Moisture In Concrete

Helene Hardy Pierce, GAF
Mark Graham, NRCA
Leanne Prybylski, Hendrick, Phillips, Salzman & Siegel

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Roadmap

- Why You Should Care
- Wrestling With This Issue
- Technical Concerns and Considerations
- How to You Can Protect Yourself
- Questions…

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Helene Hardy Pierce
VP, Building Science & Systems, Regulations & Industry Support
GAF

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Why You Should Care

- High potential for problems
- Cost of failure is high
- While we don't "make decks", we're supposed to know what can go over them
- Too often, anyone in the roofing industry is considered the "SME" for anything that has to do with the roof…EVEN for concrete decks!

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Wrestling With the Issue

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Wrestling With the Issue

- NRCA staff research and many discussions with individual manufacturers ~ approached over 25 manufacturers/marketers
- Significant web research…
- And even a basic definition

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2021…We Have Unicorns & Ostriches

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Before We Go Further… need to know what "**dry**" is

(simply put, this word is being used a lot when folks talk about concrete!)

- Cambridge: **dry**, adj, used to describe something that has no water or other liquid in, on, or around it
- Merriam-Webster: **dry**, adj, free or relatively free from a liquid and especially water
- Dictionary.com : **dry**, adj, free from moisture or excess moisture; not moist; not wet:

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C • Dictionary.com : **dry**, adj, free from moisture or excess moisture; not moist; not wet (WHO defines what "excess moisture" is…???)

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From a 2001 (yes, 20 years ago!) Modified Bitumen Spec Book

From the Design Section on Decks…

Design and Construction Considerations

- Must be adequately smooth and level to provide support and maximum contact surface for roofing materials.
- Must be dry (free of moisture in any form), clean, free of debris, sharp projections and depressions. All depressions, holes, deformations, etc. shall be made smooth prior to application of roofing materials.

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From a 2001 (yes, 20 years ago!) Modified Bitumen Spec Book

And Specifically on…

Poured Structural Concrete Decks

- Poured in place structural concrete decks consist of Portland cement, water, and aggregate.
- These decks typically vary from 4" to 12" (10.2cm to 30.5 cm) in thickness.
- Must be poured over removable forms or must provide for bottom side drying. Poured in place structural concrete decks that are poured over non-vented metal decks or pans that remain in place can trap moisture in the deck under the roof system and are not acceptable.
- The underside of the concrete decks, either the vented metal forms or exposed concrete, must remain unobstructed to the escape of water vapor. Materials that retard the flow of vapor must not be installed directly below the deck. Foil-faced insulation secured to the bottom of the deck, spray-on fireproofing, or paint, which obstructs the venting of the concrete, are just three examples of the unacceptable deck assemblies.

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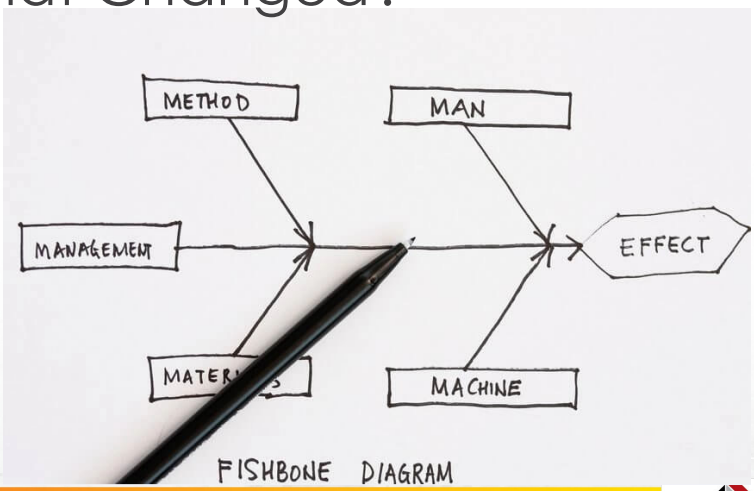
What Changed?



