

What to do with a Problem R-PANEL METAL ROOF SYSTEM

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Background

Most metal roofs are installed on pre-engineered metal buildings (PEMBs), supplied as a package from a metal building manufacturer. PEMB are installed for the most part by general contractors. The National Roofing Contractors Association (NRCA) surveys roofing contractor members and publishes data on the quantity of various types of roofs installed (Figure 1). Metal roofs account for 7.4% of all roof systems installed by NRCA members. The NRCA survey data does *not* include metal roofs installed by metal building contractors, either on new metal building projects or retrofit roof projects. Data gathered by the Metal Building Manufacturers Association (MBMA) include new metal building and metal retrofit roof sales. When

the MBMA data are combined with the NRCA data (Figure 2), the ranking of roof systems is adjusted slightly. The “Other” category includes shingle and shake products used on non-residential projects.

History of Metal Buildings

PEMBs, based on the rigid frame design, came into existence in their present form just prior to World War II. The rigid frame design, the basis for PEMB construction, was refined during WWII for use as barracks, hospitals, aircraft hangars, etc. In late 1945, manufacturers of PEMB looked for ways to use metal buildings to support the demands of the fast-growing, post-war economy. In the past 56 years, metal building construction has

New and Retrofit Roofing

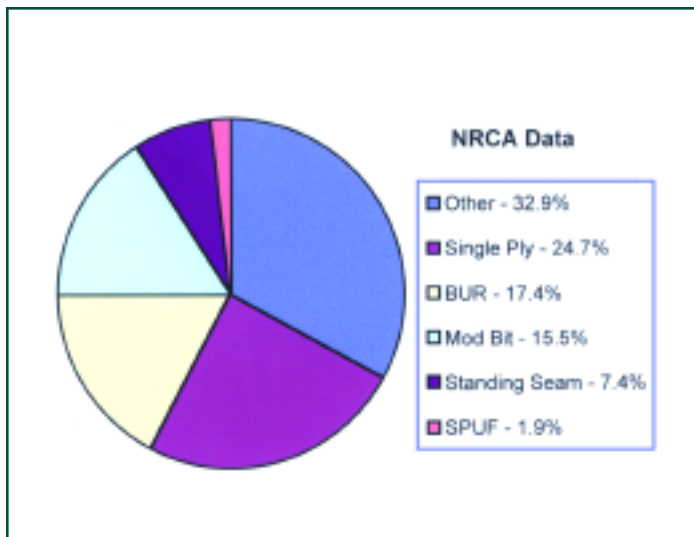


Figure 1 — NRCA Market Data (Year 2000).

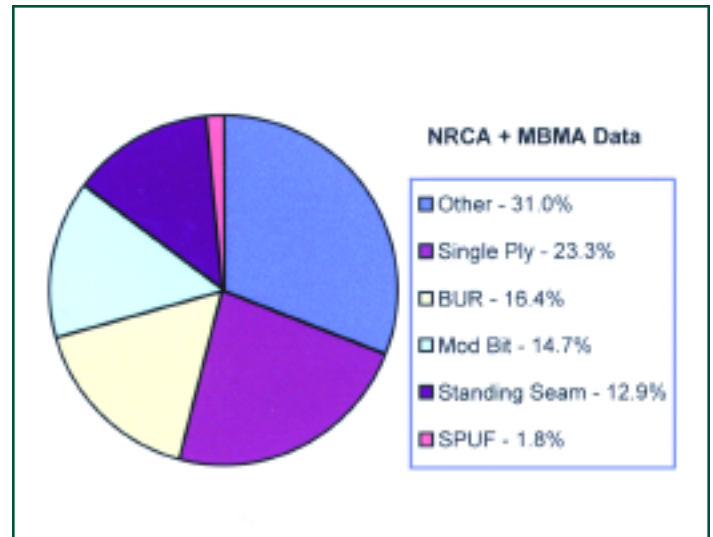


Figure 2 — Combined NRCA & MBMA Data (Year 2000).

grown to become commonly used for warehouses, manufacturing plants, distribution centers, schools, shopping centers, etc.

Metal building usage has grown to become almost two-thirds of all new one-story and two-story non-residential construction in the United States. Twenty-six gage (0.017" nominal thickness) coated steel, through-fastened R-panel type roofs have been the predominant roof type installed on PEMBs over the past 56+ years. A through-fastened R-panel, with typical 36-inch-wide coverage, has 1 to 1-1/2 inch tall trapezoidal shaped ribs, spaced at 12 inches on center. Estimates range from 30 to 50 billion square feet of existing through-fastened metal roofs in use on buildings in the United States today. What does this mean to the roof consultant? If one has not been on a problem through-fastened R-panel metal roof in the past, there's a good chance he or she will be called upon to provide consulting in the near future.

Typical Construction

On metal buildings, the 26-gage (or in some cases, 24- or even 28-gage) coated steel roof panels are typically installed over some type of 16-gage or heavier, cold-formed "Z" or "C" steel structural member. In some cases, the structural members supporting the roof panels are bar joists, wood joists, or a hybrid structural member. On buildings over 40 years old, the structural members might be hot-rolled channels or beams. The structural members are typically spaced at 5 foot on center, but the structural spacing can vary from as little as 2 feet to more than 6 feet.

Screw-type fasteners are used to secure the panels to the underlying structural members and to join (stitch) the panels together at their sidelap and endlap joints. The fasteners used to attach the panels to each other, at their lap joint, are commonly referred to as "stitch screws." Self-drilling screws are the predominant fastener used today. Some self-tapping screws requiring pre-drilling or pre-punching of the panels and structural members are used. On early metal buildings, the fastener of choice was the bolt and nut or the rivet. The most common fastener material is carbon-steel. Carbon-steel fasteners have zinc or cadmium plating to provide corrosion resistance. In some cases, stainless steel or aluminum fasteners are utilized. Carbon-steel fasteners provide a more consistent, secure connection because they cannot easily be over-driven (stripped out). Aluminum fasteners are typically the rivet or clamping type. Fasteners are typically spaced at 6 inches on center at the panel sidelaps and typically 12 inches on center for the panel-to-structural member attachment connection.

