Journal of the Roof Consultants Institute

Interface

May 2004
Vol. XXII, No. 5
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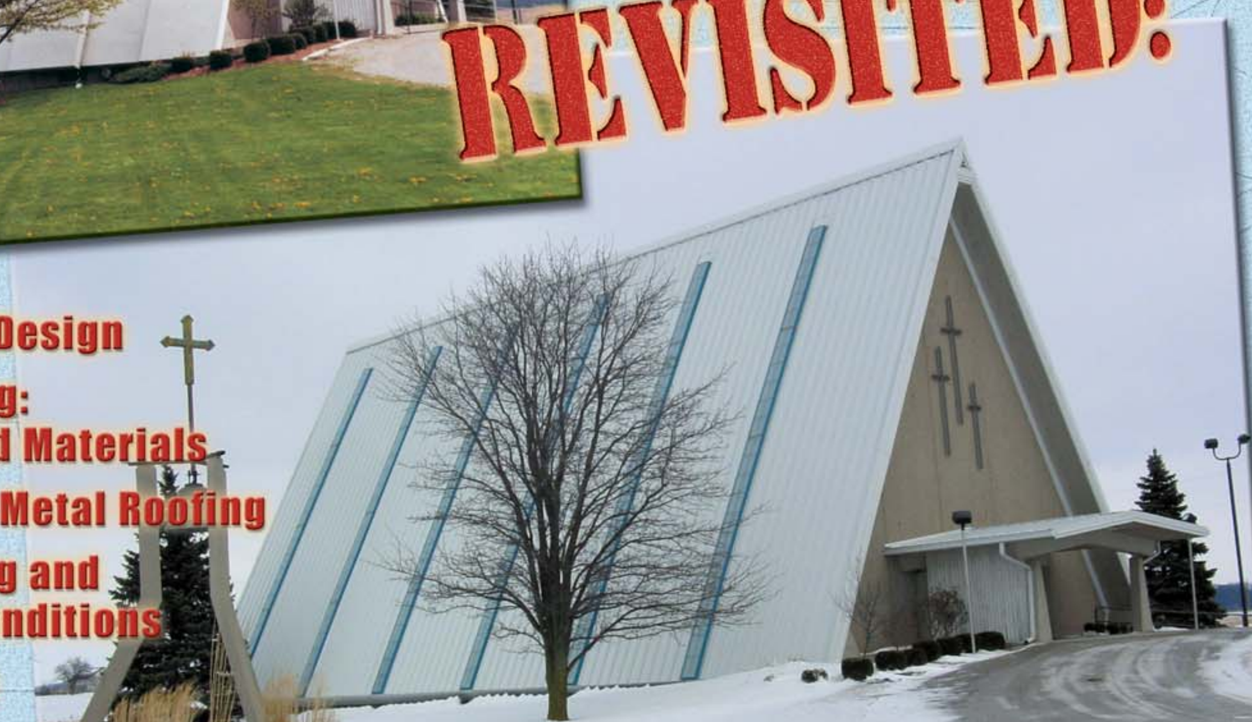
BEFORE RETROFIT

METAL ROOFING REVISITED:

- Terne Metal Design
- Metal Roofing: History and Materials
- Coatings for Metal Roofing
- Metal Roofing and Interior Conditions
- Roof Retrofit



AFTER RETROFIT

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May 2004 • Vol. XXII, No. 5

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RCI was chartered, in part, to bridge the gap between the seemingly disparate elements of the roofing profession. It is the intent of *Interface* to connect with these elements, educate and inform about roofing-related topics, establish a common ground for discussion, promote Institute programs, and branch out toward even more people. *Interface* is circulated monthly to over 3,000 people (nationwide and overseas) including RCI members, specifiers, facility managers, owners, industry contacts, and a growing number of highly placed professionals. *Interface* is frequently distributed at various trade shows, as well as educational and institutional functions. The articles contained in this publication are intended to provide information that may be useful to members of the Roof Consultants Institute. RCI does not necessarily endorse this information. The reader must evaluate the information in light of the unique circumstances of any particular situation and independently determine its applicability.

About This Issue: Previous issues of *Interface* set out to reinforce the attributes of metal roofs. Now, no such validation is necessary. Read further to learn about the wide appeal of this configuration.

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President's Message

Grand Opportunities: The Power of Three

Do you ever catch yourself reflecting on your past and imagining the future? You know – like those moments when you wake up before the alarm goes off or when you're sitting in a waiting room for an appointment with nothing else to do? I know it happens quite often for me. Perhaps it is an age thing – who knows? It's at these times that I think about where I have been in my life, where I am headed, and how blessed I am to be where I am today. I feel very fortunate to be living a rewarding life.

Over the years, I have developed several life-lesson tenets. One of them is what I call the *Power of Three* and it goes like this. Within our adult life, fate will deliver each of us three chances to seize a grand opportunity for personal, professional, or spiritual growth. Don't ask me where I got three – I'm not really sure. But it is a number I believe in for myself. For a long time, I thought I had been granted my three grand opportunities and was proud to say I had seized two of the three. I figured, "That isn't too bad, I only missed one out of three and even that one I didn't miss entirely." But I have to admit, I wished I had more than three. I was certain I knew what my three were, when they had presented themselves, and what I did with each one. I was a bit depressed about my theory and the thought I had already used up my three. For a long time, I found some peace in thinking my theory might be flawed. Perhaps we get five or nine or 27?

However, thinking I was wrong about my theory was not something I wanted to embrace either. Then it occurred to me. My theory wasn't wrong; my math was. Now I have a newly revised theory on this subject and the significance of "three." Opportunities are everywhere and unlimited. Some we recognize; some we miss. But when we do recognize an opportunity and seize it for grand results, three more opportunities present themselves. It is as though life has its own multi-level marketing plan (pyramid scheme) for us – the *Power of Three*.

I recently left a cherished business partnership that I helped create in 1986. It was one of the most difficult things I have ever done. I maintain a deep admiration for my partners and will always appreciate the chance they took on a 28-year-old draftsman who didn't have a clue about running a business. For years, being a part of that partnership was what I saw as one of the three grand opportunities that I was fortunate enough to seize. With my new theory, I can also look back and see it was an opportunity to prepare myself for my own new business venture, develop my speaking skills, and afford me the time to be involved in RCI. There's that *Power of Three* again.

One blessing that I can trace back through my own *Power of Three* path with RCI involvement is the opportunity to be president. Now that the time has arrived for me to step into this role, I can look back and see how a combination of seized opportunities put me here. Years from now, I am confident I will look back at this year as president with fond memories. I appreciate the confidence you have given me and look forward to seizing the *Power of Three* for the current and future success of RCI.

This year's for you, Mike!

Luther C. Mock, RRC,
President

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Re: February 2004 Interface article, "Rooftop Gardens"

Dear Sirs:

I appreciate the time and effort it took Karen Liu to test for and report on the advantages of the heat gain or loss and the water runoff in green roofs. All of these facts should be a no-brainer to a qualified architect or roofing consultant. Everyone I have seen who has written articles on green roofs is only reviewing the energy and water retainer points of green roofs.


ENGINEERING PERFORMANCE OF
Rooftop Gardens
THROUGH FIELD EVALUATION
By Karen Liu, Ph.D.

I have been in the roofing field now for 54 years. I completed green roofs as a roofing contractor 30 or 40 years ago. I feel before any green roof design should be considered, you must first review the expense and what will happen when and if there is a failure in the system. As I reviewed *Figure 1* on page 5 showing the green roof, I surely would not recommend this design because I know it will fail in a very short time. The total expense to remove the dirt and planting and complete the waterproofing application correctly should cost the owners or probably the roofing contractor over ten times what the green roof cost to install.

I believe the first step in a correct green roof application is to find out if the owner wants to spend the huge extra amount of money to install a green roof. I have seen contractors go broke after installing a green roof as shown in page 5. The following items are of more importance than the energy savings or the water retention or run-off.

A. The only deck type that should be used for a green roof is a solid concrete pour including the walls in the same pour. This will require a lot of extra money for the supporting members under the deck, which should have already been specified with any green roof.

B. The membrane cannot be installed anywhere but over and attached to the deck, not over any type of insulation. Once the dirt is put in the green roof area, the defection could break, crack, or damage the new membrane if it is installed over the top of any type of insulation. I feel Pittsburgh Corning Foamglass is the worst insulation type to use in this type of application.

C. On page 6, it states that a 2-ply modified bituminous waterproofing (roofing) was installed. This, like a lot of other types of membrane, should not be used. If you check the manufacturer's specifications on these products, I believe you will find they do not allow this type of material to be installed in planters or covered. I have been hired by a major manufacturer of torched-down materials and I found that some modified material actually takes in moisture. I have seen moisture running through the center of some modified cap sheets, and this causes the sheet to rot from the inside out.

D. The membrane should only be a proven and tested liquid type installed in three applications.
   1. The first application of the waterproofing should include repairing holes and pits in the deck, priming only the areas of the walls and any cracks and installing a waterproofing plus a rubber-type material over these cracked areas, including the walls.
   2. After this application dries, prime the rest of the area that has not been repaired and install the first application of the liquid or heated waterproofing on the complete area, including the walls and the deck.
   3. Install the second full waterproofing over the complete area, including the walls.
   4. No one should work or walk over the surface until the waterproofing has been protected with VisQueen and at least a 1/8th-inch protection course. A water test can be completed if specified.
   5. This completed waterproofing should never be left exposed to work over or walked on. It must be covered just as fast as possible once it is water tested.

Green roofs are nothing new. They have been installed for many years. If the total green roof system is not installed correctly and in the correct method, it cannot work. The cost to repair or replace is very high. No sun can touch any part of the total waterproofing system, including the walls or curbs.

All penetration flashings must go to the surface and be bent over above ground level for them to work correctly.

Sincerely,
Lawrence T. Musil
Interbay Roof Inspection Consultants
Bothell, WA

AUTHOR'S RESPONSE:

Dear Mr. Musil:

Thank you for sharing your experience with green roof installation in your letter. I appreciate your comments and I will try to address some of your concerns:

"As I reviewed Figure 1 on page 5 showing the green roof, I surely would not recommend this design because I know it will fail in a very short time."

The figure is not a design drawing; it is simply intended to give an idea on the various components in the Reference and Green Roofs. The Reference Roof is a typical conventional roof design in Canada. The Green Roof is a commercially available system and was installed according to the manufacturer's specifications by a professional roofing contractor. The roof has been in service for slightly over three years and we did not experience any problem or any sign of premature failure.

"The only deck type that should be used for a green roof is a solid concrete pour including the walls in the same pour."

In North America, many people view green roofs as roof terraces where there are trees and planter boxes full of flowers, perhaps beside some lounge chairs and a swimming pool; for example, the roof gardens on New York's Rockefeller Center and San Francisco's Union Square, which were built 40-50 years ago. Many such examples can be found in T. Osmundson's *Roof Gardens – History, Design, and Construction.* These terrace roofs usually consist of a few feet of soil, weighing over 150 psf. Because of the heavy weight, they are usually installed on concrete decks. These are called intensive green roofs.

In Europe, lightweight systems that are called extensive green roofs are more common. They consist of 3 to 6" of lightweight growing medium and weigh only 25-60 psf when fully saturated. They contain small plants that are hardy and self-generating, such as grasses, sedums, and wild flowers. Because of their light weight, they are usually installed on steel decks and wood decks (houses). For example, the XeroFlor green roof system (developed in Germany) on Ford's Rouge Center consists of sedum planted in 4" topsoil, with a saturated weight of only 25 psf, and was installed on a 3" galvanized steel roof deck (see p.35 of the same *Interface* issue).

"The membrane can not be installed anywhere but over and attached to the deck, not over any type of insulation."