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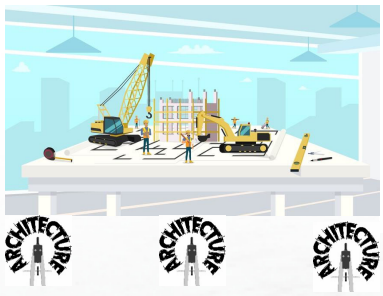
How Concrete Decks Are Made Changed…

But Those With the Pencils, Didn't Read What We Know Works



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Some Other Things Changed Too…

- What We Know About Concrete & Drying
  - ❑Phase I & II of the NRCA Concrete Study (coming up next)
- How We Install Roofs, e.g., changes in adhesives
- What We Know We Don't Know…

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Some Other Things Changed Too…

- Roles have changed too…more design/build, blurred lines
- In new construction, dysfunctional "teams"

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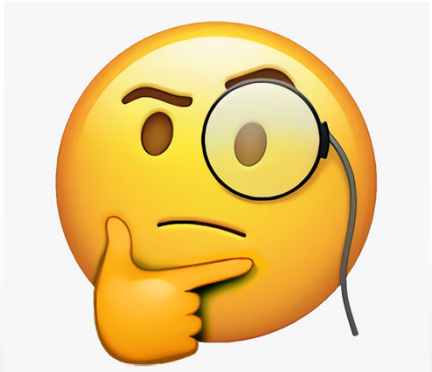
How Are Manufacturers Addressing?



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About Those Unicorns & Ostriches…

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About Those Unicorns & Ostriches…