To weatherproof the fasteners, a gasketed washer is used under the fastener head. Until the early '90s, the gasket material was primarily Neoprene. After a few weather cycles, the Neoprene gasket would start to dry and crack until the fastener became a potential source of leaks. Today, more durable ethylene polypropylene diene monomer (EPDM) is available for the washer gasket material, although the less expensive Neoprene material is still widely used.

Waterproofing at the panel sidelap and endlap joints is accomplished with the use of field-applied tape or pumpable

butyl rubber sealants. Butyl sealants vary widely in quality. High quality (high percentage of butyl rubber vs. chalk filler material) sealants can last as long as 20+ years while lower-quality sealants will last as little as a few years before losing elasticity and contributing to leak problems.

Metal Roof Problems

When an existing metal roof has problems, the fix is typically not simple and, in most cases, can be quite expensive. Problems can run the gamut from poorly designed details, to incorrectly installed materials, to use of inferior quality materials.

Figures 3 through 6 show typical metal roof problems:

- Figure 3 – Poor panel alignment leads to poor fit-up of the panel closure.
- Figure 4 – Pipe penetration blocks water between panel ribs.



Figure 3 — Poor panel alignment leads to poor fit-up of the panel closure.

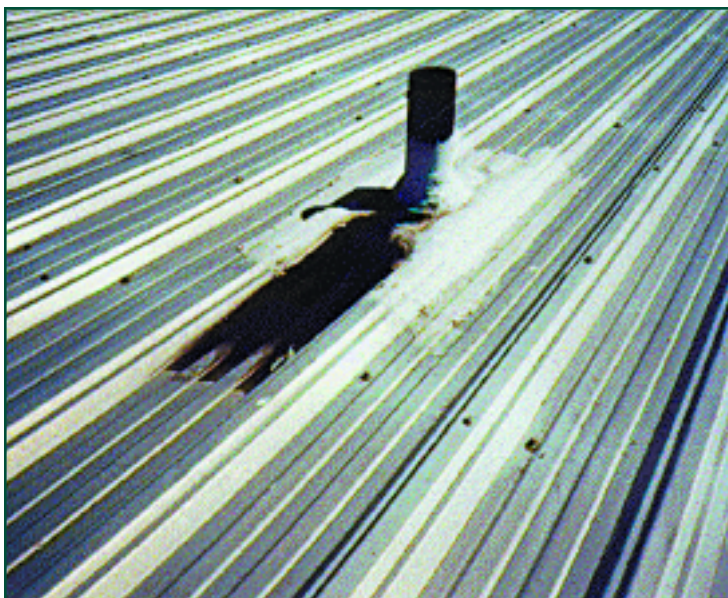


Figure 4 — Pipe penetration blocks water between panel ribs.



Figure 5 — Curb penetration has exposed screws and ponded water.

- Figure 5 – Curb penetration has exposed screws and ponded water.
- Figure 6 – Poor roof transition design, detailing and installation.

Typical metal roof problems:

- Poor design and detailing used for trim, flashing, and penetration conditions.
- Inadequate slope – poor drainage.
- Panels installed in an out-of-module alignment – poor fit-up of panels and closures.
- Inadequate provision for thermal movement of panels and flashings.

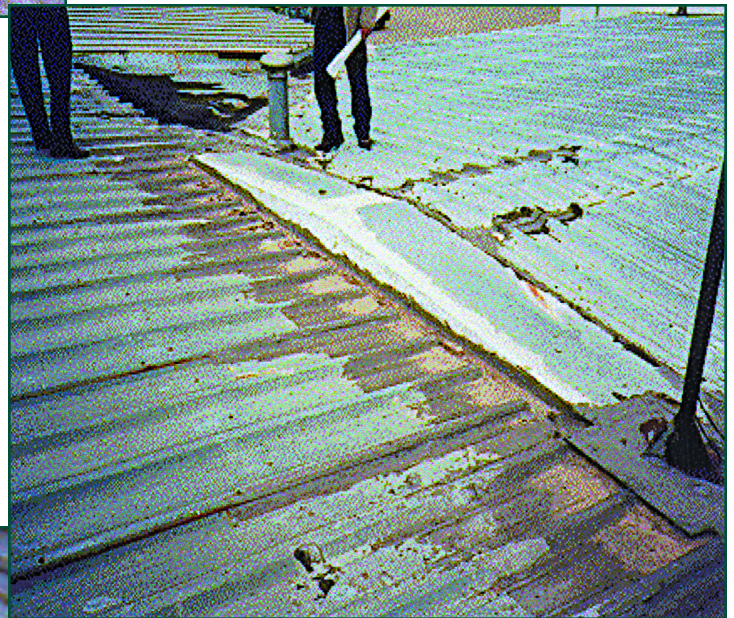


Figure 6 — Poor roof transition design, detailing, and installation.

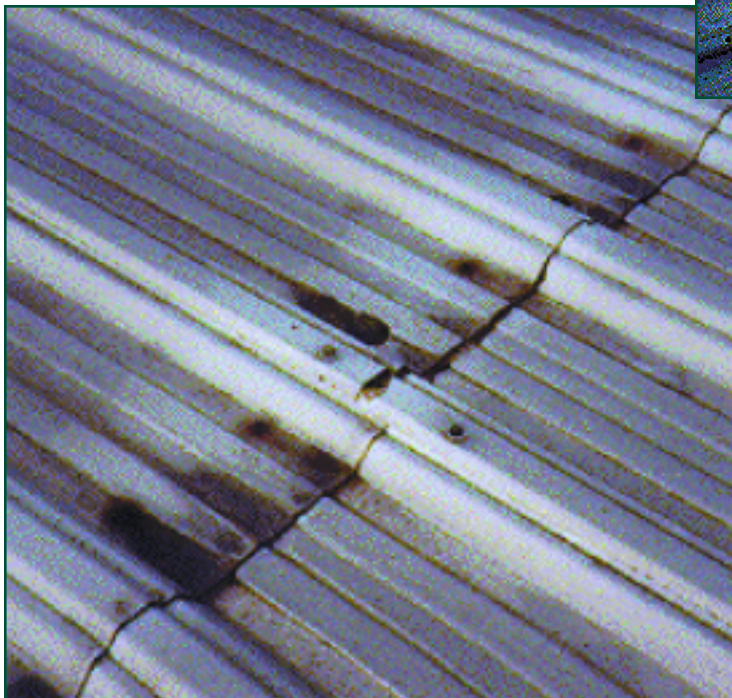


Figure 7 — An out-of-module installation is the result of poor quality installation.

