PROCEEDINGS

Repair Strategies for Metal Roofing

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Addressing the Building Envelope

ABSTRACT

The purpose of this paper is to review the evolution of the conditions of a metal roof system throughout its service life and present various repair options and strategies available to the design professional. Our typical field investigation procedures for an existing metal roof system will be presented, as well as factors to consider when evaluating an existing roof system when determining repair options. Various repair options for an existing metal roof system, as well as photos and/or details of completed projects, will be presented, including the following:

- Isolated repairs and refurbishment
- Simplification of roof system and detailing
- Elastomeric coatings
- High-performance finish systems
- Overlay with nested panels
- Overlay with thermoplastic roofing membrane
- New metal roofing system on overlay furring system
- Metal roof removal and replacement

SPEAKER

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JAMES RIPLEY has practiced architecture since 1976 and has been involved in roof and waterproofing consulting full time since 1993 at A/R/C Associates, Inc. in Orlando, FL. His practice has offered a unique opportunity to observe metal roofing performance and deterioration at an accelerated rate in a high-humidity, high-ultraviolet, high-wind environment. He has observed the long-term performance and failure of several industry standard repair methods and numerous installation methods, as well as storm damage due to hurricanes. In the course of his work with different clients over the years, Mr. Ripley has used various strategies to repair and renovate existing metal roof systems and extend their service lives. Over the years, Ripley's firm has been involved in the analysis, repair, and replacement of well over 50 metal roof systems in varied applications and at various points of their service life. All of these projects have been extensively detailed, installation has been carefully observed, and their successful long-term performance has been monitored through ongoing client relationships.

Repair Strategies for Metal Roofing

INTRODUCTION

A/R/C Associates, in Orlando, FL, is an architectural firm that has specialized in roofing and waterproofing almost exclusively during the last 29 years. Over the years we have come to realize that working throughout the entire Florida peninsula has provided us with a rather unique perspective on the life cycle and aging of a roof system.

Florida's subtropical climate can be a very severe environment for roofs, which has allowed A/R/C to observe an accelerated life cycle of numerous metal roof systems and repair methods in comparison with other, more temperate areas of the country.

1. The ultraviolet exposure in Florida is severe enough that numerous paint manufacturers have test facilities in the state.
2. The wind speeds for which we need to design vary from a minimum of 110 mph to more than 150 mph.
3. Exposure to moisture varies from droughts during the winter and spring to daily thunderstorms with rainfalls in excess of 5 inches per hour during the summer and fall on a normal basis, without taking into account the occasional hurricane.
4. The majority of our population is in the coastal areas of the state, and exposure to this salt air environment has caused accelerated corrosion problems.
5. Florida is a right-to-work state with few unions and, therefore, a lack of training programs for roof system applicators. Consequently, many of the metal roofs with which we have come in contact have been assembled with less than ideal workmanship.

Much of the company's practice is remedial, and we are typically retained to investigate, analyze, resolve, and repair existing problems. This paper is based on many of the metal roof conditions we have encountered over the years.

ROOFING CHARACTERISTICS

In reviewing some of the characteristics and different types of metal roofing, one sees that it can be divided into three categories: architectural, structural, and industrial. These categories have the following characteristics:

1. Tends to be installed at a steeper roof slope and is more visible.
2. Considered a rain-shedding roof system instead of a waterproof system.
3. Panels typically interlock or snap together.
4. Needs an underlying deck or structural support system.
5. A waterproof underlayment is recommended or required.
6. The roof system has a concealed fastening system that allows for panel movement due to thermal expansion and contraction.
7. The roof system is usually fixed at the ridge or the high point of the panel.

1. Can be installed at a lower roof slope than an architectural panel.
2. Considered a waterproof roof system.
3. Panels are mechanically interlocked using a seaming machine in the field.
4. Designed to be installed over open framings, although can be installed over solid deck.
5. Aesthetics are often less important, based on building use.
6. The roof system has a concealed fastening system that allows for panel movement due to thermal expansion and contraction.
7. The roof system is usually fixed at the drip edge or the low point of the panel.
8. This roof system is typically used in preengineered metal buildings.

