Roofing Week in Chicago
January 15-17, 2020

Roofing technical issues – From design, compliance and installation

Mark S. Graham
Vice President, Technical Services
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NRCA

1

Topics

- New City of Chicago codes
- MB testing
- Steel roof decks/seam-fastened systems
- Moisture in concrete roof decks
- Questions/dialogue

2

New City of Chicago codes

3

Adoption and implementation dates

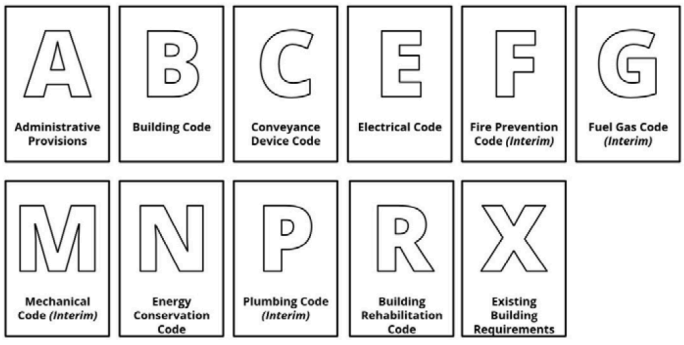
- Electrical Code and Elevator Code
  - Already in effect
- Energy Code
  - Went into effect June 1, 2019
- Administration Code (Adopted April 2019)
  - July 2019
- Building Code (Adopted April 2019)
  - Optional: December 1, 2019
  - Mandatory: August 1, 2020

4

Adoption and implementation dates – cont.

- Planning and work groups:
  - Fire Code
  - Mechanical Code
  - Plumbing Code
  - Others

5



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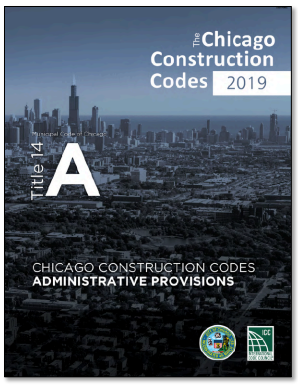
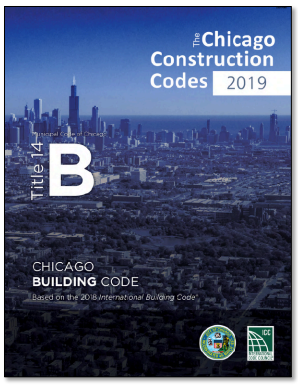
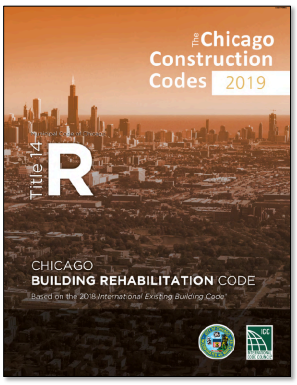