- Poor installation quality – bad workmanship.
- Poor material quality – inferior quality of materials used.
- Improper repairs and fixes used.
- Abuse and neglect of the roof by owners.

An example of out-of-module installation, as seen in Figure 7, is the result of poor quality installation. Metal panels have a defined width of coverage. For through-fastened R-panels, this coverage is typically 36 inches. However, a 36-inch coverage panel can be made to cover more or less than the 36-inch defined coverage. When this happens, the installed panel is described as being “out-of-module.” Out-of-module panel installation causes problems due to poor fit-up of panel lap joints, closures, and flashings. Long-term problems can occur due to restricted panel movement. Roof weathertightness is then dependent primarily on sealants filling large gaps between panels, closures, and flashings.

Out-of-module installation and misalignment of panels sometimes go hand-in-hand. Figure 8 shows a standing seam roof that has been installed out-of-module and been misaligned as evidenced by the changes in direction of the panel seam.

Why aren't metal roof problems easy to fix? The easiest and least expensive solutions are applied to the surface of the roof. Replacing problem fasteners and sealants, applying surface roof coatings, and overlaying the existing roof with a new roof are all relatively straightforward solutions. However, to repair the existing roof, improperly installed panels, flashings, penetrations, etc. must be disassembled and reassembled to provide a long-term, weathertight solution. When weighed against the potential for business interruption, the “repair” of the existing roof becomes less attractive than a roof overlay solution.

Pros and cons of metal roof solutions

In order to evaluate the suitability of various metal roof solutions, existing conditions must be investigated. The condition of the existing roof must be evaluated for the amount and severity of corrosion (on both top and bottom panel surfaces). The panel-to-structural member attachment must also be evaluated for structural integrity.

Warning: Care should be exercised when inspecting any roof, because there are fall hazards at the edge of the roof and even at the interior of the roof. The interior roof hazard is the potential to fall through a rusted, deteriorated metal panel. This is especially true of lighter, 28- or 26-gage metal panels. Coatings can conceal roof panel deterioration as well as make translucent fiberglass panels difficult to detect.

The thickness and condition of any existing insulation should be evaluated for the:

- Condition and location of the vapor retarder (insulation facing – most likely vinyl).
- Presence of moisture in the insulation and/or on the bottom side of the panel.

A dewpoint analysis based on the building usage should be performed to determine the proper amount of insulation required, combined with the location of the vapor retarder.



Figure 8 — A standing seam roof that has been installed out-of-module and also has been misaligned as evidenced by the changes in direction of the panel seam.

Important note: PEMB designs are optimized for the original intended loads. PEMB designs *do not* provide capacity for the added dead load of future roofing materials. Any reroofing of a PEMB should include analysis of the current system by a qualified structural engineer familiar with PEMB design assumptions and construction. Changes in the American Iron and Steel Institute (AISI) Cold-formed Steel Design Manual (CFSDM), 1996 latest edition, have reduced the capacity of cold-formed steel purlins from the previous 1980 and 1986 editions. Therefore, an existing purlin that worked using the 1980 or 1986 edition of the AISI CFSDM will typically not support the same loads when designed with the 1996 edition of the AISI CFSDM.

Model building codes include very little, if anything, about retrofitting metal roofs or metal buildings. However, the 1997 Uniform Building Code contains the following chart in the “Appendix to Chapter 15 – Reroofing.”

Figure 9, Table A-15-A, “Allowable Reroofs Over Existing Roofing,” indicates that for a

**TABLE A-15A—ALLOWABLE REROOFS OVER EXISTING ROOFING
(Inspection and Written Approval Required Prior to Application)**

EXISTING ROOFING	NEW OVERLAY ROOFING							
	Built Up	Wood Shake	Wood Shingle	Asphalt Shingle	Tile Roof	Metal Roof	Modified Bitumen	Spray Polyurethane Foam
Built Up	Yes	NP	Yes (3:12)	Yes (2:12)	Yes (2.5:12)	Yes	Yes	Yes
Wood Shake ¹	NP	NP	NP	NP	Yes ²	Yes ²	NP	NP
Wood Shingle ¹	NP	Yes ³ (4:12)	Yes ⁴	Yes ⁴	Yes ²	Yes ²	NP	NP
Asphalt Shingle ¹	NP	Yes ³ (4:12)	Yes ⁴ (3:12)	Yes	Yes (2.5:12)	Yes	Yes	NP
Asphalt over Wood	NP	NP	NP	Yes	Yes ²	Yes ²	Yes	NP
Asphalt over Asphalt	NP	NP	NP	Yes	Yes	Yes	Yes	NP
Tile Roof	NP	NP	NP	NP	NP	NP	NP	NP
Metal Roof	NP	NP	NP	NP	NP	Yes	NP	NP
Modified Bitumen	Yes	NP	Yes (3:12)	Yes	Yes (2.5:12)	Yes	Yes	NP

NP = Not Permitted.
 Note: (Minimum Roof Slope)
¹See Section 1515.2 for specific requirements.
²Board and batten leveling system must be firestopped in accordance with Section 1516.3.
³One layer 18-inch (457 mm) Type 30 nonperforated felt interlaced between shake courses required.
⁴Type 30 nonperforated felt underlayment required for reproofing.

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Figure 9 — Table A-15-A from the 1997 Uniform Building Code.

