AIA Baton Rouge

Membership Meeting
March 12, 2021

Moisture in Concrete Roof Decks

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ROOFING SOLUTIONS

We build with passion and skill.

presented by

NRCA

Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association

1

Speaker bio.

- Raised in a three-generation family in the construction business
- BS degree in Architectural Engineering
- Roofing contractor
- Consultant and designer (and expert witness)
- Last 28 years at NRCA:
  - Staff lead on Technical Services
  - Codes and standards
  - Problem analysis
  - Contributing editor to *Professional Roofing* magazine

2

Learning objectives

- Identify deck moisture-related problems with membrane roof systems
- Learn of legacy concrete deck dryness research and guidelines
- Review NRCA concrete deck dryness research
- Learn moisture mitigation techniques

3

Reported problems

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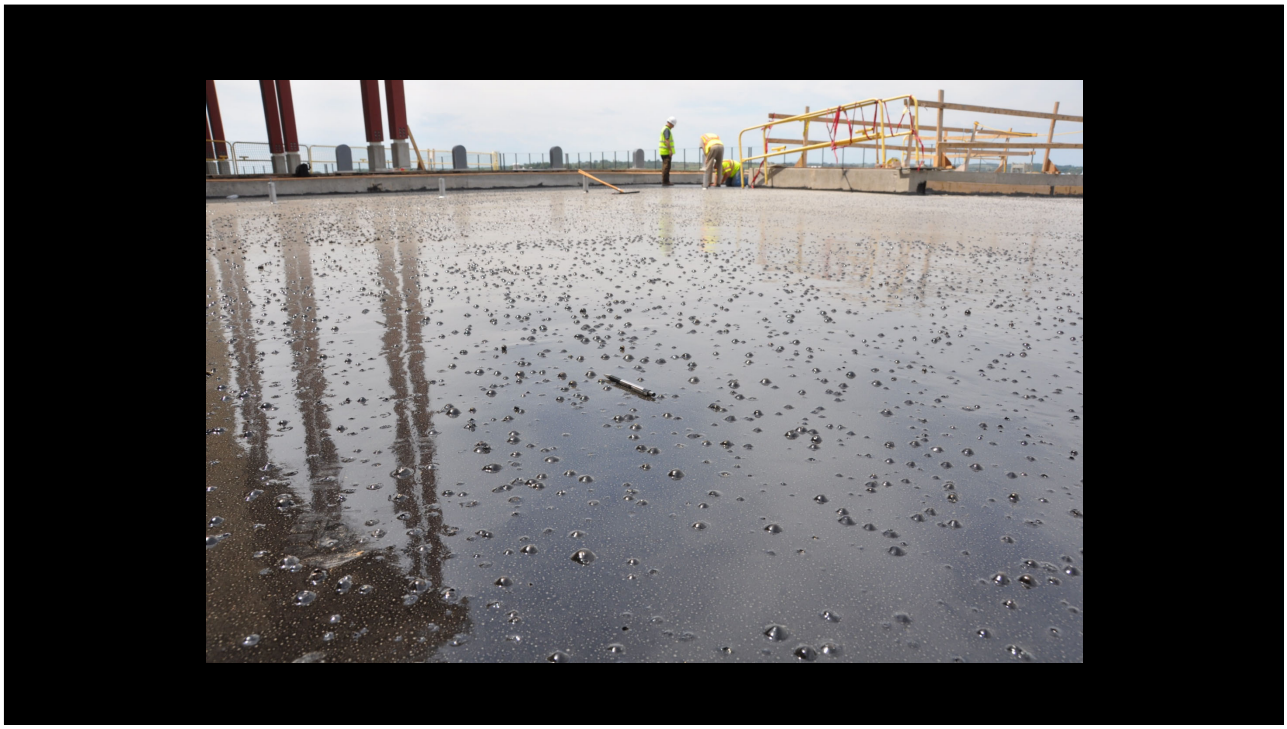
4



