# Uplift Strength of Clay Tiles Installed on Self-Adhering Roofing Membrane



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## Research Motivation

➤ Failed tile roof systems key contributors to wind-borne debris



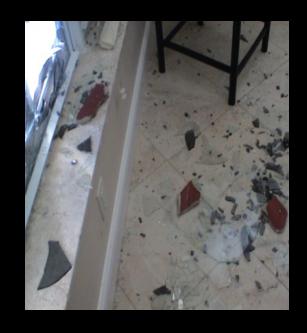






### Research Motivation

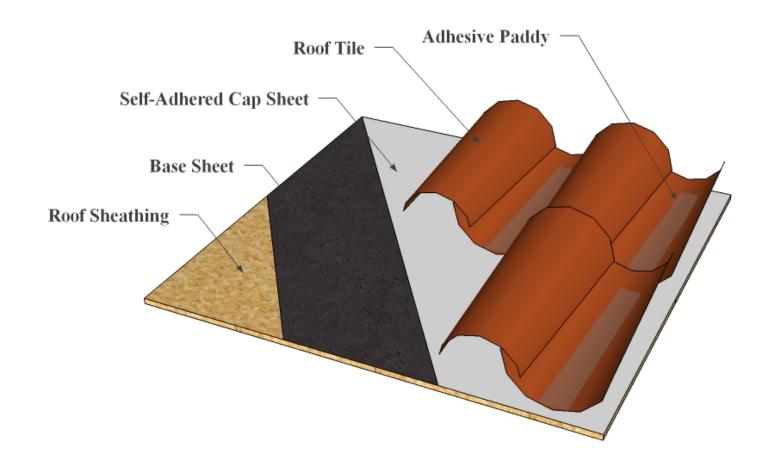
- Failure in load path for tile roof systems is key contributor to wind-borne debris
- ➤ Typical installation: tile → self-adhered secondary water barrier → nailable base sheet → roof deck.







## Standard Tile Roof Components



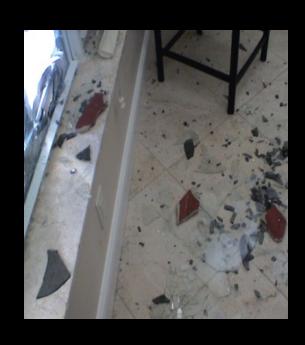






### Research Motivation

- Failure in load path for tile roof systems is key contributor to wind-borne debris
- ➤ Typical installation: tile → self-adhered secondary water barrier → nailable base sheet → roof deck.
- Tiles are installed with self-adhered membranes, direct to deck, i.e., no nailable base sheet.
- Question: does deck-to-deck selfadhering installation provide adequate uplift performance for clay tile?









## Project Scope

- Develop a test method to evaluate uplift capacity of clay tile roof systems on membrane
- ➤ Investigate uplift capacity of tile roof systems with directto-deck application
- > Compare direct-to-deck application with standard application methods with respect to uplift capacity



