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Moisture-related issues
with concrete roof decks

presented by

Mark S. Graham

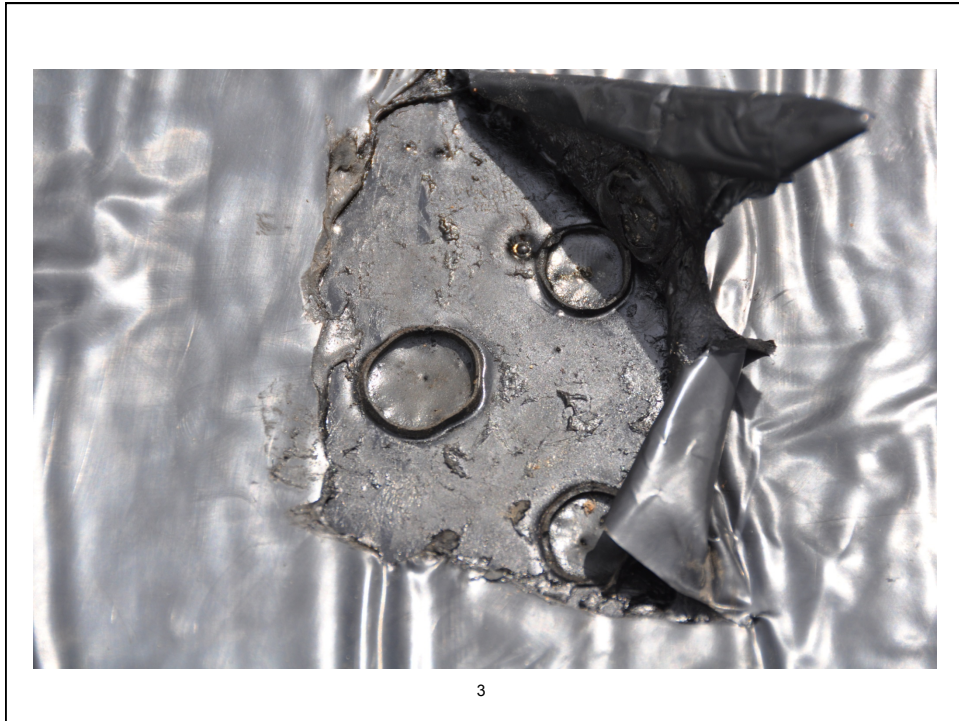
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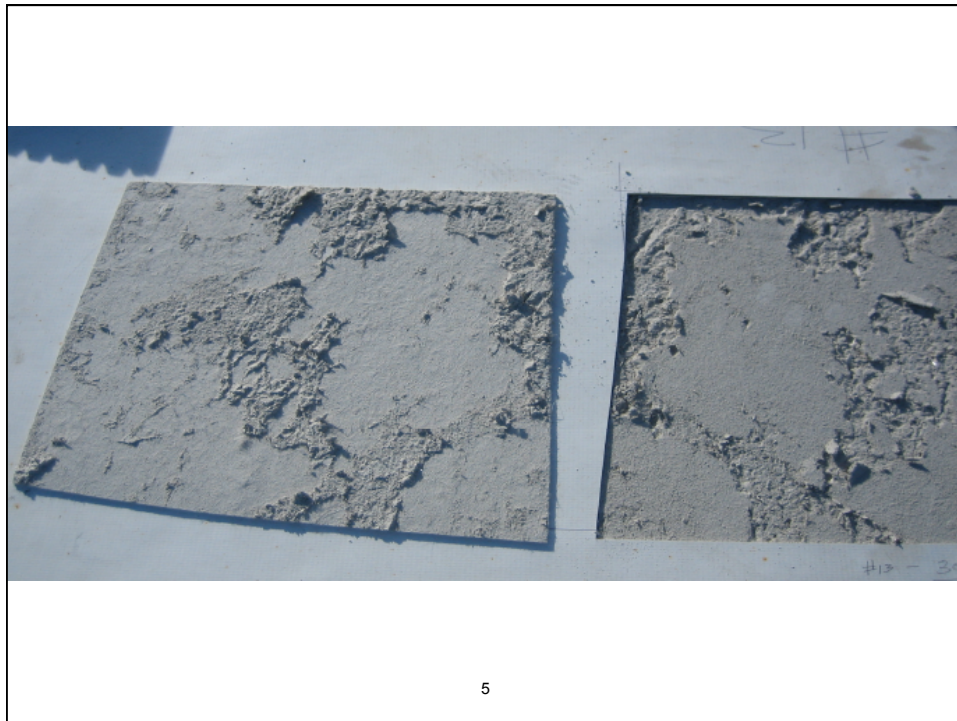