Water-saturated soil is heavy and may create deflection of membrane over flexible insulation in intensive systems, but is not a major concern for extensive systems due to the light system weight. Also, fiberboard can be placed on top of the insulation to help distribute the load. For example, on the Ford Rouge Center green roof, Siplast's 2-ply modified bitumen was installed on 2" ISO with a perlite top board. In fact, "floating" of extruded polystyrene can sometimes become a problem for extensive systems installed over protected membrane systems (see p. 31 of the same *Interface* issue).

"On page 6, it states that a 2-ply modified bituminous waterproofing (roofing) was installed. This, like a lot other types of membrane, should not be used."

Modified bituminous systems are commonly used in Germany on green roofs with a good performance track record. In North America, many major manufacturers (e.g., Soprema, Siplast, and Garland) provide warranties on their modified bituminous roofing membranes to be used on green roofs. Waterproofing may be preferred for flat roofs, but as long as positive drainage is provided and water is allowed to flow freely away from the membrane, moisture infiltration should not be a problem.

Sincerely,
Karen Liu
National Research Council Canada

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St. Peter Lutheran Church

ROOF (OR WALL) RETROFIT PROJECT

By Luther C. Mock, RRC

St. Peter Lutheran Church is located just five miles south of the rural farm in which I grew up and where I live today. I have many memories of driving by it during my youth and admiring the unique A-frame design. It rises above the corn and soybean fields and can be seen for miles from the northeast Indiana flatlands.

The 23:12 slope structure of the building is built from 8-inch-thick, 8-foot wide precast concrete slabs. They are anchored at the base of a precast concrete floor slab and nested at the ridge with complicated-shaped, precast concrete keyways. The gross floor area is approximately 5,000 sq. ft., and the roof surface is roughly 11,000 sq. ft. The concrete design was inspired by the availability of specially designed components that could be made at a nearby precast plant.

The original architect designed a 6-inch continuous window inset that profiles the A-frame shape by staggering the concreted slabs at 14 inches. The inset window detail (skylight) consists of a 1 x 1-3/4-inch aluminum glazing stop and a translucent 1/4-inch acrylic sheet. Southern sun exposure creates an impressive, rich blue light in the church sanctuary.

In the summer of 2000, the congregation contacted me to design a new roof system. They reported they had endured roof leaks on the facility since its construction in 1970. The original roof covering was sprayed polyurethane foam (SPF) with an acrylic coating. A few years later, the original SPF was covered with 8-foot-wide fiberglass panels designed and formed specifically for the unique profile of the roof. This system also provided minimal success from water infiltration – primarily at the glazing detail. The 14-inch depression of every other concrete panel, coupled with the depth of both the SPF and the fiberglass covering, created a natural waterway against the skylight.

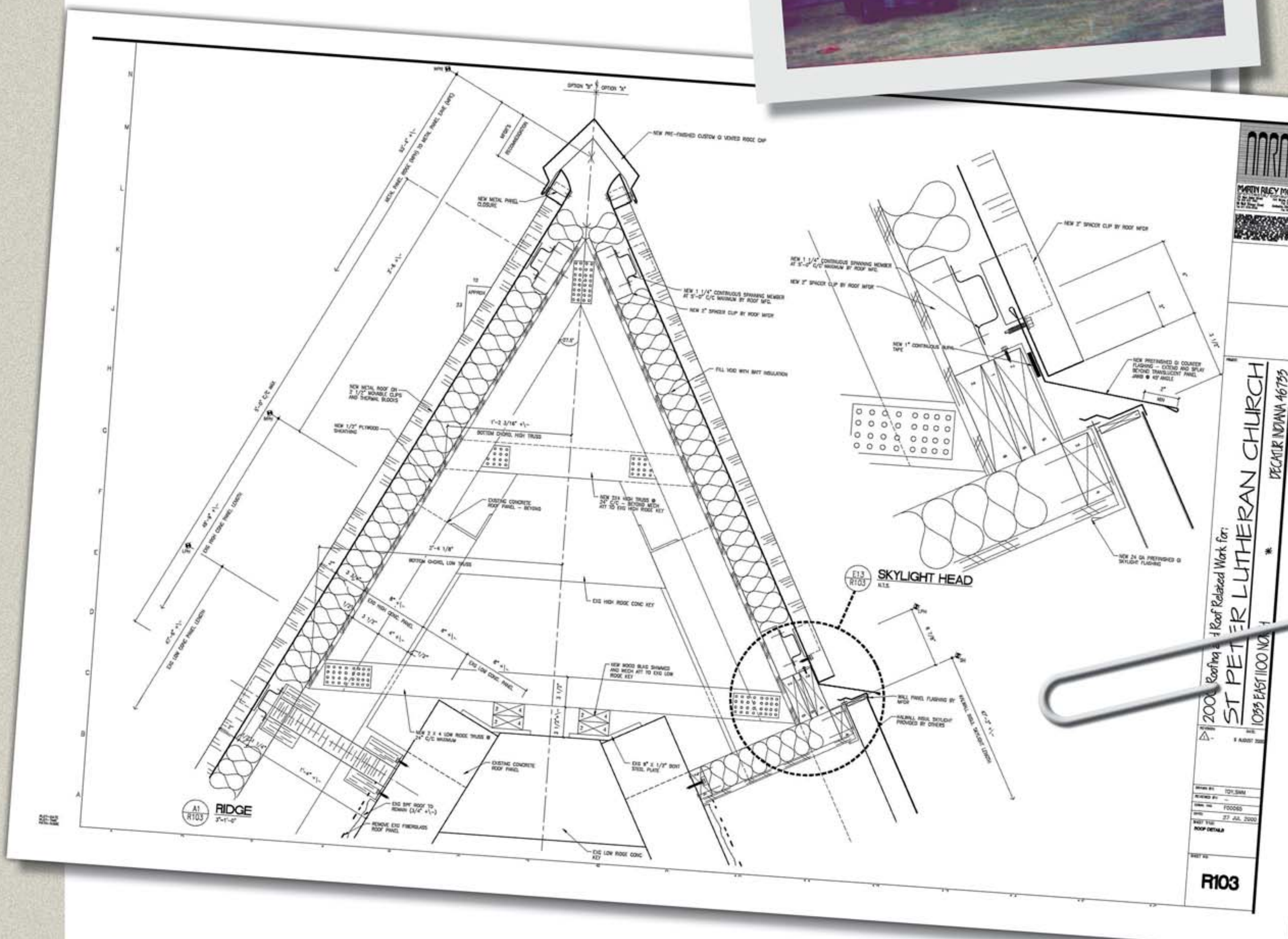
Early in the project, there was a lot of discussion about keeping or abandoning the 6-inch light detail. We were confident a watertight detail could be designed for the skylight. But it would certainly be less costly if these were removed and covered over. Abandoning the skylights would not only cost less, it would eliminate air infiltration and heat loss.

The primary design criteria for the roof-covering choice were low-maintenance, aesthetics, and long-term performance. The church project committee was willing to invest in a higher initial cost to realize these preferences. In order to identify the true cost of saving the skylights, we designed the reroofing project as Option A (keep the skylights) and Option B (abandon the skylights). When all the options were considered, a standing-seam metal roof covering was chosen. The low bidder for Option A was $228,800 and Option B was $168,800. Keeping the skylights would be a $60,000 (36%) premium. The congregation felt strongly about keeping the skylights and their powerful effect the blue light has on the interior space; therefore, Option A was chosen.

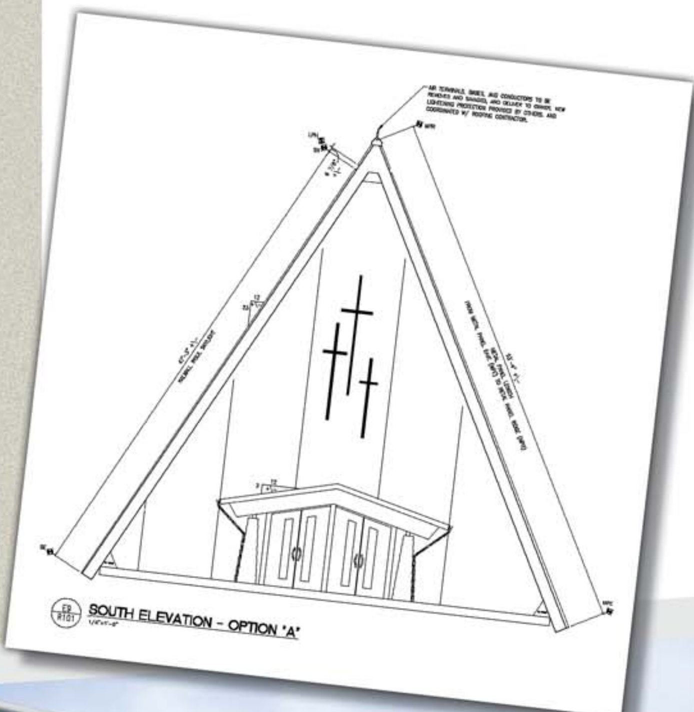
It was felt that the staggered concrete roof slabs of the original design created a pleasing exterior effect. However, it also created hundreds of linear feet of flashings that increased cost and water infiltration vulnerability. The project team chose to eliminate the staggered panel effect for the value of less flashings and cost savings. But the choice to change the roof into a flat plane created new challenges to maintaining the interior, natural light effect of the skylights.

The retrofit design includes 1-1/4-inch structural steel members that run perpendicular to the slope at 5 feet, center-to-center. They span over the 14-inch depressed concrete pan-

Removal of 8-foot-wide fiberglass panels and exposure of original sprayed polyurethane foam roof.



els and are supported by 2-1/2-inch post supports. A 1'-1" inside dimension light trough was created with wood blocking adjacent to the 6-inch-deep light inset. The walls of the trough were extended above the surface of the new metal roof covering to act as a curb for a new skylight assembly. The inside surfaces of the light trough were painted white to maximize light reflectivity.



The skylight covering had to be virtually maintenance free and have high impact resistance like the metal panel. In addition, the skylight covering had to offer some insulating qualities and be fabricated to fit the project dimensions. A translucent, fiberglass-reinforced sandwich panel with high insulating qualities was chosen. The product has the unique ability to fill a space with uniform, usable, natural daylight – even on cloudy, dark days. The face of the sandwich panel has millions of prismatic glass fibers that refract sunshine.

The prior roof systems included minimal insulation – approximately 1-1/2-inches of SPF. The installation of the spanning members offered the opportunity to upgrade the thermal resistance of the assembly. Blanket fiberglass insulation fills the cavities of both levels of the concrete panel.

The previous ridge was approximately 36 inches across on a horizontal plane, which is too wide for the new manufactur-

View of translucent, fiberglass-reinforced sandwich panel for interior light penetration.

er's standard ridge detail. A small wood truss structure with plywood sheathing was designed that effectively raised the height of the building by six feet. The space in the cavity is uninsulated and vented with a triangular louver at each end.

The roof system qualified for a 20-year, no dollar-limit warranty for both product and workmanship. The congregation chose to purchase the warranty but there have been no leaks in the four years since the system has been installed. Not only has the congregation enjoyed a leak-free building, but also a 40-50% reduction in heating bills. The metal roof system manufacturer, skylight product manufacturer, general contractor, and specialty contractors were extremely sensitive to the unique demands of this project and delivered high quality results. ■

Design Team:

Luther Mock, Designer
Sean Motter, Project Manager
EDIFIS Building Exterior Solutions
Fort Wayne, Indiana

General Contractor:

Michael Brown, Project Manager
Hagerman Construction Corporation
Fort Wayne, Indiana

Specialty Contractor (Metal Panels):

Chris King, President
Exterior 2000, Inc.
Bluffton, Indiana

Specialty Contractor (Skylights):

Stan Hegerfeld, President
Premier Glass, Inc.
Hoagland, Indiana

Metal Roof Panel Manufacturer:

Butler Manufacturing Company
VSR™ Roof System

Skylight Manufacturer:

Kalwall Corporation

About the Author

Luther C. Mock, RRC

Luther Mock is the founder of Foursquare Solutions, Inc., Monroeville, Indiana, and serves as its corporate president. Prior to his current position, he was an owner of Martin, Riley & Mock, Inc. since its inception in 1986 and managing partner of EDIFIS Building Exterior Solutions. He has been involved in roofing and moisture technology since 1978. Since 1986, he has specialized in building envelope design, asset management, and failure analysis. Luther has been involved in more than 800 building envelope related projects. Mock is currently president of the Roof Consultants Institute and is also a member of the American Institute of Architects (AIA), Construction Specifications Institute (CSI), American Society of Testing and Materials (ASTM), and the Midwest Roofing Contractors Association (MRCA). He earned his RRC in 1990.

