


Annual Meeting & Program
Oakbrook, IL – Wednesday, January 21, 2015

Concrete roof decks: Is “dry” really “dry”?

presented by

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SPRI/PIMA/RCI Industry Information Bulletin

No. 2-13, July 31, 2013

INDUSTRY INFORMATION BULLETIN

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 risks 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-renewable, form decks 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 re-wetting 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):

- Spot application of hot bitumen;
- Electrical impedance;
- ASTM D4263 (Plastic Sheet);
- ASTM F1889 (Calcium chloride); and
- ASTM F2170 (relative humidity probe).

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:

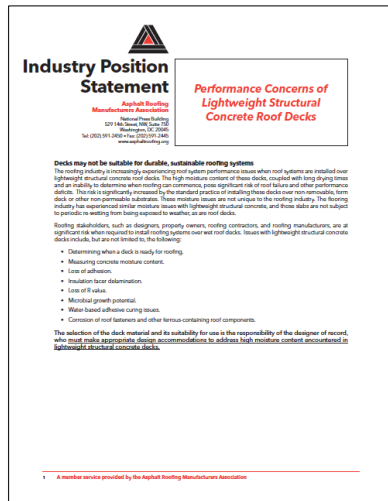
- Adhesive applied or self-adhering products may show acceptable adhesion, but can be compromised due to high elevated moisture content and upward vapor drive.
- Exposed to high/elevated levels of moisture, insulation factors can delaminate from the substrate or the insulation core and membranes that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

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ARMA Industry Position Statement



Industry Position Statement
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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 to roof failure and other performance issues. This risk is significantly amplified 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 roofing industry has experienced similar moisture issues with lightweight structural concrete, and these risks are not subject to periodic re-wetting from being exposed to weather, as are roof decks.

Roofing manufacturers, such as design-build property owners, roofing contractors, and roofing manufacturers, face a significant risk when required to install 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 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.

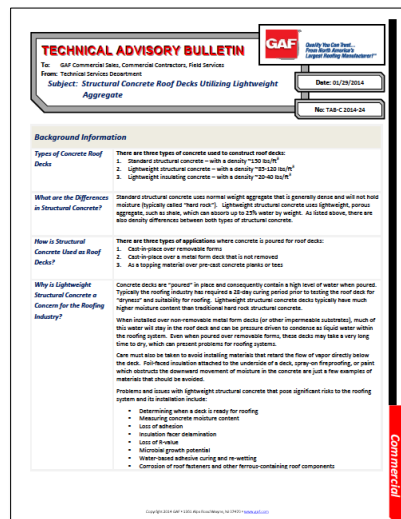
* A member service provided by the Asphalt Roofing Manufacturers Association

“...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
The GAF Commercial Sales, Commercial Contractors, Field Services
Home Technical Services Departments
Subject: **Structural Concrete Roof Decks Utilizing Lightweight Aggregate**
Date: 01/29/2014
Rev: 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 "100 lbs/cu ft"
3. Lightweight insulating concrete - with a density "20-40 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 rock"). Lightweight structural concrete uses lightweight porous aggregate, such as cinder, which can absorb up to 20% water by weight. As stated above, there are size density differences between both types of structural concrete.

How is Structural Concrete Used as Roof Deck?
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. As a topping material over pre-cast concrete panels 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 installing 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 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. Fall-head insulation attached to the underside of a deck, spray-on fireproofing, or paint which restricts the outward movement of moisture in the concrete are such 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 layer 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

“...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...”



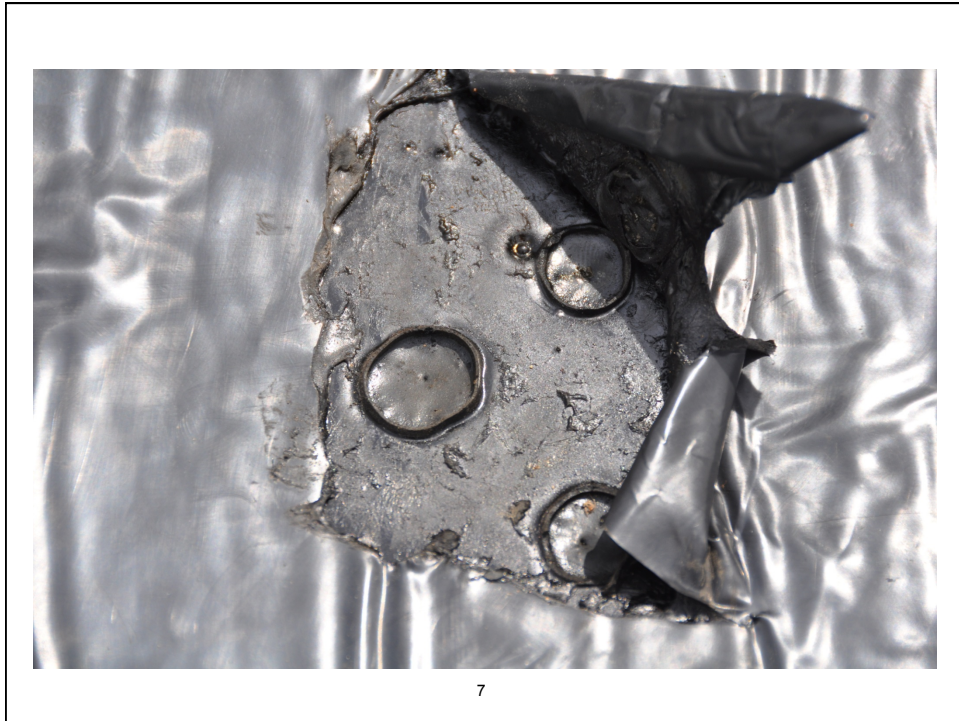
NRCA’s position...