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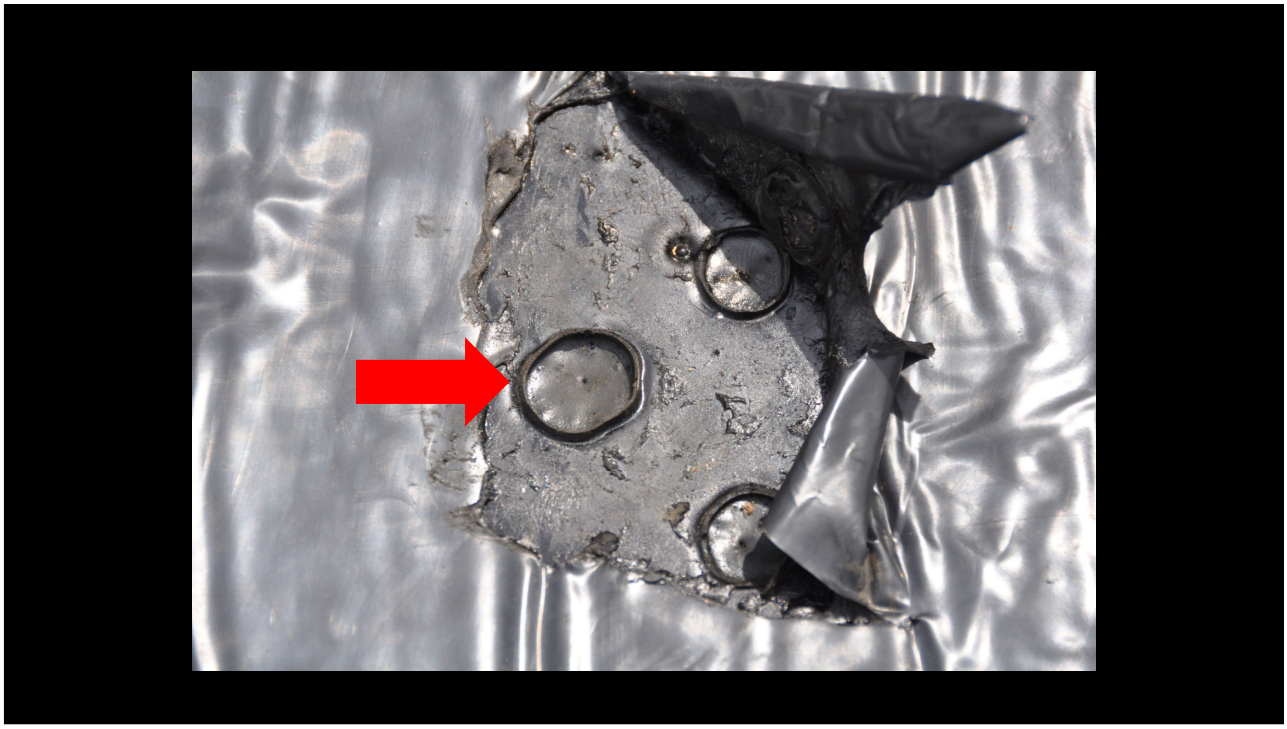