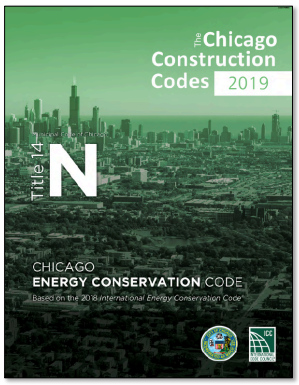
Administrative



Building

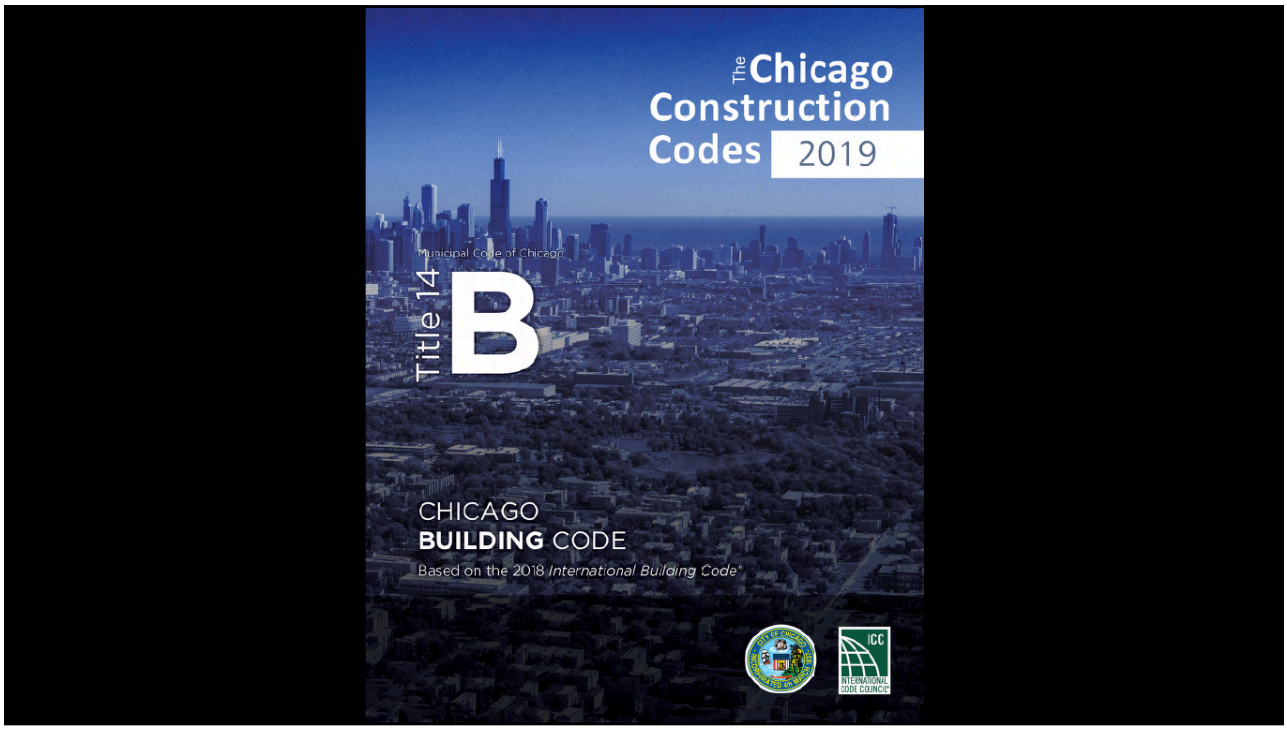


Building Rehabilitation



Energy Conservation

7



8


The Chicago Construction Codes 2019
Municipal Code of Chicago
Title 14
R
CHICAGO
BUILDING REHABILITATION CODE
Based on the 2018 International Existing Building Code®

9


The Chicago Construction Codes 2019
Municipal Code of Chicago
Title 14
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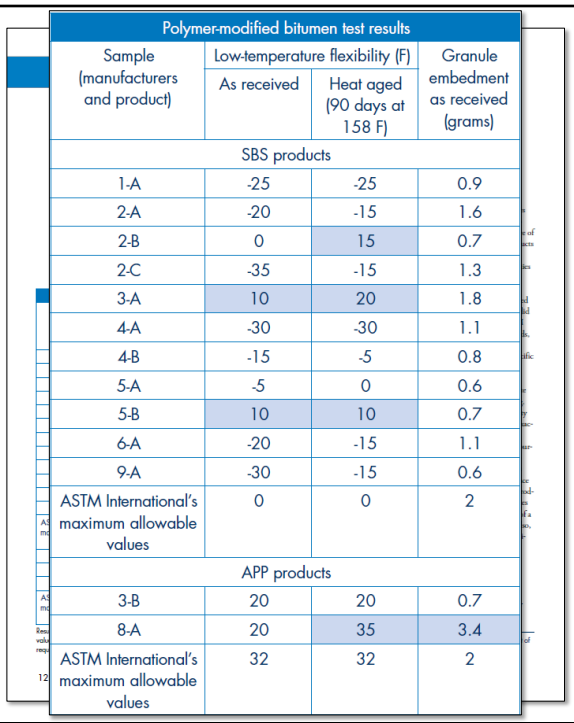
CHICAGO
ENERGY CONSERVATION CODE
Based on the 2018 International Energy Conservation Code®

10

11

Polymer-modified bitumen sheet testing

12



Polymer-modified bitumen test results

Sample (manufacturers and product)	Low-temperature flexibility (F)		Granule embedment as received (grams)
	As received	Heat aged (90 days at 158 F)	
SBS products			
1-A	-25	-25	0.9
2-A	-20	-15	1.6
2-B	0	15	0.7
2-C	-35	-15	1.3
3-A	10	20	1.8
4-A	-30	-30	1.1
4-B	-15	-5	0.8
5-A	-5	0	0.6
5-B	10	10	0.7
6-A	-20	-15	1.1
9-A	-30	-15	0.6
ASTM International's maximum allowable values	0	0	2
APP products			
3-B	20	20	0.7
8-A	20	35	3.4
ASTM International's maximum allowable values	32	32	2

Professional Roofing
February 2016

Nine of 13 products tested complied…

13

2011 testing

Only six of the 16 products tested complied….

14

2019 MB testing

- ASTM D5147 -- Low-temperature flexibility (as received)
- ASTM D4977 -- Granule embedment (as received)

15

Products tested

2019 MB testing

- 18 products tested:
  - 7 APP
  - 11 SBS
  - 15 products with granules
  - 3 products without granules (granule embedment doesn't apply)
- Manufacturers:
  - 10 (CertainTeed, Derbigum, Firestone, GAF, Garland, JM, Polyglass, Siplast, Soprema and Tremco)

16

Results – SBS products

2019 testing

Sample ID	Modifier	ASTM designation	Low-temp. flex. (F)	Granule loss (g)
1-A	SBS	ASTM D6164, Type I, Grade G	-13	0.56
3-A	SBS	ASTM D6164, Type I, Grade S	-27	NA
3-B	SBS	ASTM D6164, Type II, Grade G	-15	0.48
4-A	SBS	ASTM D6164, Type II, Grade G	-16	1.13
5-A	SBS	ASTM D6162, Type III, Grade G	-15	2.05
6-A	SBS	ASTM D6164, Type I, Grade G	-13	0.34
6-B	SBS	ASTM D6164, Type II, Grade G	-13	0.53
6-C	SBS	ASTM G6164, Type I, Grade G	-9	0.55
8-A	SBS	ASTM D6163, Type I, Grade G	-20	0.09
9-A	SBS	ASTM D6164, Type I, Grade G	-8	0.53
10-A	SBS	ASTM D6163, Type III, Grade G	Less than -40	1.16
		ASTM spec.	0 (max.)	2.0 (max)