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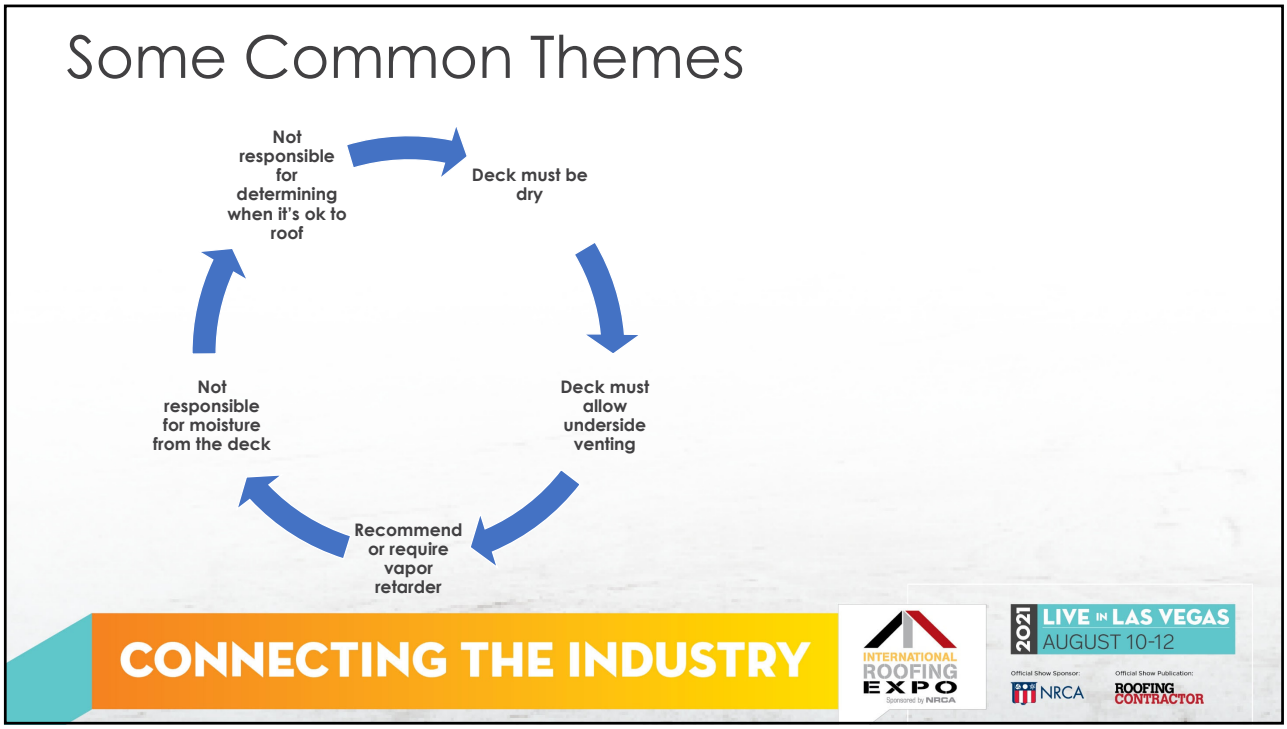
Some Common Themes
Not responsible for determining when it's ok to roof
Deck must be dry
Deck must allow underside venting
Recommend or require vapor retarder
Not responsible for moisture from the deck
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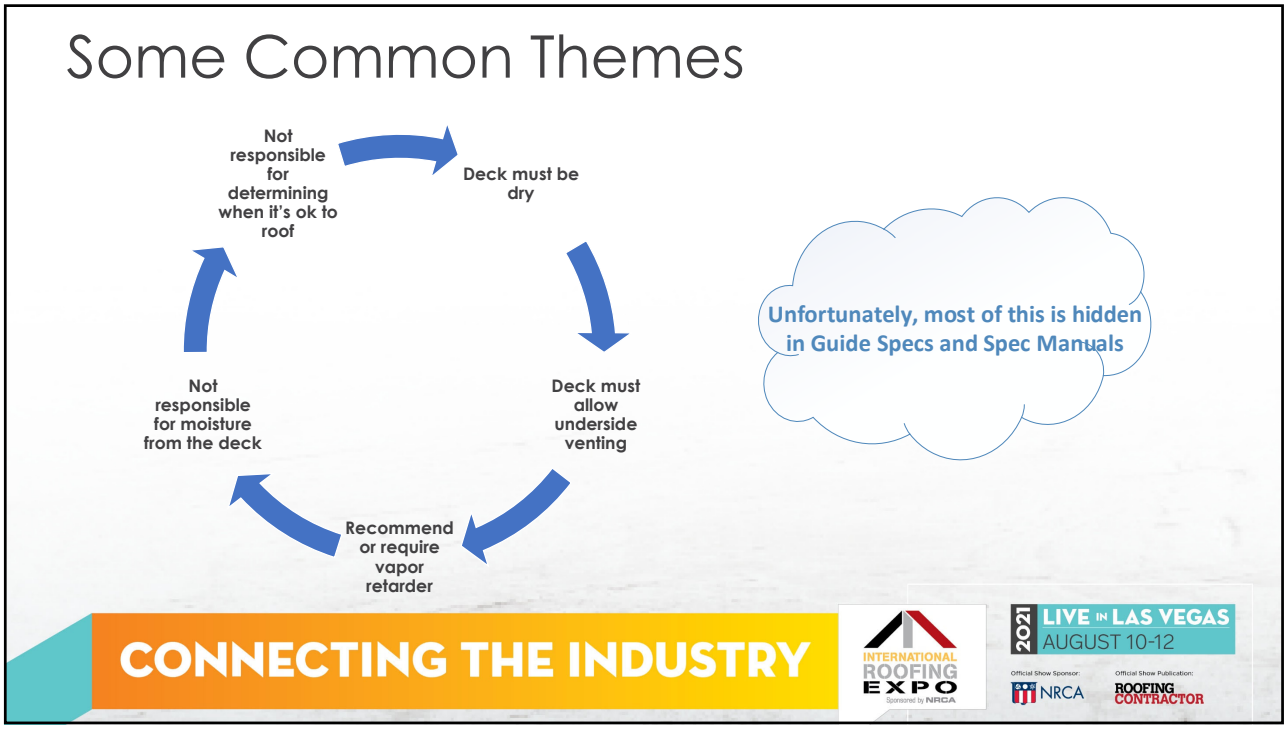
Some Common Themes
Not responsible for determining when it's ok to roof
Deck must be dry
Deck must allow underside venting
Recommend or require vapor retarder
Not responsible for moisture from the deck
Unfortunately, most of this is hidden in Guide Specs and Spec Manuals
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From a Guide Spec:

A. Structural Concrete (Poured or Pre-cast):
1. Decking shall be installed in strict conformance with industry standards, practices and/or pre-cast panel manufacturer's installation requirements.
2. Decking shall be installed to provide positive slope and subsequent positive drainage of the new [redacted] Adhered Roofing Systems.
3. Finished decking shall be properly cured and dried prior to the installation of approved insulation.
4. Finished surfaces to receive new roof system shall be smooth and level without significant surface depressions or irregularities. Camber differentials greater than 3/16 inch (5 mm) must be leveled using a cementitious grout.
5. Finished surfaces shall be dry, free of moisture, dust, loose debris and any other irregularities that may hinder the proper performance of the new [redacted] Roofing Systems.