Good Architecture, Poor Roof

By Thomas L. Smith, AIA, RRC

Figure 1: General view of the roof.

ABSTRACT

A terne metal roof was specified and installed on a new church during the winter of 1996-1997. The building is located in the eastern part of the U.S., in an area subject to snowfall. Shortly after construction, leakage periodically occurred at clerestory windows and some roof areas. The architect, general contractor (GC), and roofing contractor attempted to address the problems, but their attempts were unsuccessful. In 2001, the author was retained by the building owner to investigate the leakage problems. Because they could not be effectively repaired, in the latter part of 2001 and early 2002, all of the roof coverings were removed and replaced. The clerestory windows were also removed, new sill flashings installed, and the windows reinstalled.

As part of the investigation, the National Research Council of Canada performed extensive analysis pertaining to corrosion of the metal panels.

INTRODUCTION

The church is a very unique and aesthetically pleasing building *(Figure 1)*. Five shed roofs cover the sanctuary (roof areas 1-5 on *Figure 2*). These roofs have different slopes, from 2-3/4:12 to 5:12. The eave-to-ridge distance also varies, with the greatest distance being 112'. These roofs drained into a stainless steel, built-in gutter. Clerestory windows occur at the walls between the different roof areas *(Figure 3)*.

Five shed roofs cover other areas of the church (roof areas 6-10). These roofs also have different slopes, from 1:12 to 3-3/4:12. The entry canopy is also a shed roof that slopes toward the build-

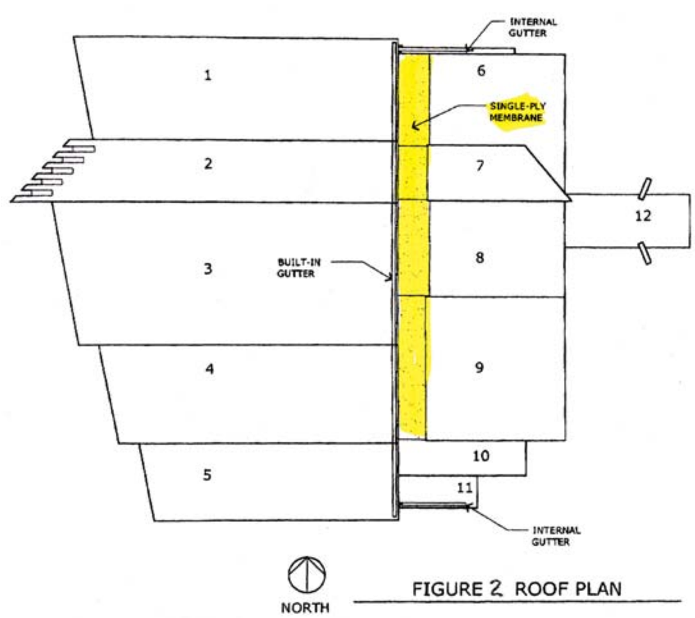


Figure 2: Roof plan.

Figure 3: View of some of the clerestory windows. Although the roof overhangs provide some protection from rainfall, they do not protect the windows from wind-driven rain.

ing at a 3/4:12 slope (roof area 12). Roof areas 1-10 and 12 had standing seam terne panels with 1"-high ribs. Roof 11 has a slope of 1/2:12; it had a soldered, flat-locked, terne roof. A TPO membrane occurred at the valley between the toe of roof areas 6-10 and the wall below the eave of the sanctuary sheds *(Figure 4)*. The water from roof areas 6-11 drained to two stainless steel internal gutters. The water from roof area 12 drained into a stainless steel internal gutter at the wall juncture.

Figure 4: View of the TPO membrane in the valley area. Water falling from the TPO membrane eroded the paint on the terne below.

The roof assembly over the sanctuary (1-5) consisted of the following components:

- Terne metal panel, field painted on the topside with a mill-applied shop coat on the underside. (Terne is a sheet steel that is factory-coated on each side with an alloy of 80% lead and 20% tin.)[1]
- Rosin paper.
- #30 asphalt-saturated felt.
- OSB.
- Rigid insulation.
- Tongue-and-groove wood decking.

The roof assembly over areas 6-12 was similar to the above, except for the deck, which was metal. The TPO was fully adhered to OSB.

INITIAL LEAKAGE AND RESPONSE

Initial leakage occurred in the sanctuary. Water dripped from the vicinity of several clerestory windows. The architect made a site visit, but did not perform any destructive observations. His report incorrectly attributed the leakage to the soffit installation. However, no corrective action related to the soffit was taken.

The clerestory windows contained a high-quality, commercial-grade storefront glazing. The system was designed with an internal gutter to intercept water that penetrated the glazing gasket. The intercepted water would drain from an opening between the sill flashing and the sill face cap. Sealant had been applied between the sill flashing and the sill face cap, thereby blocking drainage of water that penetrated the gaskets *(Figure 5)*. Application of the sealant exacerbated the window leakage problem. The window leakage was due to lack of upturned ends on the sill flashing, as will be discussed later.

As the window leakage continued, leaks began to develop in other areas of the building. At the time of the author's investigation

Figure 5: In a misguided attempt to solve the window leakage problem, the general contractor applied sealant (noted by arrow) at the drainage slot between the sill flashing and sill face cap.

Figure 6: View of the down-slope end of the sill flashing after removal of the face caps and glazing. The only provision preventing water running down the sill from entering the building was a fillet-profile sealant joint between the sill flashing and EIFS. The double arrows show a piece of the sealant joint. The sealant was not well adhered to the EIFS or sill flashing. Water was able to flow past the sealant, where it had an unobstructed path into the building.

in February 2001, in addition to the clerestory leakage in the sanctuary, leakage had occurred at the north end of the TPO roof, the southwest portion of roof 6, roof 11, and roof 12 (at the wall juncture).

The author was retained by the building owner to investigate the leakage, determine the causes, and recommend corrective action.

PAINT PROBLEMS

The terne manufacturer's specifications require the panels to be field painted "immediately after application or as soon as proper painting conditions prevail." Painting soon after application is important to avoid corrosion, for the thin lead/tin coating offers very limited corrosion resistance. The panels were installed during the winter and temperature conditions were much too cold for painting. Rather than tent over the building, painting was delayed until May, at which time widespread peeling failure was experienced. The author was not involved in that problem, but was advised that after arbitrating the dispute, the roof was repainted in the fall of 2000. During the author's leakage investigation in February 2001, the new paint had also peeled in several areas.

AUTHOR INVESTIGATIONS

During the author's initial investigation, a technical representative of the window manufacturer was on-site, as well as representatives of the general contractor, roofing contractor, and glazing contractor. The author directed the glazing contractor to remove some of the glazing caps. After removing the caps, it was apparent that due to lack of upturned ends on the sill flashing, water was

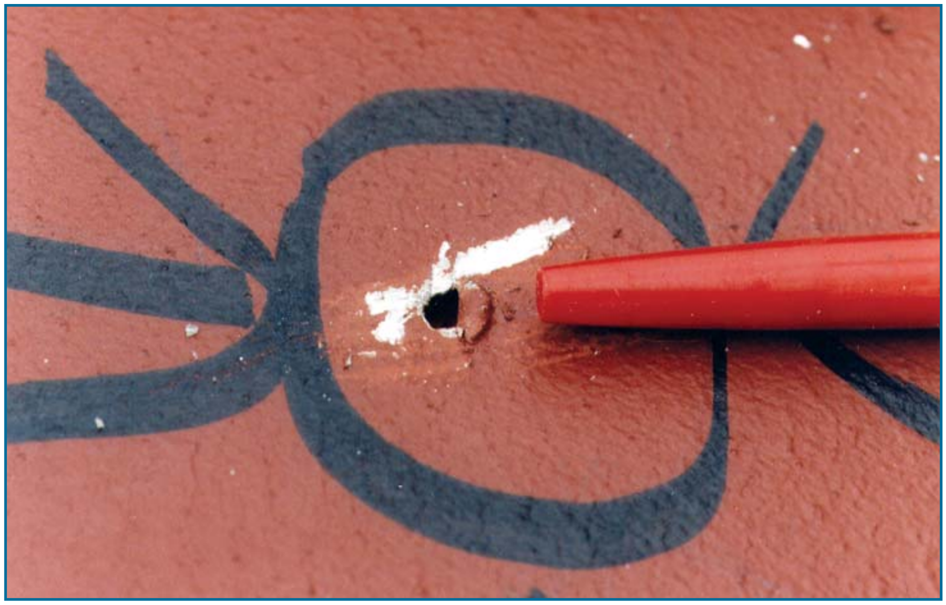


Figure 7: A hole through the terne at roof 6. This hole was caused by mechanical damage.

able to flow past the window frame *(Figure 6)*.

At two locations over the sanctuary, very small corrosion-induced holes through the metal panels were found. The author initially attributed these holes to lack of paint, but as discussed below, they developed from underneath the panels. The holes were temporarily patched.

At the north end of the TPO roof and roof 11, the author believed the leakage problems were related to the built-in gutters or the drain lines. Instructions were prepared for the owner to plug the outlet tubes and fill the gutter with water. When both gutters were water tested, it was discovered that when the plugs were removed, leakage occurred due to a piping error. The drain line from the gutter emptied into an open funnel at the end of a major drain line. Other drain lines from the sanctuary roofs also emptied into the funnel. Thus, during a deluge of water, water overflowed the top of the funnel.

At the leakage area at roof 6, two small holes through the metal panels were found *(Figure 7)*. These were caused by mechanical damage. A tear was found through the nearby TPO. At another TPO area, the membrane was torn by a nail head emerging from the OSB. The leakage at the canopy

Above: Figure 8: View of corrosion-induced holes through the terne on roof 3. Holes occurred on both sides of the rib. These holes occurred a few inches upslope of an endlap. Note the buckled rib. See Figure 9.

Right: Figure 9: View of the underside of the panel shown in Figure 8. The circle indicates the upper end of the down-slope panel. A panel clip with two nails occurs in the lower right portion of the photo.

roof was due to inadequate flashing between the roof and wall.

During the summer of 2001, additional holes were discovered through the metal panels. The author performed a follow-up investigation in August 2001. During this investigation, several metal panels and ridge cap flashings were removed. Severe corrosion was observed on the underside of the panels *(Figures 8 and 9)*. Wind-driven water and water from power washing prior to painting had driven past the ridge cap flashing and flowed underneath the panels. Water was also driven underneath the endlaps *(Figure 10)*. Water had also leaked through some of the ribs on the low-sloped roofs. Enough water had reached the underside of the panels and enough time had elapsed by August 2001 that the corrosion was penetrating the panels in numerous areas. In addition to panel penetration, the corrosion had significantly impaired several of the concealed clips, hence the roof was vulnerable to wind blow-off.