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Some terminology

- **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

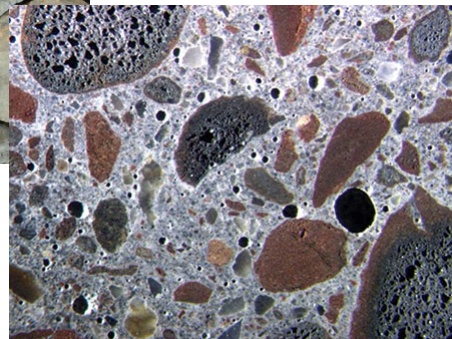
**Lightweight structural concrete
inherently contains more moisture**



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An up-close look



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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)



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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



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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



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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

Let's NRCA has reported an increase in reports of moisture-related problems with low-slope residential roof systems applied to newly poured, nonmetallic 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 a year after construction. In most of the instances reported, it was determined that the distribution was ununiform and on the order of several millimeters. Nevertheless, NRCA has some recommendations for avoiding such problems.

Concrete decks

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

However, the roofing industry has used to apply a roofing membrane to newly poured concrete roof decks. The 28-day period concrete needs to cure to high compressive strength. These delays contribute between the 28-day period and concrete's "dryness."

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

Up to the publication of *The NRCA Roofing and Waterproofing Manual, Fourth Edition* in 1976, NRCA recommended that plastic sheeting be used 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 admixtures in concrete can improve curing and curing compounds during concrete placement greatly can reduce or retard concrete curing and release of free moisture. Similarly, weather conditions, curing tank placement, curing of concrete from removal, and temporary heating or misting of concrete slabs after concrete placement can affect the rate of concrete's cure and its ultimate 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 slab to be beyond roofing contractors' control. The use of the maximum available amount of water, concrete mix design, placement, curing and drying, curing conditions are the primary factors to be considered in the information necessary to make such a decision.

Also, though a roofing contractor can assess the dryness of a concrete's top 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 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: Handbook Roof Systems—2012*.

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 in Georgia Tech and Roof System Performance held in Washington, D.C., Steve Dupont, 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-scientific 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 splash or flash on the deck, the deck can be considered "dry." Other historical methods include the "Mason in Concrete" test for moisture content. This procedure is defined by ASTM D1525, "Standard Method for Measuring Moisture in Concrete by the Plastic Sheet Method." Another method involves no spraying or pouring bitumen on the concrete deck surface. This procedure is defined by ASTM D1525, "Standard Method for Measuring Moisture in Concrete by the Plastic Sheet Method." In our research, Dupont and I conducted limited ASTM D1525 testing and found more reliable humidity values from 100 percent in 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, Kansas reports relative humidity values from 65 to 85 percent typically an acceptable in the heating industry. Applying the same theory to roofing, the relative humidity values for concrete roof decks no longer are adequate.

Also, though normal-weight structural concrete used for floor slabs may reach acceptable levels in less than 30 days, lightweight 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 D1525 testing has been overlooked, Dupont 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 D1525 testing of the concrete roof deck should be considered.

For more information, please contact the 28 other research papers from the symposium, an available from NRCA by visiting <http://www.nrca.net> or contacting dupont@nrca.net.

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-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 strength 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 stratification.** 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-component epoxy compounds.** Excessive moisture can affect adhesive curing and drying rates. Also, moisture can result in adhesive "beading," resulting in bond strength loss.
- **Metal and polymer 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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