B. Lightweight Structural Concrete:
1. Care is to be taken when roofing over lightweight structural concrete due to the excessive moisture retention of the aggregate.
2. [redacted] does not recommend bonding insulation directly to lightweight structural concrete.
3. A venting vapor retarder is required when installing a [redacted] Roofing System over lightweight structural concrete.
4. [redacted] may accept the installation of a [redacted] approved base sheet adhered in [redacted] SBS Adhesive over lightweight structural concrete.
5. The [redacted] Roofing Systems may use a mechanically fastened insulation and composite with an adhered membrane or a conventional mechanically fastened [redacted] Roofing System.

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From another Guide Spec:

From Project Conditions Section, 1.9:

E. Moisture: Do not proceed with installation where potential exists for condensation or uncontrolled moisture migration into the roof system from construction-related moisture or installation over moisture bearing substrates or interiors without adequate ventilation and moisture control.

And then,

3.2 SUBSTRATE PREPARATION

A. Structural Concrete Deck:
1. Deck shall be finished to a smooth uniform surface free of sharp edges, ridges and irregular surfaces with minimum thickness of 4 inches.
2. Sumps where provided for roof drains shall be cast into the deck.
3. Cracks in excess of 1/8" in width must be repaired in accordance with the deck manufacturer's recommendations.
4. Roof deck shall be dry, free of frost or surface moisture and permitted to cure 28 days before start of roof system ~~application~~. Underside shall be open and designed to allow adequate ventilation for drying with form materials removed.
5. Composite form concrete decks, decks with painted, insulated or other condition restricting underside drying require review by IB Technical Services.
6. Primers, when used, must be allowed to dry prior to the application of insulation adhesive and balance of the roofing system.
7. Field uplift resistance testing of insulation adhesives is recommended to confirm acceptable roof system attachment and adhesive performance.

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Other Common Themes

- Many recommend or require the use of a vapor retarder
- Differences in recommendations/requirements depending on how the system is attached
- Reference to/Acceptance of ASTM F2170 & 75% RH

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Actually, There Are …

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Some Are Very Clear:

[redacted] Recommendations and Requirements for Roofing over Concrete Roof Decks

- [redacted] is **not** responsible for any moisture-related problems associated with concrete roof decks.
- Determining when a newly installed concrete substrate is suitable for roofing is the responsibility of the building's structural engineer, general contractor, concrete contractor, roofing contractor and/or roofing design professional. This is **not** the responsibility of the roofing manufacturer.

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So What Is Available?

(Other than "don't roof over wet")

- Technical Bulletins
- Architectural Education
  - Articles
  - Technical Presentations
  - Webinars/Seminars
  - Blogs/Vlogs

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How Can You Use?
(Other than say "don't roof over wet")
• Technical Bulletins
Strengthen YOUR position & educate the folks involved in a given project
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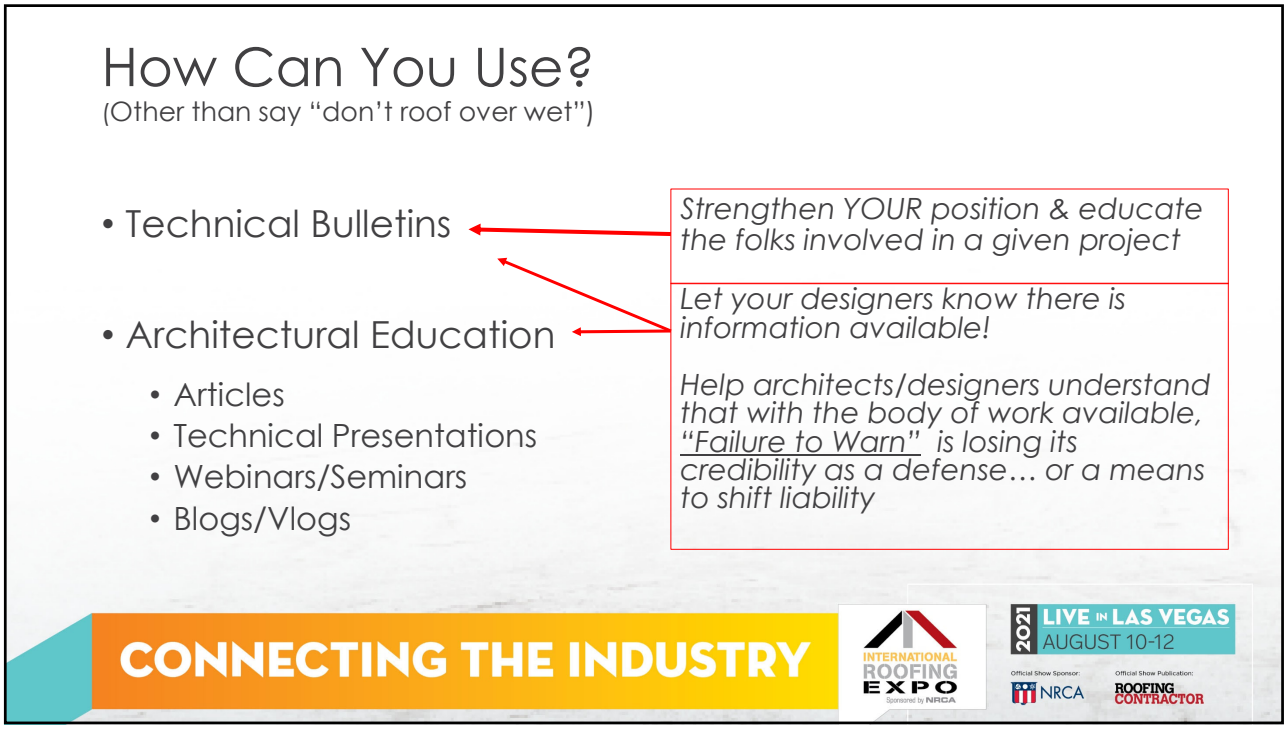
How Can You Use?
(Other than say "don't roof over wet")
• Technical Bulletins
Strengthen YOUR position & educate the folks involved in a given project
• Architectural Education
Let your designers know there is information available!
Help architects/designers understand that with the body of work available, "Failure to Warn" is losing its credibility as a defense… or a means to shift liability
• Articles
• Technical Presentations
• Webinars/Seminars
• Blogs/Vlogs
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Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association (NRCA)

