


**Spring Technical Session**  
April 26, 2018 – Troy, MI

## Moisture in concrete roof decks

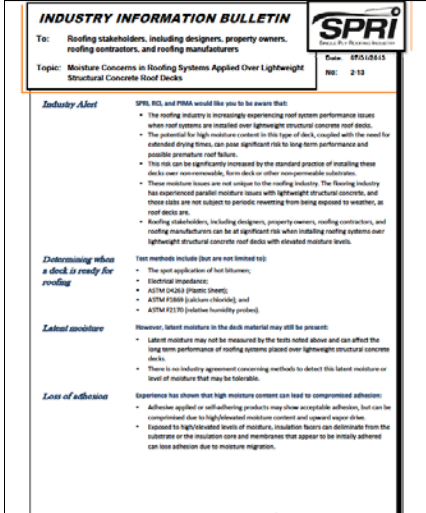
presented by

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



## SPRI/PIMA/RCI Industry Information Bulletin

No. 2-13, July 31, 2013



“... Because of these performance issues and the potential risk for roof system failure, SPRI, RCI, and PIMA urge building designers to select roofing components and system with great care...”

## ARMA Industry Position Statement

**Industry Position Statement**  
**Performance Concerns of Lightweight Structural Concrete Roof Decks**

**Asphalt Roofing Manufacturers Association**  
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 Lincoln, NE 68502  
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**Decks may not be suitable for durable, sustainable roofing systems**  
 The roofing industry is increasingly experiencing moisture performance issues when roof systems are installed over lightweight structural concrete roof decks. The high moisture content of these decks, coupled with long curing times and an inability to determine when roofing can commence pose significant risk of roof failure and other performance issues. The risk is significantly increased by the standard practice of installing these decks over non-ventilated, form decks or other non-permeable substrates. These conditions are not unique to the roofing industry. The roofing industry has experienced similar moisture issues with lightweight structural concrete, and these risks are not subject to performance testing being required to evaluate, or cure, decks.

Roofing manufacturers, such as designers, property owners, roofing contractors, and roofing manufacturers, are of significant use when specifying roofing systems over roof decks. Issues with lightweight structural concrete decks include, but are not limited to, the following:

- Determining when a deck is ready for roofing
- Measuring concrete moisture content
- Loss of adhesion
- Insulation layer delamination
- Loss of E-value
- Moisture growth potential
- Water based adhesive curing issues
- Corrosion of roof fasteners and other non-ferrous-containing roof components

The selection of the deck material and its suitability for use is the responsibility of the designer of record, who must make appropriate design accommodations to address high moisture content encountered in lightweight structural concrete decks.

1 A member service provided by the Asphalt Roofing Manufacturers Association

“...The selection of the deck material and its suitability for use is the responsibility of the designer of record, who must make appropriate design accommodations to address high moisture content encountered in lightweight structural concrete decks.”

## GAF Technical Advisory Bulletin

TAB-C 2014-24 – January 29, 2014

**TECHNICAL ADVISORY BULLETIN**  
 GAF  
 GAF Commercial Sales, Commercial Contractors, Field Services  
 Title: Technical Services Department  
 Subject: Structural Concrete Roof Decks Utilizing Lightweight Aggregate  
 Date: 01/29/2014  
 Ref: TAB-C 2014-24

**Background Information**

**Types of Concrete Roof Decks**  
 There are three types of concrete used to construct roof decks:  
 1. Standard structural concrete - with a density "130 lbs/cu ft"  
 2. Lightweight structural concrete - with a density "108-120 lbs/cu ft"  
 3. Lightweight insulating concrete - with a density "80-90 lbs/cu ft"

**What are the Differences in Structural Concrete?**  
 Standard structural concrete uses normal weight aggregate that is generally dense and will not hold moisture. Typically called "hard core", lightweight structural concrete uses lightweight, porous aggregate, such as cinder, which are spaced so as to reduce its weight. As these decks, there are also density differences between both types of structural concrete.

**How is Structural Concrete Used on Roof Decks?**  
 There are three types of applications where concrete is poured for roof decks:  
 1. Cast-in-place over removable forms  
 2. Cast-in-place over a metal form deck that is not removed  
 3. An in-situ, monolithic over pre-cast concrete panels or tiles

**Why is Lightweight Structural Concrete a Concern for the Roofing Industry?**  
 Concrete decks are "purer" in place and consequently contain a high level of water when poured. Typically the roofing industry has required a drying curing period prior to installing the roof deck for "greater" and suitability for roofing. Lightweight structural concrete decks typically have much higher moisture content than traditional heavy roof structural concrete.

When installed over non-removable metal form decks (or other impermeable substrates), much of this water will stay in the roof deck and can be pressure driven to condense as liquid water within the roofing system. Even when poured over removable forms, these decks may take a very long time to dry, which can present problems for roofing systems.

