SOUTHEASTERN MICHIGAN ROOFING CONTRACTORS ASSOCIATION

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Troy, Michigan

Steel roof decks and mechanically-attached single-ply membrane roof systems

NRCA

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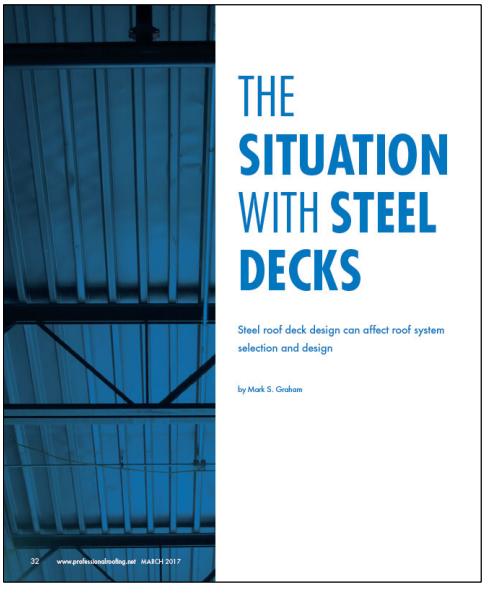

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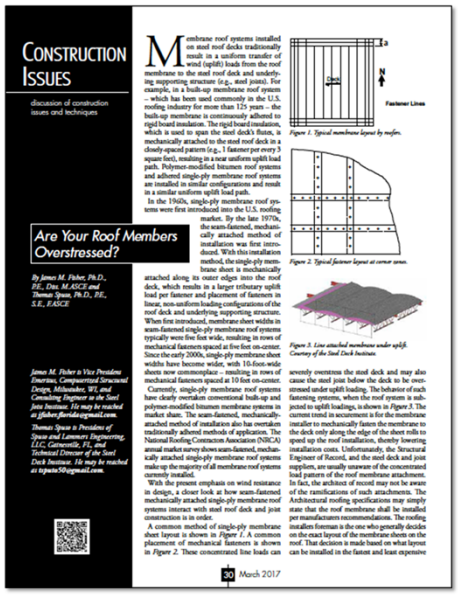

CONSTRUCTION ISSUES

discussion of construction issues and techniques

Are Your Roof Members Overstressed?

By James M. Fisher, Ph.D., P.E., Dist. M.ASCE and Thomas Sputo, Ph.D., P.E., S.E., F.ASCE

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Membrane roof systems installed on steel roof decks traditionally result in a uniform transfer of wind (uplift) loads from the roof membrane to the steel roof deck and underlying supporting structure (e.g., steel joists). For example, in a built-up membrane roof system – which has been used commonly in the U.S. roofing industry for more than 125 years – the built-up membrane is continuously adhered to rigid board insulation. The rigid board insulation, which is used to span the steel deck's flutes, is mechanically attached to the steel roof deck in a closely-spaced pattern (e.g., 1 fastener per every 3 square feet), resulting in a near uniform uplift load path. Polymer-modified bitumen roof systems and adhered single-ply membrane roof systems are installed in similar configurations and result in a similar uniform uplift load path.

In the 1960s, single-ply membrane roof systems were first introduced into the U.S. roofing market. By the late 1970s, the seam-fastened, mechanically attached method of installation was first introduced. With this installation method, the single-ply membrane sheet is mechanically attached along its outer edges into the roof deck, which results in a larger tributary uplift load per fastener and placement of fasteners in linear, non-uniform loading configurations of the roof deck and underlying supporting structure. When first introduced, membrane sheet widths in seam-fastened single-ply membrane roof systems typically were five feet wide, resulting in rows of mechanical fasteners spaced at five feet on-center. Since the early 2000s, single-ply membrane sheet widths have become wider, with 10-foot-wide sheets now commonplace – resulting in rows of mechanical fasteners spaced at 10 feet on-center.

Currently, single-ply membrane roof systems have clearly overtaken conventional built-up and polymer-modified bitumen membrane systems in market share. The seam-fastened, mechanically-attached method of installation also has overtaken traditionally adhered methods of application. The National Roofing Contractors Association (NRCA) annual market survey shows seam-fastened, mechanically attached single-ply membrane roof systems make up the majority of all membrane roof systems currently installed.

With the present emphasis on wind resistance in design, a closer look at how seam-fastened mechanically attached single-ply membrane roof systems interact with steel roof deck and joist construction is in order.

A common method of single-ply membrane sheet layout is shown in *Figure 1*. A common placement of mechanical fasteners is shown in *Figure 2*. These concentrated line loads can severely overstress the steel deck and may also cause the steel joist below the deck to be overstressed under uplift loading. The behavior of such fastening systems, when the roof system is subjected to uplift loadings, is shown in *Figure 3*. The current trend in securement is for the membrane installer to mechanically fasten the membrane to the deck only along the edge of the sheet rolls to speed up the roof installation, thereby lowering installation costs. Unfortunately, the Structural Engineer of Record, and the steel deck and joist suppliers, are usually unaware of the concentrated load pattern of the roof membrane attachment. In fact, the architect of record may not be aware of the ramifications of such attachments. The Architectural roofing specifications may simply state that the roof membrane shall be installed per manufacturers recommendations. The roofing installers foreman is the one who generally decides on the exact layout of the membrane sheets on the roof. That decision is made based on what layout can be installed in the fastest and least expensive

Figure 1. Typical membrane layout by roofer.

Figure 2. Typical fastener layout at corner zones.

Figure 3. Line attached membrane under uplift. Courtesy of the Steel Deck Institute.