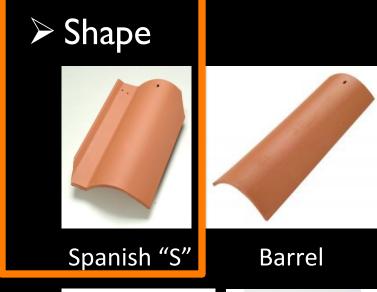




## Tile Options













Slate

Synthetic

Roman

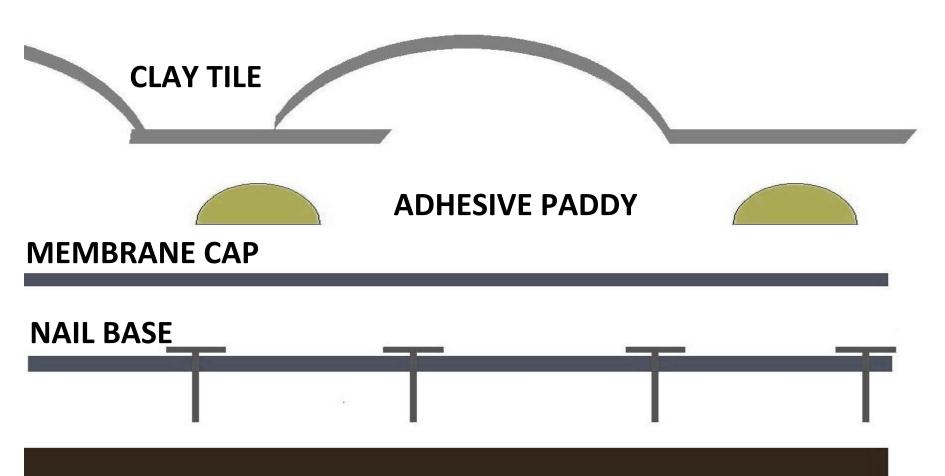
Flat







### Two-ply System (Membrane A)

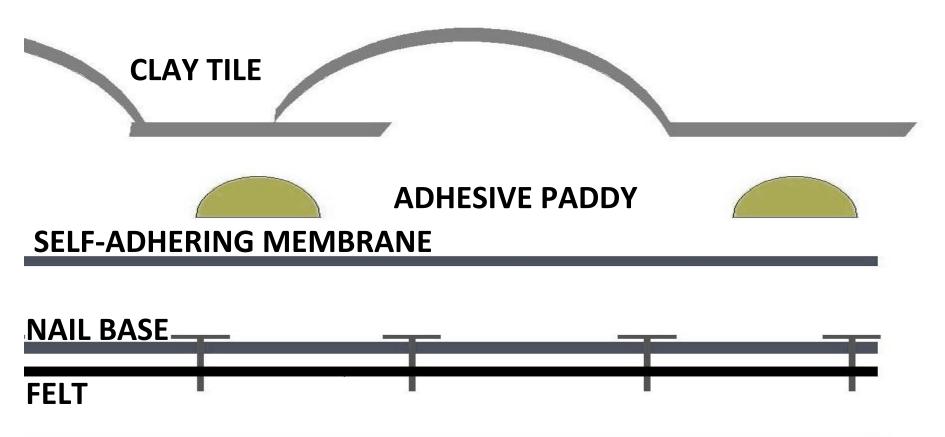








### Two-ply System with felt (Membrane A)

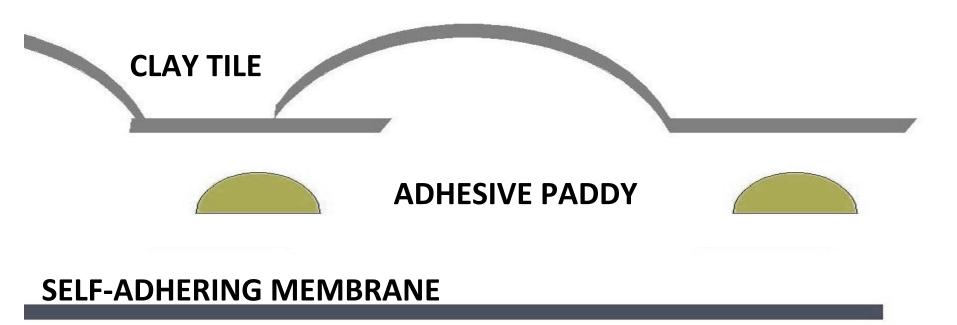








### Single-ply direct-to-deck (membranes B,C,D)

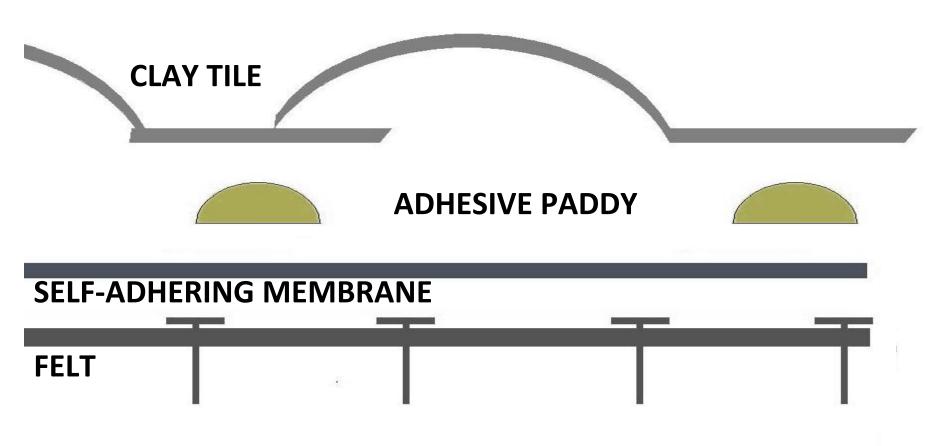








### Single-ply on felt (membranes B,C,D)









### Standard Protocols for Tile Roofs



Standard Test Method for Wind Resistance of Concrete and Clay Roof Tiles (Mechanical Uplift Resistance Method)

time 1.3, 11.4, 12.3, 12.4, 12.7, and 10.6 were consolid until to your date changed on May 13, 2008.

which relates to the wind resistance of an air-permeable roof

systems, adhesive art attachment systems, and mortas art atare used to apply tile to a roof.