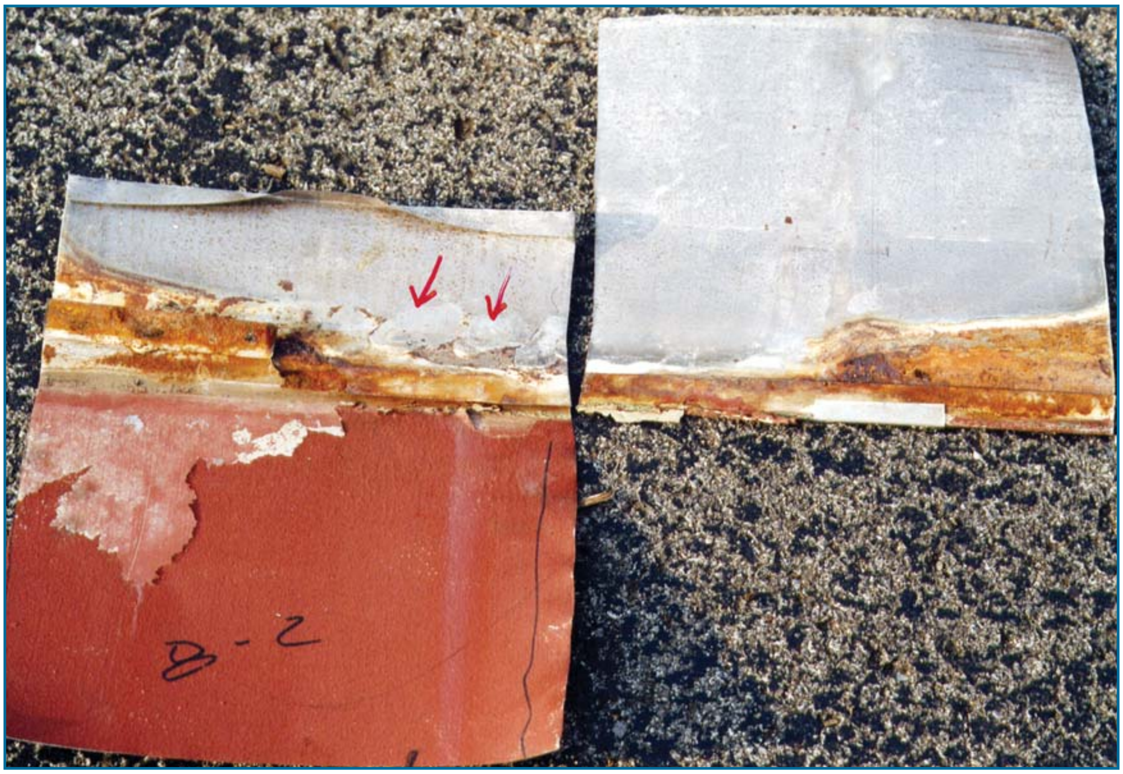


Figure 10: The left panel is the down-slope panel. The arrows indicate solder that was used to attach the lock-strip. Both sides of the lock-strip were very corroded. The right panel is the underside of the up-slope panel.

Because the corrosion attack was coming from the underside of the panels and it was in an advanced state, the panels could not be effectively repaired. To avoid damage to the OSB and wood decking, the author recommended that the entire roof covering be removed and replaced. Reroofing work commenced that fall.

LABORATORY INVESTIGATIONS

Several samples taken by the author were sent to the National Research Council of Canada for various evaluations to further understand the corrosion problem. The thickness of the steel substrate and metallic top and bottom coatings was relatively uniform and without pinholes. The tested specimens complied or substantially complied with the manufacturer's specification. No significant manufacturing deficiencies were found with the terne.

The lab determined that the corrosion was caused by the presence of water and oxygen on the underside of the panels. Analysis of the corrosion products did not indicate the presence of common atmospheric pollutants such as chloride or sulfur. The solder that was used was the correct type. It did not contribute to the corrosion. There was no indication that the flux that was used in the soldering process contributed to the corrosion.

Rosin paper

Leachate from wet rosin paper had a pH between 6 and 7, which is similar to water in the natural environment. The leachate also increased the conductivity of the water, thereby releasing electrolytes. This increased conductivity helps to facilitate electron transfer and accelerate corrosion. When submersed in water, the rosin paper absorbed a substantial amount of water.

Although it did not leach highly corrosive chemicals, the paper had the ability to hold a substantial amount of water, which if present, would increase the relative humidity in the enclosed space between the paper and metal panels. High humidity on the underside of the panel and the presence of electrolytes from the rosin paper create good conditions for corrosion to occur. In addition, when wet rosin paper is in contact with the metal, it provides a moderately corrosive water film (with a potential pH of 4 to 5) next to the panel. A water film generally contains a high concentration of dissolved oxygen, which also increases the corrosion rate. Therefore, when wet, the presence of the rosin paper could accelerate the corrosion process.

Felt

The panel manufacturer's recommendations adamantly and repeatedly recommend against the use of asphalt-saturated felt below terne (only rosin paper is recommended between the metal and the wood substrate). However, felt was installed below the rosin. In a few small areas, the felt was in direct contact with the terne, but in those areas, only minor, superficial "white rust" was found. (White rust was caused by corrosion of the metallic coating. Red rust was caused by corrosion of the steel substrate.)

Leachate from the felt had nearly the same pH as the wet leachate from the rosin paper. However, the felt leachate did not increase the conductivity nearly as much as the rosin paper leachate. The felt also absorbed less water when submerged. The felt unlikely promoted corrosion.

ISSUES

This was a complicated building. To avoid leakage problems, it was necessary to give special attention to: 1) selection of building envelope systems, 2) the design of the details, 3) submittal review, and 4) field observation. The architect failed in all four areas.

Roof system selection

Selection of metal panels for roofs 1-5 was appropriate. However, a copper or PVDF painted aluminum-zinc alloy ("Galvalume") standing seam system would have been a better choice. These alternative systems would have been more resistant to underside corrosion, and they would have been less maintenance intensive than terne. According to the manufacturer, terne requires repainting "at least once every eight years." The cost of repainting this roof was considerable.

In the writer's opinion, selection of metal panels for roofs 6-12 was inappropriate. Most of these roofs are low-slope, which present design and installation challenges. These roofs are essentially not visible from the ground; hence, there was no aesthetic justification for selecting metal. A membrane roof would have been more reliable and economical.

The writer also believes that selection of a single-ply membrane was inappropriate because of susceptibility to puncture and tearing. Metal panels were installed after installation of the TPO; hence, during that time, the risk of damage was great. Also, during painting operations, substantial foot traffic presented damage opportunity.

Metal panel specification

This section was very deficient; it was only two pages, whereas the much smaller and less complicated single-ply membrane section was five pages. Flat-locked terne was specified, which complied with the manufacturer's recommendations. However, the SMACNA *Architectural Sheet Metal Manual* recommends stainless steel or copper for flat-locked seamed roofs. Stainless steel would have been more resistant to corrosion and puncture. The spec did not specify special provisions for those panels on slopes less than 3:12.

Drawings

The roof plan indicated that the panels at roofs 1-5 were to have two endlaps (i.e., three panels from eave to ridge). On three of these roofs, the panel lengths were 30.6', 33', and 37'. The manufacturer recommended the use of expansion clips when the panels exceeded 30'. Expansion clips were not specified, nor were they installed.

The endlap detail did not specify the manufacturer's recommendation to field-paint the underside of the endlap. Considering the limited corrosion resistance of the metallic coating, field painting the unexposed portion of the endlap was important and should have been included with the detail. Field painting of the concealed area was not done, and severe corrosion resulted.

There were no provisions for ice dam protection at the eaves of roofs 1-5. The rake and ridge details were only shown schematically, making the design intent unclear.

The transition between the TPO and metal panels was not detailed. Neither the details nor window specification called for upturned legs on the sill flashings.

Submittal review

Expansion clips were not shown for the panels over 30' in length, painting of the underside of the endlaps and the flat locked panels was not noted, the TPO/metal transition was shown (but it did not allow for escape of water that reached the underlayment), no special provisions were shown for the low-sloped roofs (such as sealant tape in the ribs, as recommended by the manufacturer), the ridge rake flashings were poorly detailed, and several special details were not included.

Pre-roofing conference

A pre-roofing conference was specified, but it was not held. Considering the complexities of this roofing project, it is bewildering that this effort was omitted. The architect should have insisted on the conference.

Periodic field observations

The architect performed periodic field observations. Either the person conducting the observations was unfamiliar with the manufacturer's installation recommendations or was not diligent in evaluating the work with respect to it. In either case, the roof observations were inadequate, in this author's opinion.

Submittal preparation

As previously discussed, the submittal was very deficient. While many of the items that should have been shown on the submittals were not addressed in the contract specifications or drawings, they were addressed in the panel manufacturer's specifications, of which the roofing contractor should have been aware.

Workmanship

Workmanship on the exposed portions of the roof generally exhibited good workmanship (with the exception of the field-applied paint, which was applied by a painting contractor). Workmanship errors included lack of paint on the underside of the endlaps and the flat locked panels, poor fabrication of the ridge cap detail, three nail punctures (two through the metal) – either due to nail back-out or they were not flush with the OSB at time of installation, puncture of a metal panel by a small rock underneath the panel, and use of fixed clips on panels in excess of 30'.

As previously noted, the window drainage slots should not have been sealed.

REROOFING

The author recommended the following:

Roofs 1 - 6: Remove the existing metal panels and underlayment, replace damaged OSB, install an APP modified bitumen base sheet, red rosin paper, and new standing seam metal panels. A modified bitumen base sheet was specified because it is more robust than a #30 felt. APP was specified because of its great resistance to high-temperature flow. The base sheet laps were to be sealed for a distance of 9' above the gutter for ice dam protection. Two options were given for the metal: PVDF painted aluminum-zinc alloy or copper. At the time the reroofing was about to commence, the price of copper was relatively low, so the owner elected to have copper installed.

All other roof areas: Remove the existing metal panels and underlayment, replace damaged OSB, install a mechanically-attached SBS modified bitumen base sheet and white, granule-surfaced SBS cap sheet set in cold adhesive. Walkway pads were specified in the vicinity of the gutter drip line to avoid damage from falling ice. Pads were also specified at the vertical drops from one roof area to another to avoid water erosion.

The clerestory windows were removed, new sill flashings with upturned ends installed, and the windows were reinstalled.

A local architect, relatively knowledgeable about roofing, was retained by the owner to work with the roofing contractor to develop numerous custom details. The reroofing work was negotiated with a local general contractor and local roofing contractor familiar with standing seam metal and modified bitumen roofing.

Leakage has not been reported since the reroofing and window work was completed in early 2002.

POTENTIAL TERNE PITFALLS

There are potential pitfalls with terne and terne II of which designers and contractors should be made aware:

1. **Repainting:** Owners should be made aware of the manufacturer's recommendation to repaint at least every eight years and the cost implications thereof.

2. **Underlayment:** The manufacturer recommends against inclusion of felt underlayment. However, if the manufacturer's recommendations are followed and only rosin paper is specified, an adequate underlayment will not be achieved. Rosin paper is effective in avoiding bonding between the metal panels and felts, but it is easy to tear during application, and it has limited water resistance. An appropriate underlayment system is a layer of asphalt-saturated base sheet (or a modified bitumen base sheet) and a layer of rosin paper.

   The problem for the specifier is that if the manufacturer's recommendations are followed, a poor underlayment system results. If a good underlayment system is specified, it violates the manufacturer's recommendations, which is not desirable. Based on the results of the author's field observations and laboratory testing, the manufacturer should change its underlayment specification.

3. **Ventilation:** The manufacturer's specification states that "an air space must be provided under roof deck to facilitate ventilation and eliminate condensation." While this recommendation is easy to accommodate when an attic space

occurs below the roof deck, it is difficult and expensive to accommodate when there is no attic space. Had a ventilation cavity been provided on the church roof, the panel corrosion problem would not have been affected. Furthermore, a ventilation cavity below the deck will not necessarily prevent condensation on the underside of the panels. As with the underlayment issue discussed above, the manufacturer should revise its recommendations regarding ventilation so that they are technically valid.

4. **Low slopes:** For slopes below 3:12, the manufacturer should be contacted for special requirements (in 2002, the special requirements were not published in the manufacturer's literature).

5. **Field painting:** Field painting very soon after panel application is important. This should be specified and rigidly enforced. If panel application will occur when it is colder than 50 degrees F, the roof should be tented during painting, panel application delayed, or a panel that does not require field painting should be specified. Specify field painting of the end laps and rigidly enforce this requirement.