30 March 2017

Structure magazine
March 2017
www.structuremag.org

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Steel roof deck design

- SDI Design Manual
- AISI S100, "Specifications for the Design of Cold-formed Steel Structural Members"
- ANSI/SDI RD1.0-2006, "Standard for Steel Roof Deck"
- ANSI/SDI RD-2010, "Standard for Steel Roof Deck"
- SDI *Roof Deck Design Manual, First Edition* (Nov. 2012)
- ANSI/SDI RD-2017, "Standard for Steel Roof Deck"
- SDI *Roof Deck Design Manual, Second Edition* (June 2020)
- ANSI/SDI SD-2022, "Standard for Steel Deck"

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Steel roof deck design

Wind uplift resistance

- Minimum 30 psf uplift (uniform loading)
- Minimum 45 psf uplift (uniform loading) at roof overhangs

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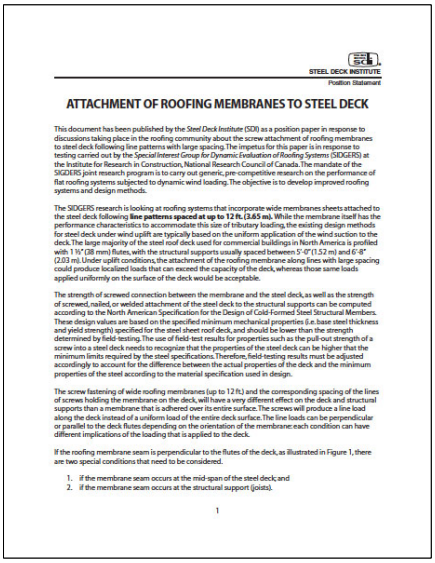
SDI bulletin

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 SIDGERS 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).

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- 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

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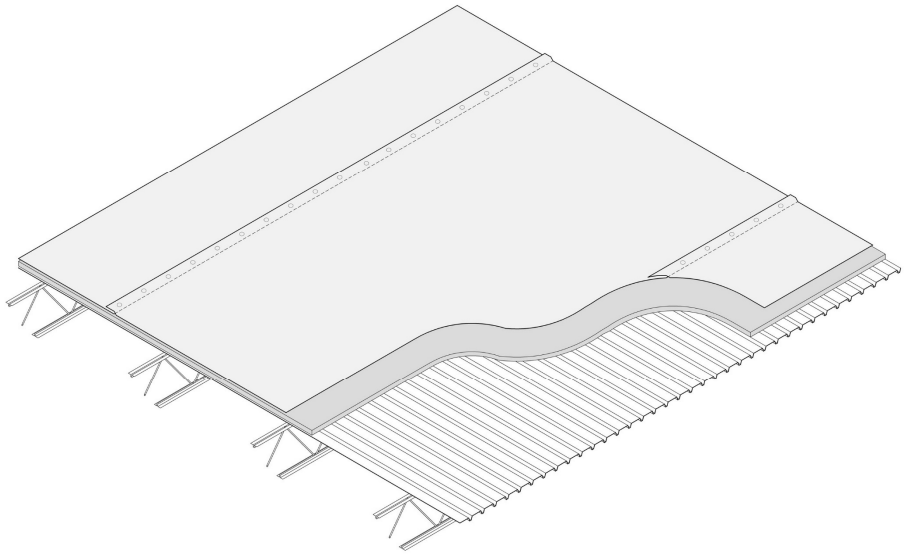
Membrane seams across deck flutes



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

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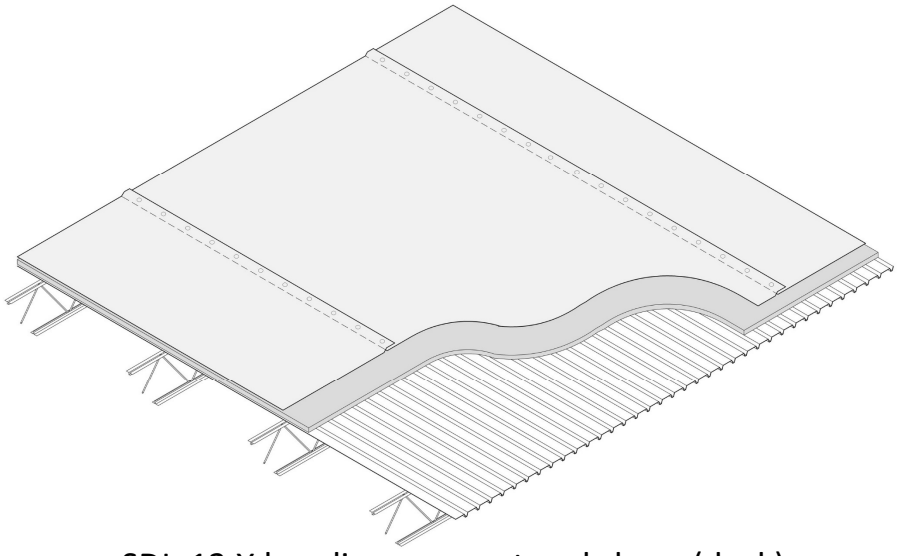
Membrane seams in deck flute direction



SDI: 12 X bending moment and shear (deck)

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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."

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TECH TODAY

Changes reduce some FM classifications

FM 4470 has been revised, resulting in different uplift resistance criteria

by Mark S. Graham

FM Approvals has revised its criteria for determining the uplift resistance of membrane- and liquid-applied roof assemblies. Because many roofing professionals rely on FM Approvals' classifications when designing and specifying low-slope roof assemblies, you should be aware of the changes made and their effects on specific roof assembly classifications.

FM 4470

FM 4470, "Approval Standard for Single-Ply, Polymer-Modified Bitumen Sheet, Built-Up Roof (BUR) and Liquid Applied Roof Assemblies for use in Class 1 and Noncombustible Roof Deck Construction," is the basis for FM Approvals' determination of 1-60, 1-90, 1-120, etc., classifications used for low-slope membrane and liquid-applied roof assemblies.

In June 2012, FM Approvals revised FM 4470; the effective date of the new standard was Dec. 31, 2012. The revisions include adding NFPA 276, "Standard Method for Fire Tests for Determining the Heat Release Rate of Roofing Assemblies with Combustible Above-Deck Roofing Components," to determine combustibility below the roof deck; changes to the conditions of acceptance for wind uplift and hail damage resistance testing; and adding an alternative test method for determining fasteners' corrosion resistances.

One of the more significant changes to FM 4470 is how steel roof decks are evaluated. With the revised standard, steel roof decks cannot exceed the allowable stresses provided for in AISI S100, "North American Specification for the Design of Cold-Formed Steel Structural Members." The maximum allowable deflection for steel roof decks is based on a 200-pound point load; previously, a 300-pound point load was used. Also, minimum designs of steel roof decks now are based on a minimum 0.7-mm-thick (slightly less than 22-gauge), 33-ksi yield strength steel. Previously, minimum 0.75-mm-thick (22-gauge) steel complying with the ASTM International specification was used for evaluation.