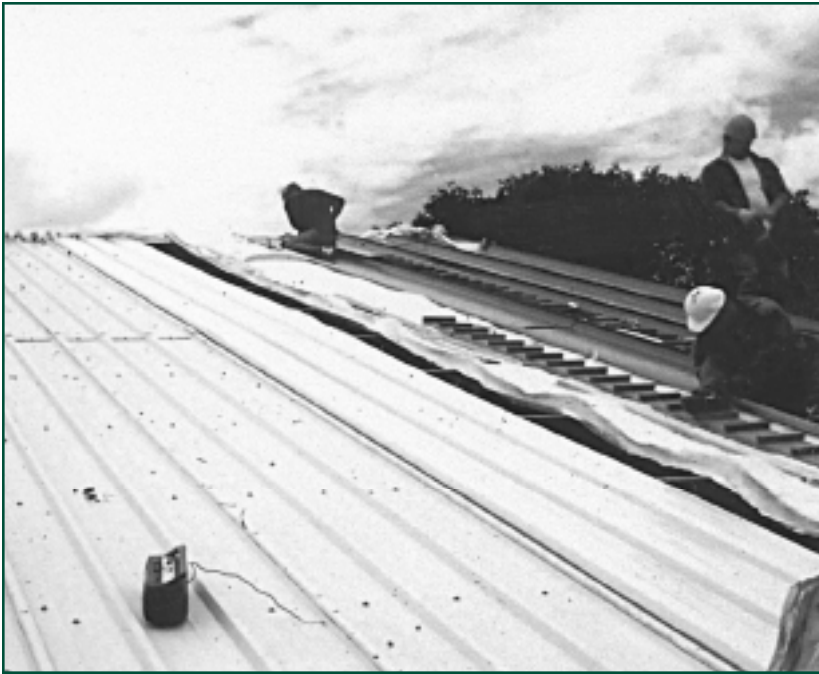


Figure 10 — A through-fastened R-panel roof (light-colored panel) being removed.



Figure 11 — A new standing seam roof (dark-colored panel) being installed from the right.

metal roof, the only allowable retrofit is another metal roof. To help explain the metal roof retrofit restriction, ask yourself, “Is a 26 gage through-fastened R-panel or 24 gage standing seam panel an adequate supporting structural deck for the application of conventional roofing materials?” Almost every conventional roof weathertightness warranty contains an exclusion for “excessive building or structure movement.” As we review the pros and cons of the various metal roof overlay solutions, keep this consideration in mind.

Solutions for leaking or deteriorating metal roofs come in many shapes, sizes, and costs. The pros and cons of each solution must be evaluated against the overall cost, expected service life, compatibility with the PEMB, and suitability of the materials for the application.

Available through-fastened R-panel metal roof solutions are:

- Tear-off and replace the existing roof.
- Coat the existing roof with:
 - elastomeric (acrylic- and urethane-based) coatings for waterproofing.
 - asphalt-based coatings containing aluminum to inhibit rust.
- Overlay the existing roof with:
 - sprayed polyurethane foam (SPUF).
 - a single ply membrane roof.
 - a plywood deck with various conventional roof systems applied.
 - a metal retrofit using a through-fastened R-panel roof or standing seam roof.

Tear-off and Replacement

Tear-off and replacement of the existing roof adds little if any additional weight. However, in most cases, a through-fastened R-panel roof cannot be replaced with a standing seam roof. The PEMB design takes advantage of the through-fastened R-panel roof to help brace the top flange of the purlins. Also, a through-fastened R-panel roof might have been used as a wind diaphragm similar to a structural roof deck. A standing seam roof will not brace the top flange of the purlins and cannot act as a wind diaphragm.

During tear-off and replacement, safety is a major consideration while working over open structural members. Also, the building contents and/or operations are much more susceptible to damage and/or interruption due to weather. Figures 10 and 11 show a through-fastened R-panel roof (light-colored panel) being removed and a new standing seam roof (dark-colored panel) being installed from the right. The light material between the old and new roof panels is the new fiberglass blanket insulation.

Of course, a new through-fastened R-panel roof could be used to replace the old through-fastened R-panel roof without affecting the PEMB. In order to evaluate a tear-off and replacement solu-

tion using a standing seam roof, a structural engineer should check the PEMB design, especially the cold-formed purlins. It is always prudent to have any existing building checked by a structural engineer prior to any type of roof work being done.

Roof Coating

The weight of a coating adds minimal dead load weight to the existing roof. The application of coatings can be done with

spray equipment, brushes, or rollers, giving the contractor flexibility. Coatings come in a variety of colors. White coatings are reflective, providing an energy benefit in summer (cooling load) months. Most coatings have good flexibility and elongation properties to accommodate movement and thermal stress. There are many different coatings to address leaks and rusting of metal panels. Acrylic-based elastomeric coatings are popular for addressing leak problems and asphalt-based coatings containing aluminum are popular as a rust inhibitor.

Important note: Any coating over integral skylight panels or deteriorated panels creates a safety hazard for foot traffic on the roof.

The success of a coating application is dependent upon the condition and surface preparation of the existing panel to create proper coating adhesion. If a coating loses adhesion, the resulting delamination of the coating from the panel surface can allow moisture to become entrapped, resulting in an accelerated deterioration of the existing panel. To properly prepare the roof surface for the application of the coating, any foreign material must be removed. Foreign material can include surface-applied sealing products, previous coatings, oxidation (steel, aluminum, zinc, etc.), loose paint, etc. The applicator must be skilled not only in the proper application methods for the coating, but also in the permissible environmental conditions (temperature, humidity, wind, etc.) necessary for successful application.

Figure 12 shows an attempted fix using asphalt-based products that must be fully removed before application of an elastomeric



Figure 12 — An attempted fix using asphalt-based products that must be fully removed before application of an elastomeric type coating.

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type coating. *Figure 13* shows failure (bleed-through of underlying material) of an elastomeric coating due to improper surface preparation (asphalt products not properly cleaned from the roof surface).