6. **Underside corrosion:** The manufacturer's warranty is voided if the terne is "subjected to underside moisture, either from roof leakage or condensation resulting from inadequate ventilation." Specifiers should be aware that terne has a much shorter time-to-failure from underside corrosion than other common metal roofing panels such as aluminum-zinc alloy and copper. ■

FOOTNOTE

1 Because of environmental concerns related to lead, production of terne was discontinued in 1998 and replaced with terne II, which has a zinc/tin coating.

Editor's Note: This article was originally presented as a paper at the RCI 19th International Convention and Trade Show in Reno, Nevada, on April 3, 2004.

About the Author

Thomas L. Smith, AIA, RRC

Thomas L. Smith, AIA, RRC, is president of TLSmith Consulting Inc. He specializes in architectural technology and research, with an emphasis on roof systems. Smith is a licensed architect and a registered roof consultant. His interest in roofing began in 1974. From 1988 to 1998, he was the research director for the National Roofing Contractors Association (NRCA). Prior to that time, he was in private practice in California and Alaska. He has designed roofs from the arctic to the tropics. Smith has been a member of the committee that is responsible for ASCE 7, Minimum Design Loads for Buildings and Other Structures, since 1990.

Asphalt Demand to Grow

Global demand for asphalt (bitumen) is projected to advance to 107 million metric tons, or 654 million barrels of primary asphalt by the year 2007. Of this amount, demand for asphalt in roofing applications is expected to rise 2.5% a year through 2007, to 12.4 million metric tons. That pace will mirror growth during the 1997-2002 period, as gains in developing regions offset a deceleration of demand in the large U.S. market.

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COATINGS FOR METAL ROOFING

By the Roof Coatings Manufacturers Association

Metal roofing systems have been used for many years. After World War II, metal roofs were employed on industrial facilities such as warehouses and on farm and agricultural buildings. Due to improved aesthetics, materials, and sound damping, the use of metal roofs has been increasing. Since the late 1970s, modern roofing has been using an aluminum/zinc alloy (known as Galvalume® coated steel) as the predominant metal material. Traditional galvanized steel roofs are still manufactured and are the most common metal roof panel currently in place. Metal roof panels may have baked on finishes for aesthetic or functional reasons. Metal roofs can be extremely durable, but as they age, the coating degrades and may benefit from recoating. Metal roofing with exposed fasteners can develop leaks at the attachment points that call for repair or sealing prior to coating.

RCMA
Roof Coatings Manufacturers Association

Coatings for Metal Panels

Many different types of coatings are used to coat metal panels. The products include asphalt or polymeric (elastomeric) coatings.

The asphalt coatings may be a solvent or water-based product. Reflective asphalt coatings are typically used as a coating for a metal roof. Polymer-modified asphalt coatings, which offer improved elongation and recovery properties over conventional asphalt coatings, are also used.

Elongation and recovery are important properties in a metal roofing system, as the metal panels expand and contract with changes in temperatures. Pigmented latex coatings are the most common materials used in coating metal panels, as they offer a wide range of resistance to chemicals, oils, and solvents, and have good elongation and recovery. Polyurethane coatings are often used in areas where industrial chemicals or oils are present.

Solvent-borne elastomeric coatings have very good elongation and recovery and can be formulated for tenacious adhesion to metal. The resistance to solvents and oils is lower than acrylic or polyurethane coatings, so these coatings are not used in areas such as restaurants, where oils and solvents are present.

Roof Evaluation

The metal roof should first be evaluated to determine the extent of the degradation. The roofing manufacturer should be contacted if warranty conditions are involved or if replacement is required. The condition of the seams, both vertical and horizontal, should be determined first. The primary seal for the metal roofing system is the seam tape or caulk that is put in the joints between the metal panels. As the system ages, the primary sealant may degrade. To repair the primary sealant, seams that are leaking should be inspected, screws tightened, and washers replaced as needed.

The field of the panels should be inspected to see if any panels need to be replaced or if there is white or red rust. White rust can occur on galvanized roofs, appears to be a chalking of the metal, and is the first stage of corrosion. If there is white rust on the roof, use a solvent-based or water-based rust preventative primer to seal the area. Red rust is a later stage of deterioration, and will continue unless it is removed from the panel. If there are small amounts of surface red rust, power washing, sand blasting, or wire brushing can remove it. The area should then be sealed with a rust preventative primer. Situations where red rust is prevalent or has started to corrode the metal panel require repair and are beyond the scope of this document. Structural metal roofs with red rust may be unsound and should not be walked on.

Even if no rust is present, the roof should be cleaned and free of any dirt, oils, or residual coating. Sealing washers around fasteners degrades them and may necessitate replacement. If there are any screws missing, they should be replaced, and a dab of caulk should be put on the screw heads. The seams should then be sealed by using either elastomeric caulks, specialty tapes designed for this purpose, or fabric embedded in elastomeric sealant.

Coating the Metal Panels

A primer is used in many instances to improve the adhesion of the coating to the metal panels. The coating manufacturer should be contacted for recommendations on the use of a primer.

Depending on the system chosen, a base and topcoat are usually required. Spray, squeegee, brush, or roller may be used to apply coatings, which are available in various size containers, including 5-gallon pails, 55-gallon drums, totes, or bulk. A base coating is often used. The topcoat of the system is usually applied perpendicular to the base coat at the same rate of coverage. The manufacturer should be consulted for recommended application rates.

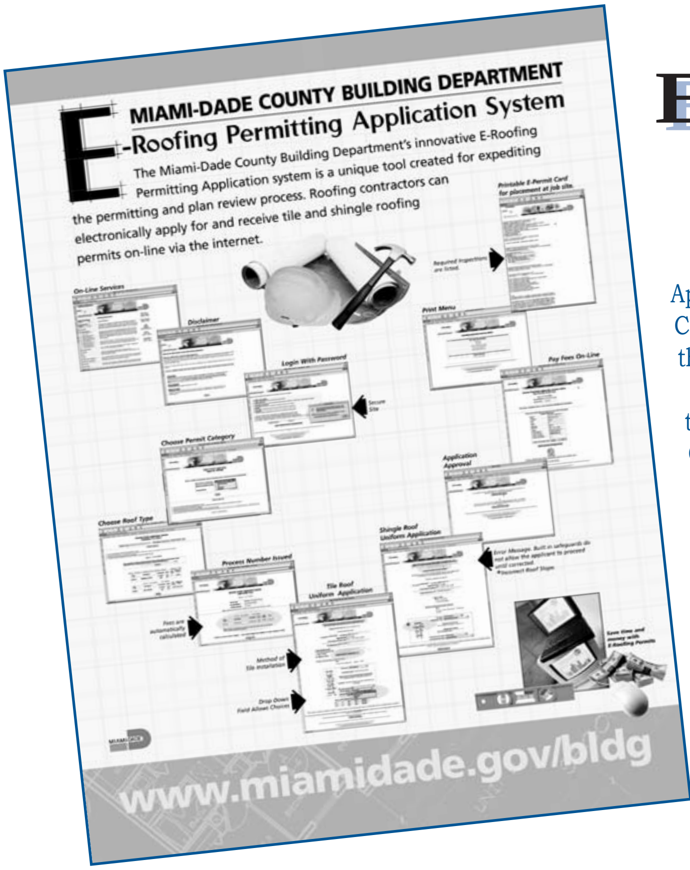
Reflective pigmented roof systems are often used to reduce the energy consumption of a building. This is especially true on dark-colored roofs where there is little or minimal insulation.

Metal roofing is a very durable roofing system. If the roof and the coating are maintained, the life of a metal roof can be extended indefinitely.

For additional information on cold-applied roof coating materials, or about any of the Roof Coating Manufacturers Association (RCMA) manufacturer member companies, contact the RCMA at 1156 15th Street, NW, Suite 900, Washington, DC 20005, telephone: 202-207-0919; facsimile: 202-223-9741; website: **www.roofcoatings.org**. ■

About the Author

This Tech Note was prepared by and has the approval of the Roof Coatings Manufacturers Association (RCMA), 1156 15th Street NW, Suite 900, Washington, DC 20005 (202-207-0919 or www.roofcoatings.org). This note is for informational purposes only and is not intended to revoke or change the requirements or specifications of the individual roofing material manufacturers or local, state, and federal building officials that have jurisdiction in a given area. Any question or inquiry as to the requirements or specifications of a manufacturer should be directed to the roofing manufacturer concerned.

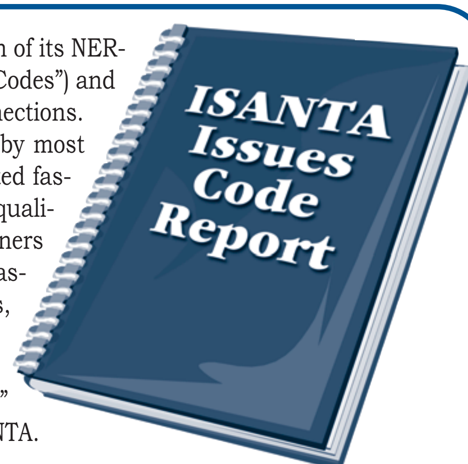


Miami-Dade E-Roofing Permitting System Honored

The Miami-Dade County Building Department's "E-Roofing Permitting Application System" has been named the winner of the National Roofing Contractors Association's (NRCA's) 2004 Gold Circle Award for Service to the Industry.

The system allows roofing professionals to obtain roofing permits via the Internet in an average of 15 minutes for tile and shingle roofs. Qualified contractors visit a secure website accessed by a password, where they fill out a permit application form electronically. A process number is assigned automatically, and permit fees are calculated based upon the square footage of the job.

Assemblies submitted for permitting must have a valid Miami-Dade County Product Control Approval as proof that the material to be installed has been tested to meet the requirements of the High Velocity Hurricane Zone of the Florida Building Code. Current product control approvals are maintained in a database that is accessed by the E-Roofing system. Code-related defaults built into the E-Roofing System require that the contractor enter data in compliance with the Florida Building Code.



The International Staple, Nail and Tool Association (ISANTA) has announced revision of its NER-272 Evaluation Report. The revision updates the report to cover International Codes ("I-Codes") and the latest editions of the older codes, and incorporates recent research on stapled connections.

Evaluation reports are issued by the people who write the "model codes" adopted by most municipalities. NER-272 covers fasteners and fastening schedules. It indicates that listed fasteners were tested for conformance with specifications and are manufactured under a quality control system. Its fastening schedules indicate in what quantity or spacing the fasteners must be used. Building officials use it as a basis for approving use of power-driven fasteners. It has tables on shear walls, horizontal diaphragms, framing, roof coverings, sheathing, and decking.

Copies of the report can be downloaded from ISANTA's website, **www.isanta.org**, by selecting "Building Codes," then "Evaluation Report," and then clicking on "NER-272." Single, complimentary printed copies of the 64-page report can be requested from ISANTA.

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METAL ROOFING & INTERIOR CONDITIONS

BY E. FRANK KELM, RRC

As metal roofing becomes more commonplace, it is being called upon to protect different interior environments. These environments include offices, classrooms, and manufacturing facilities, to name a few. As expected, the requirements of each environment can vary greatly.

One component that should be addressed very early in the planning stage is the interior relative humidly (RH) of the occupied space. Higher interior humidity may require the use of different materials or construction techniques. Geographic location can also be a factor. Designs that work well in southern climates may not give the desired performance when constructed in northern climates.

It may be difficult to locate a specific manufacturer's recommendations for design based upon interior conditions. However, one manufacturer's design manual contains suggested guidelines for various interior humidity levels. Page 70-01.7 of the *Butler Roof Systems Design/Specifiers Manual* offers the following:

> "The standard application of the MR-24 roof system using faced blanket insulation meets most building end use requirements where the interior relative humidity (RH) is 30% or less. Building interiors requiring 30% to 50% RH require blanket insulation with a quality foil facing for specific vapor control, special attention to insulation application at joints and roof-to-wall transitions, and provisions for adequate air movement. Building interiors with RH requirements of 50% or greater require a mechanical engineer's approval of the insulation system planned in conjunction with adequate vapor control and air movement."