17

Results – APP products

2019 testing

Sample ID	Modifier	ASTM designation	Low-temp. flex. (F)	Granule loss (g)
2-A	APP	ASTM D6223, Type I, Grade G	21	0.95
2-B	APP	ASTM D6223, Type I, Grade S	10	NA
2-C	APP	D6223, Grade G	14	0.60
2-D	APP	ASTM D6222, Type II, Grade G	10	0.65
2-E	APP	D6223, Grade G	9	NA
7-A	APP	D6222, Grade G	Greater than 41	0.10
7-B	APP	D6222, Type I, Grade G	Greater than 41	0.88
		ASTM spec.	32 (max.)	2.0 (max)

18

Summary of results

- 15 of the 18 products tested comply
- Results notably are better than 2015 and 2011
- Still some reason(s) for concern

19

Recommendations

2019 MB testing

- Select MB products carefully
- Consider seeking out products with third-party verification of compliance:
  - UL product certification
  - PRI Product Validation
  - Dade County Approval
- As always, call NRCA Technical Services if you see anything unusual

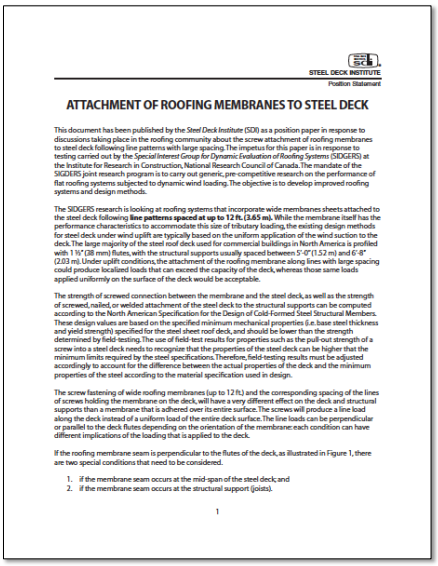
20

Steel roof decks/seam-fastened systems

21

SDI bulletin

2009



STEEL DECK INSTITUTE
Position Statement

ATTACHMENT OF ROOFING MEMBRANES TO STEEL DECK

This document has been published by the *Steel Deck Institute* (SDI) as a position paper in response to discussions taking place in the roofing community about the screw attachment of roofing membranes to steel deck following line patterns with large spacing. The impetus for this paper is in response to testing carried out by the *Special Interest Group for Dynamic Evaluation of Roofing Systems* (SIDGERS) at the Institute for Research in Construction, National Research Council of Canada. The mandate of the SIGDERS joint research program is to carry out generic, pre-competitive research on the performance of flat roofing systems subjected to dynamic wind loading. The objective is to develop improved roofing systems and design methods.

The SIDGERS research is looking at roofing systems that incorporate wide membranes sheets attached to the steel deck following **line patterns spaced at up to 12 ft. (3.65 m).** While the membrane itself has the performance characteristics to accommodate this size of tributary loading, the existing design methods for steel deck under wind uplift are typically based on the uniform application of the wind suction to the deck. The large majority of the steel roof deck used for commercial buildings in North America is profiled with 1 ½" (38 mm) flutes, with the structural supports usually spaced between 5'-0" (1.52 m) and 6'-8" (2.03 m). Under uplift conditions, the attachment of the roofing membrane along lines with large spacing could produce localized loads that can exceed the capacity of the deck, whereas those same loads applied uniformly on the surface of the deck would be acceptable.

The strength of screwed connection between the membrane and the steel deck, as well as the strength of screwed, nailed, or welded attachment of the steel deck to the structural supports can be computed according to the North American Specification for the Design of Cold-Formed Steel Structural Members. These design values are based on the specified minimum mechanical properties (i.e. base steel thickness and yield strength) specified for the steel sheet roof deck, and should be lower than the strength determined by field-testing. The use of field-test results for properties such as the pull-out strength of a screw into a steel deck needs to recognize that the properties of the steel deck can be higher that the minimum limits required by the steel specifications. Therefore, field-testing results must be adjusted accordingly to account for the difference between the actual properties of the deck and the minimum properties of the steel according to the material specification used in design.

The screw fastening of wide roofing membranes (up to 12 ft.) and the corresponding spacing of the lines of screws holding the membrane on the deck, will have a very different effect on the deck and structural supports than a membrane that is adhered over its entire surface. The screws will produce a line load along the deck instead of a uniform load of the entire deck surface. The line loads can be perpendicular or parallel to the deck flutes depending on the orientation of the membrane: each condition can have different implications of the loading that is applied to the deck.

If the roofing membrane seam is perpendicular to the flutes of the deck, as illustrated in Figure 1, there are two special conditions that need to be considered.