The method of analyzing attachment of steel decks also has been revised. Deck fasteners now are tested for fastener "pull over" (pull through) of the deck material. Also, strain calculations are performed on both steel decks and fastener heads, and the lower of the two values is used as the basis for classification.

FM 4470 also now includes additional provisions allowing for optional ratings for dynamic punch-through resistance of roof coverings, noncombustible cover for roof insulation and solar reflectance of roof surfaces.

All products tested after Dec. 31, 2012, are required to satisfy the new standard's requirements. Products FM Approvals already approved under previous editions of FM 4470 also need to comply with the current edition by the effective date or forfeit classification.

What this means

If a specific classified assembly results in an overstressed steel roof deck, FM Approvals has, upon consultation with the manufacturer, either changed the assembly's parameters to compensate for the deck overstress or reduced the assembly's wind rating to a level where the deck no longer is overstressed. Assembly parameters likely changed include reducing the deck span and/or increasing the deck's steel thickness and/or yield strength (from 33 ksi to 80 ksi).

For assemblies where the wind rating has been reduced, the assemblies' previous RoofNav numbers have been withdrawn and new RoofNav numbers issued to avoid confusion.

If you use the new version of FM 4470 for an allowed roof assembly applied to a 1½-inch-thick, 22-gauge steel deck at a 6-foot maximum span, FM Approvals has indicated maximum classifications are limited to 1-165 when using a 33-ksi steel deck and 1-300 when using an 80-ksi steel deck. For seam-fastened mechanically attached single-ply membrane assemblies, classifications will vary based on assembly parameters and seam fastener row spacing, but generally classifications will be noticeably lower than with FM 4470's previous version.

Proceed cautiously

Roof system designers and specifiers need to be aware of FM 4470's revision and its effect on assembly parameters, uplift ratings and RoofNav numbers for membrane and liquid-applied roof assemblies using steel roof decks.

For roofing projects designed before the implementation date but that will be installed after the implementation date, clarification needs to be sought regarding which version of FM 4470 applies. If the current version applies, changes to the roof assembly specification may be necessary and affect a project's cost.

I encourage roof system designers and specifiers and roofing contractors to work closely with manufacturers when determining changes to specific assembly parameters, uplift ratings and RoofNav numbers.

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

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FM 1-29 updated

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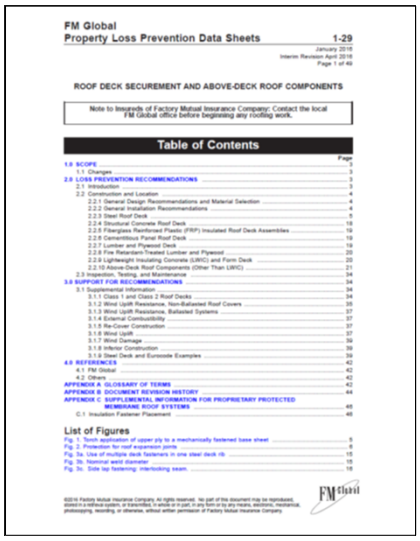

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ROOF DECK SECUREMENT AND ABOVE-DECK ROOF COMPONENTS

Table of Contents

New criteria for steel roof deck uplift:

- Uniformly-distributed loading
- Concentrated loading

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2.2.3.2 When designing the steel deck, give consideration to the needed wind rating, and how the load is applied (concentrated vs. uniformly distributed) from the above-deck components to the deck. Where the distance between rows of roof cover fasteners is greater than half the deck span, treat as a concentrated load.

As an alternative to using Tables 1A or 1B for concentrated loads, a performance-based approach may be used if calculations are conducted by a licensed S.E. or P.E. in structural engineering. This applies to situations where the distance between rows of roof cover fasteners is greater than one-half the deck span. Make the following assumptions:

A. Assume a 3-span structural condition.

B. Assume the first row of roof cover fasteners is located at mid-point of the first deck span.

C. Assume maximum allowable stresses are determined using allowable strength design (ASD) in accordance with AISI S100-2012, or comparable standard outside the United States

Due to the more brittle nature of higher grade steels, the maximum yield stress used in the analysis is 60,000 psi (414 MPa), even for 80,000 psi (552 MPa) yield stress steel. Use Tables 1A through 1E as follows to facilitate deck selection:

Table 1A. Use for roof covers or base plies that are mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is more than half the deck span and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with a minimum yield stress of 33,000 psi (228 MPa).

Table 1B. Use for roof covers or base plies that are mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is more than half the deck span and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with a minimum yield stress of 60,000 psi (414 MPa).

Note: Where the minimum specified yield stress is between 33,000 psi (228 MPa) and 60,000 psi (414 MPa), it is reasonably accurate to interpolate the maximum deck span linearly based on Tables 1A and 1B.

Table 1C. Use for roof covers or base plies that are adhered to insulation or cover board, or mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is one-half the deck span or less and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with minimum yield stresses of 33,000 psi (228 MPa) and ultimate wind ratings of from 60 to 225 psf (2.9 to 10.8 kPa).

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Table 1C. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, Wide Rib (Type B) Steel Deck with an Adhered Roof Cover, for Wind Ratings from 60 to 225 psf (2.9 to 10.8 kPa)
(NOTE: Use this table when the distance between rows of roof cover fasteners is one-half the deck span or less. Green font indicates that deflection governs over bending stress.)

Yield Stress psi	Deck Gauge	Ultimate Wind Rating per RoofNav (psf) Maximum Span (ft)											
		60	75	90	105	120	135	150	165	180	195	210	225
33,000	22	7.10	7.10	7.10	7.10	7.07	6.67	6.33	6.03	5.78	5.55	5.35	5.17
	20	7.78	7.78	7.78	7.78	7.78	7.43	7.05	6.72	6.44	6.18	5.96	5.76
	18	9.08	9.08	9.08	9.08	9.08	8.66	8.22	7.84	7.50	7.21	6.95	6.71
	16	10.36	10.36	10.36	10.36	10.36	9.89	9.38	8.94	8.56	8.23	7.93	7.66
40,000	22	7.10	7.10	7.10	7.10	7.10	7.10	6.96	6.64	6.35	6.10	5.88	5.68
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.76	7.40	7.08	6.80	6.56	6.33
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.04	8.62	8.25	7.93	7.64	7.38
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.32	9.84	9.42	9.05	8.72	8.43
45,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.04	6.74	6.48	6.24	6.03
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.51	7.22	6.95	6.72
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	8.76	8.41	8.11	7.83
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	9.99	9.60	9.25	8.94
50,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.93	6.66	6.42	6.20
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.72	7.42	7.15	6.91
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.00	8.65	8.33	8.05
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.28	9.87	9.51	9.19
55,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.90	6.67
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.69	7.43
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	8.97	8.66
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.24	9.89
60,000 +	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.97
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.77
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.06
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.34

Green font indicates that deflection governs over bending stress.