Care must also be taken to avoid installing materials that retard the flow of vapor directly below the deck. Air-tight moisture barriers to the underside of a deck, during or after pouring, or joints which obstruct the downward movement of moisture in the concrete are just a few examples of materials that can result in moisture problems.

Problems and issues with lightweight structural concrete that pose significant risks to the roofing system and its installation include:

- Determining when a deck is ready for roofing
- Measuring concrete moisture content
- Loss of adhesion
- Insulation layer delamination
- Loss of E-value
- Unwanted green potential
- Water based adhesive curing and wetting
- Corrosion of roof fasteners and other non-ferrous-containing roof components

“...For new construction, roofing contractors should not accept responsibility for determining when a newly placed concrete substrate is ready for roofing. That decision should be made by the building’s structural engineer, general contractor, concrete contractor and/or the roof system designer.

Where these decks are encountered in re-roofing, GAF recommends that roofing contractors consult a design professional for the appropriate roofing system design to address high moisture content...”

**NRCA's position...**







### Some terminology

- **Structural concrete (normal weight)**
  - 150 lbs/ft<sup>3</sup>
- **Lightweight structural concrete**
  - 85–120 lbs/ft<sup>3</sup>
- ~~**Lightweight insulating concrete**~~
  - 20–40 lbs/ft<sup>3</sup>

### **Concrete mix design**

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

### **Concrete Aggregates**

60-80% of Concrete Mix Design

- Normal-weight aggregates (stone):
  - Dense
  - Absorb about 2% by weight
- Light-weight aggregates (expanded shale):
  - Porous
  - Absorbs from 5 - 25% by weight

***Lightweight structural concrete  
inherently contains more moisture***

### An up-close look



### Uses for lightweight structural concrete

- Cast-in-place roof decks (removable forms)
- Composite roof decks (metal form deck stays in-place)
- Deck topping (e.g., topping over precast concrete)

## What is the appeal?



Water Tower Place (1975)  
Chicago, IL  
859 feet tall

- Reduced weight:
  - Transportation
  - Pumping
  - Placement
  - In-place (Dead load)
- Similar strength
- Similar workability:
  - Begin finishing earlier
- Sustainability credit:
  - LEED

## Reported roofing-related problems

- Moisture within the roof system
- Loss of adhesion
- Insulation facer delamination
- Adhesive curing issues
- Mold growth
- Fastener/metal corrosion
- R-value loss



## **When is it OK to roof?**

Historical guidelines

- After 28 days
- 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***

## **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”

### ASTM F2170 apparatus

Measure relative humidity (RH %) and temperature

### Trial ASTM F2170 tests

Existing lightweight structural concrete roof decks

	Roof 1	Roof 2	Roof 3
Roof age (yrs)	4	7	7
Area (ft <sup>2</sup> )	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.*

**Concrete Floors and Moisture, 2<sup>nd</sup> Edition**

Howard M. Kanare, CTL Group

75% internal RH can be achieved:

- Normal weight structural concrete
  - Less than 90 days
- Lightweight structural concrete
  - Almost 6 months

**Conclusions**

- Concrete roof decks – normal weight and light-weight structural – present challenging moisture-related considerations.
- Further complicated by the use of admixtures and method of finishing.
- NRCA does not support the 28-day drying period or the plastic sheet test

## Conclusions - continued

- Roofing contractors can only visually assess the dryness of the concrete's top surface
- Roofing contractors cannot readily assess any remaining free moisture within concrete or its likely release

**Roofing contractors are not privy to and may not be knowledgeable about the information necessary to make "...when to roof..." decisions**

## Some useful information

Professional Roofing, Feb. 2010

Professional Roofing, Jan. 2012

**Moisture in concrete roof decks**  
Concrete's curing and drying rates can affect roof systems  
by Mark S. Graham

**CONCRETE** has experienced an increase in reports of moisture-related problems with low-slope membrane roof systems applied to newly poured, unadorned and lightweight structural concrete roof decks.

In the present literature, significant amounts of water have been found within roof systems within several months to up to three years after construction. To insure the moisture evaporates, it was determined that membrane roof waterproofing and the use of moisture inhibitors. Nevertheless, NRCA has extensive recommendations for avoiding such problems.

**Concrete decks**

When mixed, poured and finished, initial weight and lightweight structural concrete contain aggregate amounts of water. As long as concrete is kept moist through hydration and curing, it gains strength. For example, a batch batch concrete will gain about 10 percent of water for each square foot of surface area.

Historically, the roofing industry has not recommended that a rigid membrane waterproofing be applied to concrete roof decks. The 20- to 40-day period usually cited for curing time of concrete before it is ready for design compressive strength. There is a wide variation between the 20-day period and concrete that "bleeds".