1.3 The values stated in inch pound units are to be regarded as the standard. The values in parenthous are given for . 3. Terminology 1.4. This signified store not purpose to address all of the

aging concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish approrelate safety and health practices and determine the applicasity of regulatory destrations prior to use

### 2. Referenced Documents

### 2.1 ARTM Stendards 5

C43 Terminology of Structural Clay Products<sup>2</sup> C67 Test Methods for Sampling and Testing Brick and

Structural Clay Tile CH40 Test Methods for Sampling and Testing Concrete Massery Units and Belated Units COST Specification for Clar Boot Tiles.

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SECCE SIDT II SECCE THE Standard for Departs Wind Resistance of Concrete or Clay Boof Tiles

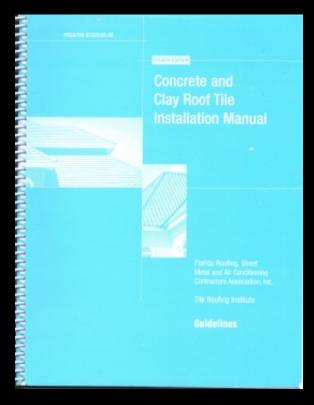
Note: 1—The standard is based on the beautifued Code Change's ECCHRCE SVID II Text foundard for Entermining Ward Reviewer of Concrets or Clay Boof Tiles, and work derived from the tile industry's testing programs completed in the Redfard Wind Tournel in the UK.

Schnitzer-For definition of term med in this test method refer in Terminology C43, and Specifications C1167

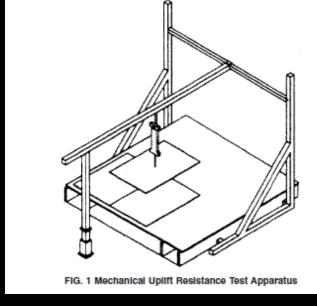
4.1 The method of attachment of roof this to the roof duck. and clay mod little to the active of wind. Naverall systems of the tile, when applied to the roof by any attachment system approved by, and in accordance with, the manufacturer's instructions, is a primary factor in the tiler's resistance to the action of wind. This test method determines the mechanical splift resistance that is related to revisioner to the splift frence. acting as a result of wind. Natural wind conditions differ with respect to intensity, duration, and turbulence: these conditions are beyond the means of this test method to simulate.

5.1 A test apparatus shows in Fig. 1 shall be used to test the mechanical uptill resistance of neil tiles. The triangulated framework and loading har shall be constructed of tubular steel of sufficient strength to remain rigid when loads of up to 500 By are applied to the test tile. The frame shall be fixed in the floor to provide a solid. reference clear for Arthorise measurements. The inists of the frame shall be rigid, however, the leading har rotates about the frame to facilitate the leading of the test life. The other and of

ASTM C1568 – Standard Test Method for Wind Resistance of Concrete and Clay Roof Tiles







ASTM C1568 Test Setup

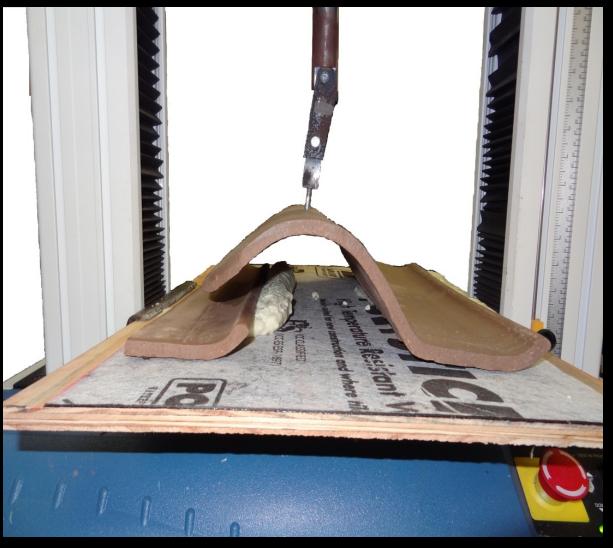
- TAS No. 101-95 Test Procedure for Static Uplift Resistance of Mortar or Adhesive Set Tile Systems
- RAS No. 120 Mortar and Adhesive Set Tile Application
- RAS No. 113 Standard Requirements for Job Site Mixing of Roof Tile Mortar