So here we have one manufacturer's basic guidelines to follow for three distinct humidity ranges. These ranges are:

- Less than or equal to 30%
- 30% to 50%
- Greater than 50%.

Note these recommendations do not include a corresponding interior temperature. A volume of air at 70% RH behaves very differently at 0˚F, 70˚F, and 100˚F. If the RH of the same volume of air is constant, the vapor pressure will increase as the temperature increases. This raises another important point: interior tempera-

Photo 1: Moisture seeping through corrosion in roof panel.

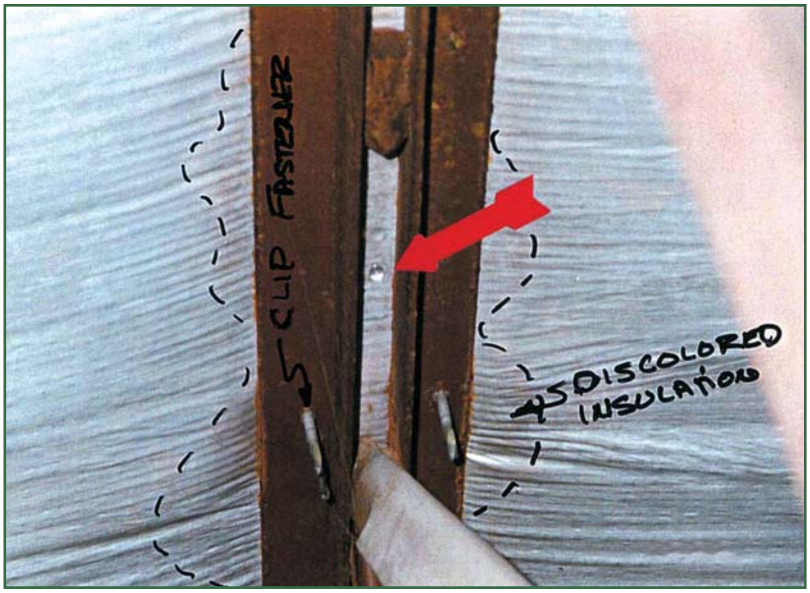
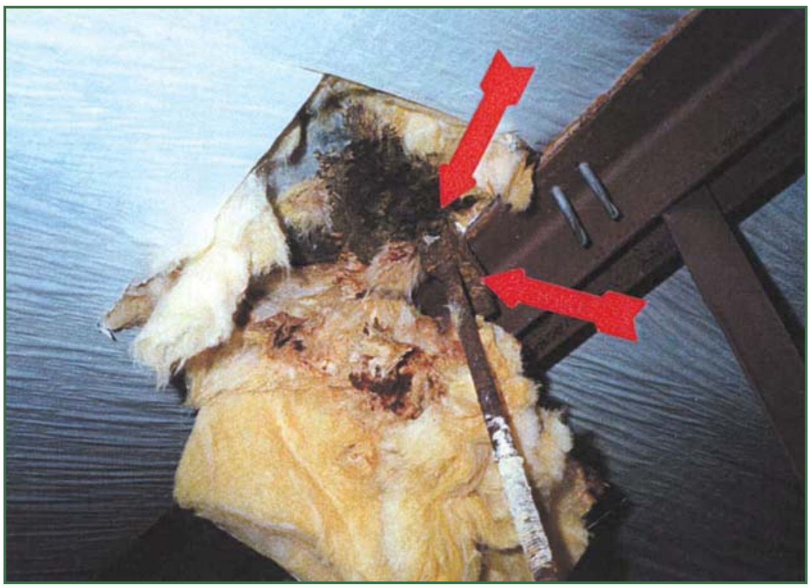


Photo 2: Condensation forming on insulation facer.



Above: Photo 3: Deterioration of beam clamp and underside of roof panel.

ture is also a major consideration of moisture control. If there is a higher than normal interior temperature (>75˚F), it may be prudent to consult with a mechanical engineer regardless of the anticipated relative humidity. For this article, we'll assume that the manufacturer has set these ranges based upon an interior temperature of 70˚F.

So the next question is, what relative humidity can we expect to encounter? To paraphrase, ASHRAE Standard 55 suggests that the comfort range for relative humidity is between 40% and 60%. These values are clearly above the 30% maximum previously stated for "standard applications" and extend into the >50% range at which a mechanical engineer should be consulted. Therefore, it seems prudent that within "normal" office environments (40% to 60% RH and 65˚F to 75˚F), one should always consult with the manufacturer, and possibly with a mechanical engineer, when designing a metal roofing system. Topics of discussion should include insulation, vapor retarder, detailing, and ventilation requirements.

How important is it to follow these recommendations? Each situation must be considered upon its own merits, but two examples are offered. The first involves a project located in Iowa with a standing seam roof installed with standard insulation, vapor retarder, and detailing (no special provisions for high humidity). The roofing system was seven years old and suffering from corrosion of the metal roof panels.

One could actually walk across the roof and see water seep out of the roofing system. Corrosion had penetrated the panel, and moisture was released by the saturated insulation when it was compressed by foot traffic *(see Photo 1)*.

Inside, virtually all of the roof insulation blankets were discolored and sagging. In several instances, condensation could be viewed on the surface of the vapor retarder *(Photo 2)*.

It was also interesting to view the damage that had occurred at a beam clamp. The clamp had been used to support a sprinkler line and was installed on the top chord of a truss. The head of the clamp had penetrated the vapor retarder and was in contact with the underside of the metal roof panel *(Photo 3)*. The clamp, threaded rod, and deck panel were all badly corroded at this point.

This roofing system had clearly suffered significant damage. Our investigation revealed high

Photo 4: Buckets suspended from roof framing.

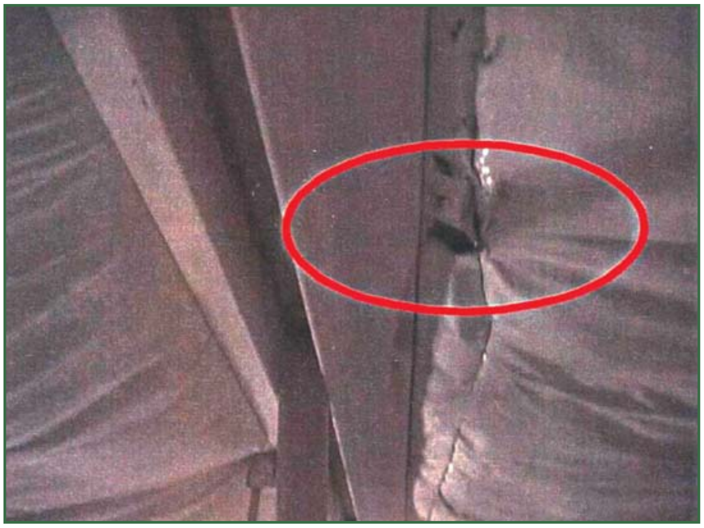


Photo 5: Insulation sidelap is "open" and not centered over framing member.

interior temperatures and humidity. Conditions recorded in the damaged area ranged from 36% to 68% RH and temperatures from 67˚F to 81˚F. The worst case recorded was an interior temperature of 75˚F, RH of 62%, with a resulting dew point of 61˚F.

In keeping with the previously listed recommendations, the manufacturer and a mechanical engineer should have been consulted during the design process. A few extra dollars spent up front could have saved the owner the frustration and expense of a costly and premature repair.

The second example involves a manufacturing facility, also located in Iowa. The parent company had several operating plants located in the South, all based upon a standardized, pre-engineered metal building design. When the Iowa plant was completed and placed into operation, nuisance leaks were reported throughout the plant, primarily during periods of cold weather.

When we viewed the interior of the building, we found that a large portion of the insulation blanket was wet, sagging from position, and dripping water where it had been punctured. As the blanket insulation became wet and sagged, the owner periodically punctured the "low point" of the blanket to allow water to escape in an effort to prevent the blanket from becoming dislodged and falling.

As we walked through the plant, we noted that buckets had been suspended from the roof trusses. These had been placed in strategic locations to prevent water from dripping onto sensitive equipment *(Photo 4)*.

The sidelaps of the blanket insulation were found to have gaps and were not taped or sealed together *(Photo 5)*. We also found that the blanket insulation had not been sealed around projections *(Photo 6)*.

When the client was asked about the building's interior conditions, he stated that the ideal operating conditions for the plant were 70˚F and 42% RH. On-site measurements revealed that the interior temperature ranged from 70˚F to 80˚F, and the RH varied from 40% to 50%. These ranges were within the client's acceptable operating limits.

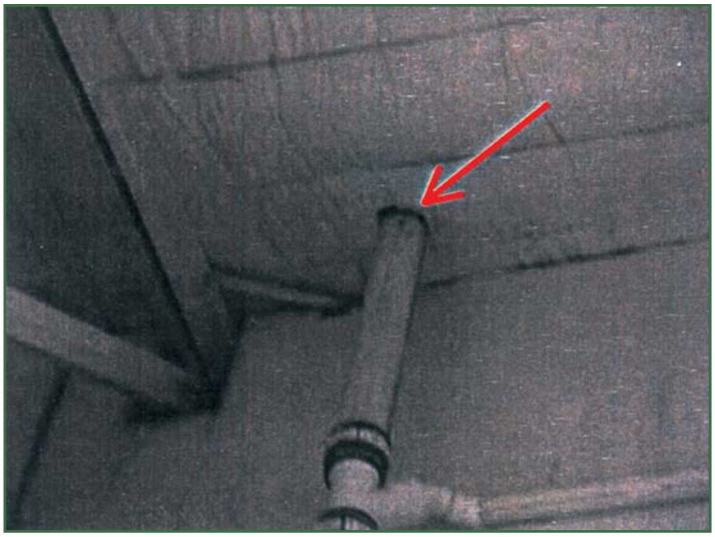


Photo 6: Insulation facer is not sealed around projection through roof.

The client was dismayed when its previously successful design (which worked fine in the South), failed to perform in a more northern climate. This example points out another variable to be considered – geographic location.

The National Roofing Contractors Association (NRCA) recommends “that dew point related problems be considered in the design of the roofing when the outside mean January temperature is below 40˚F, and/or the expected interior relative humidity is 45 percent or greater.”

Had the designers heeded (or been aware of) the guidelines listed above, they may have been able to prevent this unpleasant surprise. As a result, the owner was faced with an expensive repair that could have been avoided. As is often the case, the cost to make repairs after the fact is much greater than if these enhancements were incorporated into the original construction.

In summary, we should all be aware that the interior temperature, relative humidity requirements, and the project’s geographic location can have a dramatic effect on the proper design of a roof. ■

About the Author

Frank Kelm is a project manager for the Howard R. Green Company, located in Cedar Rapids, Iowa, and works primarily with building exteriors. He has more than thirty years’ experience in the roofing industry, and is a Registered Roof Consultant (RRC) with the Roof Consultants Institute.