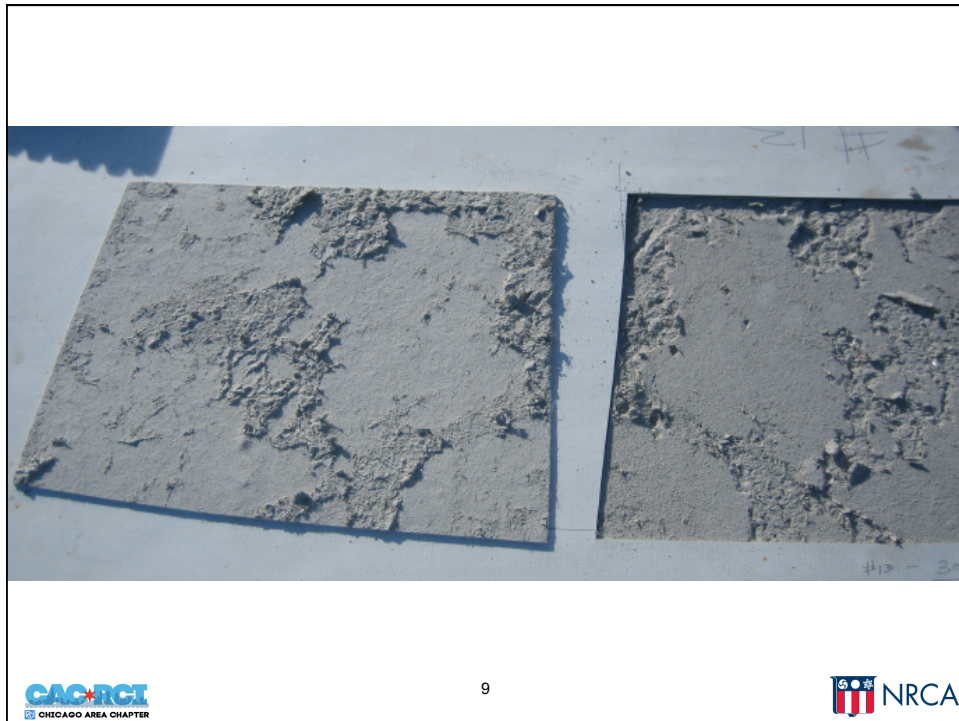


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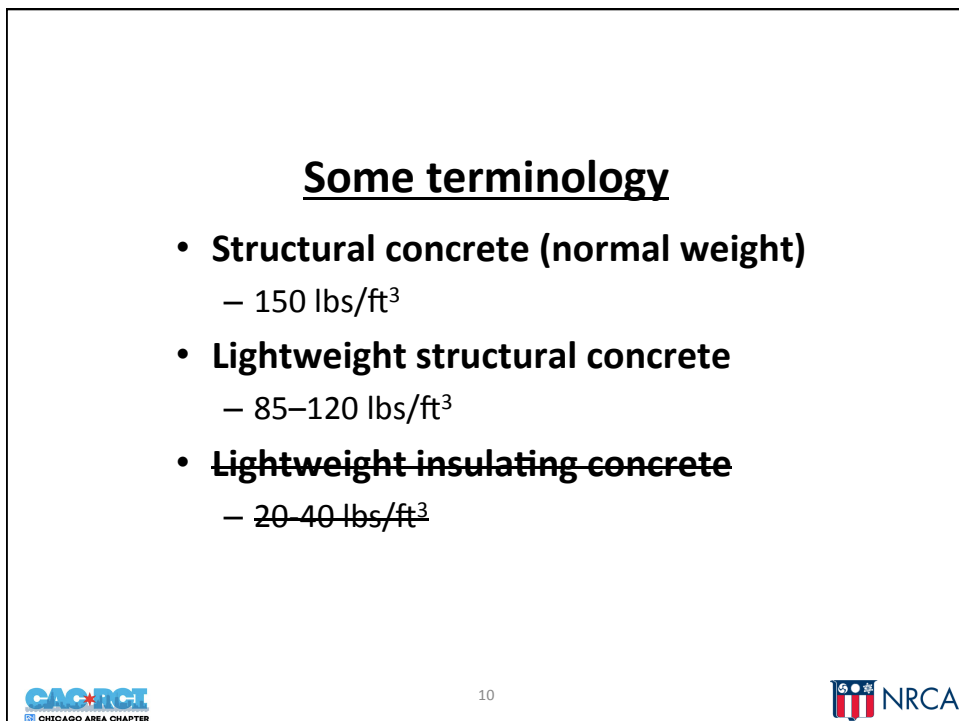
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Some terminology