### Test Setup



- Spanish "S" tile
- 2 deck types
- → 4 membrane systems
- Foam adhesive & mortar

Instron 3367 Test Machine
1.0 in. per min. at tile center







## Test Matrix

	Sheathing Type		Membrane Type					Adhesive Type		#
SAMPLE	PLYWOOD	OSB	30#	Type A	Type B	Type C	Type D	FOAM	MORTAR	Samples
1	X			X				X		30
2	X		X	X				X		20
3	Χ			X					X	20
4		X		X				X		20
5		X	X	X				X		20
6	X				X			X		20
7	X		X		X			X		20
8		X			X			X		20
9		X	X		X			X		20
10	X					X		X		15
11	X		X			X		X		15
12	Χ						X	X		20
13	X		X				Х	X		20
14	Χ						X		X	20
Total									280	







## Material Properties

Underlayment Type	Product	Thickness	Top Surface	Fastener	Fastener Pattern
D. C. and L. and C. C.	Cap Sheet	59.1mils	Permanent Film	Nails	(2) Staggered Rows 18" O.C.
Membrane A	Base Sheet	157.5mils	Granular Mineral	Self-adhered	n/a
Membrane B	Cap Sheet	80mils	Polyester Fabric	Self-adhered	n/a
Membrane C	Cap Sheet	100mils	Ceramic Granules	Self-adhered	n/a
Membrane D	Cap Sheet	55.9mils	Polyester Fabric	Self-adhered	n/a
Felt	30# Felt	40.5mils	Smooth	Nails	12" O.C.





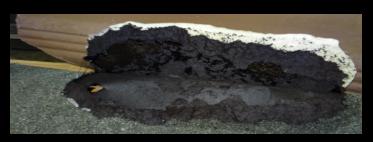


## Analyzing Testing Results

- Peak Failure failure mechanism at Peak Load, causing decrease in capacity
- Secondary: other observed failure mechanisms
  - Adhesive Failure (to tile, within adhesive, or to cap sheet)
  - Membrane Failure (cohesive or adhesive)
  - Membrane tearout around nail