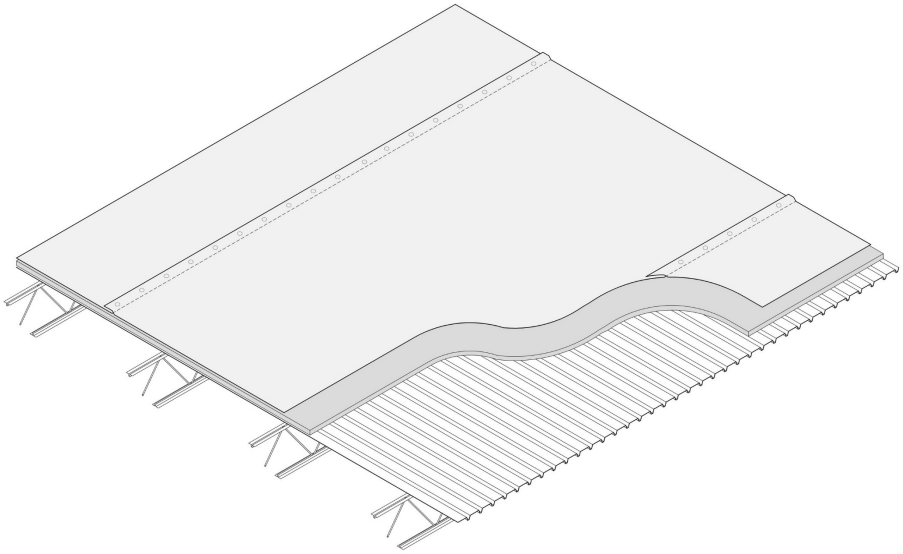
1. if the membrane seam occurs at the mid-span of the steel deck; and
2. if the membrane seam occurs at the structural support (joists).

1

- Decks designed for joist spacing between 5’ and 6’ 8” o.c.
- Deck designed for uniform loading
- Seam-fastened single-ply membranes are a concern

22

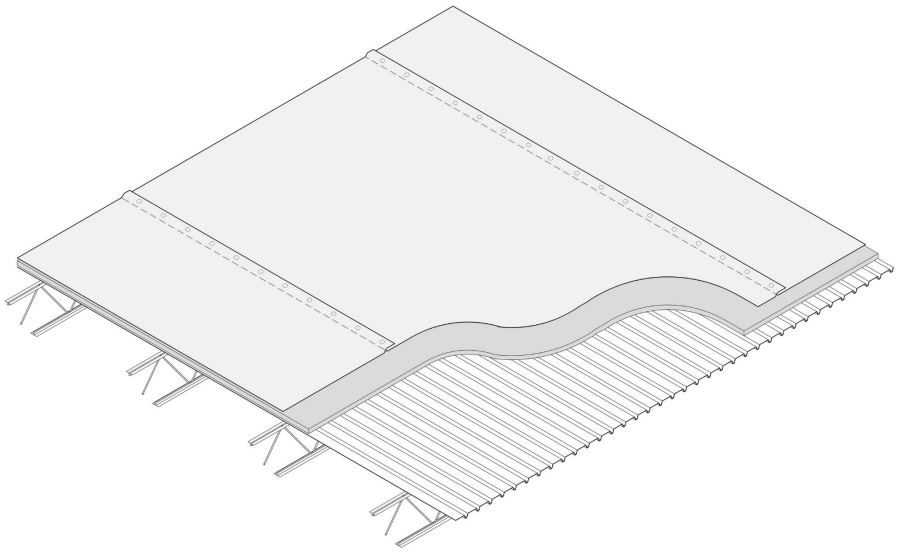
Membrane seams across deck flutes



SDI: 3.8 X moment (deck); 2 X load (joists)

23

Membrane seams in deck flute direction



SDI: 12 X bending moment and shear (deck)

24

SDI bulletin – Conclusion

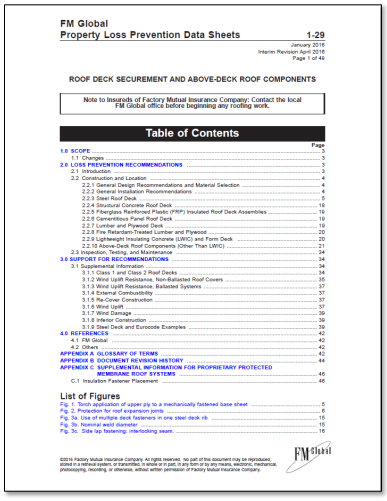
2009 bulletin

"…SDI does not recommend the use of roofing membranes attached to the steel deck using line patterns with large spacing unless a structural engineer has reviewed the adequacy of the steel deck and the structural supports to resist to wind uplift loads transmitted along the lines of attachment. Those lines of attachment shall only be perpendicular to the flutes of the deck."

25

FM Global's Loss Prevention Data Sheet 1-29

April 2016



FM Global
Property Loss Prevention Data Sheets 1-29

January 2016
Interim Revision April 2016
Page 1 of 49

ROOF DECK SECUREMENT AND ABOVE-DECK ROOF COMPONENTS

Note to Insureds of Factory Mutual Insurance Company: Contact the local FM Global office before beginning any roofing work.