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What we now know… what we have learned

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

MOISTURE MIGRATION –
CONCRETE SLAB-ON-GROUND

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

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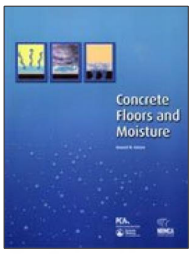

***Concrete Floors and Moisture* (2008)**
Howard Kanare

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

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Some other things we have learned…

- Concrete requires a water-to-cement ratio of about 0.25 for proper hydration; additional water is added to facilitate handling and placement
- Actual field measured water-to-cement ratios of 0.5 to 0.75 are not unusual
- Concrete will continue to cure when it's internal RH is about 80% or higher and its temperature is about 40 F or higher

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- Concrete's porosity is at its highest shortly after placement and its porosity gradually decreases over time (curing)
- Fly ash (a concrete additive) typically reduces concrete's porosity
- Concrete finishing techniques can impact concrete's porosity
- Many concrete admixtures will retard concrete drying
- Power finishing air-entrained concrete mixes can result in surface dusting, crazing and spalling.
- Concrete is a highly variable construction material

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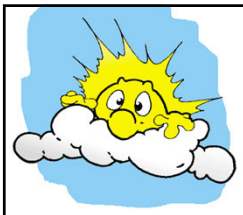
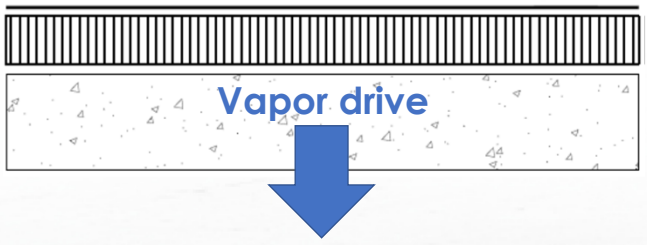


Warm outside air

Summer conditions



"Cool" conditioned air

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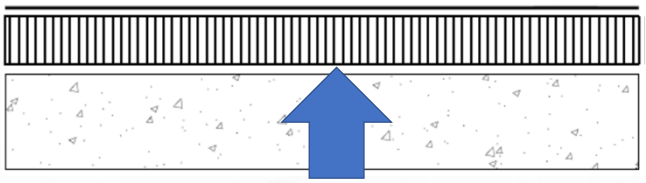
Cold outside air

Winter conditions



Vapor drive

Warm inside air

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Roofing industry research

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

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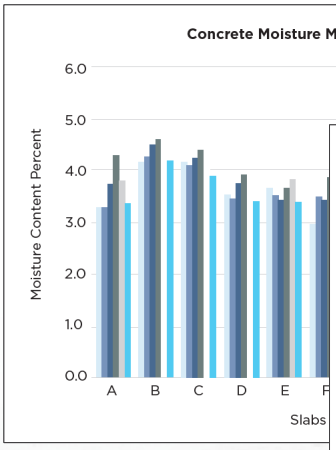
Phase 1 results



Re-wetting is a significant issue for concrete roof decks

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.