Most coatings can accommodate uniform panel thermal movement. However, movement concentrated at panel lap joints and flashings can exceed the coating's allowable elongation. Excessive vertical deflection from live loads (foot traffic, equipment, etc.), snow loads, or even horizontal deflection from wind loads can exceed the allowable elongation of the coating system. Coatings typically will not span holes or gaps in the existing panel. In most cases, this can be addressed by imbedding a reinforcing fabric in the coating. The reinforcing fabric typically has little elongation, reducing the allowable elongation of the installed coating system.

Sprayed Polyurethane Foam

Sprayed polyurethane foam (SPUF) is a two-part chemical compound that is mixed at the point of application on the roof. SPUF provides a lightweight, thermally efficient roof system that is easily applied with spray equipment. Adhesion of SPUF is typically good to many types of substrates. The foam can be sprayed to vertical surfaces (parapet walls and curbs) and sloped surfaces as well as applied horizontally. A protective coating must be applied to shield the foam from the attack of ultraviolet light. Many protective coating options are available for application onto the foam. SPUF relies on the integrity and stiffness of the existing "roof deck" to provide structural support.



Figure 13 — Failure (bleed-through of underlying material) of an elastomeric coating due to improper surface preparation.

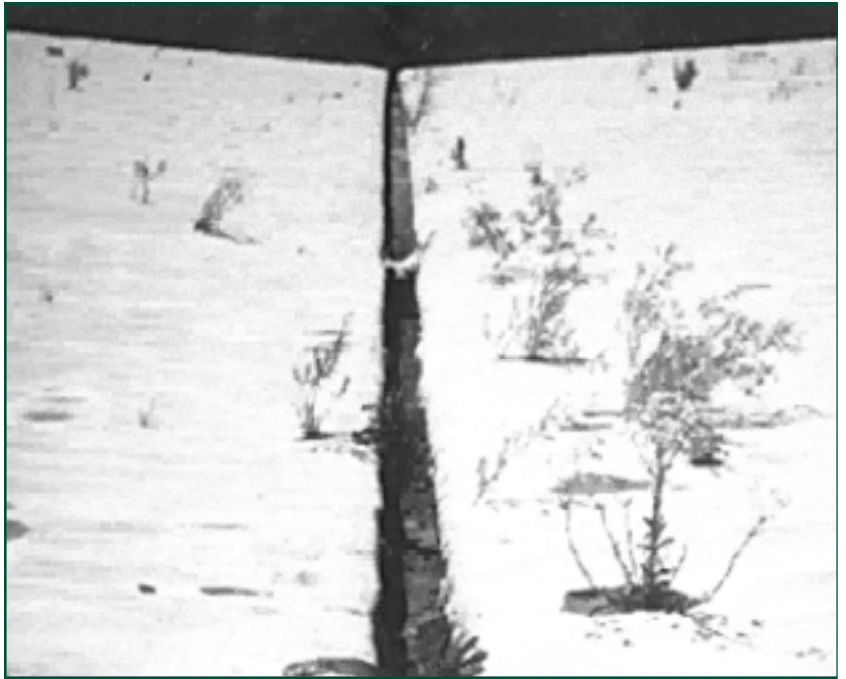


Figure 14 — An interior gutter between two metal buildings.

The success of an SPUF application is dependent on the condition of the existing panel (structural integrity) as well as proper, allowable environmental conditions (temperature, humidity, wind, etc.). Outside of the Southwest, much of the U.S. has few available days with weather conditions that fall within the published SPUF application guidelines. The applicator must be extremely careful in windy conditions, as airborne polyurethane foam can adhere to almost any surface.

Improper application, coating over foreign material, and other factors can introduce voids into the foam. These voids can become the vehicle through which moisture enters and becomes entrapped, resulting in accelerated deterioration of the supporting panel. SPUF can accommodate little movement (thermal or deflection) without damage. Isolating the existing panel (roof support substrate) from temperature fluctuations is key to avoiding damage from thermal movement. Applying foam over integral skylight panels creates a fall hazard. SPUF is susceptible to attack from birds, animals, and plant growth.

Figures 14 and 15 show a through-fastened R-panel roof with SPUF applied. *Figure 14* shows an interior gutter between two metal buildings. *Figure 15* shows the through-fastened R-panel rib pattern through the applied foam.

Single Ply Overlay

Single-ply membrane systems are available in a wide variety of materials (EPDM, TPO, PVC, etc.) and in several configurations (ballasted, adhered, and mechanically fastened). However, the application of a single-ply membrane over an existing metal roof typically utilizes a reinforced single ply membrane either mechanically fastened to the underlying, supporting



Figure 15 — The through-fastened R-panel rib pattern through the applied foam.

structural members or to the existing panel. PEMB purlins typically are spaced at 5'-0" on center; however, on steeper pitches, the spacing can be 5'-3" (for a 4:12 slope) or more. It is recommended that a registered professional engineer verify the design and attachment of the single ply system to the PEMB. Using the 26-gage through-fastened R-panel roof as the only attachment for a single ply membrane overlay is not recommended.

Single ply membrane systems are relatively easy for contractors to install, and they require little or no specialized equipment. However, on steep slopes, heat welding can become more difficult to accomplish correctly. White membranes are reflective, providing an energy benefit in summer months. Because the single ply membrane sheet will be mechanically fastened at the existing purlins, the sheet width will be 5 to 6 feet wide. While un-reinforced single ply membranes can provide as much as 200 to 300 percent elongation, reinforced membranes provide 10 percent or less elongation. The elongation of the single ply membrane must be capable of accommodating the expected thermal and wind movement of the PEMB and the metal roof. *Figures 16 and 17* show a 26 gage through-fastened metal roof with a two-layer insulation system and a single ply membrane roof system.