Table of Contents

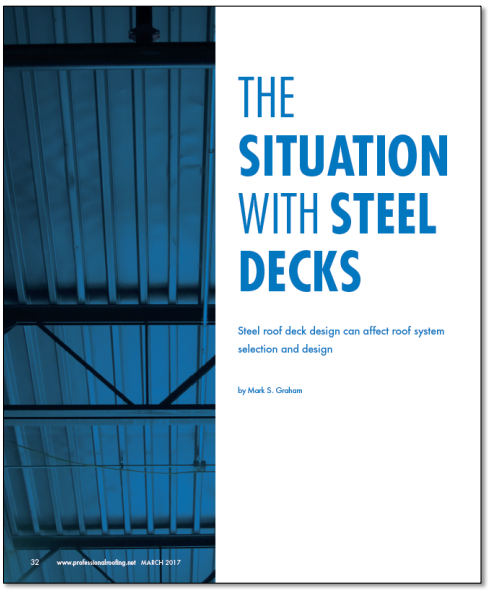
Page

List of Figures

Revised/new criteria:

- Steel roof decks:
  - Uniformly-distributed loading
  - Concentrated loading
- Lightweight structural concrete

26



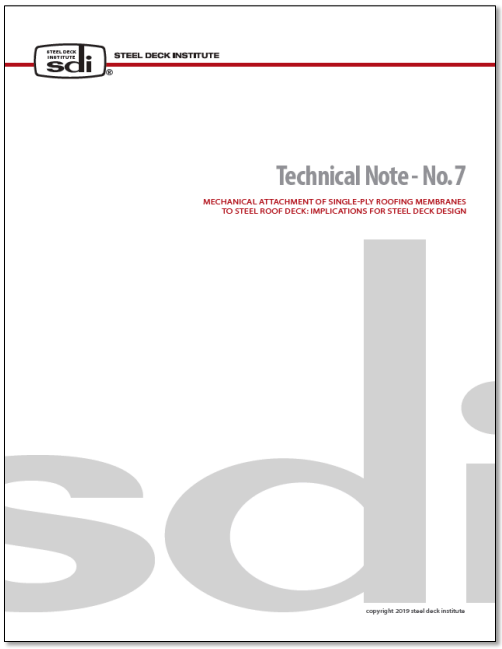
Professional Roofing
March 2017
www.professionalroofing.net

27

Fastener pull-out tests…

There is little correlation between fastener pull-out resistance and a steel roof deck's yield strength and uplift (bending) strength

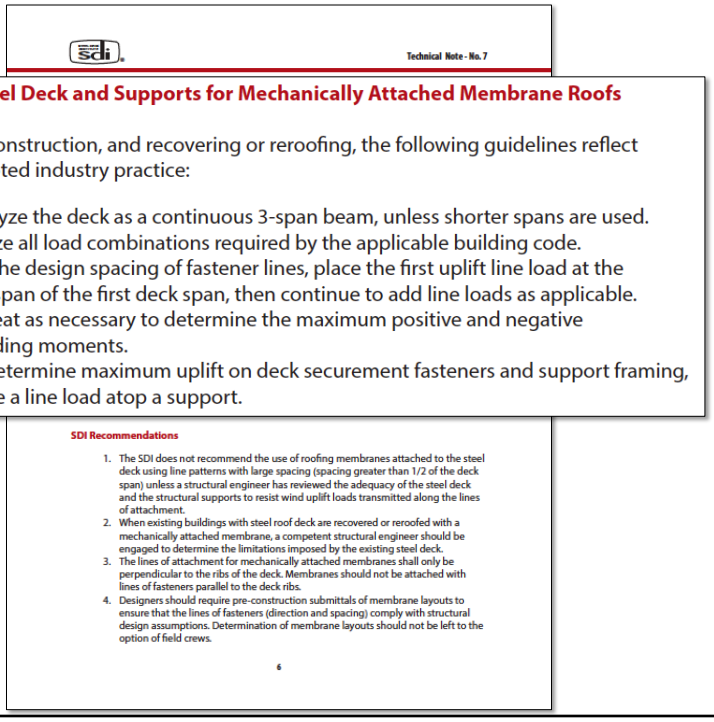
28



SDI Technical Note-No. 7 (Nov. 2019)

Mechanical attachment of single-ply roofing membranes to steel roof deck: Implications for steel deck design