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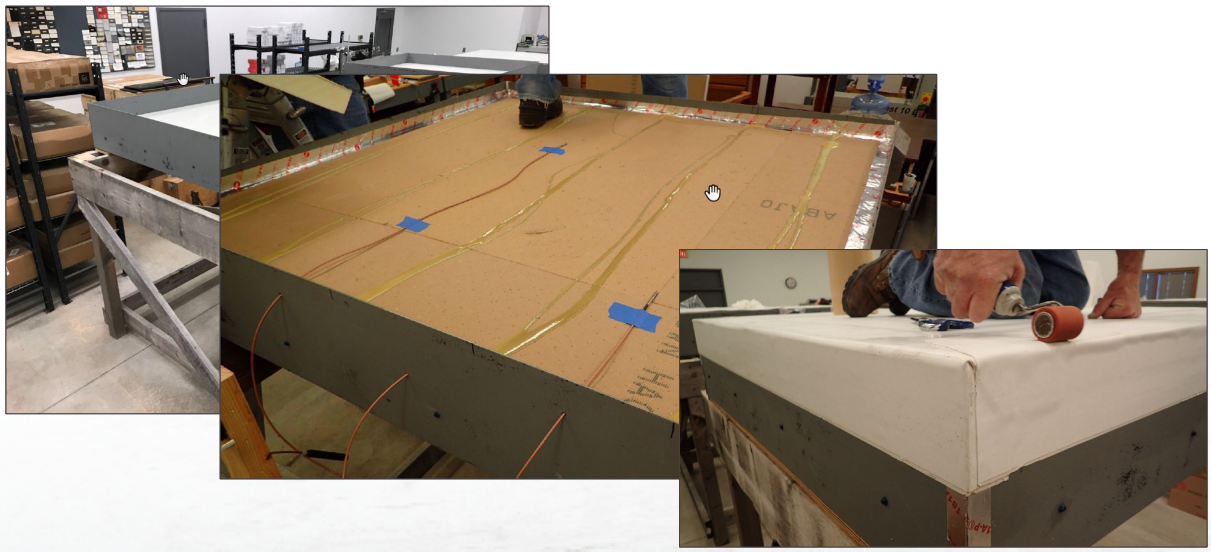

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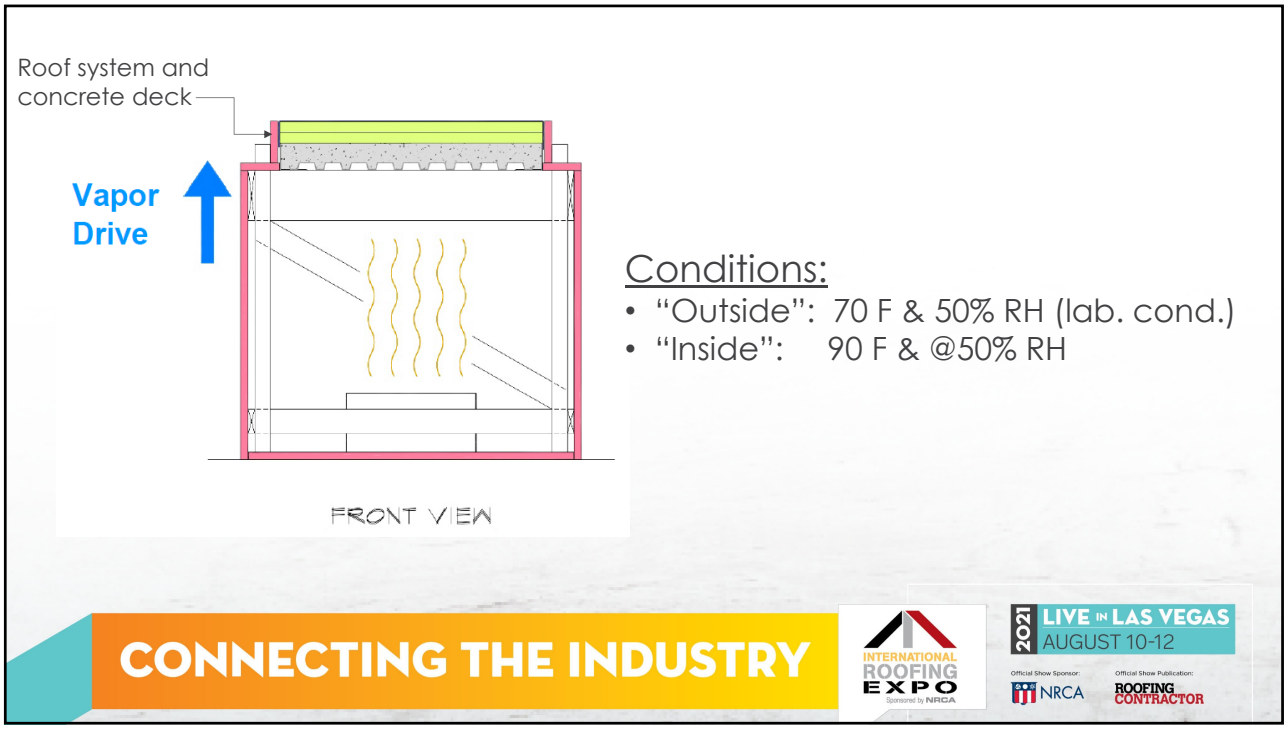