- **Structural concrete (normal weight)**
 - 150 lbs/ft³
- **Lightweight structural concrete**
 - 85–120 lbs/ft³
- **Lightweight insulating concrete**
 - 20–40 lbs/ft³



Concrete mix design

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



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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

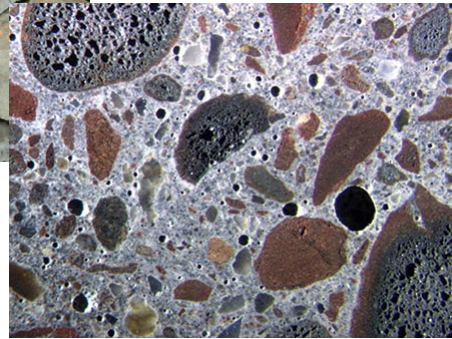
**Lightweight structural concrete
inherently contains more moisture**



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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

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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 are not appropriate for current generations of concrete mixes



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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”



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ASTM F2170 apparatus

Measure relative humidity (RH %) and temperature

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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.

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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



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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



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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



Additional 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

Letter: NRCA has reported an increase in reports of moisture-related problems with low-slope residential roof systems applied to newly poured, nonmetallic or lightweight structural concrete roof decks.

In the reported instances, significant amounts of water have been found within roof systems within several months to up to three years after construction. In the case of the moisture reported, it was determined that the distribution was ununiform and on the order of several million gallons. Nevertheless, NRCA has never recommended the following methods:

Concrete decks

When mixed, poured and finished, normal-weight and lightweight structural concrete requires significant amounts of water. As concrete cures and hardens, a substantial large amount of the water through evaporation and absorption. For example, a 1-inch-thick concrete slab will release about 1 quart of water for each square foot of surface area.

Historically, the roofing industry has used a minimum 28-day period as a guideline to apply roofing materials on newly poured concrete roof decks. The 28-day period coincides with the curing and high compressive strength. There is little correlation between the 28-day period and concrete's moisture "release."

In some instances, a plastic sheet test has been used to determine concrete dryness. Which is a plastic sheet (a vinyl sheet polyethylene) is taped to the concrete surface and the plastic sheet is held in place for the purpose of condensation.

Up to the publication of *The NRCA Roofing and Waterproofing Manual*, Fourth Edition in 1976, NRCA recommended the plastic sheet test as a method for determining a concrete surface's dryness.

However, with the publication of *The NRCA Roofing and Waterproofing Manual*, Fifth Edition in 2001 and continuing with the publication of *The NRCA Roofing Manual* this year, NRCA no longer considers the plastic sheet test a valid assessment of concrete's dryness.

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

For example, the use of concrete admixtures in concrete design and curing compounds during concrete placement greatly can influence or retard concrete curing and release of free moisture. Similarly, weather conditions, curing tank placement, curing, timing of concrete form removal, and temporary heating or misting of a building's interior after concrete placement can affect the rate of concrete's spread or release of free moisture.

In these times, NRCA no longer reports the 28-day drying period for plastic sheet test.

NRCA's recommendations

NRCA considers the decision of when it is appropriate to cure a newly poured concrete substrate to be beyond roofing contractors' control. The use of the maximum available amount of water, concrete mix design, placement, curing and drying, curing conditions can be primary to and best used by the knowledge of the information necessary to make such a decision.

Also, though a roofing contractor can assess the degree of concrete's exposure surface, he or she cannot readily assess any 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 or roof system designer, roof system manufacturer and roofing contractor. It also would be useful for designers to consult structural engineers, general contractors, concrete suppliers and concrete placement contractors who likely have more knowledge of concrete's curing and moisture release rates.

