

ROOF DECKS A TO Z

Part 17: Conventional Steel Decks

By Lyle D. Hogan, F-IIBEC, RRC, PE

images courtesy of Lyle D. Hogan

ABSTRACT

This is seventeenth in a series of articles examining various deck types. This installment, which is a revision/expansion of an article appearing 27 years ago in IIBEC Interface, explores some aspects of conventional steel decks that are likely to be encountered by the practicing roof consultant. Further information on this topic is available from resources such as the Steel Deck Institute (SDI), Factory Mutual, SPRI, and various roofing trade magazines.

The type of substrate discussed in this article, conventional steel deck, is called metal, fluted, corrugated, and ribbed decking. However, it will be referred to here as “steel” decking, in recognition of SDI (sdi.org) as an authoritative source on this topic. And to avoid confusion with metal form decks, acoustical decks, and ribbed metal roof panels, we will here explore only the traditional profile, which comprises the majority of roofing substrates in the United States.¹

There are volumes of technical guidelines for properly anchoring a roof covering to its substrate. When these guidelines are followed, the result is construction with improved wind resistance. Notably, attachment of the roof assembly requires that the decking be anchored properly. However, observations in the aftermath of major wind events and during roof removal projects indicate that we should not assume that anchoring is always done correctly.

It is futile to worry about insulation and membrane fastening patterns when the deck itself is incapable of resisting wind uplift loads. **Figures 1** and **2** depict conditions that were not caused by a roofing contractor but that led to premature (avoidable) failure of the installed roof. In the first example, wind-blown deck sheets had to be shaken and cut from trees, whereas the second example depicts loose decking revealed in the course of a tear-off project. In both cases, the decking had been improperly fastened to the support framing.

SIDELAP ATTACHMENT

Sidelap attachment (clearly absent in **Fig. 3**) is fundamental to steel deck construction. In years past, bituminous membrane splitting was directly linked to poor attachment of underlying components. This problem is critical in situations where membranes with low tensile strength were used, as was the frequent behavior with old built-up roofs constructed using asbestos felts.



Figure 1. It is futile to worry about insulation and membrane fastening patterns when the deck itself is incapable of resisting uplift loads. Here, deck sheets had to be shaken and cut from trees after a coastal wind event.



Figure 2. Loose decking revealed in the course of a tear-off project.



Figure 3. Inspection showed that sidelap attachment is absent here. The deck cannot perform as a shear diaphragm without sidelap stitching screws (or another connection method).

Without sidelap connection, the deck sheets can splay apart under loading—in a manner similar to tongue-and-groove wood if the tongues are cut away or are disengaged due to lumber shrinkage.

Sidelap stitching screws are necessary to create a horizontal shear diaphragm for the structure; the rationale is comparable to installing plywood at the corners of framed wood construction. A steel roof deck is fully capable of serving as a shear diaphragm if sidelap stitching is present. However, if sidelap stitching is not present, the deck is unrated for such performance. Customary sidelap connection is usually achieved by using self-drilling screws installed at a rate of two between any pair of supports; however, in seismic zones, it is not uncommon to see up to 10 screws between any pair of supports. Connection can also be achieved by button punching, and even by welding, although the vast majority of stitching is now done with self-drilling screws.

There are three plausible methods for attaching deck sheets to steel framing components: arc welding, driven fasteners, and powder-actuated fasteners. When executed with a uniform pattern, each of these methods can yield functional attachment.

Arc Welding

Arc welding is the most common method, and most specifications cite a 3/4-in. (19-mm) arc spot weld, seeking to obtain the ubiquitous 1/2-in. (13-mm) minimum effective weld size that



Figure 4. Complete “blow-through” of the top chord of joists is shown here. This reckless welding completely degrades the load-carrying capacity, and considerable rework will be necessary.

independent reports require for decking manufacturers having their product evaluated.²

Practitioners who have done any arc welding recognize that joining a thin-gauge material (deck sheets) to a stouter-gauge item (such as bar joists, shelf-angles, and the like) can be inherently difficult.³ This is the reason why weld washers may be required; they impart some added metal mass for achieving more uniform fusion of the pieces being joined. Regulating the amperage

can be challenging, and welds sometimes completely “blow through” the top chord of joists (Fig. 4). This outcome completely degrades load-carrying capacity, and considerable rework is necessary to correct the issue.