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Phase 2 -Conclusion

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

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RESEARCH+TECH

Are admixtures the answer?

Moisture in concrete roof decks continues to be problematic

by Mark S. Graham

Professional Roofing
December 2018

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ASTM E96 testing of MVRA vs non-MVRA concrete decks

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

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ASTM E96 testing of MVRA vs non-MVRA concrete decks

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.

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From the Roofing Industry Research, Phase 1

	ASTM E96 calculated perm			
	Lightweight structural concrete		Normal weight 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

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.

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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

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Conclusions…

- It's not the roofing industry's water
- We shouldn't be held or take responsibility for concrete deck water
- Roofing contractors typically do not have the expertise or project-specific knowledge to make "dryness" or "when to roof" decisions on concrete roof decks

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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

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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

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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 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

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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

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Leanne Prybylski
Attorney
Hendrick, Phillips, Salzman & Siegel

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Note – Moisture Issues Are Not Limited to New Construction

Moisture issues can occur:

- In both new construction and re-roof projects;

AND

- With both lightweight and normal-weight structural concrete roof decks.

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Avoid Accepting Liability for Issues with the Concrete Deck

- Carefully review your contracts to make sure you are accepting only the surface of the roof deck.
- Following is an example of an unacceptable contract provision:

> Prior to commencing the Work, Roofing Contractor shall inspect all portions of the Project to determine whether they are suitable to receive Roofing Contractor's Work. Roofing Contractor shall notify General Contractor in writing of any objections to the conditions of the Project, prior to commencement of Roofing Contractor's Work. Roofing Contractor's commencing work shall constitute acceptance by Roofing Contractor of the Project as being suitable and of satisfactory condition to receive Roofing Contractor's Work.

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Avoid Accepting Liability for Issues with the Concrete Deck

- Another example of an unacceptable contract provision:

> Roofing Contractor shall verify and check the accuracy and acceptability of all adjacent work performed by others which interferes or which may affect the Roofing Contractor's Work. Roofing Contractor shall promptly report in writing to General Contractor any defect, deficiency, error or omission in any work that may impact Roofing Contractor's ability to perform the Work. Roofing Contractor shall be solely responsible for the costs of removal and replacement of any work that covers and renders inaccessible incorrect work adjacent to or under the work required by this Subcontract, including any delay impact damages resulting therefrom.

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Avoid Accepting Liability for Issues with the Concrete Deck

- Another example of an unacceptable contract provision:

> Roofing Contractor shall inspect the work provided by others onto which the Work is to be placed or to which the Work is to be applied or attached and shall notify General Contractor in writing of any defect or other detrimental condition in any such work prior to the performance of the affected Work. If Roofing Contractor fails to so notify General Contractor, Roofing Contractor shall be deemed to have accepted the condition of such work as suitable for its Work. Roofing Contractor shall be liable for any damages resulting from its performance of any Work involving any unsuitable work provided by others of which Roofing Contractor has not notified General Contractor as required, including re-performance and related costs of correction and any additional costs incurred by General Contractor, Owner or their respective contractors.