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Table 1A. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, 33,000 psi (228 MPa) Yield Stress with a Mechanically Fastened Roof Cover
(Note: Use this table when the distance between rows of roof cover fasteners is more than one-half the deck span.)

Max Deck Spans By Wind Rating/Fastener Spacing, Sheet Gauge for 33 ksi, 1½ in. Deep Wide Rib Deck

Roof Cover Fastener Row Spacing (ft)	Gauge	Wind Rating [psf] 330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
3.5	18	4.5	5.5	5.5	5.5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	4	4	4.5	4.5	4.5	5	5.5	5.5	5.5	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	4	4	4.5	4.5	4.5	5.5	5.5	5.5	6	6	6	6	6	6
4	18	4.5	4.5	5	5	5	6	6	6	6	6	6	6	6	6	6	6		6	6
	20	-	-	-	-	4	4.5	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	4	4.5	5	5	6	6	6	6	6	6	6
4.5	18	-	4	4	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	4	4	5	5	5.5	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6
5	18	-	-	-	4	4	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6	6
	20									4	4.5	5	5.5	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6	6	6
5.5	18	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5	6	6	6	6
6	18	-	-	-	-	-	-	-	-	4	5	5.5	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6	6
6.5	18	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6
7	18	-	-	-	-	-	-	-	-	-	-	-	4	5.5	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	6	6
7.5	18	-	-	-	-	-	-	-	-	-	-	-	-	4	5.5	6	6	6	6	6
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Table 1B. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, Yield Stress ≥ 60,000 psi (414 MPa) with a mechanically fastened Roof Cover (continued)
(Note: Use this table when the distance between rows of roof cover fasteners is more than one-half the deck span.)

Max Deck Spans By Wind Rating/Fastener Spacing, Sheet Gauge for 80 ksi, 1½ in. Deep Wide Rib Deck

Roof Cover Fastener Row Spacing (ft)	Gauge	Wind Rating [psf]																		
		330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
8.5	18	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	4	4	4.5	5.5	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6	6
9	18	-	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6
9.5	18	-	-	-	-	-	-	4	4	4	4.5	5	5.5	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6
10	18	-	-	-	-	-	-	-	4	4	4.5	4.5	5	6	6	6	6	6	6	6
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	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5.5	6	6
10.5	18	-	-	-	-	-	-	-	4	4	4.5	4.5	5	5.5	6	6	6	6	6	6
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	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	5.5	6
Roof Cover Fastener Row Spacing	Gauge	330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
		Wind Rating [psf]																		

Changing from 33 ksi to 80 ksi --> 6 ft. to 9.5 ft. seam spacing

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FM Global
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Table 1B. Maximum Steel Deck Span (ft) for 1 ½ in. (38 mm) Deep, Yield Stress ≥ 60,000 psi (414 MPa) with a mechanically fastened Roof Cover
(Note: Use this table when the distance between rows of roof cover fasteners is more than one-half the deck span.)

Max Deck Spans By Wind Rating/Fastener Spacing, Sheet Gauge for 80 ksi, 1½ in. Deep Wide Rib Deck

Roof Cover Fastener Row Spacing (ft)	Gauge	Wind Rating [psf]																		
		330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
3.5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	5.5	5.5	5.5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	4.5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4.5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	4	4	4.5	5	5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	4.5	5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	-	-	4	4	4.5	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6	6
5.5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	4	4.5	4.5	5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6
6	18	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6
6.5	18	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	4	5	5.5	6	6	6	6	6	6	6
7	18	-	4	4	4.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	4	4	5	5.5	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6	6	6	6
7.5	18	-	-	-	4	4.5	4.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
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8	18	-	-	-	-	4	4	4.5	5	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	4	5	6	6	6	6	6

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In summary

Hypothetical analysis using FM 1-29

- Adhered (uniform loading) roof system:
  - 6 ft. joist spacing → Class 165
- Seam-fastened (nonuniform, linear load) roof system:
  - 6 ft. seam spacing → Class 90 (33 ksi steel deck)
  - 9.5 ft. seam spacing → Class 90 (80 ksi steel deck)
  - 6 ft. seam spacing → Class 165 (80 ksi steel deck)

Seam spacing wider than joist spacing begins to get problematic

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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

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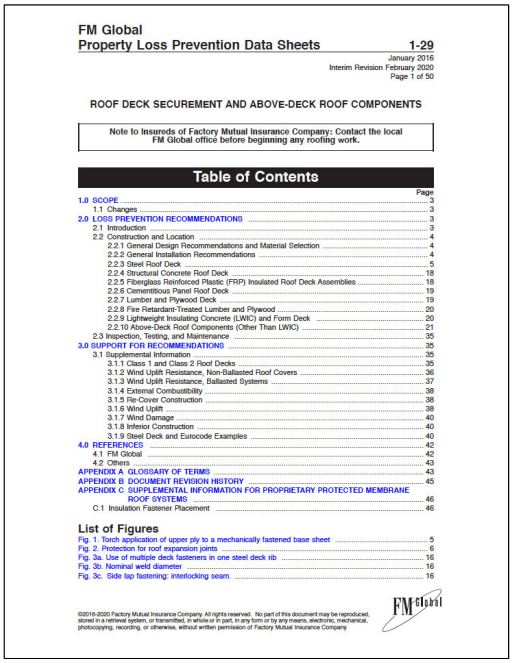

FM Global
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January 2016
Interim Revision February 2020
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ROOF DECK SECUREMENT AND ABOVE-DECK ROOF COMPONENTS