Another complication of arc welding can be “shorts” created where insulation of the welding cables has been breached. In this case, the cable tries to weld itself to the steel deck before effective working current reaches

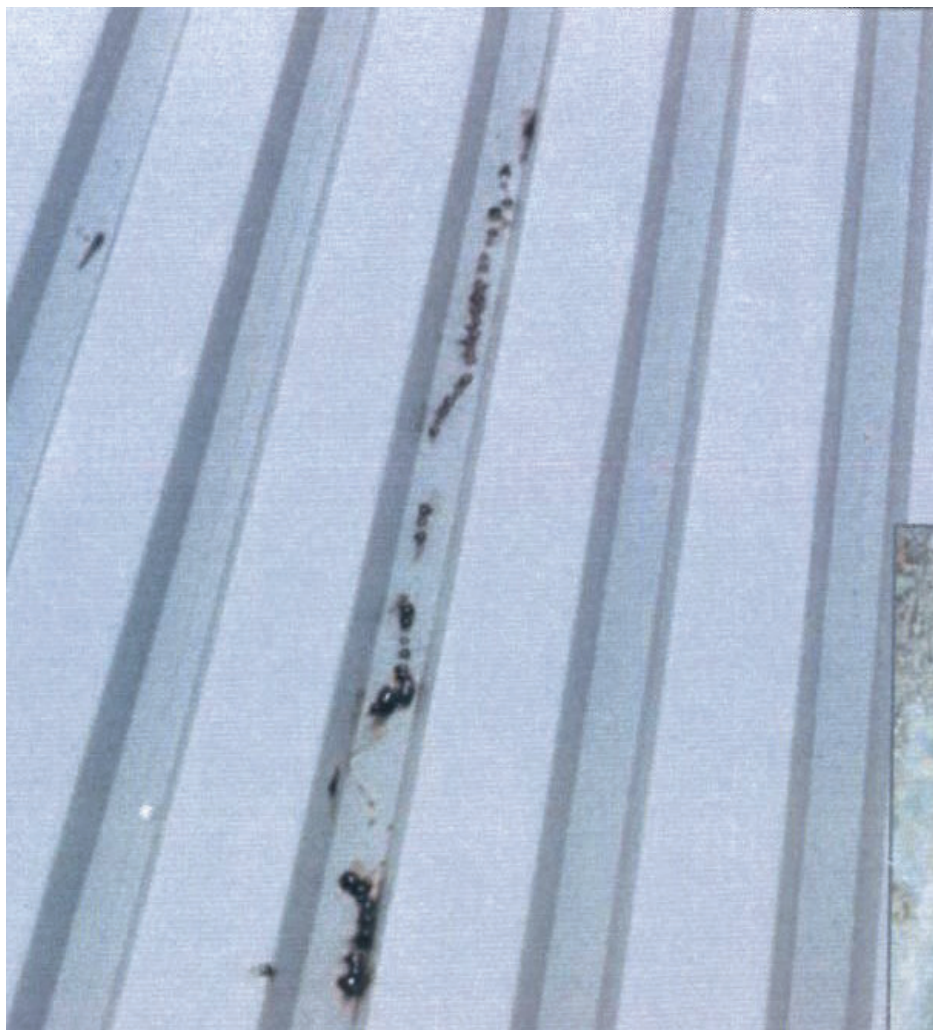


Figure 5. Where insulation of the welding leads has been breached, arc welding shorts can be created. In this case, the cable tries to weld itself to the steel deck before current reaches the stick. Weld fusion quality is seriously erratic with this condition.



Figure 6. Work of this nature (undersized welds) can quickly reveal the skill of the welder. When $\frac{3}{4}$ -in. (19-mm) weld is specified but the weld size is smaller than a dime (that is, less than 0.7 in. [18 mm]), corrective action for proper welding is required. This can mean going over most or all welds on a project with a second pass.

the stick (**Fig. 5**). Weld fusion quality can vary erratically under such conditions.

By using a chalk line, the welder can find the correct territory for welding (and, yes, the line can be seen from inside the welder's helmet). This technique can sharply reduce the "experimental welding" that can really pepper a new deck installation. Ideal welding results in a mushroom profile with penetration into, and accumulation above, the work surface. We are not building a watch here, but welding is also the least consistent manner of attachment and testing by striking the weld with a cold chisel can quickly reveal the skill of the welder. Such is the reason that special inspection is required for the welding of structural members in the building code. But back to the decking: when a $\frac{3}{4}$ -in. (19-mm) weld is specified, yet the welds can all easily hide under a dime (as shown in **Fig. 6**), it may be time to regroup.