Additional information regarding concrete roof decks is contained in *The NRCA Roofing Manual*, Fourth Edition (Form SY-2007).

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

Published in Professional Roofing February 2010

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

In September 2011, at the International Roofing Symposium 2011, Emerging Technology and Roof System Performance held in Washington, D.C., Steve Depina, president of Unimark Research Inc., Middleburg, Wis., and I presented a paper about research we have been conducting regarding the dryness of newly poured structural concrete roof decks and alternative approaches for evaluating concrete decks readiness for roofing materials.

Our research may help you if you are involved in new construction roofing projects with concrete roof decks or an existing roofing project with a concrete roof deck where moisture accumulation within the roof system is problematic.

Historical methods

Most roofing professionals have relied on historical, non-specific methods to determine the dryness level of concrete roof decks.

For example, one method is to either spray or pour hot bitumen on a concrete deck surface. If the bitumen does not splatter or flash on the deck, the deck can be considered "dry." Other historical methods include tapping into a concrete deck surface and the "feel" of the bitumen during placement or curing. This procedure is defined by ASTM D1525, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method." Another method involves no pressure or heat, but involves the use of a hot and cooling sensor of a probe that is inserted into the concrete 28 days after being poured.

Given current mix designs for concrete and increased use of admixtures, lightweight aggregates, curing compounds and surface treatments, Depina and I no longer consider the historical methods of determining the relative dryness of concrete roof decks to be adequate.

An alternative approach

During our research, Depina and I looked for the following reasons and found some distinctive methods of evaluation:

Concrete Heat and Moisture, Second Edition, written by Howard Kaman, senior principal scientist at C.T. Corp., Skokie, Ill., describes several ways to evaluate the necessary dryness of concrete floor slabs before floor covering application. Depina and I found one method to be of particular interest and practical for use in evaluating concrete roof deck dryness.

ASTM F2170, "Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using a Non-Fdestructive, Semi-empirical, Responsive Method for Determining Relative Humidity and Temperature within Concrete Slabs," and these values can be compared with required building code-determined concrete slab relative dryness.

The method involves drilling small holes in a concrete slab and placing and sealing small humidity and temperature sensors in the drilled openings. After a defined period when the probe and monitoring equipment are in place, the concrete's relative humidity and temperature can be measured. In our research, Depina and I conducted limited ASTM F2170 testing and found more relative humidity values from 80 percent to existing concrete roof decks compared to newly poured roof decks that range from 4 to 7 years old.

Concrete's acceptable and non-specific relative humidity values for concrete roof decks do not exist. However, Kaman reports relative humidity values from 85 to 89 percent typically are considered acceptable in the building industry. Depending on the floor covering being used, these values may vary.

Also, though some weight-moisture sensors are used for floor slabs, they may not be accurate. However, Kaman reports acceptable levels in fewer than 30 days, although structural concrete may take about six months to reach equivalent levels.

Additional information

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

If you are involved in projects where ASTM F2170 testing has been overlooked, Depina and I encourage you to share the test results with us. Also, if you are involved in a project with a concrete roof deck where moisture accumulation in the roof system is a concern, ASTM F2170 testing of the concrete roof deck should be considered.

For more information, please contact us at 28 other research papers from the symposium, an available from NRCA by visiting www.nrca.net, or by contacting Depina directly.

MARK S. GRAHAM is NRCA's executive director of technical services.

Published in Professional Roofing January 2012

Recommendations

Normal weight structural concrete

In new construction:

- Designer should specify “...when to roof...” criteria
 - Consult with CM/GC, concrete supplier and placement contractor, and roof system manufacturer

In reroofing:

- If evidence of moisture-related problems associated with the deck, treat the deck as lightweight structural concrete



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Recommendations – cont.

Lightweight structural concrete

In new construction:

- NRCA recommends lightweight structural concrete not be used for roof deck construction.
- If lightweight structural concrete is used, the Designer should specifically identify concrete drying parameters/when to apply roofing



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Recommendations – cont.

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

- Above-deck venting design (e.g., venting base sheet)
- Adhered vapor retarder (e.g., two-part epoxy 12-15 mils)

Adhered or loosely-laid, ballasted roof systems



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 Service 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 utilization 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 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 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 aggregate's 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—its 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 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:

- Excessive air-entrainment. 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 issues with water-based and two-liquid-epoxy compounds. Excessive moisture can affect adhesive curing and drying rates. Also, moisture can result in adhesive “beading,” resulting in bond strength loss.
- Mold and fungus 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



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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