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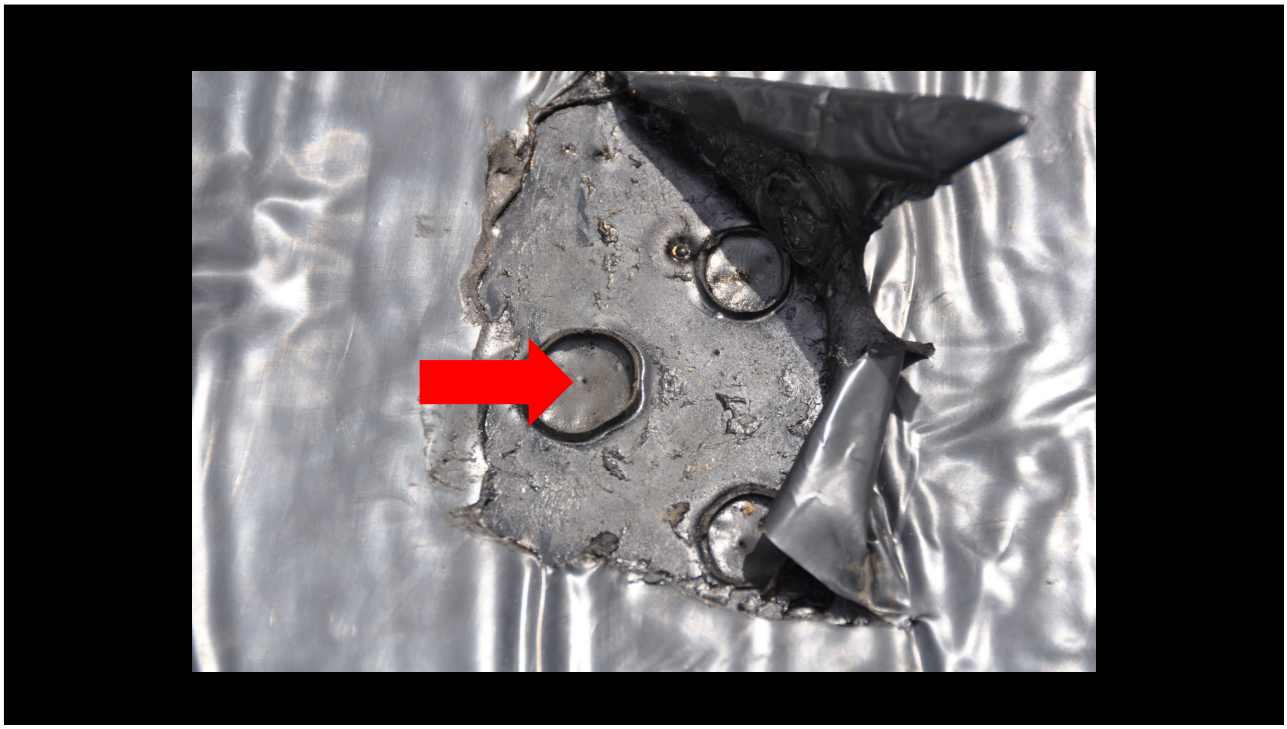

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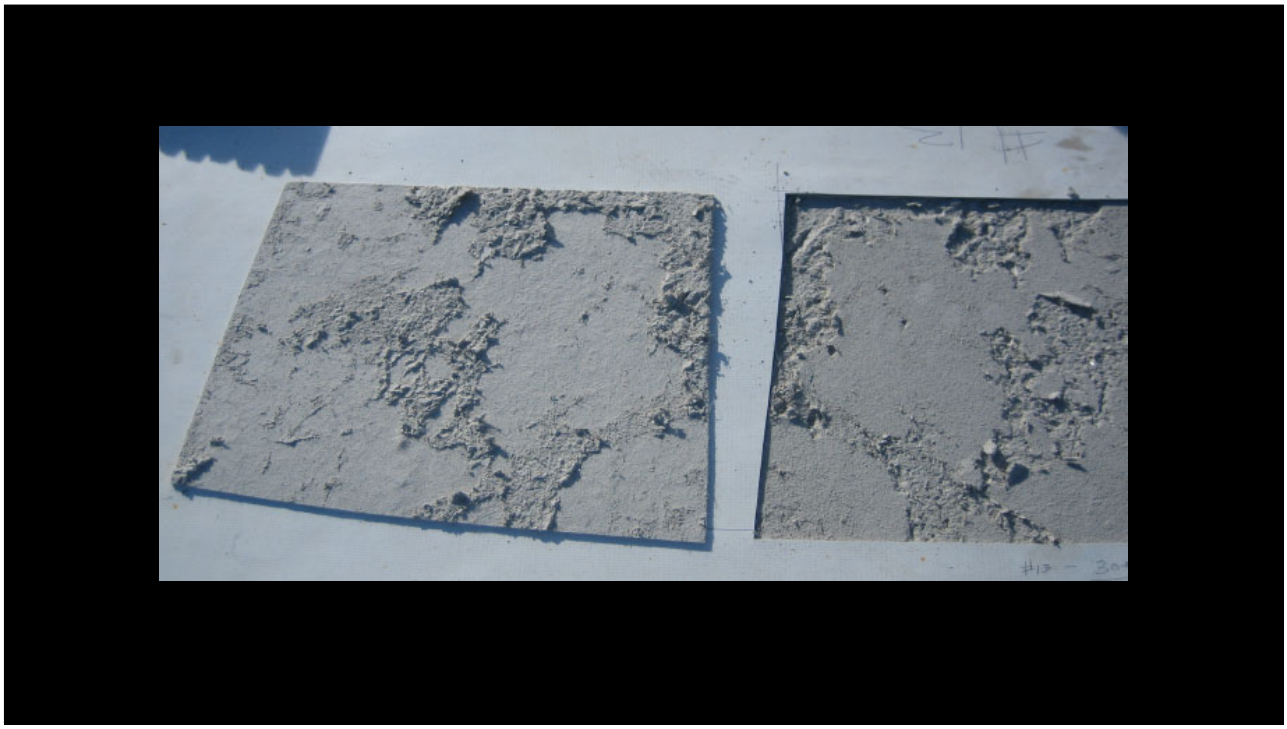