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Avoid Liability for Issues with the Concrete Deck

- Insert provisions in your Proposals and Contracts to disclaim liability for effects of moisture within the concrete deck on roofing materials.

- Insert provisions in your Proposals and Contracts to limit your obligation to a visual inspection of the concrete deck.

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Sample Proposal/Contract Provision – Disclaimer for Installation of Roof Over Concrete Deck

Roofing Contractor is not responsible to test or assess the moisture content of the deck or evaluate the likelihood of condensation from moisture drive within the building. Roofing Contractor recommends that roofing not commence until probes in concrete decks show that moisture content is no greater than 75% relative humidity if there is no organic content within the roofing materials. Wood fiberboard, perlite, and organic paper facers on polyisocyanurate insulation will generate mold with relative humidity as low as about 65-70%.

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Sample Proposal/Contract Provision – Disclaimer for Installation of Roof Over Concrete Deck

Roofing Contractor is not responsible for the effects on the roofing materials of residual moisture in concrete decks. Roofing Contractor recommends that roofing not commence until probes in concrete decks show that moisture content is no greater than 75% relative humidity.

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Sample Proposal/Contract Provision – Disclaimer for Installation of Roof Over Concrete Deck

Roofing Contractor is not responsible for the effects of moisture from within the concrete deck or adhesion of roofing materials to the concrete deck, regardless of whether admixtures, surfactants, or curing agents are used.

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Sample Proposal/Contract Provision – Disclaimer for Installation of Roof Over Concrete Deck

Customer acknowledges that Roofing Contractor has notified Customer of the potential for moisture from lightweight and/or structural concrete roof decks to cause moisture within the roofing system and failure of adhesives in the roofing system to bond to wet, damp, or inadequately cured concrete decks. Roofing Contractor is not responsible to test or assess moisture content of the deck or substrate. Roofing Contractor is not responsible for moisture from the deck or interior affecting the roofing materials.

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Sample Proposal/Contract Provision – Limit Acceptance of Adjacent or Contiguous Work / Deck or Substrate

Roofing Contractor's commencement of roof installation indicates only that Roofing Contractor has visually inspected the surface of the roof deck for visible defects. Roofing Contractor is not responsible for the structural sufficiency, quality of construction, undulations, fastening or moisture content of the roof deck or other trades' work or design and their effect on the roof and roofing materials.

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Sample Proposal/Contract Provision – Limit Acceptance of Adjacent or Contiguous Work / Deck or Substrate

Roofing Contractor's prosecution of the roof work indicates only that the surface of the deck appears satisfactory to the Roofing Contractor to attach roofing materials. Roofing Contracting is not responsible for the construction, slope, moisture content, undulations or structural sufficiency of the roof deck or other trades' work or design.

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Sample Proposal/Contract Provision – Disclaimer for Installation of Roof Over Concrete Deck / Limit Acceptance of Deck

Roofing Contractor is not responsible for the effects of moisture migration originating within the roof deck or substrate, including concrete decks, or moisture vapor drive from within the building. Residual moisture within the roof deck, particularly structural concrete decks, can adversely affect the properties and performance of roofing materials, regardless of additives or concrete admixtures that may be included in the concrete mix. Roofing Contractor's commencement of roof installation indicates only that the Roofing Contractor has visibly inspected the surface of the deck for visible defects prior to commencement of roofing and the surface of the deck appeared dry. The 28-day concrete curing period does not signify the deck is sufficiently dry.

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Sample Proposal/Contract Provision – Disclaimer for Installation of Roof Over Concrete Deck / Limit Acceptance of Deck

Roofing Contractor is not responsible for the effects of moisture migration originating within the roof deck or substrate, including concrete decks, or due to moisture vapor drive from within the building. Residual moisture within the roof deck, particularly unvented concrete decks, can adversely affect the properties and performance of roofing materials, regardless of additives or concrete admixtures that may be included in the concrete mix. The 28-day concrete curing period does not signify the deck is sufficiently dry. Roofing Contractor's commencement of roof installation indicates only that the Roofing Contractor has visibly inspected the surface of the deck for visible defects prior to commencement of roofing. Roofing Contractor is not responsible to test or assess the moisture content of the deck or evaluate the likelihood of condensation from moisture drive with the building. Roofing contractor recommends that roofing not commence until probes in concrete decks who that moisture content is no greater than 75% relative humidity.

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Questions…

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