In some instances, a plastic sheet can be used to seal concrete roof decks. While this is not a plastic sheet (and plastic sheeting) is applied to the concrete and the plastic sheet is available to measure for the presence of condensation.

Due to the publication of the NRCA Roofing and Waterproofing Manual, Fourth Edition in 1996, NRCA recommended that plastic sheet not be used for determining moisture content of concrete.

However, with the publication of the NRCA Roofing and Waterproofing Manual, Fifth Edition in 2001 and continuing with the publication of the NRCA Roofing and Waterproofing Manual, Sixth Edition in 2006, NRCA no longer considers the plastic sheet not a viable measure of moisture content.

Similar to the roofing industry, the concrete industry has seen significant advances in knowledge regarding concrete mix design, placement and curing.

For example, the use of concrete admixtures in concrete mix design and curing compounds during concrete placement greatly can reduce or control concrete curing and set off of the concrete. Similarly, in other conditions, curing newly poured concrete, curing of concrete formwork, and concrete being or avoiding of building formwork after concrete placement can affect the rate of concrete curing at a downward flow of free moisture.

For these reasons, NRCA no longer supports the 20-day drying period at plastic sheet use.

**NRCA's recommendations**

NRCA cautions the decision of when to incorporate a newly poured concrete substrate in the finished roofing construction. Because of the numerous variables associated with concrete mix design, placement, curing and drying, roofing contractors are not qualified to and may not be knowledgeable of the information necessary to make such a decision.

Also, though a roofing contractor can assess the degree of concrete's surface finish, he or she cannot readily assess the remaining free moisture within the concrete and its likely direction of release.

NRCA recommends the decision of when a newly poured concrete substrate is ready to be covered with a new roof system be made with the project's roof system design, roof system manufacturer and roofing contractor. It also would be useful for designers to consult structural engineers, general contractors, concrete and concrete placement contractors who likely have more knowledge of concrete curing and moisture release.

Additional information regarding concrete roof decks is contained at The NRCA Roofing Manual, Structural Roof Systems—2007. ■■■

Mark S. Graham is NRCA's executive vice president of technical services.

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**Concrete deck dryness**  
Alternative approaches are needed to determine when concrete decks are dry  
by Mark S. Graham

In September 2011, at the International Building Exposition 2011 Emerging Technologies and Roof System Technologies held in Washington, D.C., Ron Dupont, president of Infrared Research Inc., Middleburg, Wis., and I presented a paper about moisture and its potential impact on concrete roof decks and alternative approaches for reducing moisture levels within roof systems.

The research was helpful for us as we continued to see moisture-related problems with concrete roof decks at a roofing roofing project with a concrete roof deck when moisture accumulation within the roof system is problematic.

**Historical methods**

When roofing professionals have relied on historical, non-scientific methods to determine the degree level of concrete roof decks, the results, one method is a surface temperature test for moisture in concrete roof decks. The method involves drilling small holes in a concrete deck's surface and the depth of the hole is measured for condensation. The procedure is defined by ASTM D2032N, "Standard Test Method for Detecting Moisture in Concrete by the Plastic Sheet Method" under method number 10. The standard testing method involves the placement of a plastic sheet over the surface of the concrete roof deck. The plastic sheet is held in place by weights and the surface of the concrete roof deck is inspected for condensation. The test is performed in a 24-hour period.

Over the years, Dupont and I conducted research on the use of infrared technology to measure relative humidity values from 90 percent to 100 percent within concrete roof decks. Currently, acceptable roof systems-specific

The historical methods of determining the relative dryness of concrete roof decks no longer are adequate

relative humidity values. The concrete roof decks are not dry. However, future research relative humidity values from 90 to 95 percent are considered acceptable in the roofing industry depending on the base coating being used. Also, though several weight-related methods used for floor decks may reach an acceptable level to be more than 90 days, lightweight structural concrete may release free moisture much longer than that.

**Additional information**

A possible alternative approach for determining when a newly placed concrete deck is ready to be covered has been identified. However, before the roofing industry can implement this alternative approach, roof systems-specific acceptable values for concrete roof deck relative humidity need to be determined.


If you are involved in a project when ASTM D2179 testing has been conducted, Dupont and I encourage you to share the wet results with us. Also, if you are involved in a project with a concrete roof deck when moisture accumulation in the roof system is a concern, ASTM D2179 testing of the concrete roof deck should be considered.

Our complete report from the presentation on moisture from NRCA is at [www.nrcanet.org](http://www.nrcanet.org) under the heading "Moisture in Concrete Roof Decks."