29



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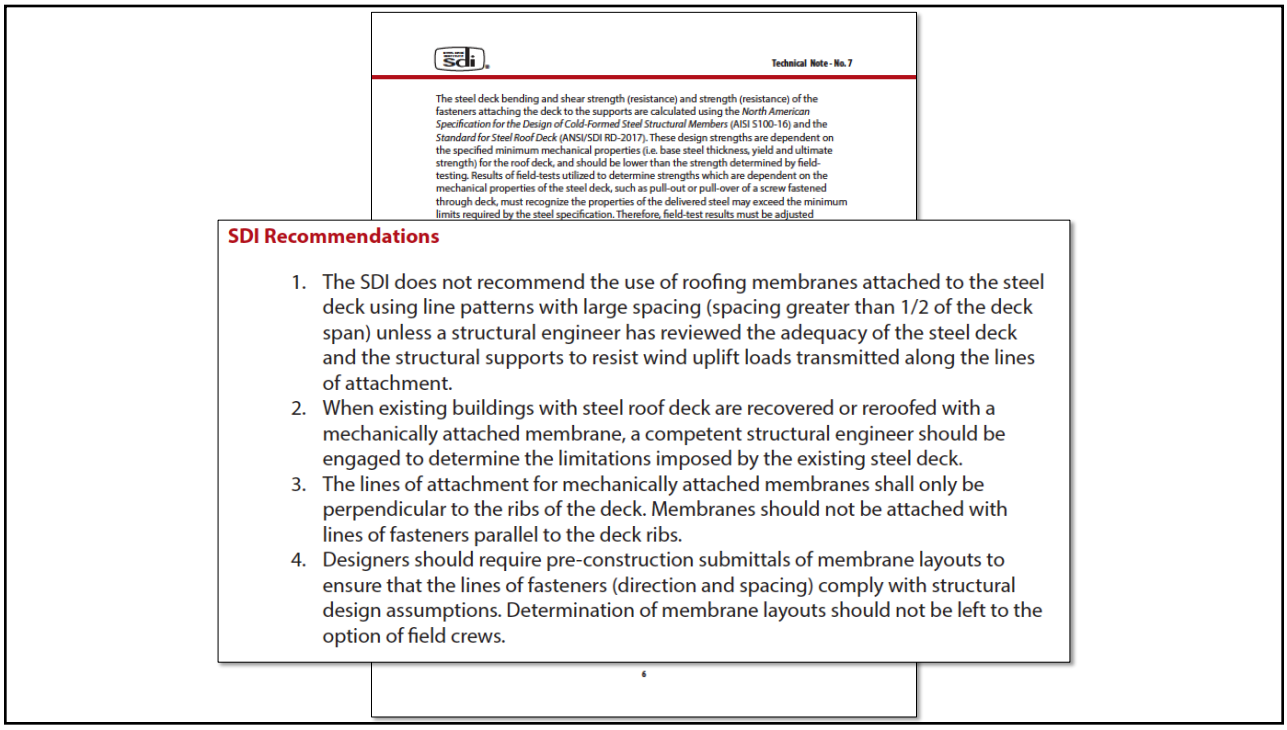


31

Expect additional scrutiny of seam-fastened, mechanically-attached, single-ply membrane roof systems

32

RESEARCH+TECH

Consider the deck

SDI provides additional guidance for steel roof deck designers

by Mark S. Graham

In November 2019, the Steel Deck Institute issued new guidance for steel roof decks that features seam-fastened, mechanically attached, single-ply membranes. Although this guidance is directed toward roof deck designers, single-ply membrane manufacturers and suppliers, roof system designers and roofing contractors also should be aware of SDI's latest guidelines.

Previous guidance

In May 2009, SDI issued a position statement, "Attachment of Roofing Membranes to Steel Deck," indicating seam-fastened, mechanically attached, single-ply membrane roof systems apply wind-uplift loads to roof decks differently than adhered membrane roof systems. Although adhered membrane roof systems apply uplift loads uniformly across a roof deck, seam-fastened membrane systems result in concentrated line loads along the deck. Such line loads can result in excess bending moment and shear applied to the deck or a doubling of uplift loads on specific structural supports (joists) depending on the orientation of the membrane sheets relative to the deck flutes and joists.

SDI's document goes on to recommend structural engineers should review the adequacy of steel roof decks and their underlying

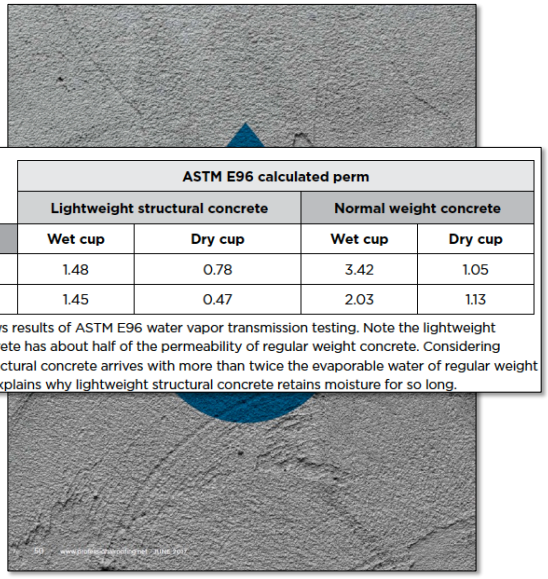
20 www.professionalroofing.net JANUARY 2020

Professional Roofing
January 2020

33

Moisture in concrete roof decks

34



	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.

Professional Roofing, June 2017

RESEARCH+TECH

Are admixtures the answer?

Moisture in concrete roof decks continues to be problematic

by Mark S. Graham

NRCA's Technical Services Section has been receiving inquiries regarding the use and effectiveness of specific concrete mix additives and topical surface treatments to address moisture release-related concerns with concrete roof decks. Such admixtures broadly are referred to as moisture vapor reduction admixtures (MVRAs) or porosity-inhibiting admixtures. NRCA provides recommendations regarding their use.