9

Concrete deck moisture-related roofing issues

- Moisture accumulation
- Adhesion loss
- Water-based and LVOC adhesives issues
- Material degradation
- Metal and fastener corrosion
- Insulation R-value loss
- Microbial growth

10

The issue is concrete deck moisture in its vapor phase…

11

Concrete basics

Moisture in Concrete Roof Decks

12

Concrete mix design

- Aggregate:
  - Large aggregate
  - Fine (small) aggregate
- Portland cement
- Water
- Admixtures:
  - Fly ash
  - Air entrainment
  - Curing compounds
  - Etc.

13

Concrete batch

Date 08-Jun-2016 Item Listing Page 1

Item Code	Description	Short Descr	Item Category	Inventory Item Code	Keep in Inventory
96506030	4000 PSI #67 AE	4500 PSI #67 AE	03658 7 B		[ ]

Constituents	Item Code	Short Descr	Quantity	
2	21005000	LAFARGE - CEMENT	520.00	lb
	21009000	FLY ASH - BULK	130.00	lb
	12210000	FINE AGG/CONCRET	1280.00	lb
	16210001	3/4" COARSE AGG/	878.00	lb
	13060000	3/4" LIMESTONE/C	878.00	lb
	20997000	AIR ENTRAINING-F	6.00	oz
	23001000	WATER	29.00	ga

242 lbs.

Page 256

14

Traditional dryness evaluation methods

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15

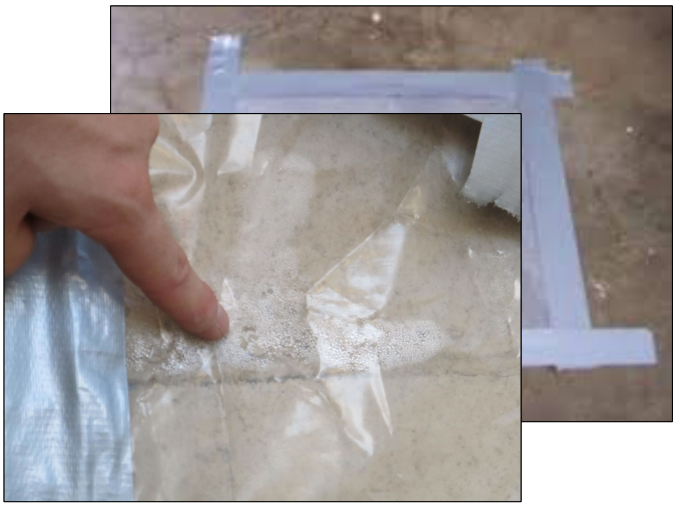
When is it OK to roof?

Historical guidelines

- 28 days after placement
- Application of hot bitumen
- Plastic film test
  - ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method"

16

Plastic film test



17

When is it OK to roof?

Historical guidelines

- 28 days after placement
- Application of hot bitumen
- Plastic film test
  - ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method"

These guidelines are not appropriate for current generations of concrete mixes

18

Flooring industry

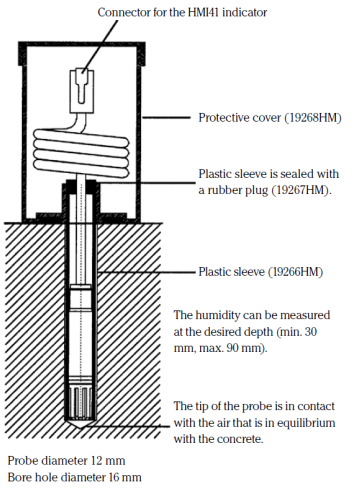
ASTM Committee F06—Resilient Floor Coverings