E. Frank Kelm, RRC

METAL ROOFING FROM A TO Z

ALUMINUM TO ZINC

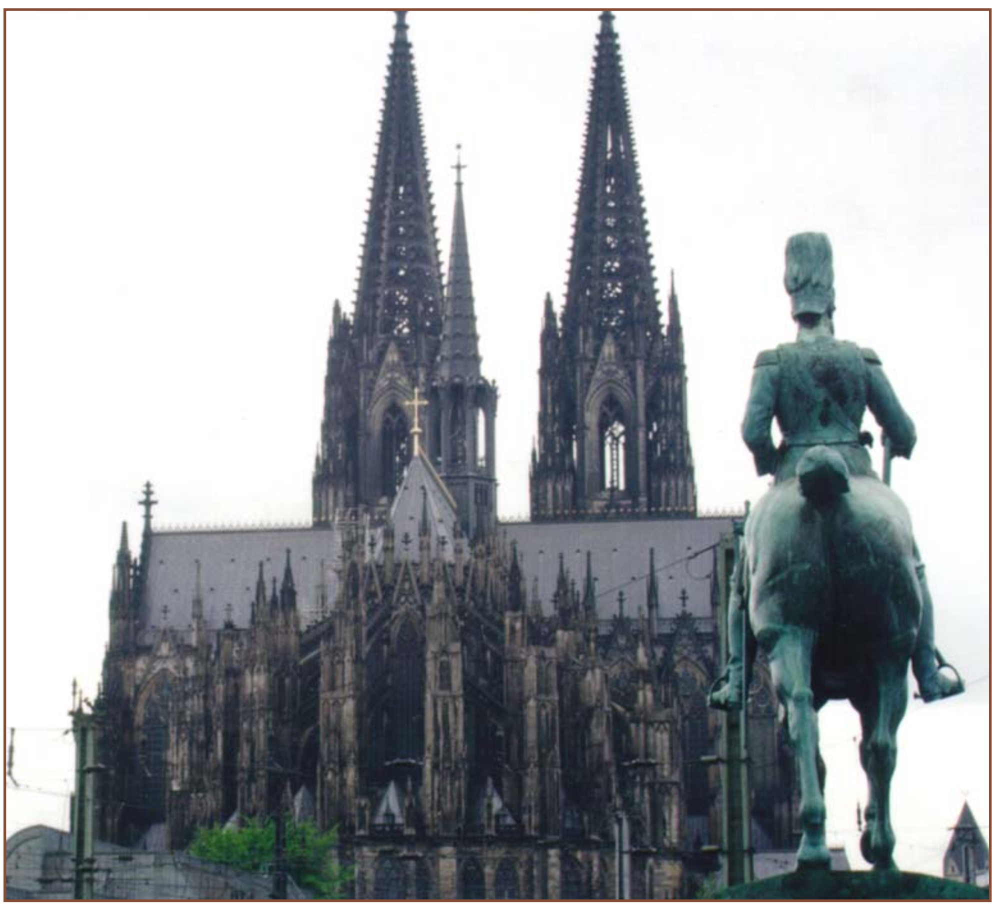
PART I: History and Materials

By Rob Haddock

Editor's note: This is the first article in a multi-part series about metal roofing in today's market. It starts with the materials and their uses and moves through coatings, system designs, and installation techniques. It is reprinted with permission of Metal Mag Magazine.

Metal continues to increase its share of the roofing market as more and more construction owners, designers, and specifiers seek more durable "sustainable" roofing materials.

As a cladding material, metal's roots and technology date back to Biblical times. It has always been coveted as a premium roofing option but historically has been handicapped by generally higher initial cost than many other options. Today's trends point toward evaluating the long-term costs of owning a roof as more landfills are overburdened with junk material (former building components) discarded because of short-sighted, budget-conscious building objectives. The life-cycle costs and environmental appeal of metal truly have some advantages, which are being touted by much of the supply side of our industry.



A lead roof was chosen for this cathedral in Köln (Cologne), Germany built in the 13th Century.

As metal roofing gains popularity and is specified for more and more projects, sadly, but inevitably, more failures will occur due to misuse or the perception that metal is magic and will do anything. While material failures are highly unusual, the common pitfalls are inappropriate product selection to suit job specifics and misapplication of the selected products.

Using metal roofing systems involves a good deal of science, so making uninformed design decisions about materials and systems is a bit like playing Russian roulette. Some knowledge and understanding of basic elements of system design, material selection, and installation will certainly improve the odds for a successful roofing project and a satisfied (and dry) customer or client for many years to come, while (hopefully) reducing gainful employment for a slew of trial lawyers.

One of the first issues to decide is what sort of metal should be used.

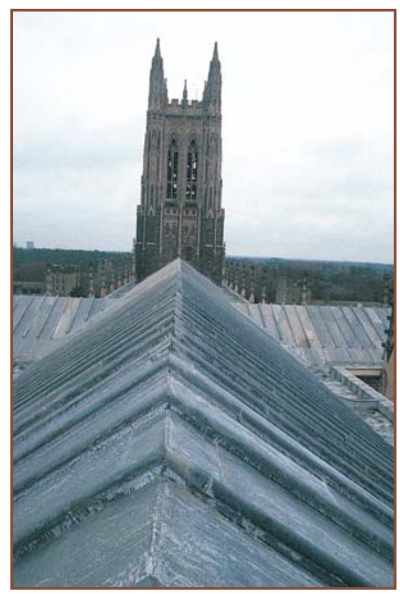
There are a number of choices, including copper, terne, aluminum, stainless steel, carbon steel, zinc, lead, and even titanium. All have pros and cons.

The Dome of the Rock, finished in 691 following the Turkish conquest of Jerusalem, is believed to have originally sported a gold roof. It is now gold leafed aluminum. (All photos courtesy of Metal Roof Advisory Group, Ltd.)

Some soft metals – copper, lead, and terne-coated stainless – can have a life expectancy measured in centuries. They also carry a premium price tag and call for a high degree of fabrication and installation skill. We refer to these metals as “crafted roofing” metals. They are favored over coated steel in most of Western Europe. They are also favored in the U.S. for high-end and historical applications. Their inorganic surface finishes and oxidation characteristics give them timeless beauty and maintenance freedom not enjoyed by organic finishes (painted metals), and they are easily solderable.

Titanium zinc, the soft, grey metal that enjoys immense popularity in Germany and other European nations, is also increasing in popularity in the U.S. It is also a crafted metal, and available in different surface finishes, including preweathered.

The material is imported from Europe by two companies: one is German (Rheinzink), the other French (Umicore, formerly VM Zinc). Popular thicknesses are .7mm and .8mm. Zinc requires some special considerations in fabrication to avoid fracturing of the finished product, and care in detailing and underlayment, as the material has a low tolerance for subsurface moisture.



Lead coated copper, one of the longest lasting metals, covers the roof of the chapel at Duke University, Durham, N.C.

Zinc is also easily soldered, but be careful – its melting temperature is much lower than other solderable metals. With appropriate precautions, zinc can have an expected life of nearly a century. There are no ASTM reference numbers for this material because it has no domestic producers.

Terne has a life expectancy greater than many other options and a moderate cost, but it requires repeated maintenance (painting). Many early 20th Century terne roofs can still be seen all over the eastern United States. Use of this tin-lead alloy coated steel is responsible for the popular misnomer, “tin roof.”

Terne-coated stainless requires no maintenance and is a solderable material, but it bears a very hefty price tag, as do zinc, lead, titanium, and lead-coated copper. Terne is most commonly used in 28 and 30 gauge, while 26 and 28 gauge are most common for terne-coated stainless. Terne falls under the carbon steel classification of ASTM A-625, while terne-coated stainless is ASTM A-240. There are no federal specification numbers for either of these metals.

Lead is one of the longest-lasting metals known to man and has been used for more than a millennium on some of the most elegant castles and cathedrals throughout Europe. It may well outlast any other roof type, metallic or not, even in a salt spray environment. But lead has a very high thermal coefficient and significant weight, so it must be appropriately designed.

The most popular lead applications are "batten-roll" profiles using gentle, radiused folds and joints. Lead has many unique qualities and installation methods all its own. "Lead burning" is practiced by fewer and fewer mechanics. Because of these facts, lead's high cost, and the bad rap it is receiving from environmental protagonists, the application of sheet lead is, unfortunately, becoming a lost art in North America.

Metals like terne, copper, and stainless, which have typically offered lead or lead alloy coatings, are now using other alloys like

Greater detail and weather integrity can be accomplished with soft crafted metals as shown on the Kronborg Castle in Denmark.

The Roskilde Cathedral in central Denmark dates back to 1170 and features a lead roof.

A copper roof tops the Kronborg Castle in Helsingor (Elsinore) Denmark (above, top), which was built in the 1500s and was the setting for Shakespeare's Hamlet.

tinzinc to have more "politically correct" public appeal.

Architectural copper is specified as ASTM B-370 and lead-coated copper is ASTM B-101. Copper is designated by the ounce-weight (the weight of 1 square foot of copper in ounces). A 12 x 12-inch piece of copper may weigh 12 to 48 ounces, depending on its thickness. The most common roofing sheet is 16 or 20-oz. Sixteen-ounce is .0216 inches in theoretical thickness, while a 24-ounce would be .0323 thick.

Titanium is an option that has recently found its way onto the list through its use on the high profile Guggenheim Museum in Bilbao, Spain **(www.guggenheim-bilbao.es).** It is unique in appearance, has an inorganic finish, a thermal coefficient even lower than steel, and incredible strength, durability, and corrosion resistance. It also has an elite price tag above other metals, and only one domestic producer, but it will almost certainly grow in use as more designers learn of its benefits.

The reference number for architectural titanium is ASTM B-265 and the most commonly used size is 28 gauge in 4-foot widths. It is also available in coils and custom lengths.

High tensile aluminum is more in the affordable range as a base metal. It also offers some structural capabilities but has an extremely high coefficient of expansion, which causes a great deal of thermal movement. Still, this material is a cost-effective alternative for salt spray coastal environments as well as acid rain environments where the longevity of coated steel alternatives may be a bit lacking and budgets do not allow lead or lead-coated alternatives. While it is preferred for such environments, the detailing must provide for increased thermal movement, and fabrication methods must allow for its more brittle behavior.

Aluminum is easily painted by modern coil coating methods, and so organic color finishes can be provided at moderate added

This LCC batten roll roof on the Chapel of Duke University (above) was installed in the late 1930s. The craft of metal roofing was brought to North America by such European artisans as Paul Revere.

cost. Another benefit of this metal is that its installation practices are generally consistent with those of coated steel products, and so the availability of installation contractors is widespread.

Aluminum is specified as ASTM B-209. The most common thickness for roofing is .032 inches, with .040 inches running a close second. The most common sheet alloys are 3004 and 3105 and the tempers for these alloys are 3105-H14 and 3004-H36.

Of all the available base metals, steel is the lowest cost and has excellent structural characteristics. Since steel rusts, a protective coating must be selected. Of all the options listed, coated carbon steel is the most common choice for metal roofing in North America, primarily for economic reasons. It is only logical then that significant development and improvements for metallic coatings used on carbon steel have originated in the U.S.

This does not imply that other materials do not have their place. In fact, when asked, “What is the best roof on the market today?” the author’s pat response is, “Lead, lead-coated copper, or titanium on a 12:12 slope.” This response is not often debated in terms of accuracy but often frustrates the inquisitor because such slopes are rather uncommon and few budgets permit the use of these materials.

Since steel dominates the domestic (U.S.) market at ratios of about 10 to 1, let’s focus on the alternatives available when using steel, such as gauge, coating type, and coating weight.

The most common gauge thickness used in the commercial roofing marketplace is clearly 24, although 26 is used on rare occasions. Since new and more stringent wind test standards (such as ASTM E-1592 and the new FM 4471) have emerged following Hurricanes Andrew, Iniki, and others, more 22-gauge material is being used. (The lower the gauge number, the thicker the material; 22 gauge is .030 inches minimum in thickness, 24 gauge is .024 inches, and 26 gauge is .018 inches minimum.)

Many contractors and designers believe that increasing the thickness will alleviate the problem of “oil canning,” which is a rippling effect in the panel surface caused by stress. It is most pronounced in very flat panels with wider covering dimensions. The stresses that produce oil canning are caused by a number of factors, few if any of which have to do with the thickness of the metal. Hence, increasing thickness adds significant cost but may not eliminate the problem. A more cost-effective approach to resolving the potential for oil canning involves:

- Reducing panel width.
- Working with a reputable manufacturer.
- Using well-tuned, roll-forming equipment.
- Using a panel profile with stiffening flutes in the flat area, if not objectionable.
- Insisting on tension-leveled coil stock with close camber and flatness tolerances.
- Ensuring that there is adequate provision for thermal movement within the system's design and installation.
- Being sure that the structure and/or deck is smooth and true-to-line.

Another little trick that can be used in architectural installations over wood deck is to install a strip of backer rod between the deck and panel to cause the "flat" of the panel to arch slightly between seams.