The application of a single ply membrane overlay requires that a board insulation product (1 to 1-1/2" thick, depending on the roof panel rib height) be used to fill the area between the ribs of the existing roof panel. A continuous layer of insulation board is then applied over the panel ribs and secured to the underlying panel using insulation plates and screws. These added holes from the insulation fasteners provide additional moisture entry points if the single ply membrane leaks. If polystyrene insulation is used in the assembly, the fire rating should be investigated. Edge details require the installation of wood blocking to adequately secure the edge flashings and terminations. The

weight of a single ply overlay system, including 2.5 inches of rigid insulation, will add approximately 1.25 pounds per square foot of dead load to the roof.

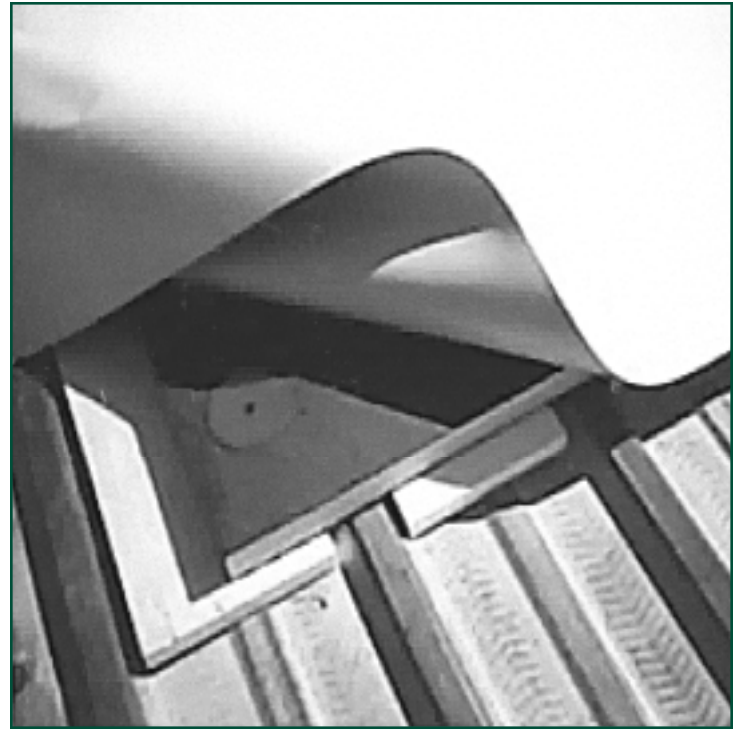
Plywood Overlay

A plywood or oriented strand board (OSB) deck, minimum 7/16-inch thick, is used as the base for many types of metal roof retrofit systems. In many cases, this wood deck is used as the base to install a modified bitumen roof system.

Nominal 1/2-inch thick wood deck adds approximately 2 pounds per square foot of dead load while nominal 3/4-inch thick wood deck adds approximately 3 pounds per square foot of dead load to the PEMB. The modified bitumen system base and cap sheets weigh 1 pound per square foot each for a total added weight (with a 1/2-inch nominal wood deck) of 4 pounds per square foot. Metal buildings typically have little, if any, capacity to carry this added load.

Wood decks are very stiff compared to a 26-gage metal through-fastened R-panel roof or a 24-gage standing seam panel. When added to a PEMB, a stiff, wood roof deck can concentrate stresses in unintended areas of the metal building. Metal buildings move differentially. When subjected to horizontal wind loads, a metal building will move (deflect) less at the stiffer rigid frame than at the more flexible z-purlins in between the rigid frames. The opposite occurs when thermal loads are imposed. Stiffer rigid frames move more under thermal loads than the more flexible z-purlins that span between the rigid frames.

Manufacturers of modified bitumen and asphalt built-up roof products recommend expansion joints (roof area separators) every 150 to 200 feet. On a metal roof this would require wood blocking to frame the roof expansion joint. These joints must be worked around the existing through-fastened R-panel roof ribs

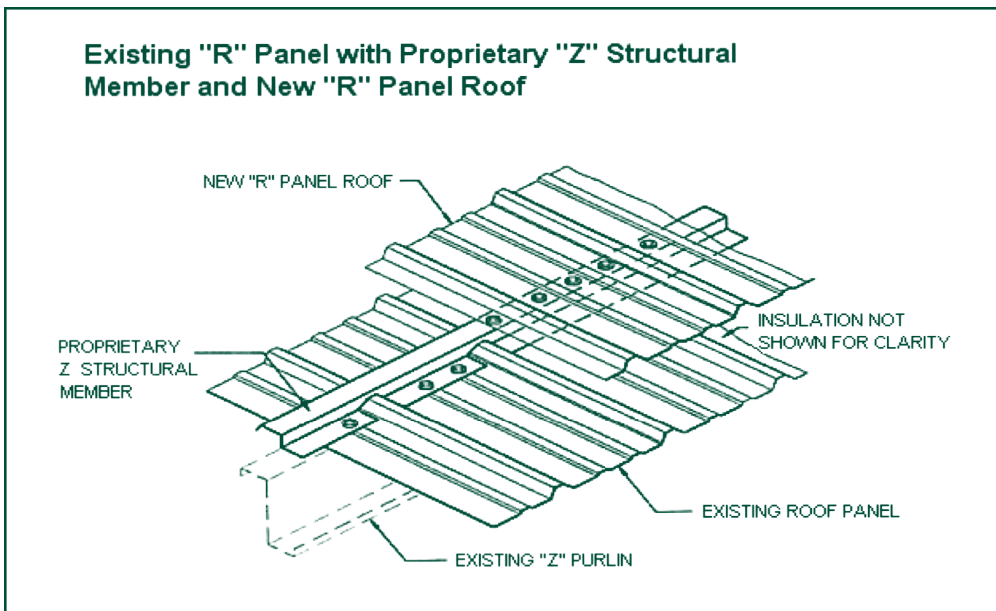


Figures 16 and 17 show a 26-gage through-fastened metal roof with a two-layer insulation system and a single ply membrane roof system.

located typically 12 inches on center. Modified bitumen systems can be secured with asphalt (hot mopped), torching, or cold adhesives. Hot asphalt and open torches introduce burn, fume, and fire hazards, both to the installation process and the building itself. Cold applied modified bitumen systems eliminate most of the fire and fume hazards associated with torches and asphalt kettles.