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

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List of Figures

FM 1-29
February 2020

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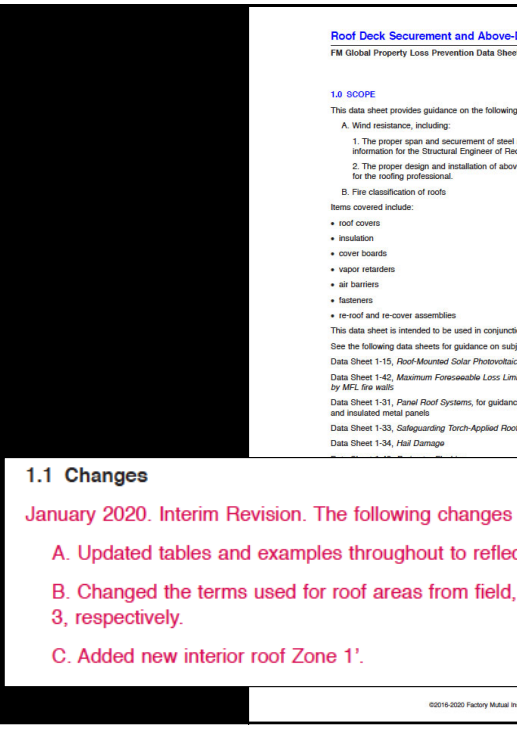

Roof Deck Securement and Above-Deck Roof Components 1-29
FM Global Property Loss Prevention Data Sheets Page 3

1.0 SCOPE

This data sheet provides guidance on the following subjects:

A. Wind resistance, including:

1. The proper span and securement of steel roof decks to supporting members. This is appropriate information for the Structural Engineer of Record (SER).

2. The proper design and installation of above-deck roof components. This is appropriate information for the roofing professional.

B. Fire classification of roofs

Items covered include:

- roof covers
- insulation
- cover boards
- vapor retarders
- air barriers
- fasteners
- re-roof and re-cover assemblies

This data sheet is intended to be used in conjunction with RoofNav and Data Sheet 1-28, *Wind Design*.

See the following data sheets for guidance on subjects that are not covered in this data sheet:

Data Sheet 1-15, *Roof-Mounted Solar Photovoltaic Panels*

Data Sheet 1-42, *Maximum Foreseeable Loss Limiting Factors, for guidance on roofs of buildings divided by MFL fire walls*

Data Sheet 1-31, *Panel Roof Systems*, for guidance on panel roofs, including lap seam, standing seam, and insulated metal panels

Data Sheet 1-33, *Safeguarding Torch-Applied Roof Installations*

Data Sheet 1-34, *Hail Damage*

1.1 Changes

January 2020. Interim Revision. The following changes were made:

A. Updated tables and examples throughout to reflect changes made to Data Sheet 1-28.

B. Changed the terms used for roof areas from field, perimeter, and corner to Zone 1, Zone 2, and Zone 3, respectively.

C. Added new interior roof Zone 1'.

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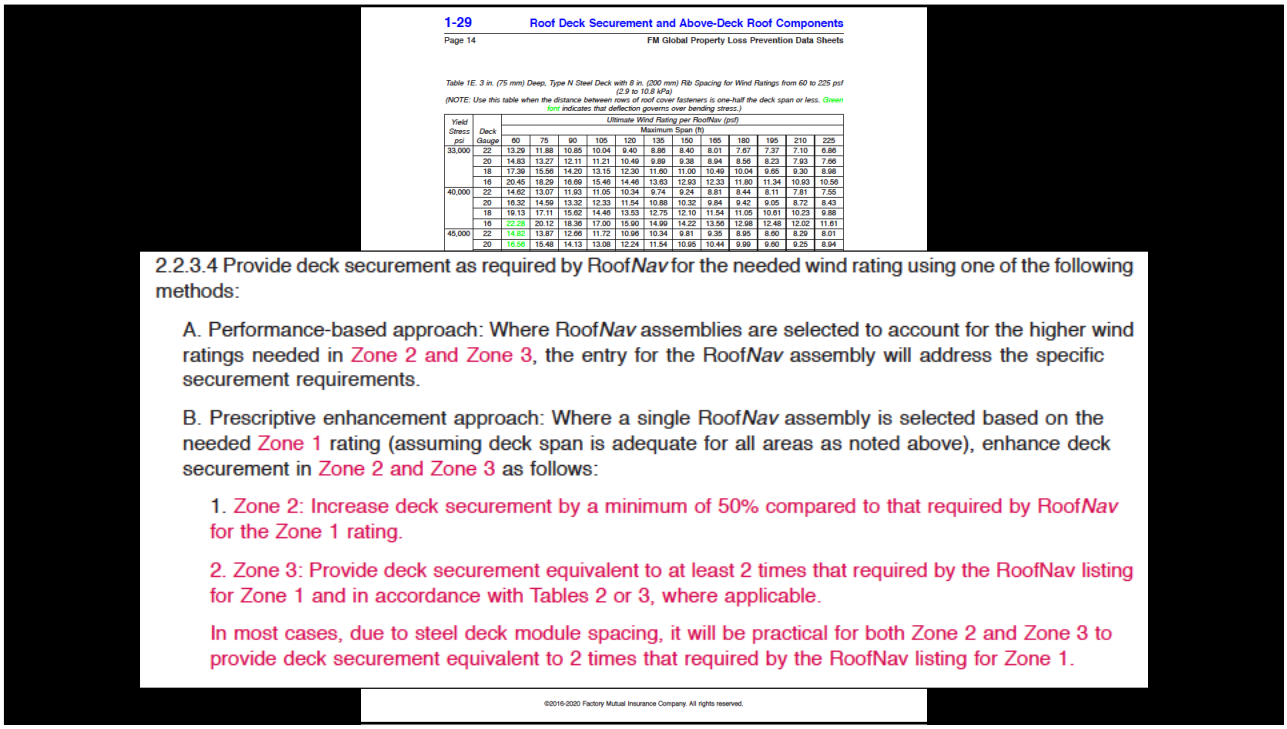

1-29 Roof Deck Securement and Above-Deck Roof Components

Page 14 FM Global Property Loss Prevention Data Sheets

Table 1E. 3 in. (75 mm) Deep, Type N Steel Deck with 8 in. (200 mm) Rib Spacing for Wind Ratings from 60 to 225 psf (2.9 to 10.8 kPa)

(NOTE: Use this table when the distance between rows of roof cover fasteners is one-half the deck span or less. Green font indicates that deflection governs over bending stress.)