- ASTM F1869, "Standard Test Method for Measuring Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride"
- ASTM F2170, "Standard Test Method for Determining Humidity in Concrete Floor Slabs Using In-situ Probes"

19

ASTM F2170 apparatus

Measure relative humidity (RH %) and temperature



20

Trial ASTM F2170 tests

Existing lightweight structural concrete roof decks

	Roof 1	Roof 2	Roof 3
Roof age (yrs)	4	7	7
Area (ft^2)	13,200	23,840	14,760
Thickness (in.)	6.5	7.5	7.3
No. of readings	13	10	8
High reading	99% RH	99% RH	99% RH
Low reading	63% RH	96% RH	84% RH
Median reading	97% RH	99% RH	99% RH
Mean reading	89% RH	99% RH	95% RH

Values of 65-85% RH are considered acceptable in the flooring industry depending upon the specific floor covering type.

21

Historical drying research

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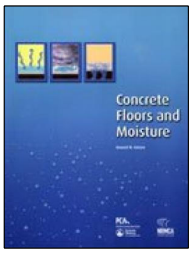
22

PORTLAND CEMENT ASSOCIATION
RESEARCH AND DEVELOPMENT LABORATORIES
Development Department • Bulletin D89

Table 1 Drying time in days at 73 F and 50% relative Humidity for a 4-inch-thick specimen to reach 3 lbs/1,000 sq. ft./24 hrs.

Water-Cement Ratio	Bottom Sealed	Bottom Exposed to Water Vapor	Bottom in Contact with Water
0.4	46	52	54
0.5	85	144	199
0.6	117	365	>>365
0.7	130	>>365	>>365
0.8	148	>>365	>>365
0.9	166	>>365	>>365
1.0	190	>>365	>>365

23



***Concrete Floors and Moisture* (2008)**
Howard Kanare

A concrete slab will reach a 75% RH
- Normal weight structural concrete
  - Less than 90 days
- Lightweight structural concrete
  - Almost 6 months

24

Re-wetting (dew, precipitation) is an issue for roof decks

25

Re-think our concept of concrete roof decks

A concrete deck is not a non-breathable, non-absorptive solid

26

Re-think our concept of concrete roof decks

27

Roofing Industry's concrete dryness research

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28

Roofing industry research

- Phase 1:
  - Characterization
  - Hygrothermal testing and initial analysis
- Phase 2:
  - Laboratory simulation
  - Computer simulations

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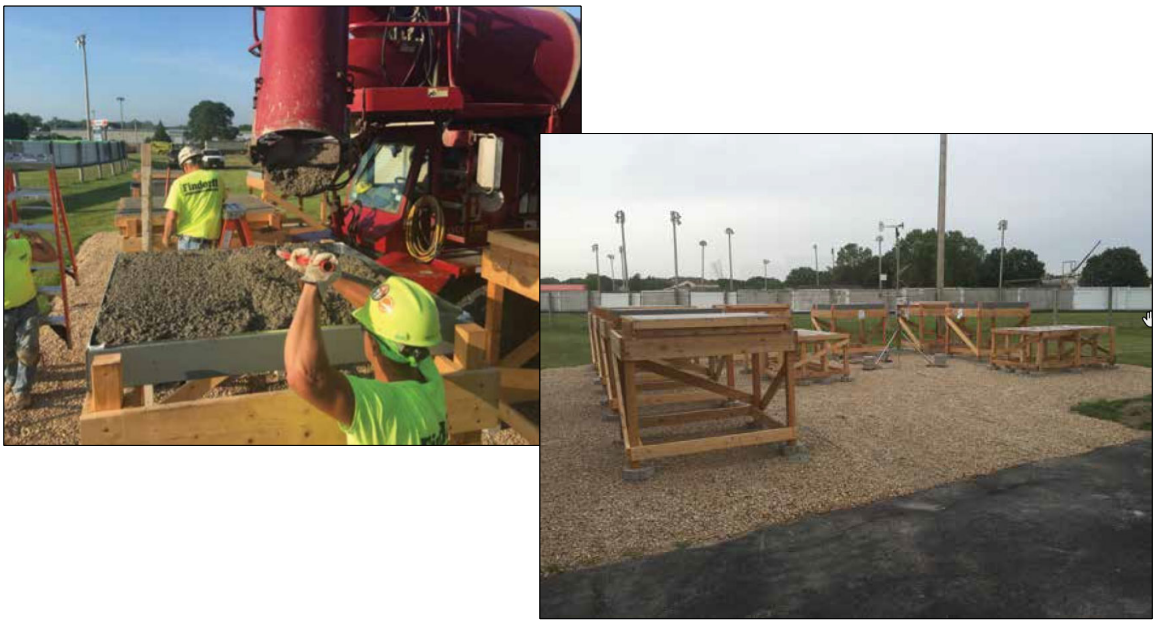
29