Metal Roof Overlay

A metal roof overlay can utilize either a through-fastened R-panel roof or standing seam roof as the new roof system. The overlay can also incorporate a new structural member directly over, and attached to, the existing structural member. This new structural member can serve as the support for the new roof and also create the depth necessary to add the desired amount of new fiberglass blanket or rigid board insulation.



NEW THROUGH-FASTENED R-PANEL ROOF VERSUS STANDING SEAM ROOF OVERLAY

How do you determine whether to use a through-fastened R-panel metal roof system or a standing seam metal roof overlay? The criteria to evaluate are the:

- 1) Desired longevity and serviceability of the new roof system.
- 2) Spacing of the underlying structural members.
- 3) Desire for added insulation.
- 4) Length of the panel run; R-panels have limited expansion/contraction capability.
- 5) Slope (pitch) of the existing structure.

Figure 18 — Existing "R" Panel with proprietary "Z" structural member and new "R" panel roof.

1) Longevity and Serviceability

- Depending on the panel system, a through-fastened R-panel metal roof can have a service life of up to 10 years. The panel finish can last well in excess of 10 years; however, exposed fastener gaskets, panel lap joints, thermal movement, penetrations, etc. can drastically reduce the service life of a through-fastened R-panel metal roof.
- Depending on the panel system, standing seam metal roofs can provide leak-free performance for 20 years or longer.

2) Existing Structural Spacing

- Through-fastened, 26-gage steel R-panel roofs can be designed to span supports in excess of 5 feet; however, the most common span is a nominal 5 feet.
- Due to wind uplift considerations, 24-gage steel standing seam metal roofs are typically limited to a nominal 5-foot span or less. Most standing seam systems have not been rated in industry wind uplift tests such as UL 580 (Class 90 rating) or FMRC Standard 4471 (I-90 rating) at spans over 5 feet.

3) Desired Insulation Thickness

Higher R-values (more insulation) cause all roof surfaces to experience large temperature differentials and, in turn, more thermal movement.

- Through-fastened R-panel roofs also have insulation thickness limitations as low as 3 inches of fiberglass blanket in some cases. With through-fastened metal roofs, insulation thickness is typically limited because of the potential for indentations around the fastener heads caused when the fasteners are tightened. These indentations can hold water at low slopes and be a source of roof leaks.
- Standing seam metal roofs are designed to handle thermal movement without damage much better than through fastened metal roofs.

4) Length of Panel Runs

- Steel, through-fastened R-panel metal roof systems have limitations for continuous panel runs of less than 150 feet. Some systems have limitations as low as a 100 foot continuous run. This length limitation is due to the lack of any provision to handle thermal movement inherent with these systems.
- Standing seam metal roofs, designed to accommodate thermal movement, can typically be installed with continuous runs from 200 feet up to 250 feet. This length is determined both by allowable panel clip movement and movement allowed by trim and flashings.

5) Existing Roof Slope

- Through-fastened R-panels should never be used at slopes under 1/2 inch per foot and, depending on the roof system details, not under 1 inch per foot. The greater the

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slope, the faster the water flows off the roof panel and the less chance for roof leaks.

- Standing seam metal roofs eliminate up to 90 percent of the exposed through-fasteners and place the panel sidelap joint well above the water flow plane. The typical standing seam metal roof can be installed on slopes as low as 1/4 inch per foot.

The cost of a metal roof overlay using a 26-gage through-fastened R-panel roof system will typically be about 15 percent less than a 24-gage standing seam metal roof system overlay.



Figure 19 — 16-gage structural members in place directly over the underlying structural members.

Standing Seam Retrofit

A standing seam metal roof overlay can be installed over an existing through-fastened R-panel roof utilizing two methods. Either a new structural support member can be installed as the support for the new roof system or the new roof system can be installed directly without a new structural support member. The difference between the two roof overlay systems is the ability to add insulation and the installed cost of each system.



Figure 20 — This standing seam metal retrofit system utilizes a standing seam roof clip attached directly to the underlying structural member.

Figure 19 shows 16-gage structural members in place directly over the underlying structural members. The new top structural member will be tied to the existing structural member with a spacer of some type and fasteners. The new standing seam metal roof and insulation will be installed over the new structural member. Figure 19 also shows additional framing around the roof unit for support of the new roof curb.

By using a different depth structural member (typically from 1 to 12 inches deep), the desired insulation thickness can be accommodated. This type of retrofit system can be installed over through-fastened R-panel roofs as well as other types of existing metal roofs including standing seam roofs. This retrofit system can be easily installed over out-of-module existing roofs. The weight of the system is typically less than 2 pounds per square foot (psf). The 24-gage metal roof adds 1.25 psf, the 16-gage structural member adds 0.5 psf, and the fiberglass blanket insulation adds less than 0.25 psf.

The new standing seam metal roof system is fully compatible with the existing PEMB system. Another advantage to this type of retrofit system is the ability to change the pitch and direction of slope of the new roof to eliminate valley gutters or difficult transitions, to simply increase the pitch if necessary, or to change the appearance of the building.

Figure 20 shows a standing seam metal retrofit system that utilizes a standing seam roof clip attached directly to the underlying structural member.

Extruded polystyrene blocks are used to transfer dead, live, and snow loads to

the existing structural members. Since the new roof is only 1-1/2 inches above the existing roof, there is an insulation thickness limitation of 3 inches. The 3-inch fiberglass blanket insulation will provide little R-value; however, condensation control is the primary objective.

This type of retrofit system can only be installed over through-fastened R-panel roofs that have *not* been installed in a severely out-of-module condition. The weight of the retrofit system is typically less than 1.50 psf. The 24-gage standing seam metal roof adds 1.25 psf and the fiberglass blanket insulation adds less than 0.25 psf.

To compare initial installed prices, a metal roof overlay will be more expensive than an inexpensive, single-layer coating. In many cases, the price for the installed metal overlay will be comparable with either a top-of-the-line, multi-layer coating system over a properly prepared metal panel substrate or a single-ply overlay properly designed and attached to the PEMB purlins.