Other specified variables in steel procurement involve tensile and yield strength and coating type and weight. The mechanical properties relate more to the manufacturing process than end use, so they are often considerations with which the contractor, designer, or specifier need not be concerned.

Coating type and weight, however, are rather important decisions which should be understood by the contractor or specifier. This refers to metallic coating of steel coil, not paint coatings.

All steel coil used in exterior applications is coated with a metallic coating to protect it from corrosion. These coatings are all applied by the continuous hot-dip method and are metallurgically bonded to the base steel. Within the domestic market, there are three distinctive options for coating types: zinc, aluminum, and alloys of the two. Within these types, there are also options concerning the rate of application of the coating, designated by weight per square foot (total of both sides). These application rates also result in different thicknesses of coatings. ■

The topic of metallic coatings for steel will be covered in the next part of this series.

About the Author

Rob Haddock

Rob Haddock, director of the Metal Roof Advisory Group Ltd., is a well-known expert and educator in the field of metal roofing technologies. He is an international metal roofing consultant and innovator, holding numerous U.S and foreign patents. He is a contributing editor for several trade publications, a member of the National Roofing Contractors Association, ASTM, the Metal Building Contractors and Erectors Association, and the Metal Construction Association. He is also a course author and presenter for RCI, NRCA, and the University of Wisconsin School of Engineering. He is a past recipient of RCI's prestigious Horowitz Award for contributions to *Interface* journal.

STEEL SHORTAGE AFFECTING CONSTRUCTION

By Ken Simonson

Contractors are reporting a variety of problems related to steel. Prices are rising at ever-increasing rates. Suppliers have added heavy surcharges to previously "firm" prices and told contractors they must pay or forgo delivery. Suppliers have shortened the period for which they will quote firm prices on new inquiries to 15, 7, 3, or even one day. They will not guarantee delivery dates or quantities in some cases. Various contractors report their suppliers are, or soon will be, allocating re-bar, sprinkler pipe, metal wall studs and fasteners, and guardrail materials.

The Associated General Contractors of America (AGC) board of directors responded by approving a resolution urging public and private owners to permit steel price adjustments in both new and existing contracts. Mary Peters, Administrator of the Federal Highway Administration (FHWA), has announced that the administration "supports the appropriate use of price adjustment clauses for products, including steel, when they can reduce contingencies in construction bids and provide for an equitable adjustment for costs that may increase during the life of a project."

Bexar Concrete of San Antonio, a fabricator of prestressed concrete for bridge girders and parking structures, laid off more than 40 workers because it could not obtain steel strand after a 77% anti-dumping duty on foreign strand led other users to turn to the only two U.S. suppliers, depriving Bexar of its supply. Bexar's inability to produce bridge girders has led to delay of one bridge project and threatens to delay two of the largest highway projects in the nation.

In employment statistics released by the Bureau of Labor Statistics (BLS), construction employment gains in the past year have accounted for all of the 122,000 growth in nonfarm employment. Average weekly hours in construction (not seasonally adjusted) moved up from 37.7 a year ago to 38.5, and average hourly earnings climbed 1.8% to $19.04, 22% higher than the all-private sector average for nonsupervisory or production workers.

The Small Business Administration (SBA) has proposed new small-business size standards for use by a variety of federal programs (**sba.gov/size/indexwhatsnew.html#restructurePR**). Under the proposed rules, size will be determined by number of employees in most cases, and the number of different size categories will be reduced from 37 to 10. SBA also proposed to establish a maximum average annual receipts amount (referred to as a receipts cap) along with the employee-based size standard. Construction is one of 31 industries under the receipts cap. To qualify as an eligible small business, a company cannot exceed the employee-based size standard and cannot exceed the specific receipts cap amount.

Editor's Note: *This series on the economy and its impact on the construction industry is published monthly in* Interface. *This month's column was prepared by Kenneth D. Simonson, chief economist for the Associated General Contractors of America (AGC). Before joining AGC, Simonson spent three years as senior economic advisor in the Office of Advocacy of the U.S. Small Business Administration and 13 years as vice president and chief economist of the American Trucking Association. Simonson may be reached at simonsonk@agc.org.*

Industry News

People

Bradford Elected NRCA President

Dane Bradford, president of Bradford Roof Management, Billings, MT, was elected 2004-05 president of the National Roofing Contractors Association (NRCA). His term will begin June 1. Bradford served as president of the Montana Roofing Contractors Association in 1991-2. Reid Ribble was also elected senior vice president of NRCA.

Products

Grace Introduces Perm-A-Barrier Liquid

Grace Construction Products has introduced Perm-A-Barrier® Liquid, an air and vapor barrier product for use in above-grade wall assemblies. The liquid is intended to allow the structure to be exposed to the environment for up to 60 days prior to the exterior building material application. For more information, visit **www.graceconstruction.com**.

Alpine SnowGuards Introduces New Product

Alpine SnowGuards unveils its new Model #30CL clear polycarbonate, pad-style snow guard. The snow guard can either be adhered to the roofing material or mechanically fastened. For more information, visit **www.alpinesnowguards.com**.

D-Mark Offers CarbonWeb Roll product

Chesterfield, MI-based D-Mark, Inc., has introduced the CarbonWeb® (CW) Filter Roll Media for temporary odor and pollution control. The media are simply cut and taped over air intakes before work on a roof begins and is removed afterwards. For information, visit **www.dmarkinc.com**.

GAF Unveils Camelot™ Shingles

GAF Material Corporation has introduced the Camelot™ Premium Designer Shingle. Camelot™ shingles feature GAF's super-heavyweight "plus" construction (approximately 460 lbs. per square) and are warranted to withstand winds up to 110 mph. They are Class A fire-rated. For more information, visit **www.gaf.com**.

Reichel & Drews Introduces Roll Winder

Reichel & Drews has introduced the Model RW20-LS Servo-Drive Roll Winder. Designed for modified bitumen roofing and waterproofing material producers, the roll winder is said to be capable of producing up to ten tightly wound rolls per minute. For more information, visit **www.reicheldrews.com**.

KeeGuard® Contractor Protects from Falls

Kee Industrial Products, Inc., Buffalo, NY, has introduced its new KeeGuard® Contractor rooftop fall protection railing system. The system is comprised of railing bases, standard steel pipe, and slip-on pipe fittings galvanized for corrosion resistance. For more information, visit **www.KeeGuard.com**.

Publications

FM Releases Publications

FM Approvals has released its 2004 edition of the *Approval Guide* in CD format. The resource contains more than 45,000 listings of fire protection, electrical, and building equipment materials and services tested and approved for property conservation by FM. It has also issued its 2004 Property Loss Prevention Reference Library, *FM Global Resource Collection*, on CD-ROM. For more information, visit **www.fmglobal.com**.

Plants

GAF to Build Shingle Factory

GAF Materials Corporation announced plans to build a new high-speed shingle manufacturing facility. It is evaluating plant sites in Maryland, Pennsylvania, and two other states. The facility will be completed in 2006 and will increase the company's laminate manufacturing capacity by more than 30% and total shingle manufacturing capacity by more than 12%.

Partnerships/ Purchases

BASF Purchases Foam Enterprises

BASF has purchased 100% of the stock of Foam Enterprises, Inc. (FEI), of Minneapolis, Minnesota. FEI, founded in 1977, supplies rigid polyurethane foam materials for roof and wall insulation, walk-in coolers, insulated building panels, spas, and boat flotation. BASF also makes rigid polyurethane foam systems and had sales of $34 billion in 2002. It is the North American affiliate of BASF AG, Ludwigshafen, Germany. FEI will operate as a subsidiary of BASF.

Plaudits

PIMA QualityMark℠
The Certified LTTR-value

Atlas Receives LTTR Validation

The Atlas Roofing Corporation became the industry's first polyiso insulation manufacturer to receive independent third party validation of its LTTR (Long Term Thermal Resistance) values for all of its permeable faced polyiso roof insulation products. The company is also the first to adopt the Quality Mark designation introduced by the Polyisocyanurate Insulation Manufacturers Association (PIMA) for LTTR third party certification.

More
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NRCA Announces Design Award Winners

The NRCA announced the winner of its first Excellence in Design Awards at its convention in February. The winner was Magco Inc., Jessup, MD. Finalists were INSPEC Inc., Minneapolis, MN; Keystone Roofing Inc., Oceanside, CA; RTE Technologies Inc., Overland Park, KS; and Southern California Roofing, Downey, CA.

Gold Circle Awardees Named

The NRCA recently bestowed its 10th annual Gold Circle Awards to NRCA members who made significant contributions to the roofing industry in the following categories: outstanding workmanship, low slope – Western Roofing Service, San Francisco, Wells Fargo Bank headquarters; outstanding workmanship, steep-slope – F.J.A. Christiansen Roofing Co. Inc., Milwaukee, WI, Holy Hill, National Shrine of Mary, Help of Christmas; innovative solutions, new construction – Edward J. Laperouse Metal Works Inc., Houma, LA., Terrebonne Parish main library; innovative solutions, reroofing – Titan Roofing Inc., Chicopee, MA., New York State Capitol; and service to the industry – Miami-Dade County Building Dept., Miami, FL., E-Roofing Permitting Application System.

Calendar of Events

MAY 2004

4-6 Roof Asia 2004
Kuala Lumpur, Malaysia
91-44-2440-5493
www.roofasia.com

5 Mid Atlantic Chapter Meeting
Virginia

6 Region I Meeting
Woburn, MA

7 Chicago Area Chapter Meeting

11 Special Program: Mold, A Balanced Approach
(Course material developed and presented by Morrison Hershfield, Toronto, Ontario)
Houston, TX

14 Region III and Ohio Valley Chapter Meeting
Indianapolis, IN

19 Roof Asset Management
Philadelphia, PA

19-22 Dach + Wand International
Munich, Germany
Info: 312-377-2657

20-21 Rooftop Quality Assurance
Philadelphia, PA

22 RRO Exam*
Philadelphia, PA

30 Ontario Chapter Meeting
Hamilton, ON

JUNE 2004

2-4 Greening Rooftops for Sustainable Communities
Portland, Oregon
Info: www.greenroofs.ca

3-4 Wind & Drainage
New Jersey

5 RRC Exam*
New Jersey

8 Mid Atlantic Chapter Meeting
Virginia

6-8 WSRCA Convention
Las Vegas, NV
Info: 800-725-0333

9 Region VI Meeting
Las Vegas, NV

10-12 AIA Annual Convention
Chicago, IL
Info: 800-242-3837

17 Region IV Meeting
Austin, TX

25 Ontario Chapter Meeting
Hamilton, ON

JULY 2004

10-11 Exec. Comm. Summer Meeting *(tentative)*

28-31 Fla. Roofing, Sheet Metal & AC Contractors Assoc.
Orlando, FL
Info: 407-671-3772

AUGUST 2004

4 Region III - Great Lakes Chapter
Rothbury, MI

5-7 Michigan Roofing Cont. Assoc.
Rothbury, MI
Info: 586-759-2140

18 Region VI Meeting
San Diego, CA

24 Waterproofing
St. Louis, MO

25 Rooftop Safety for Consultants & Building Owners
St. Louis, MO

26-27 Rooftop Quality Assurance
St. Louis, MO

28 RRO Exam*
St. Louis, MO

SEPTEMBER 2004

9 Region IV Meeting
Dallas, TX

14-15 Roof Tech. & Science I
Baltimore, MD

16-17 Roof Tech. & Science II
Baltimore, MD

16 Mid Atlantic Chapter Meeting
Maryland

17 Region II Meeting
Jacksonville, FL

17 Chicago Area Chapter Meeting

25-26 Mid-Year Board Meeting *(tentative)*
Miami, FL

Black print: Industry events
Blue print: RCI events

Calendar subject to change without prior notice.
Visit **www.rci-online.org** for schedule updates.

*A completed application must be received by Headquarters 90 days prior to sitting for an exam.

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