Yield Stress psi	Deck Gauge	Ultimate Wind Rating per RoofNav (psf) Maximum Span (ft)											
		60	75	90	105	120	135	150	165	180	195	210	225
33,000	22	13.29	11.88	10.85	10.04	9.40	8.86	8.40	8.01	7.67	7.37	7.10	6.86
	20	14.83	13.27	12.11	11.21	10.49	9.89	9.38	8.94	8.56	8.23	7.93	7.66
	18	17.39	15.56	14.20	13.15	12.30	11.60	11.00	10.49	10.04	9.65	9.30	8.98
	16	20.45	18.29	16.69	15.46	14.46	13.63	12.93	12.33	11.80	11.34	10.93	10.56
40,000	22	14.62	13.07	11.93	11.05	10.34	9.74	9.24	8.81	8.44	8.11	7.81	7.55
	20	16.32	14.59	13.32	12.33	11.54	10.88	10.32	9.84	9.42	9.05	8.72	8.43
	18	19.13	17.11	15.62	14.46	13.53	12.75	12.10	11.54	11.05	10.61	10.23	9.88
	16	22.28	20.12	18.36	17.00	15.90	14.99	14.22	13.56	12.98	12.48	12.02	11.61
45,000	22	14.82	13.87	12.66	11.72	10.96	10.34	9.81	9.35	8.95	8.60	8.29	8.01
	20	16.56	15.48	14.13	13.08	12.24	11.54	10.95	10.44	9.99	9.60	9.25	8.94

2.2.3.4 Provide deck securement as required by Roof*Nav* for the needed wind rating using one of the following methods:

A. Performance-based approach: Where Roof*Nav* assemblies are selected to account for the higher wind ratings needed in Zone 2 and Zone 3, the entry for the Roof*Nav* assembly will address the specific securement requirements.

B. Prescriptive enhancement approach: Where a single Roof*Nav* assembly is selected based on the needed Zone 1 rating (assuming deck span is adequate for all areas as noted above), enhance deck securement in Zone 2 and Zone 3 as follows:

1. Zone 2: Increase deck securement by a minimum of 50% compared to that required by Roof*Nav* for the Zone 1 rating.

2. Zone 3: Provide deck securement equivalent to at least 2 times that required by the RoofNav listing for Zone 1 and in accordance with Tables 2 or 3, where applicable.

In most cases, due to steel deck module spacing, it will be practical for both Zone 2 and Zone 3 to provide deck securement equivalent to 2 times that required by the RoofNav listing for Zone 1.

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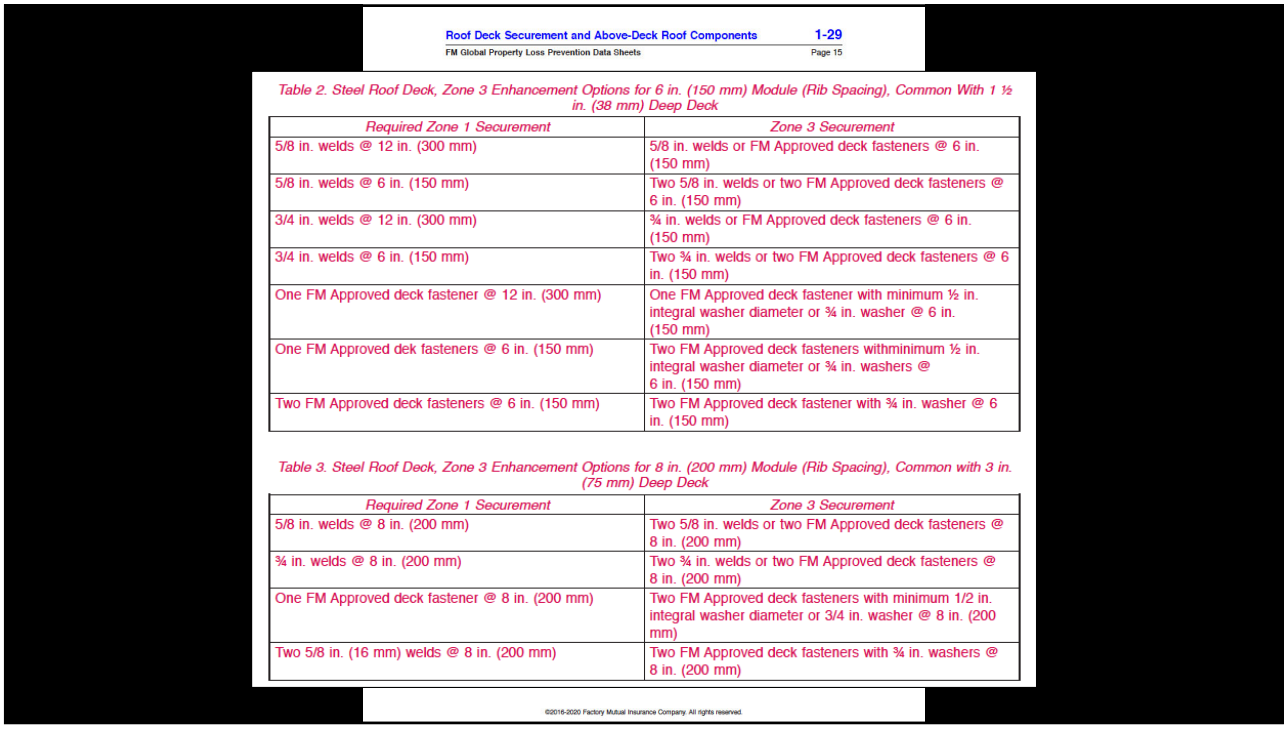

Roof Deck Securement and Above-Deck Roof Components 1-29

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Table 2. Steel Roof Deck, Zone 3 Enhancement Options for 6 in. (150 mm) Module (Rib Spacing), Common With 1 ½ in. (38 mm) Deep Deck

Required Zone 1 Securement	Zone 3 Securement
5/8 in. welds @ 12 in. (300 mm)	5/8 in. welds or FM Approved deck fasteners @ 6 in. (150 mm)
5/8 in. welds @ 6 in. (150 mm)	Two 5/8 in. welds or two FM Approved deck fasteners @ 6 in. (150 mm)
3/4 in. welds @ 12 in. (300 mm)	¾ in. welds or FM Approved deck fasteners @ 6 in. (150 mm)
3/4 in. welds @ 6 in. (150 mm)	Two ¾ in. welds or two FM Approved deck fasteners @ 6 in. (150 mm)
One FM Approved deck fastener @ 12 in. (300 mm)	One FM Approved deck fastener with minimum ½ in. integral washer diameter or ¾ in. washer @ 6 in. (150 mm)
One FM Approved dek fasteners @ 6 in. (150 mm)	Two FM Approved deck fasteners withminimum ½ in. integral washer diameter or ¾ in. washers @ 6 in. (150 mm)
Two FM Approved deck fasteners @ 6 in. (150 mm)	Two FM Approved deck fastener with ¾ in. washer @ 6 in. (150 mm)