Adhesive Failure



Membrane Failure



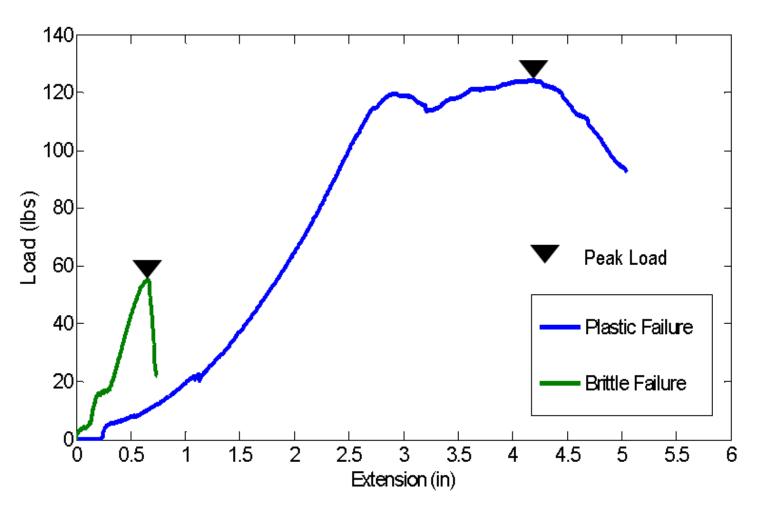
Membrane tearout around nail







### Plastic vs Brittle Failure

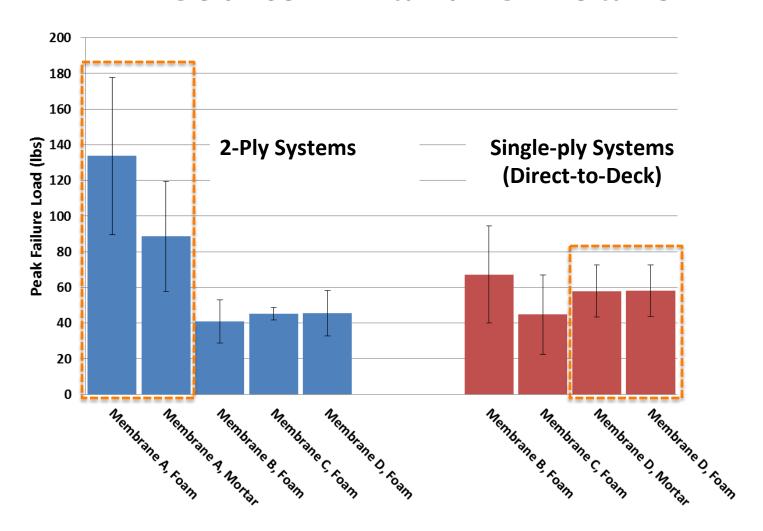








### Results – Failure Loads



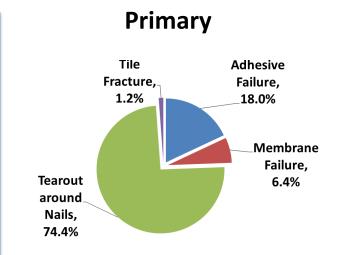




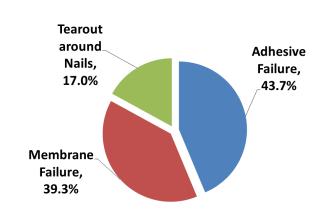


## Results – Failure Types

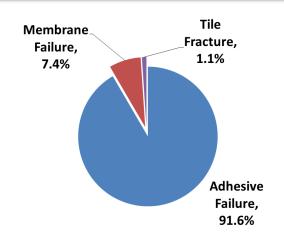
2-Ply Systems

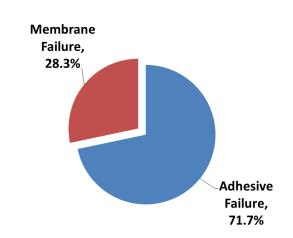






Single-ply (Direct-to-Deck)











### Conclusions

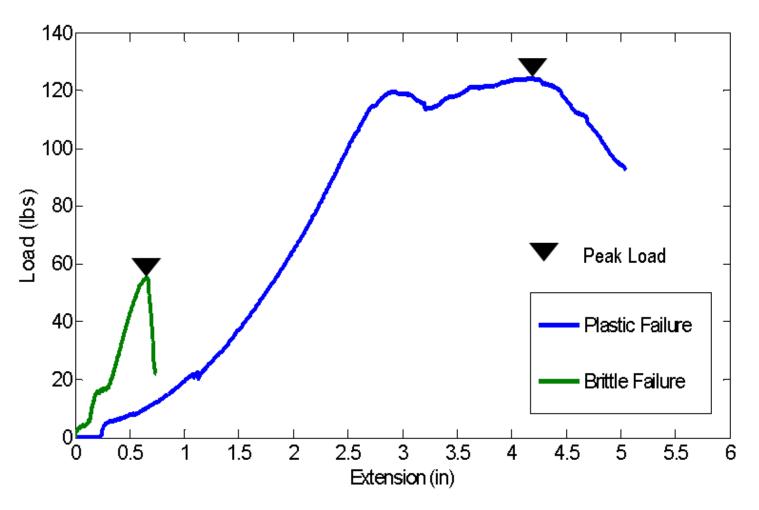
- ➤ Peak failure loads for nail base systems versus direct-to-deck systems similar in membranes from Manufacturers B, C and D
- ➤ Brittle failures in direct-to-deck application as opposed to plastic failures in systems with nail base
- ➤ Primary failure mechanisms change between standard and direct-to-deck systems







### Plastic vs Brittle Failure









## Summary

- Limitations of the results
  - Withdrawal rate (slow, controlled) vs. sudden impact wind load
  - Static, monotonic increasing load vs. dynamic wind action
  - Atypical boundary conditions (isolated tile, discontinuous membrane) to establish conservative capacity
- > Roof corner design pressure ~ 60psf at 140 mph = ~80 lb
- > Failure may not be controlled by suction
- Future tests recommended using dynamic open jet using simulated hurricane wind speed



- > Thank you for your time and attention
  - ➤ Questions/Comments?
  - Contact Information

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