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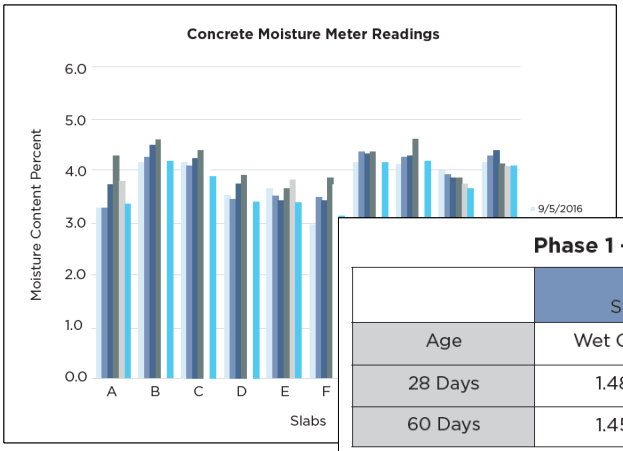
31

Phase 1 results



Phase 1 - ASTM E96 Calculated Perm-in

	Lightweight Structural Concrete		Normal Weight Structural Concrete	
Age	Wet Cup	Dry Cup	Wet Cup	Dry Cup
28 Days	1.48	0.78	3.42	1.05
60 Days	1.45	0.47	2.03	1.13

Figure 2: Results of ASTM E96 water vapor transmission testing. Note the lightweight structural concrete has about half the permeability of normal weight structural concrete. Considering lightweight structural concrete arrives with more than twice the evaporable water of normal weight structural concrete, this explains why lightweight structural concrete remains moisture laden so long.

32

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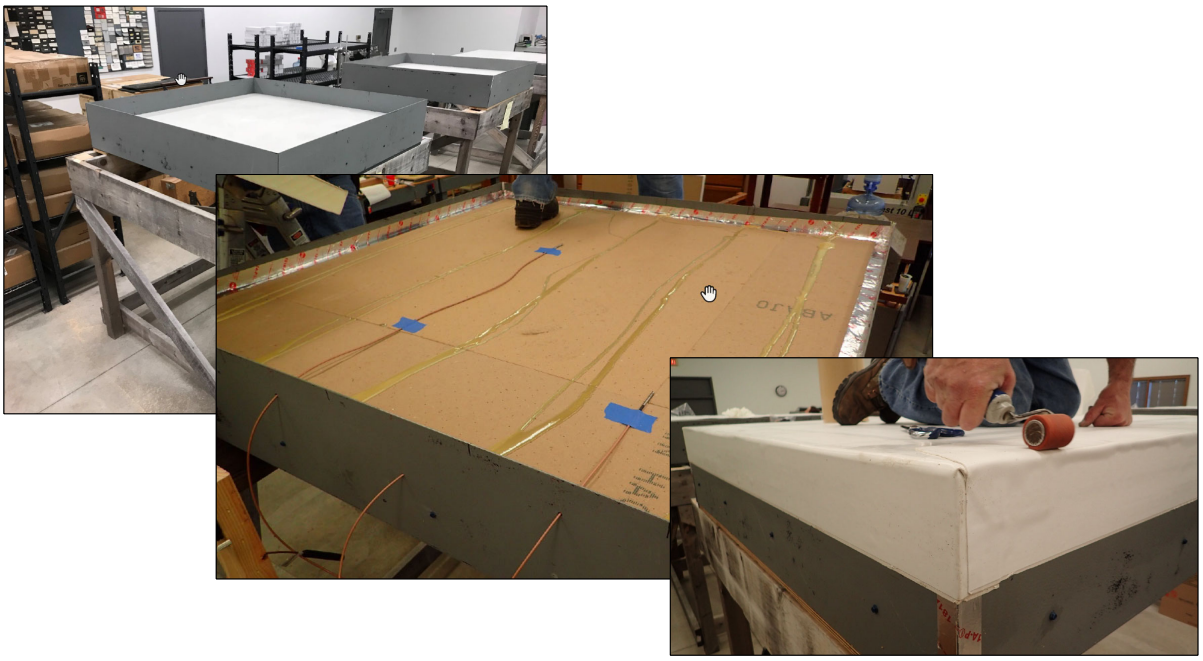
33