Table 3. Steel Roof Deck, Zone 3 Enhancement Options for 8 in. (200 mm) Module (Rib Spacing), Common with 3 in. (75 mm) Deep Deck

Required Zone 1 Securement	Zone 3 Securement
5/8 in. welds @ 8 in. (200 mm)	Two 5/8 in. welds or two FM Approved deck fasteners @ 8 in. (200 mm)
¾ in. welds @ 8 in. (200 mm)	Two ¾ in. welds or two FM Approved deck fasteners @ 8 in. (200 mm)
One FM Approved deck fastener @ 8 in. (200 mm)	Two FM Approved deck fasteners with minimum 1/2 in. integral washer diameter or 3/4 in. washer @ 8 in. (200 mm)
Two 5/8 in. (16 mm) welds @ 8 in. (200 mm)	Two FM Approved deck fasteners with ¾ in. washers @ 8 in. (200 mm)

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***Structure* magazine**

March 2017

Reasons for few reported deck/joist failures to date:

- A majority of roofs have not seen ASCE 7 design uplift loads (no major hurricanes in 10+ years)
- Design uplift of deck-to-joist does not exceed the fasteners' safety factor
- Decks likely have actual yield strengths higher than the 33 ksi design yield strength (60 ksi vs. 33 ksi can increase deck flexural strength by about 70%)

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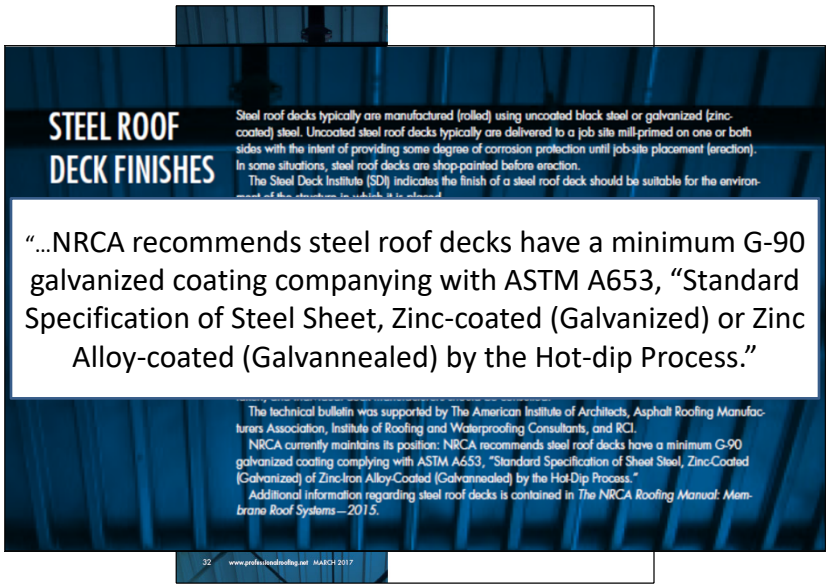
Professional Roofing

March 2017 – Sidebar, page 37



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

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

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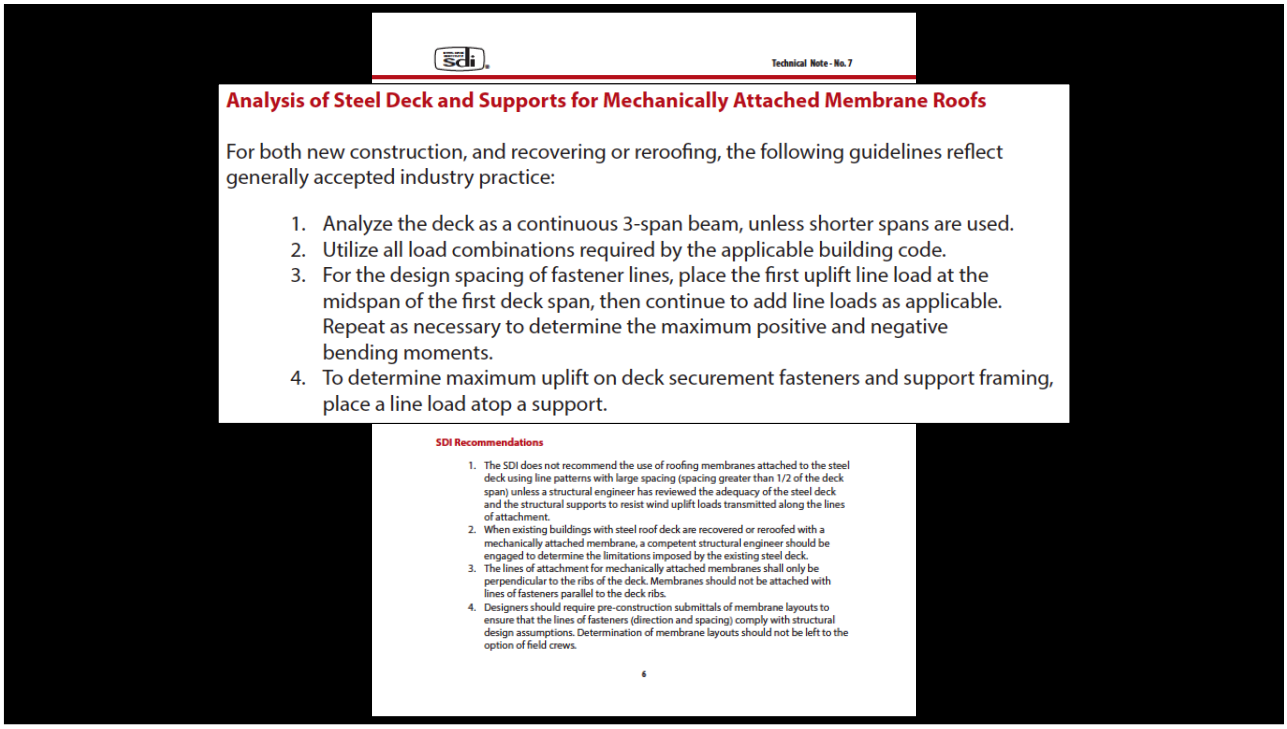

