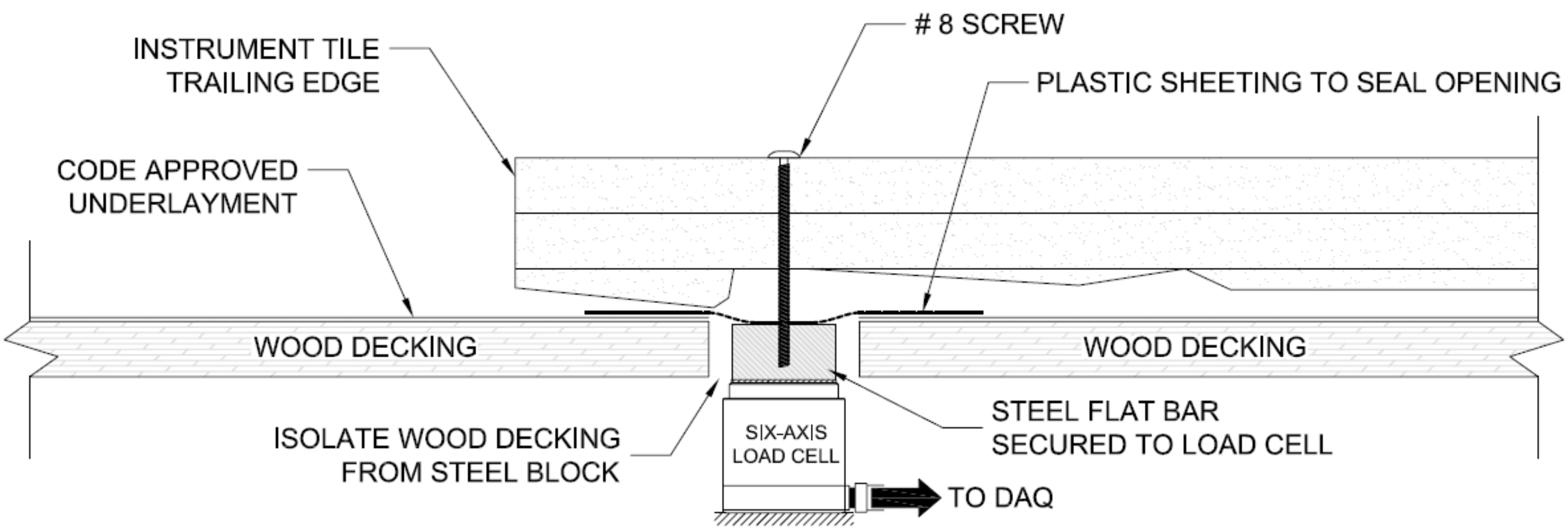
CODE APPROVED UNDERLAYMENT
INSTALLATION HOLES
0°
WOOD DECK
WIND FLOW
45°
WOOD DECK
WIND FLOW
90°
WOOD DECK
WIND FLOW

Phase II

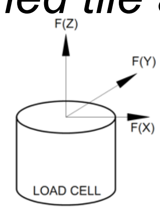

TILE ARRAY
TEST SECTION
WIND FLOW
MODEL TILE
STATIONARY TEST DECK
AND UNDERLAYMENT

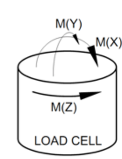
Quantify Wind-Induced Reaction Forces

Load cells will be affixed to fastening locations of tiles during wind-induced loading inside the DFS test section



Typical mechanical fastened tile and load cell arrangement





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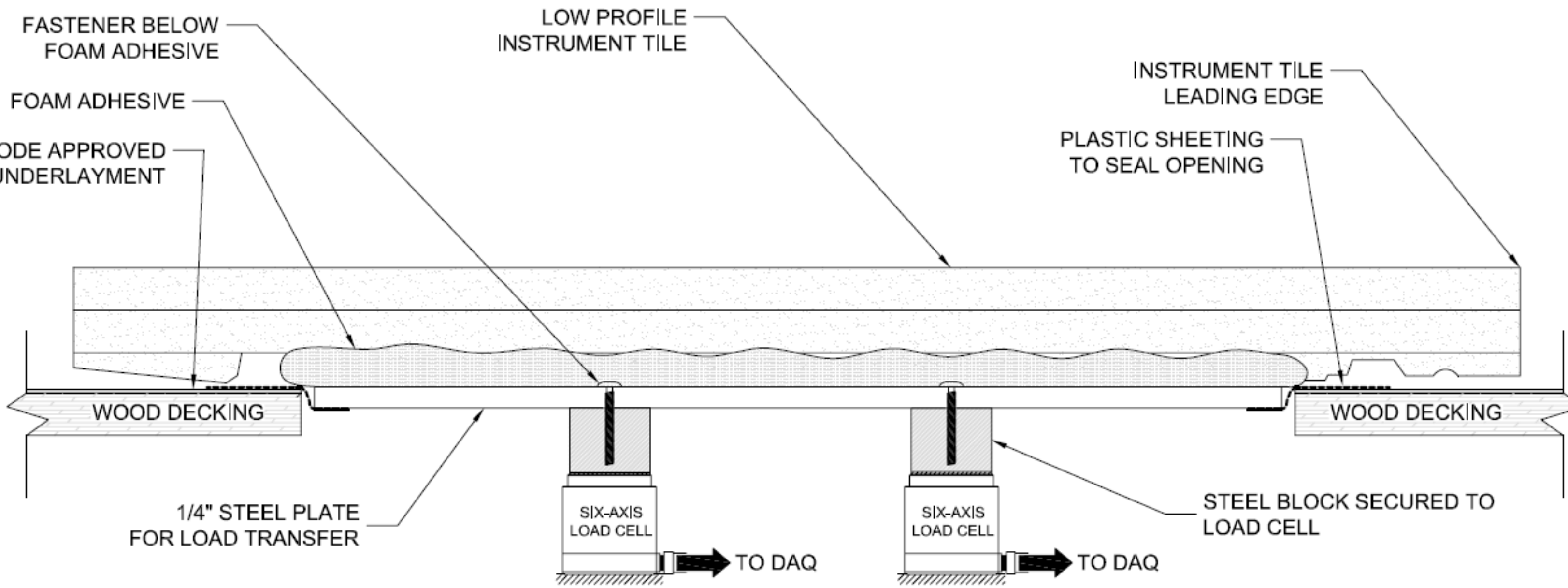
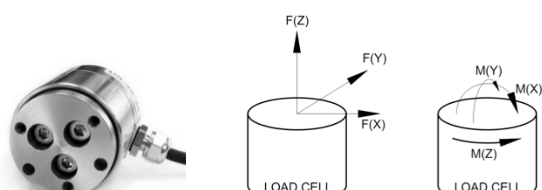
Quantify Wind-Induced Reaction Forces