Too many specifications fall short in this respect, but a weld is not finished until it has been wire brushed and painted with a rust-inhibiting primer. Welding might, at first, seem to be the least expensive method; however, the additional labor needed to finish the weld (and possibly correct substandard work) equalizes the cost among the two options explored in the following two sections: driven fasteners and powder-actuated fasteners.

Driven Fasteners

The use of self-drilling, hex-head screws is probably the next most popular method for attaching deck sheets to steel framing components. Positive attachment does not depend on the penetration and puddle welding; moreover, the attachment is finished when the fastener is tooled down, as there is no wire-brushing and painting to follow.

The working end of the fastener is a self-starter with tip geometry similar to a drill bit. The fastener is considered self-tapping because of the respective diameter of the drill point relative to the threaded shank. On several occasions, this author has been impressed by how sturdy underfoot a screw-attached deck is relative to those attached by other methods.

Powder-Actuated Fasteners

When discussing this fastening method, the correct adjective is not "power-actuated," as too many specifications and articles have indicated. All of the fastening methods involve "power" to some extent, but this one involves *powder*—as in gunpowder. The fastener (really a drive-pin) is actuated by a 0.22- or 0.27-caliber powder charge fired into the support framing. Proper

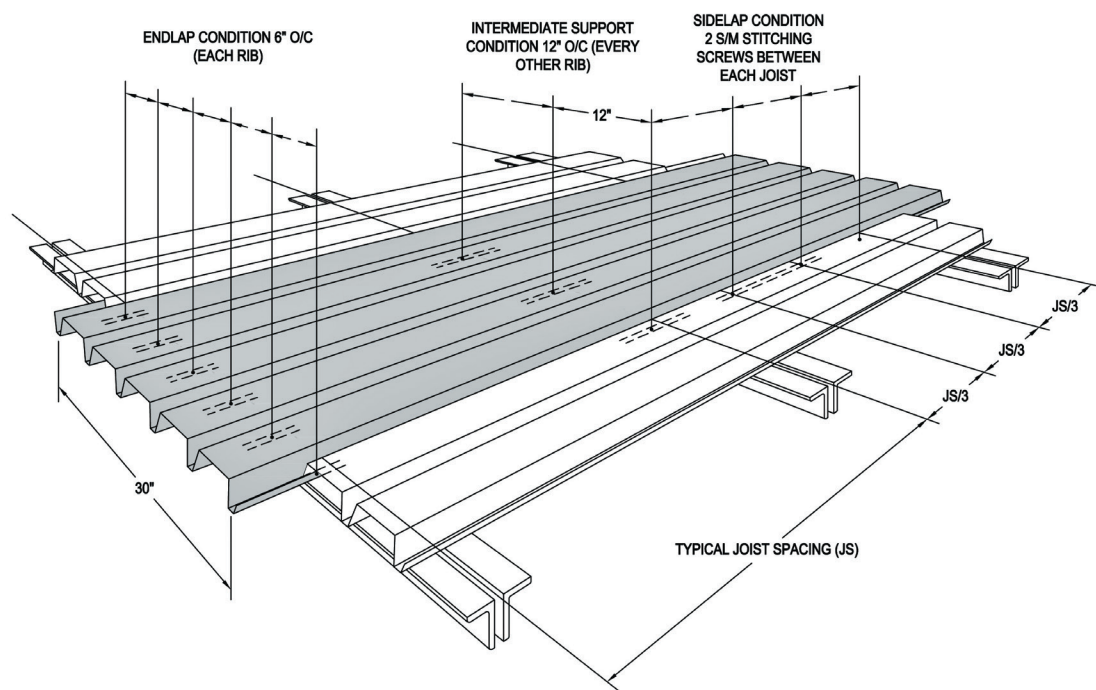


Figure 7. Three particular requirements should be well communicated in the project documents: the endlap condition, the sidelap condition, and fastening along the intermediate supports.

training is required before operating the equipment. Laaly⁴ has summarized this requirement as follows:

Operators become qualified only after they have received training from an authorized instructor on the safety points covered in ANSI (ANSI/ASSE A10.35), as well as PAT (powder-actuated tool) safety in general and proper safety procedures for the particular tools they may be using, as set forth by the individual manufacturer. The qualified operator receives a card identifying them, which is to be carried whenever they are using a powder-actuated system.