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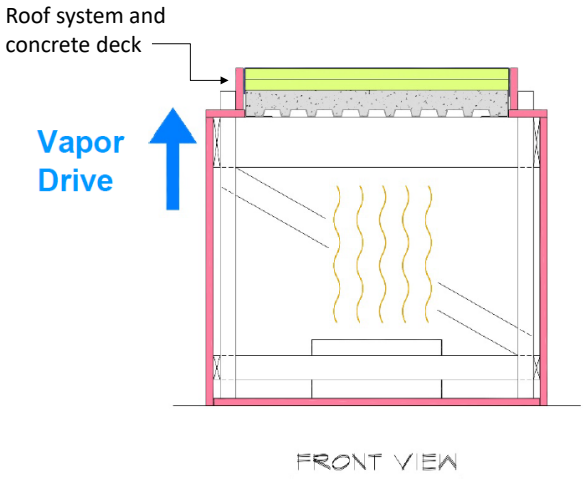

Conditions:

- "Outside": 70 F & 50% RH (lab. cond.)
- "Inside": 90 F & @50% RH

35

Phase 2 -Conclusion

- A very low perm. vapor retarder is needed to prevent moisture vapor drive from a concrete roof deck into the roof system

36

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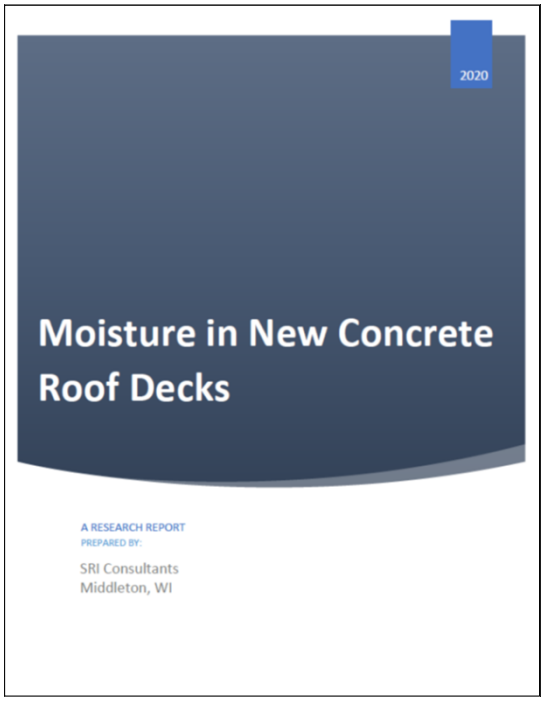
37



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38

Additional research

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39


RESEARCH + TECH

Are admixtures the answer?

Moisture in concrete roof decks continues to be problematic

by Mark S. Graham

NRCA's Technical Services Section has been receiving inquiries regarding the use and effectiveness of specific concrete mix additives and topical surface treatments to address moisture release-related concerns with concrete roof decks. Such admixtures broadly are referred to as moisture vapor reduction admixtures (MVRAs) or porosity-inhibiting admixtures. NRCA provides recommendations regarding their use.

MVRAs

Concrete admixtures intended as MVRAs are specific chemicals added during concrete's batching and mixing to provide an additional chemical reaction during the concrete's hydration and curing process. MVRAs use the concrete mix's excess water and chlorides to create a calcium silicate hydrous gel within the concrete. The gel is said to fill the small pores and capillary openings in curing concrete, minimizing the concrete's ability to pass and release moisture vapor. The gel is intended to be permanent and integral throughout the concrete's entire thickness.