**MARK S. GRAHAM** is NRCA's executive vice president of technical services.

12 [www.professionalroofing.com](http://www.professionalroofing.com) 04/16/2017 20:12

## NRCA Industry Issue Update, August 2013



**INDUSTRY ISSUE UPDATE**

NRCA Member Benefit

### Moisture in Lightweight Structural Concrete Roof Decks

Concrete Moisture Presents Challenges for Roofing Contractors

NRCA's Technical Services Section is receiving an increasing number of inquiries relating to the application of roof systems over concrete roof decks. These inquiries can be separated into two general questions: When is a concrete roof deck dry enough to apply a roof covering? And why is a roof system applied over a concrete roof deck showing signs of moisture infiltration when the roof covering is leaking?

**CONCRETE BASICS**  
There are three general types of concrete: normal-weight structural concrete, lightweight structural concrete and lightweight insulating concrete.

Normal-weight structural concrete is what most people think of as concrete. It has a density of about 150 pounds per cubic foot (pcf). Lightweight structural concrete has structural load-carrying capabilities similar to normal-weight structural concrete, but has a density in the range of 85 to 120 pcf. Lightweight insulating concrete, which many roofing professionals are familiar with as an insulating, slope-in-place deck topping, typically has a density in the range from 20 to 40 pcf.

Structural concrete—normal-weight structural concrete and lightweight structural concrete—is produced by mixing large and small aggregates, Portland cement, water and, in some instances, admixtures such as fly ash or various chemical additives. Admixtures can add entrained air to the concrete, accelerate concrete's setting, retain concrete's excess moisture and/or lengthen concrete's finishing time. Use of admixtures typically is not visually identifiable in the field; microscopic analysis usually is needed for post-application identification of admixtures.

The primary difference in the composition of normal-weight structural concrete and lightweight structural concrete is the large aggregate type. Normal-weight structural concrete contains normal-weight aggregates such as stone or crushed gravel, which are dense and typically will absorb no more moisture than about 2 percent by weight. Lightweight structural concrete uses lightweight, porous aggregates such as expanded shale, which will absorb about 5 to 25 percent moisture by weight. Lightweight aggregate needs to be saturated with moisture—it often soaks it ponds—before mixing. As a result, lightweight structural concrete inherently contains much more water than normal-weight structural concrete.

Lightweight structural concrete is used in roofing-related applications for cast-in-place concrete roof decks using removable form composite roof decks where a metal form deck remains in place and as a deck topping material, such as a concrete topping surface over precast concrete planks or slabs.

Once poured, lightweight structural concrete typically cannot be easily distinguished from normal-weight structural concrete.

Visual identification is possible using magnification, typically a microscope used by a trained technician.

**REPORTED PROBLEMS**  
The problems reported to NRCA associated with lightweight structural concrete roof decks include the following:

- **Moisture accumulation.** Excessive moisture from a concrete deck can be pressure-differential driven into and condensed within a roof system.
- **Adhesive del.** The presence of moisture can result in deterioration of moisture-sensitive roofing materials and adhesive bond loss between adhered material layers.
- **Adhesive resin and resin-based adhesive compound.** Excessive moisture can affect adhesive curing and drying rate. Also, moisture can result in adhesive "rewetting," resulting in bond strength loss.
- **Metal fastener corrosion.** Excessive moisture can contribute to and accelerate metal component corrosion, including fastener corrosion.
- **Insulation R-value del.** The accumulation and presence of moisture in most insulation products will result in reduced thermal performance (lower effective R-value).
- **Microbial growth.** The presence of prolonged high-moisture

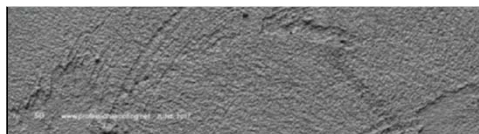
## Professional Roofing

June 2017



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.



## Moisture on concrete roof decks



**Professional Roofing,**  
Sept. 2017

## NRCA's interim recommendations

Structural concrete roof decks

In new construction:

- Use of lightweight structural concrete should be avoided
- Designers need to specify "...when to roof..." criteria
  - Consult with CM/GC, concrete supplier and placement contractor, and roof system manufacturer
  - ASTM F2170 testing
- Designers should specify a high bond-strength, adhered vapor retarder

## **Recommendations – cont.**

Structural concrete roof decks

Existing concrete roof decks (known to be lightweight structural concrete or where moisture-related problems are evident):

- Designers should specify a high bond-strength, adhered vapor retarder.

*NRCA has still not seen capillary-blocking or water-retention admixtures perform successfully in concrete roof deck applications*

*The roofing industry needs to re-think  
the concept of concrete roof deck “acceptance”*

**NRLRC’s Contract Provisions, Vol. III**

“Roofing Contractor’s commencement of the roof installation indicates only that the Roofing Contractor has visually inspected the surface of the roof deck for visible defects and has accepted the surface of the roof deck. Roofing Contractor is not responsible for the construction, structural sufficiency, durability, fastening, moisture content, suitability, or physical properties of the roof deck or other trades’ work or design. Roofing Contractor is not responsible to test or assess moisture content of the deck or substrate.”





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