IDENTIFYING AND ADDRESSING SPECIFIC CHALLENGES

Most specifications will have some boilerplate language to the effect that commencing roof installation will constitute acceptance of the deck surface. Before commencing work in new construction, roofing contractors should inspect deck surfaces (from above and below).

The contractor reroofing a building may be tasked with repairing a damaged, rusty, or otherwise deteriorated steel deck. Three specific attachment requirements should be well com-

municated in the project documents (Fig. 7): the endlap condition, the sidelap condition, and the fastening along the intermediate supports (that is, at joists other than those occurring beneath an endlap). Specifications and drawings that do not communicate these requirements are incomplete.

Unframed openings have been found to be a leading contributor to deck failure in a number of collapses investigated by the author (Fig. 8). New openings into existing decks (or large openings into any deck) compromise the substrate. Cutting only two ribs out of a deck sheet will sharply reduce the load-carrying capacity, and cutting more than that can make the deck go as soft as a couch cushion. The new roof curb may return some measure of stiffness to the deck edges, but proper treatment uses four-sided framing to restore load-carrying capacity (Fig. 9); such an arrangement also prevents deflection under loading episodes such as periodic ponding water (large rooftop curbs are a drainage impediment during torrential rainfall), rooftop maintenance activities, and so on.

In similar fashion, drain installations will usually disrupt three deck ribs, or sometimes more. Therefore, sump pans or receiver pans are a necessary component for the openings. Moreover, a below-deck clamp is needed to draw the components together tightly

(Fig. 10). The work is not finished until these components are present. A receiver pan (Fig. 11) simply accommodates the drain bowl lip, whereas a sump pan (Fig. 12) recesses the device below the plane of the roof. Note that both of these types of pans spread the contact over a larger area than the drain bowl diameter. However, unless the pans are fastened with stitching screws to the decking at a close interval, underdeck framing will still be required, as outlined later in this article. The type of pan to be selected stems from the amount of incoming roof slope; that is, a shallow slope usually has some resid-

ual ponding at the drain (remember, the height of the top clamping ring), so a deeper recess is desirable.

Common protocol is for the steel erector to supply the sump pans, usually leaving them on the new deck surface, to be installed later by the plumbing contractor. Those two trades are hopefully orchestrated well enough that a roofing contractor does not bear responsibility for the pan omission when it is revealed later. Any roofing contractor would be wise to register a complaint if sump pans/receiver pans are not supplied on a project.

There are multiple rib configurations and several different depths (and gauges) available. The most common profile is 1½-in.-deep (38-mm) ribs, but other supplied modules include 3-, 4½-, 6-, and even 7½-in. ribs (75-, 114-, 150-, or 190-mm). Fig. 13 depicts a 3-in. (75-mm) deck that was quite sturdy under foot; the 6-in. profile shown in Fig. 14 was not as sturdy. A review of span tables in the SDI catalog will reveal that for any particular gauge, a wide-rib profile has greater load-carrying capacity than does the equivalent narrow-rib version. FM 1-28⁶ is a resource for, among other things, the terminology defining steel deck shapes and profiles.

Extensive wind research on roof systems has resulted in well-recognized zones of the roof where enhanced fastening is needed (perimeters,



Figure 8. Unframed openings can be a serious defect, especially at large penetrations. Cutting out five ribs (as shown here) will make the deck go as soft as a couch cushion.



Figure 9. The roof curb, if fastened properly, offers some measure of stiffness; however, proper treatment is a four-sided framing arrangement to restore load-carrying capacity and to prevent deck deflection under loading.



Figure 10. A below-deck clamp is needed to bring the drain components together tightly. A drain assembly is not complete until clamps are installed—both above and below. Note that four-side framing is missing at this opening.

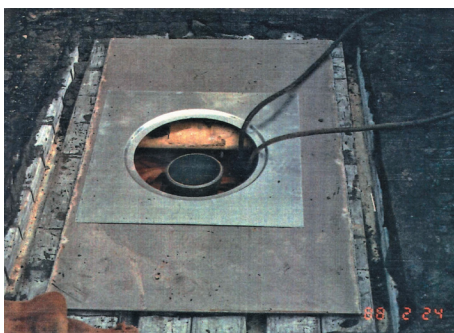


Figure 11. A receiver pan simply has a shallow “land” to accommodate the drain bowl lip. Here, old drains were being replaced during reroofing, and the receiver pan is coupled with a stout-gauge flat sheet because the deck opening was rather large.