24 www.professionalroofing.net DECEMBER 2018

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Professional Roofing
December 2018

40

Moisture vapor reduction admixtures (MVRAs)

NRCA still has not seen an MVRA perform successfully in concrete roof deck applications

41

ASTM E96 testing of MVRA vs Non-MVRA concrete decks

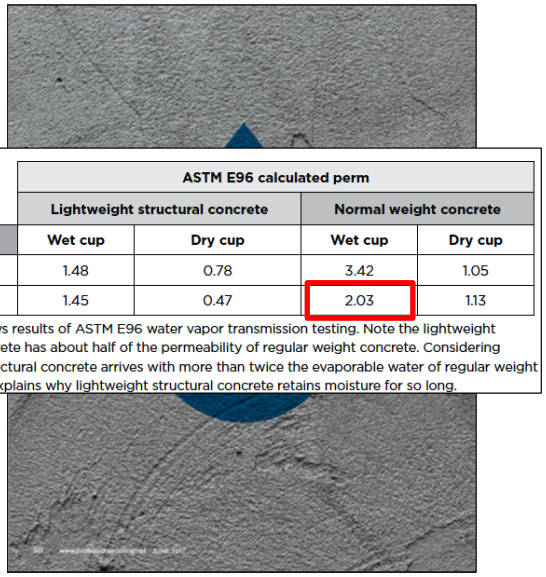
Figure 1 – Roofing concrete cores without MVRA, samples 6-1 and 6-2

42

Figure 2 – Roofing concrete cores with MVRA, samples A-1 and A-2.

Figure 3 – Roofing concrete cores with MVRA, samples B-1 and B-2.

43



	ASTM E96 calculated perm			
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Age	Wet cup	Dry cup	Wet cup	Dry cup
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The figure shows results of ASTM E96 water vapor transmission testing. Note the lightweight structural concrete has about half of the permeability of regular weight concrete. Considering lightweight structural concrete arrives with more than twice the evaporable water of regular weight concrete, this explains why lightweight structural concrete retains moisture for so long.

Professional Roofing, June 2017

Professional Roofing, December 2018

44

Without an MVRA

With an MVRA

TABLE 2.1 SUMMARY OF AVERAGE WATER VAPOR TRANSMISSION PROPERTIES

	SAMPLES 6-1 AND 6-2		SAMPLES A-1 AND A-2		SAMPLES B-1 AND B-2	
SAMPLE ID	6-1	6-2	A-1	A-2	B-1	B-2
Perm-in	1.9	1.8	3.7	3.4	3.7	3.8
Permeance for 25.4 mm (ng/Pa*s*m2)	108	101	214	195	210	215
Permeability (ng/Pa*s*m)	2.8	2.6	5.4	4.9	5.3	5.5

The specimens containing an MVRA have tested WVT values about two times (i.e., more "vapor open") more than the specimens without the MVRA

45

NRCA's recommendations

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46

NRCA's recommendations

Addressing moisture in concrete roof decks

- For structural concrete roof decks in new construction, designers should specify a high bond-strength/well adhered vapor retarder
- For structural concrete roof decks in reroofing where there is evidence vapor migration from the roof deck, designers should consider specifying a high bond-strength/well adhered vapor retarder

47

NRCA's recommendations – cont.

Addressing moisture in concrete roof decks

- Experience has shown a 2-ply, hot-applied, built-up membrane applied to a primed concrete deck has performed successfully.
- Designer should include specific details for sealing edges and penetrations in the vapor retarder

48

NRCA's recommendations – cont.

Addressing moisture in concrete roof decks

- Designers should specify a roof system type that does not involve the use of insulation or membrane fasteners (that would penetrate the vapor retarder)
  - Use adhered, loose-laid and ballasted or protected-membrane roof systems
  - Avoid mechanically-attached rigid board insulation and mechanically-attached membrane systems

49

NRCA's recommendations – cont.

Addressing moisture in concrete roof decks

- Additional design considerations:
  - Consider avoiding moisture-sensitive, organic content roofing products
    - Polyiso. insulation with reinforced cellulosic facers (Type II, Class 1)
    - Perlite board insulation
    - Wood fiberboard insulation

50

Deck acceptance

Whose moisture is it in the concrete?

51

Roofing contractors do not have the necessary information – and, in many cases, the expertise – to make when to roof decisions over structural concrete roof decks

- Mark S. Graham

52

This concludes the AIA credit portion of the program

53

Questions…

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54

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55