Great Lakes Chapter of RCI, Inc.

Spring Technical Session
April 26, 2018 – Troy, MI

Moisture in concrete roof decks

presented by

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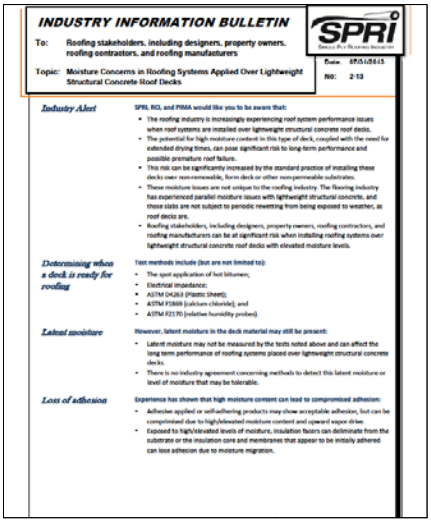
National Roofing Contractors Association

NRCA

SPRI/PIMA/RCI Industry Information Bulletin

No. 2-13, July 31, 2013



INDUSTRY INFORMATION BULLETIN

SPRI

To: Roofing stakeholders, including designers, property owners, roofing contractors, and roofing manufacturers

Topic: Moisture Concerns in Roofing Systems Applied Over Lightweight Structural Concrete Roof Decks

Date: 07/31/2013
No: 2-13

Industry Alert

SPRI, RCI, and PIMA would like you to be aware that:

- The roofing industry is increasingly experiencing roof system performance issues when roof systems are installed over lightweight structural concrete roof decks.
- The potential for high moisture content in this type of deck, coupled with the need for extended drying times, can pose significant risk to long-term performance and possible premature roof failure.
- This risk can be significantly increased by the standard practice of installing these decks over non-permeable, form deck or other non-permeable substrates.
- These moisture issues are not unique to the roofing industry. The flooring industry has experienced parallel moisture issues with lightweight structural concrete, and those slabs are not subject to periodic rewetting from being exposed to weather, as roof decks are.
- Roofing stakeholders, including designers, property owners, roofing contractors, and roofing manufacturers can be at significant risk when installing roofing systems over lightweight structural concrete roof decks with elevated moisture levels.

Determining when a deck is ready for roofing

Test methods include (but are not limited to):

- The spot application of hot bitumen;
- Electrical impedance;
- ASTM D4263 (Plastic sheet);
- ASTM F1869 (calcium chloride); and
- ASTM F2170 (relative humidity probes).

Latent moisture

However, latent moisture in the deck material may still be present:

- Latent moisture may not be measured by the tests noted above and can affect the long term performance of roofing systems placed over lightweight structural concrete decks.
- There is no industry agreement concerning methods to detect this latent moisture or level of moisture that may be tolerable.

Loss of adhesion

Experience has shown that high moisture content can lead to compromised adhesion:

- Adhesive applied or self-adhering products may show acceptable adhesion, but can be compromised due to high/elevated moisture content and upward vapor drive.
- Exposed to high/elevated levels of moisture, insulation facers can delaminate from the substrate or the insulation core and membranes that appear to be initially adhered can lose adhesion due to moisture migration.

"… 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

Asphalt Roofing Manufacturers Association

Performance Concerns of Lightweight Structural Concrete Roof Decks

Decks may not be suitable for durable, sustainable roofing systems

The roofing industry is increasingly experiencing roof system performance issues when roof systems are installed over lightweight structural concrete roof decks. The high moisture content of these decks, coupled with long drying times and an inability to determine when roofing can commence, pose significant risk of roof failure and other performance defects. This risk is significantly increased by the standard practice of installing these decks over non-permeable, form deck or other non-permeable substrates. These moisture issues are not unique to the roofing industry. The flooring industry has experienced similar moisture issues with lightweight structural concrete, and those slabs are not subject to periodic re-wetting from being exposed to weather, as are roof decks.

Roofing stakeholders, such as designers, property owners, roofing contractors, and roofing manufacturers, are at significant risk when required to install roofing systems over wet 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 facer delamination.
- Loss of R-value.
- Microbial growth potential.
- Water-based adhesive curing issues.
- Corrosion of roof fasteners and other ferrous-containing roof components.

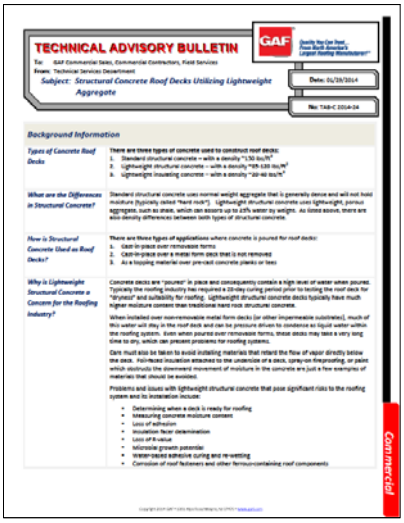
The selection of the deck material and its suitability for use is the responsibility of the designer of record, who must make appropriate design accommodations to address high moisture content encountered in lightweight structural concrete decks.