Figure 12. A sump pan recesses the drain below the plane of the roof. Unless these pans are fastened with stitch screws to the decking at a close interval, underdeck framing will be required.

corners, etc.). However, if steel deck anchoring is not similarly embellished in these areas, there can still be wind loss of the entire assembly. Consider what may occur in the long direction of decking where sheets are attached at the building edge. A continuous shelf angle (**Fig. 15**) or other provision should be present at these edges to facilitate the necessary attachment. Note that the uplift load experienced by the decking for adhered membranes differs from that imparted by seam-fastened, one-ply systems. Depending on deck orientation, a single rib may carry uplift load that exceeds the strength of decks welds. These concentrated line loads should be avoided where possible.⁷

A hindrance for roofing contractors is a meandering line of deck installation (**Fig. 16**). Years ago, in situations where a single layer of relatively thin insulation was used, there was often a specification requirement that board edges must lie atop a bearing surface (that is, no cantilevered board edges). When deck sheets were poorly aligned, insulation would have to be cut and trimmed to comply with the project specification—a very frustrating way to build a roof. The National Roofing Contractors Association took a position on this matter decades ago. The horizontal alignment of steel deck sheets should meander no more than $\frac{1}{4}$ in. per 100 ft ($\frac{1}{4}$ in per 100 ft = 6.5 mm to 30.5 mm) (1:4800) of length.⁸ This is not a burdensome requirement, and a good deck installer routinely satisfies this parameter. Meandering is also not as problematic now with the use of thicker and



Figure 13. A 3-in. (75-mm) roof deck profile was selected for this medical testing facility. It was fastened well and was sturdy under foot.



Figure 14. The 6-in. (150-mm) rib profile shown here (in a decades-old building) was not as sturdy as the profile in Fig. 13; note that the sidelaps were elevated so they could be button-punched.



Figure 15. A continuous shelf angle (or other framing provision) should be present along the long direction of steel decking at perimeters. Otherwise, enhanced fastening of the roof assembly to the deck is of little value.

sturdier insulation boards—usually occurring in multiple layers. However, a meandering deck may well portend other aspects of substandard workmanship as outlined previously.

The roofing contractor may also be asked to rework a new roof installation that is “riding high” in areas (Fig. 17). This condition is especially noticeable on low-slope, smooth-surface membranes; however, the culprit is the four plies of metal at deck-sheet intersections. Unless deck installation began and continued with staggered ends (which would be most unusual), a four-layer thickness would be present at every converging corner. The presence of thin layers of earlier insulation would telegraph this condition upward through the membrane; surface undulations resulting from this arrangement are not the doing of the roofing contractor.

ASPECTS OF REROOFING

As discussed previously, loose decking may be encountered during reroofing, but only at the time of tear-off. This condition may be the outcome of poor work during the original installation, or detachment may result where insulation has been wet long enough to compromise whatever good attachment was present



Figure 16. A meandering deck may well portend that other aspects of work are of substandard quality.

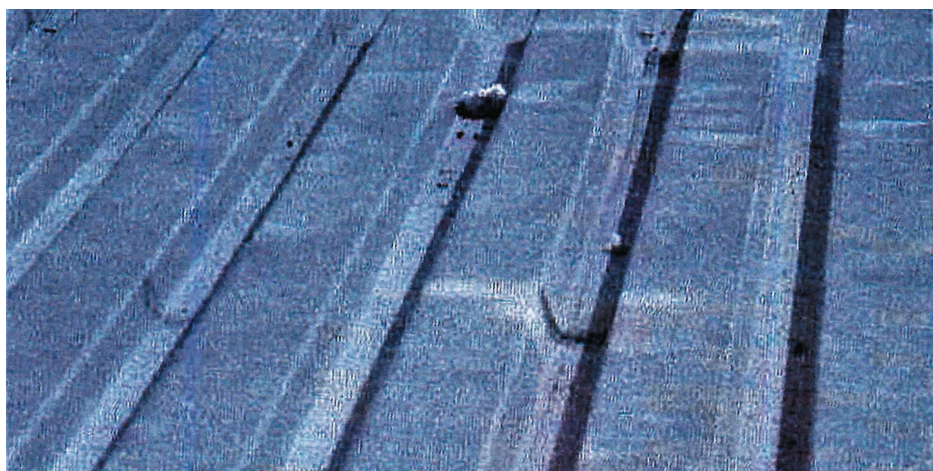


Figure 17. A new roof installation that is “riding high” can result from the four layers of metal present at every converging corner. Surface undulations resulting from this arrangement are not the doing of the roofing contractor.

originally. This issue underscores the need for wire brushing and priming the welds.