Testing will begin upon completion of DFS test section calibration and wind-induced pressure characterization testing

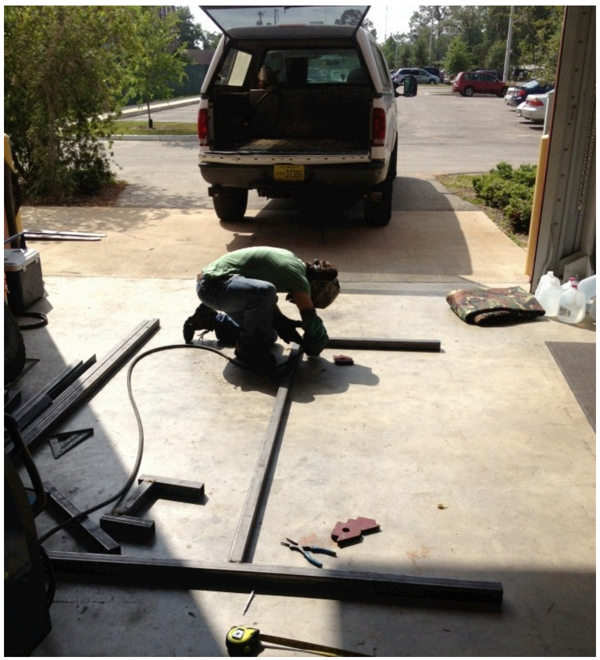


Typical adhesive set tile and load cell arrangement



Mechanical Uplift Testing

- A steel test frame was constructed for use with the UTM to test for uplift resistance of roof tile attachments



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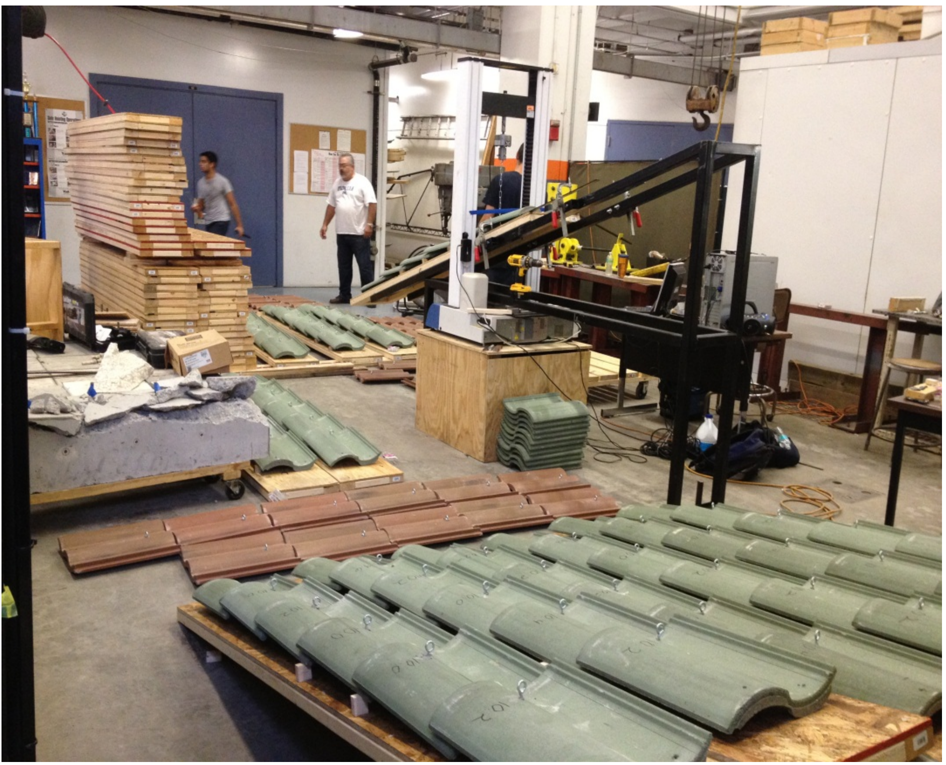
Mechanical Uplift Testing

- Mechanically fastened low, medium, and high profile tiles are tested for uplift resistance (120 tests completed thus far)



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Project Timeline

- Complete DFS test section calibration (August 2012)
- Characterize wind-induced pressures (September 2012)
- Quantify wind-induced reaction forces (October 2012)
- Complete mechanical uplift testing (August – November 2012)
- Hip/Ridge attachment (Spring 2013)

More Information

Please visit http://tileroofing.windengineer.org/

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