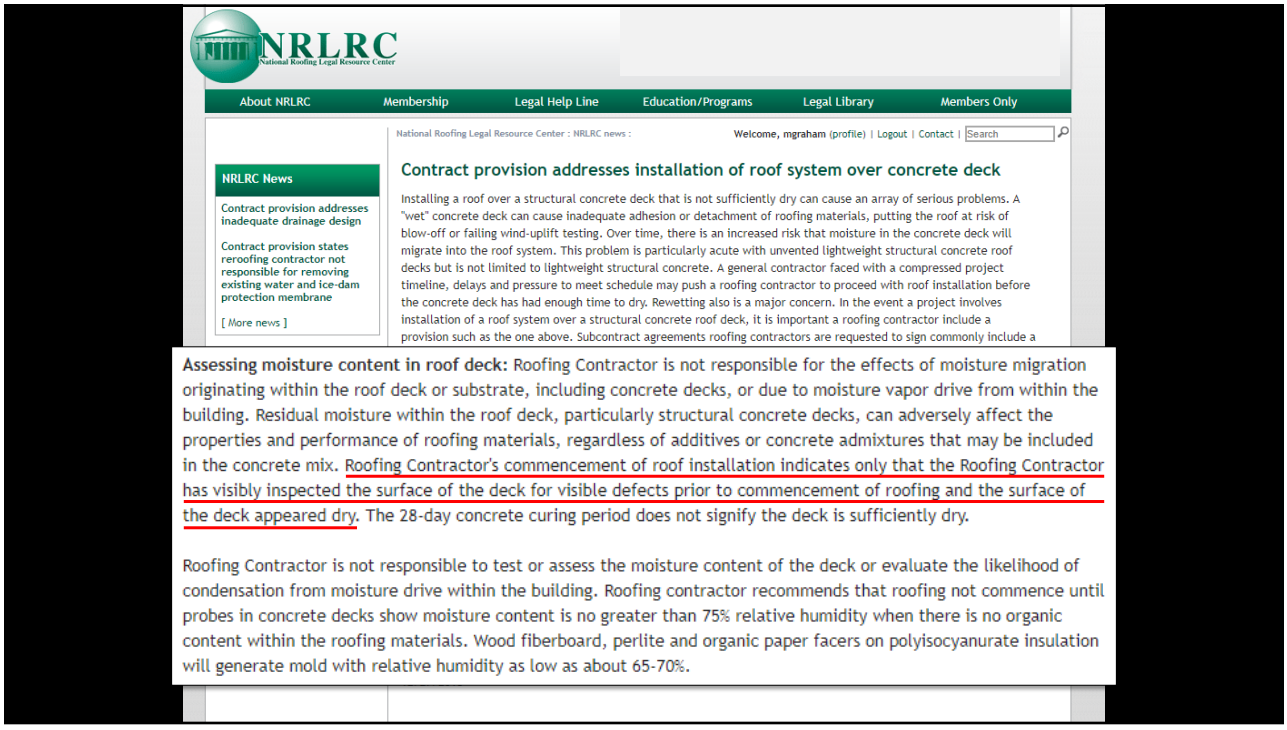
MVRAs

Concrete admixtures intended as MVRAs are specific chemicals added during concrete's batching and mixing to provide an additional chemical reaction during the concrete's hydration and curing process. MVRAs use the concrete mix's excess water and chlorides to create a calcium silicate hydrate gel within the concrete. The gel is said to fill the small pores and capillary openings in curing concrete, minimizing the concrete's ability to pass and release moisture vapor. The gel is intended to be permanent and integral throughout the concrete's entire thickness.

24 www.professionalroofing.net DECEMBER 2018

Professional Roofing, December 2018

35



NRLRC National Roofing Legal Resource Center

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NRLRC News

Contract provision addresses inadequate drainage design

Contract provision states reroofing contractor not responsible for removing existing water and ice-dam protection membrane

[More news]

Contract provision addresses installation of roof system over concrete deck

Installing a roof over a structural concrete deck that is not sufficiently dry can cause an array of serious problems. A "wet" concrete deck can cause inadequate adhesion or detachment of roofing materials, putting the roof at risk of blow-off or failing wind-uplift testing. Over time, there is an increased risk that moisture in the concrete deck will migrate into the roof system. This problem is particularly acute with unvented lightweight structural concrete roof decks but is not limited to lightweight structural concrete. A general contractor faced with a compressed project timeline, delays and pressure to meet schedule may push a roofing contractor to proceed with roof installation before the concrete deck has had enough time to dry. Rewetting also is a major concern. In the event a project involves installation of a roof system over a structural concrete roof deck, it is important a roofing contractor include a provision such as the one above. Subcontract agreements roofing contractors are requested to sign commonly include a

Assessing moisture content in roof 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 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.

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 moisture content is no greater than 75% relative humidity when 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%.

36

Concrete Roof Deck Moisture Research—Executive Summary

By Matt Dupuis, PhD, P.E.

Matt Dupuis, PhD, P.E.

History

In recent years, The Roofing Industry has experienced numerous newly installed roof system failures attributed to latent concrete moisture. This moisture is free evaporable moisture that is contained in the core of the concrete roof deck and visually undetectable to the installing roofing contractor, as the surface visually appears dry, and very well may be dry.

Starting in 2016, a collection of industry partners pooled funds to research the concrete roof deck moisture issue. These partners included a nonprofit association, trade associations, including CRCA, Chicagoland Roofing Council (CRC), the National Roofing Contractors Association (NRCA) and manufacturers from the United States and Canada. The research was principally conducted by SRI Consultants at their laboratory in Middleton, Wisconsin. The study examined existing literature, moisture measurement techniques, full scale instrumentation and computer modeling. Data collection was concluded in Q4 of 2018 and a research report delivered in Q2 2019. This report is available from the National Roofing Contractors Association (NRCA).