High electrical conduits in a building (Fig. 18) can also complicate a reroofing project. This is commonly traceable to shortcuts by an electrician who elected to forgo proper hangers (it is more convenient to situate conduits on top of the purlins). Deck screws that pierce conduits can prompt maladies such as injury to

the installing roofing mechanic and disruption of activities within a building. For instance, conveyor lines can be shut down, office wiring (such as lighting, computer service lines, and the like) can be interrupted, and even halon fire suppression systems can be inadvertently deployed. For several reasons, threaded deck screws should engage the high rib (more appropriately called the top flange) of a steel deck

(Fig. 19). This can be a challenge when installing a tapered insulation, but it can be managed with some forethought regarding the board layout.

Reroofing projects can present a number of issues that become the domain of the roofing contractor, particularly in the case of steel decks. Ideally, these matters will have been anticipated and handled with appropriate unit-price solicitations on the bid form. If not, the contractor should include a footnote (or, preferably, separate quotes) regarding unforeseen conditions.

CONCLUSION

The prudent designer will consider all of the foregoing topics in advance of a roofing project. A properly developed bid package will address these considerations with unit prices solicited for appropriate remedy. Meandering decks, undersized or unpainted welds, unframed openings, missing sump pans, loose decking, rusting, missing sidelap attachment, and high conduits should be dealt with by prompt communication among the contracting parties. If a designer of record is involved, all of these aspects should be addressed in Division 05 of the specification. 



Figure 18. High electrical conduits can seriously complicate a reroofing project. Deck screws that pierce conduits can prompt injury to the roofing mechanic and interruption of operations within a building.

Figure 19. Threaded deck screws should engage the top flange of a steel deck. While achieving this can be challenging with a tapered insulation system, it can be managed with some forethought regarding the board layout. Note also the line of sidelap stitching screws for this project in a seismic zone.



REFERENCES

1. "Insulfoam. 2012. Roof Decks." In *Insulfoam Roofing Manual*, 15-22. Puyallup, WA: Insulfoam. https://www.insulfoam.com/wp-content/uploads/2014/04/Roofing_Manual_print_small-rez.pdf.
2. Achter, J. L. 2016. "How Effective Are Your Arc Spot Welds?" *Structure Magazine* (July): 59. <https://www.structuremag.org/wp-content/uploads/2016/06/D-EngineersNB-Achter-July161.pdf>.
3. Canon, R. P. 2007. "Screw the Deck AND the Welds." *Interface* (October): 44-46. <https://iibec.org/wp-content/uploads/2016/04/2007-10-canon.pdf>.
4. Laaly, H. O. 1992. "Safety in Roofing." In *The Science and Technology of Traditional and Modern Roofing Systems*, 69-29. Los Angeles, CA: Roofing Materials Science & Technology.
5. American Society of Safety Engineers (ASSE). 2013. *Safety Requirements for Powder-Actuated Fastening Systems*. ANSI/ASSE A10.3—2013. Park Ridge, IL: ASSE.
6. FM Global. 2021. *Wind Design*. Property Loss Prevention Data Sheet FM 1-28. Park Ridge, IL: FM Global.
7. Graham, M. S. 2020. "Consider the Deck." *Professional Roofing* (January): 20-22. <https://www.professionalroofing.net/Articles/Consider-the-deck-01-01-2020/4597>.
8. Wallace, R. 1993. "Are FM Guidelines and Common Industry Practices at Odds?" *Professional Roofing* (July): 29.

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**Lyle D. Hogan,
F-IIBEC, RRC, PE**

Lyle D. Hogan, F-IIBEC, RRC, PE, is owner and principal engineer with Fincastle Engineering Inc. in Greensboro, North Carolina. He is a registered engineer, a Registered Roof Consultant, a Fellow of IIBEC, and an International Code Council structural masonry inspector. For more than 40 years, Hogan has evaluated,

designed, and administered roofing projects in half of the United States, using a variety of systems. His articles have appeared in numerous technical publications and conference proceedings.