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Technical Note - No. 7

The steel deck bending and shear strength (resistance) and strength (resistance) of the fasteners attaching the deck to the supports are calculated using the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-16) and the *Standard for Steel Roof Deck* (ANSI/SDI RD-2017). These design strengths are dependent on the specified minimum mechanical properties (i.e. base steel thickness, yield and ultimate strength) for the roof deck, and should be lower than the strength determined by field-testing. Results of field-tests utilized to determine strengths which are dependent on the mechanical properties of the steel deck, such as pull-out or pull-over of a screw fastened through deck, must recognize the properties of the delivered steel may exceed the minimum limits required by the steel specification. Therefore, field-test results must be adjusted

SDI Recommendations

1. The SDI does not recommend the use of roofing membranes attached to the steel deck using line patterns with large spacing (spacing greater than 1/2 of the deck span) unless a structural engineer has reviewed the adequacy of the steel deck and the structural supports to resist wind uplift loads transmitted along the lines of attachment.
2. When existing buildings with steel roof deck are recovered or reroofed with a mechanically attached membrane, a competent structural engineer should be engaged to determine the limitations imposed by the existing steel deck.
3. The lines of attachment for mechanically attached membranes shall only be perpendicular to the ribs of the deck. Membranes should not be attached with lines of fasteners parallel to the deck ribs.
4. Designers should require pre-construction submittals of membrane layouts to ensure that the lines of fasteners (direction and spacing) comply with structural design assumptions. Determination of membrane layouts should not be left to the option of field crews.

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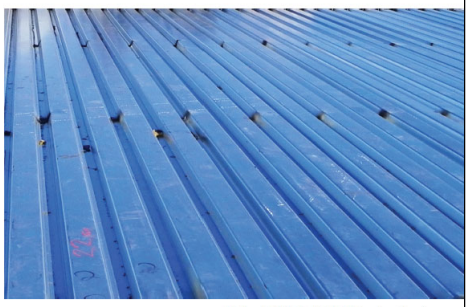
RESEARCH+TECH



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

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Professional Roofing
January 2020

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Steel roof decks are rarely attached to FM's guidelines

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SDI Roof Deck Design Manual, Second Edition

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Section 2.14 Mechanically Attached Single-Ply Roof Membranes

For both new construction and reroofing or recovering of existing roofs, mechanically attached single-ply roofing membranes are often used. As opposed to adhered membranes which are continuously adhered to the insulation board, and uniformly load the deck when loaded by wind uplift, mechanically attached membranes are attached using lines of mechanical fasteners at the membrane seams. These seams can be spaced from 4 foot to over 20 foot on center in some applications. Then loaded by wind uplift, these membranes load the steel deck with line loads that can increase the bending moment by several hundred percent over a uniformly applied uplift.

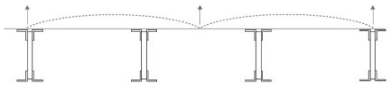

Figure 2.4 – Membrane Loading Deck

Some key points that the Designer should keep in mind.

1. The lines of fasteners must not be permitted to be placed parallel to the roof deck ribs. In this case, the deck resistance in reduced to that of a single rib, and failure of the steel deck is inevitable.
2. The Designer must consider the effect of the line loads on the steel roof deck and underlying framing, and design the deck and framing accordingly.
3. When reroofing or recovering an existing roof, strict attention must be given to the capacity of an existing steel deck that was originally designed for a uniform uplift load. A mechanically attached membrane may not be feasible.

SDI Technical Note 7, "Mechanical Attachment of Single-ply Roofing Membranes to Steel Roof Deck: Implications for Steel Deck Design" should be referred to for additional information.

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Mechanically Attached Membrane:

Mechanically Attached Membrane	$M_{n\,max} / \Phi M_n$	Moment Increase over Adhered Membrane	$M_{p\,max} / \Phi M_p$	Moment Increase over Adhered Membrane
Zone 1 (Interior)	0.86	430%	0.34	143%
N-S Perimeter in Zone 2 (Edge)	0.52	175%	0.42	109%
N-S Perimeter in Zone 3 (Corner)	0.80	179%	0.63	106%
E-W Perimeter, attached parallel to deck ribs	3.18	1065%	4.17	1065%

Observations:

1. A mechanically attached membrane greatly increases the flexural demand on the deck over an adhered membrane. Except where attached parallel to the deck ribs in the E-W perimeter, the 40 ksi WR deck has adequate flexural capacity. Lower strength 33 ksi deck may have been overloaded in flexure in Zone 1 and 3.
2. It is important that the membrane width be decreased in the edge zones as defined in ASCE 7. If the 10 foot membrane width was continued in the edge zones, the deck would have been overloaded in flexure in Zones 2 and 3.
3. Membrane width is important. A 12 foot membrane width, as opposed to the 10 foot width in this example, would have most likely overloaded the deck in flexure. Membranes much wider than 12 foot are currently in use.
4. The effect on deck securement to the support framing, and the uplift loads on the support framing, also need to be considered.
5. Deck formed from steel of higher strength than 40 ksi, or thicker gage, may be considered in new construction.
6. Careful analysis of existing structures being re-roofed or re-covered with a mechanically attached membrane, that originally had an adhered membrane, must be performed. Narrower membrane widths may be needed.

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NRCA's recommendations

Uniformly-loaded vs. non-uniform, linear pattern loaded steel roof decks

New construction:

- Structural engineer awareness of roof system design
  - Note load pattern and steel's yield strength on structural drawings and shop drawings
- Roof system designer awareness of steel roof deck design

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NRCA's recommendations – cont.

Uniformly-loaded vs. non-uniform, linear pattern loaded steel roof decks

Reroofing:

- Realize steel roof decks are not likely designed to current SDI, FM Global and FM Approvals' standards
- If steel deck design cannot be verified:
  - Use narrow fastener row/seam spacing (rows/seams ≤ joist spacing)
  - Use a uniform uplift loading roof system (BUR, MB, adhered single ply)

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Although roofing contractors sometimes are given the responsibility of inspecting and accepting steel roof decks to receive a new roof system, determining a roof deck's design adequacy is beyond the expertise of most roofing contractors.

This determination is best made during a project's design phase.

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Questions

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