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

To: GAF Commercial Sales, Commercial Contractors, Field Services

From: Technical Services Department

Subject: Structural Concrete Roof Decks Utilizing Lightweight Aggregate

Date: 01/29/2014

No: 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 "150 lbs/ft³
2. Lightweight structural concrete – with a density "95-120 lbs/ft³
3. Lightweight insulating concrete – with a density "20-40 lbs/ft³

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 rock"). Lightweight structural concrete uses lightweight, porous aggregate, such as shale, which can absorb up to 25% water by weight. As listed above, there are also density differences between both types of structural concrete.

How is Structural Concrete Used as Roof Decks?

There are three types of applications where concrete is poured for roof decks:

1. Cast-in-place over removeable forms
2. Cast-in-place over a metal form deck that is not removed
3. As a topping material over pre-cast concrete planks or tees

Why is Lightweight Structural Concrete a Concern for the Roofing Industry?

Concrete decks are "poured" in place and consequently contain a high level of water when poured. Typically the roofing industry has required a 28-day curing period prior to testing the roof deck for "dryness" and suitability for roofing. Lightweight structural concrete decks typically have much higher moisture content than traditional hard rock 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 removeable 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. Foil-faced insulation attached to the underside of a deck, spray-on fireproofing, or paint which obstructs the downward movement of moisture in the concrete are just a few examples of materials that should be avoided.

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 facer delamination
- Loss of R-value
- Microbial growth potential
- Water-based adhesive curing and re-wetting
- Corrosion of roof fasteners and other ferrous-containing roof components

Commercial

" …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…


2

Some terminology

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

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

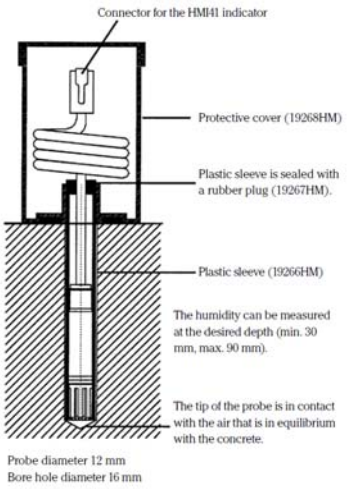
Flooring industry

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^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.

Concrete Floors and Moisture, 2nd 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**

Tech Today

Moisture in concrete roof decks

Concrete's curing and drying rates can affect roof systems

by Mark S. Graham

Concrete decks

NRCA's recommendations

***Professional Roofing*, Jan. 2012**

TECH TODAY

Concrete deck dryness

Alternative approaches are needed to determine when concrete decks are dry

by Mark S. Graham

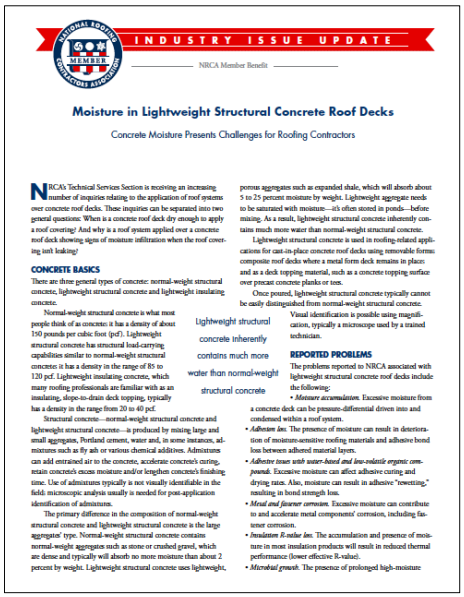
The historical methods of determining the relative dryness of concrete roof decks no longer are adequate

An alternative approach

Historical methods

Additional information

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 isn't 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: it 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-to-drain 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 curing, 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 aggregates' 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's often stored in 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 forms; 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 tees.

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.

Lightweight structural concrete inherently contains much more water than normal-weight structural concrete

REPORTED PROBLEMS

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

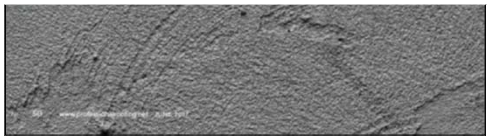
- *Moisture accumulation.* Excessive moisture from a concrete deck can be pressure-differential driven into and condensed within a roof system.
- *Adhesion loss.* The presence of moisture can result in deterioration of moisture-sensitive roofing materials and adhesive bond loss between adhered material layers.
- *Adhesive issues with water-based and low-volatile organic compounds.* Excessive moisture can affect adhesive curing and drying rates. Also, moisture can result in adhesive "rewetting," resulting in bond strength loss.
- *Metal and fastener corrosion.* Excessive moisture can contribute to and accelerate metal components' corrosion, including fastener corrosion.
- *Insulation R-value loss.* 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


RESEARCH+TECH

Moisture in concrete roof decks

Normal-weight and lightweight structural concrete cause some concern

by Mark S. Graham

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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