Concrete Types

Early roof system failures reported to the NRCA revolved around the use of light weight structural concrete. This is structural concrete using light weight manufactured aggregates, in lieu of crushed stone. Light weight structural concrete, due to the light weight aggregates, will contain a greater amount of moisture, than normal weight structural concrete, when it is poured. Once the concrete has cured, there is no reasonable method to detect which concrete type, light weight or normal weight, the roof deck is comprised of.

As time progressed, more reports of moisture related roof system failures over normal weight concrete roof deck came to the NRCA's Technical Services' attention. Currently, both concrete types are known to be a risk factor for new roof systems. Appropriately, both concrete types were researched in this study.

Concrete Moisture Measurement Methods

There are numerous methods that have been utilized to determine the suitability of a concrete roof deck to receive the new roof system. These include asphalt spot test, the mat test (ASTM D4263), calcium chloride (ASTM F1869), electronic meters (ASTM F2659) and drilled in probes (ASTM F2170). A full discussion of these methods with their strengths and weaknesses are contained in the full report.

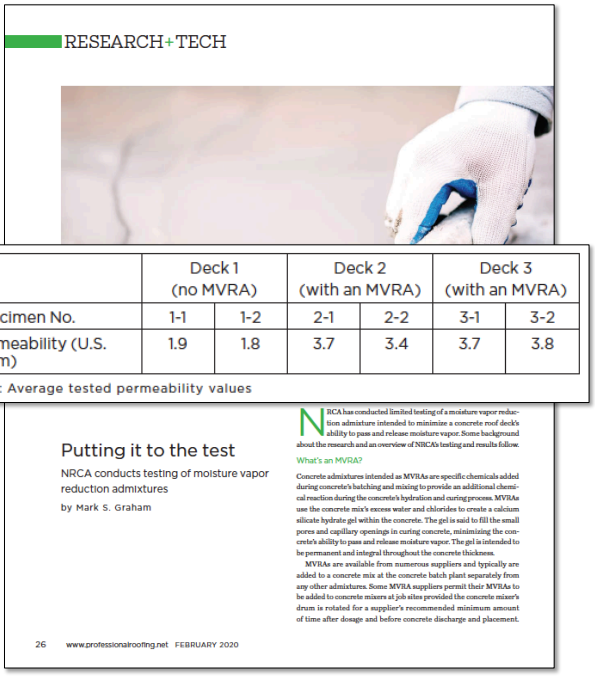
The results of the research have identified the electronic meter (ASTM F2659) as suitable for the roofing industry to determine when the surface of the concrete is suitably dry. Readings on an electronic meter, such as the Tramex CMExpert II Digital Concrete Moisture Meter, that are within a 3.0-4.0% range, should be considered "surface dry". Research has shown the surface dry condition is the extent of what a roofing contractor can do in the field, to evaluate concrete moisture. NRCA's Legal Resource Center has released suggested contract language to this effect.

Therefore, a roofing contractor can only determine that the surface of the concrete deck is visually clean and suitably dry, using an electronic meter. Conversely, a roofing contractor is not in a position to determine whether the core of the concrete is suitably dry and should not be made responsible for the consequences of such a decision. The roof system design, via the Designer of Record, needs to take into account the moisture potential within the concrete roof slab.

The use of Drilled in probes (ASTM F-2170) has been researched and utilized in the field work. Within the typical window of concrete pour to roof system installation, these probes will typically read full scale (i.e. 100% Relative Humidity). These full-scale readings are resultant from the process of rewetting. The rewetting

CRCA Today
Winter 2020

37



RESEARCH+TECH

	Deck 1 (no MVRA)		Deck 2 (with an MVRA)		Deck 3 (with an MVRA)	
Specimen No.	1-1	1-2	2-1	2-2	3-1	3-2
Permeability (U.S. perm)	1.9	1.8	3.7	3.4	3.7	3.8

Table: Average tested permeability values

Putting it to the test

NRCA conducts testing of moisture vapor reduction admixtures

by Mark S. Graham

NRCA has conducted limited testing of a moisture vapor reduction admixture intended to minimize a concrete roof deck's ability to pass and release moisture vapor. Some background about the research and an overview of NRCA's testing and results follow.

What's an MVRA?

Concrete admixtures intended as MVRAs are specific chemicals added during concrete's batching and mixing to provide an additional chemical reaction during the concrete's hydration and curing process. MVRAs use the concrete mix's excess water and chlorides to create a calcium silicate hydrate gel within the concrete. The gel is said to fill the small pores and capillary openings in curing concrete, minimizing the concrete's ability to pass and release moisture vapor. The gel is intended to be permanent and integral throughout the concrete thickness.

MVRAs are available from numerous suppliers and typically are added to a concrete mix at the concrete batch plant separately from any other admixtures. Some MVRA suppliers permit their MVRAs to be added to concrete mixers at job sites provided the concrete mixer's drum is rotated for a supplier's recommended minimum amount of time after dosage and before concrete discharge and placement.

Professional Roofing
February 2020

"…These test results contradict claims an MVRA minimizes concrete's ability to pass and release moisture vapor…"

38

Questions…. dialogue

39

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40