Insulation, Vapor Retarder, and Dew Point

Most PEMB projects that are over 25 years old have a layer of 1-1/2 inch fiberglass blanket insulation with a vinyl vapor retarder. Typically, the fiberglass blanket insulation is compressed and provides little if any real R-value. The old vinyl vapor retarders become soiled, brittle, torn, and do little to prevent vapor migration because of their 1.0 to 1.2-perm rating.

An important consideration for any reroof project is the investigation and evaluation of the condition of the existing insulation and vapor retarder. The existing insulation system plus

any added insulation must be evaluated against the project usage and historical, local weather conditions. A dew point analysis is the tool used to conduct the evaluation and determine the optimum amount of required insulation.

On retrofit roof projects, insulation is typically added above the existing metal R-panel roof. To address the correct vapor retarder and dew point location, a good solution involves removing the existing insulation from the underside of the existing R-panel roof. This is accomplished by cutting through the vapor retarder and insulation with a razor knife adjacent to the PEMB secondary structural member. The existing R-panel roof not only acts as the new vapor retarder, but also provides a like-new reflective ceiling for the building interior. Based on the results of the dew point analysis, the proper amount of unfaced fiberglass blanket insulation is then added on top of the existing R-panel roof.

Summary

With the large number of existing metal through-fastened R-panel roofs in service, a metal roof retrofit project is just around the corner. When a roof consultant encounters his first or next metal roof retrofit project, he should carefully consider the suitability of the various retrofit roof solutions and choose the system that meets the code requirements and provides the best overall performance and value to the owner.

As in every retrofit application, a qualified structural engineer must check the structural capacity of the existing building and the connection of the new roof to the existing structural mem-

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bers or panels. The 26-gage, existing through-fastened R-panel is most likely not adequate as a substrate for most proposed retrofit systems. The condition of the existing through-fastened R-panel can determine or strongly influence the retrofit solution chosen.

A dewpoint analysis can determine the optimum amount of insulation to add with the retrofit roof. By selecting the right retrofit solution, the new roof system can provide the owner with many years of worry-free service. n

ABOUT THE AUTHOR

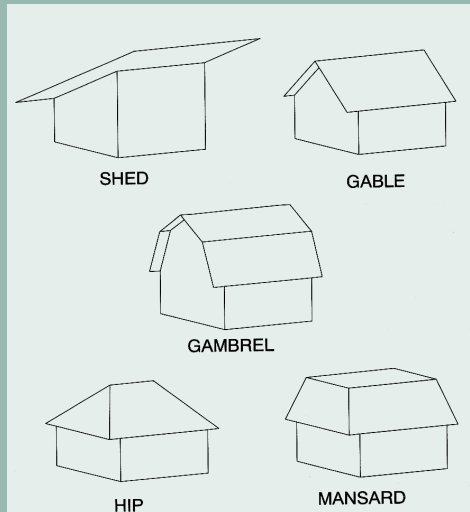
Raymond K. Heisey Jr., PE, RRC, earned a degree in civil/structural engineering from Lehigh University in 1978. He has worked at Butler Manufacturing Co. for over 23 years and has a wide variety of experiences, encompassing plant engineering, metal building design, computer system development, roof product development, and roof regional sales and sales management. Ray has two U.S. patents and numerous foreign patents on metal roof system components. He received his RRC designation in 1993. Heisey has won six Butler sales awards in an eight-year period. He presented a report on standing seam roof clip design to the ASCE's Structural Congress and has taught seminars on various roof-related subjects.



RAYMOND K. HEISEY JR., PE, RRC,

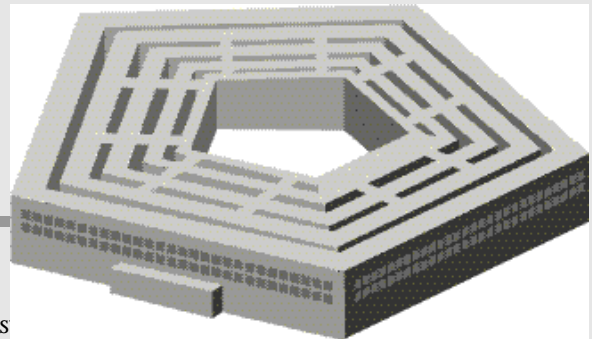
SMACNA Publishes Sheet Metal Guidelines

A new 130-page manual released by the Sheet Metal and Air Conditioning Contractors' National Association Inc. (SMACNA) highlights commonly used details for residential sheet metal work. In addition to generic detail drawings, design data located in certain sections and the appendices are designed to help users adapt the drawings to local climate and project conditions. For information, visit www.smacna.org and select "publications."



Common roof styles, from SMACNA Residential Sheet Metal Guidelines.

NRCA MEMBERS REROOF PENTAGON



When AA Flight 77, piloted by terrorists, hit the Pentagon on September 11, 20,000 gallons of jet fuel set the building on fire. The slate roof was nailed to wood sheathing, which was attached to a concrete deck with a slope of 23 degrees (5 in 12). This included a two-ply underlayment mopped to the deck during its installation in 1943.

Firefighters, at first unaware that the system included wood sheathing, poured more than 6 million gallons of water on the roof, which did its originally-intended job very well: it shed most of that water. It was not until firefighters broke through the slate that they realized it was not just insulation that was burning underneath and were then able to stop the fire from spreading further. Over an acre of the Pentagon's roof system – some 40,000 square feet – was damaged beyond repair.

But in a project launched by John Francis of Northern Virginia Roofing, and spearheaded wholeheartedly by National Roofing Contractors Association Executive Vice President Bill Good, that organization is reroofing the damaged structure with volunteer labor and materials.

Good notes that the total value of donations has been in excess of \$500,000. Even the NRCA's lone member in Ghana, Africa, informed Good that the community there had taken up a collection to pay travel and housing expenses for a roofing worker to travel to the Pentagon to provide labor.