1. Often considered a subset of the structural roofing systems.
2. Considered a waterproof roof system only if properly sealed during assembly.
3. Panels are simply overlapped during installation.
4. Designed to be installed over open framings, although can be installed over solid deck.
5. Aesthetics are often less important, based on building use
6. Uses exposed fasteners, which do not allow for panel movement due to thermal expansion and contraction.
7. The roof system is usually fixed at the drip edge or the low point of the panel.
8. Panels are anchored at each support point; although they accommodate movement at the ridge for the system as a whole, they depend on the structural framing system having some ability to move.
9. Utility panels are typically used for roof and wall panels for preengineered metal buildings such as warehouses, agricultural, and industrial buildings.

DESIGN CONSIDERATIONS

When anticipating the design and selection of a metal roof system or evaluating an existing metal roof system for repair or refurbishment, the following general principles for metal roof systems should be taken into consideration:

1. Metal roof systems can provide a very long service life when properly designed and installed, limited only by the service life of the metal itself.
2. A key point is that "properly designed and installed" metal roofs are extremely unforgiving and can be very difficult to permanently repair.
3. Proper design and detailing of a metal roof is essential, and this will be more time-consuming and expensive than most other roof systems.
4. A properly designed metal roof system will initially be more expensive to install than many other roof sys-

tems, or than a poorly designed metal roof system.
5. The low maintenance and long service life can make a metal roof system quite cost-effective over the life of the roof system.
6. Metal roofs are best suited for simple building shapes; complex roof configurations can quickly complicate metal roof design and installation.
7. The design of any connection or flashing must allow for the thermal movement due to expansion and contraction of a metal roof.
8. Selection of the base metal (steel, Galvalume, aluminum, stainless steel, or copper) will affect the detailing and installation methods.
9. A properly designed metal roof system should be able to be installed and be weathertight without the use of any exposed sealants or gaskets. Sealants and gaskets should be a secondary means of protection only (except for roofs with exposed fasteners).

Just as important as what to consider when designing a metal roof installation, repair, or replacement, is what mistakes to avoid. In our practice, we have seen numerous reasons for the failures of metal roof systems. The age of the roof is often identified as the problem in relation to failure of the gaskets or sealants—usually the result of a roof designed to depend on sealants or a roof system with exposed fasteners. The age of the roof is also related to corrosion problems. Corrosion can be either delayed or accelerated, depending on the details, materials, and methods used to assemble the metal roof system.

A typical building owner with an eight-year-old leaking metal roof initially wants an explanation as to why his metal roof is leaking, but after it is explained to him that the roof system is leaking because of how it was installed, the owner usually starts searching for someone to blame. Original construction drawings will then be reviewed when available, looking for defective details. We usually discover that the details aren't wrong; they just aren't there. Those design and detailing decisions had been left to the mechanic in the field with his metal shears, pop rivets, and caulking gun to resolve. For a metal roof to perform, all those transitions, edges, and fabrications need to be properly designed and detailed by someone who truly understands how a metal roof works.

As mentioned earlier, a metal roof system will move due to temperature changes—Mother Nature guarantees that—and it will move with a force that no amount of anchors or fasteners can resist.

Then of course, some metal roof failures must be blamed on architects and designers who often use metal roofs for an application where it is simply not appropriate. As mentioned earlier, metal roofs are best when applied to simple shapes. Unless the designer is willing to detail each and every flashing condition, a metal roof system shouldn't be selected and specified for a complex roof configuration. Metal building manufacturers deserve a little blame, too. Their business is to sell metal building systems, but there really are some applications for which a metal building system is inappropriate.

METAL ROOF REPLACEMENT

We have worked with multiple metal roofing projects over the years and many have simply been removal and replacement of an existing metal roof "in-kind," which is most easily accomplished for an architectural roof panel over a solid substrate (as shown in *Photo 1*). But many of our roofing projects involve an existing and occupied building that must remain functional during the course of the work. Under these conditions, removal and replacement is much less feasible with a structural metal panel roof system over open purlins. Removal of the roof panels would expose the interior of the building to weather and damage, endanger the safety of the occupants, and eliminate any working platform for the laborers and installers. Installation of a furring system over which the new metal roof is installed becomes a viable option that allows the existing metal roof system to remain in place and avoids the cost of removal and disposal of the existing metal roof system, provided the structural system has adequate capacity to support the additional dead load.

This can be done either using a double

Photo 2 – In this double furring system, the first layer of furring runs up the roof slope and a second layer of furring runs across the roof slope.

Photo 1 – Replacement of an architectural roof panel over a solid substrate.

Photo 3 – A replacement system that seems to be unique to utility panels with exposed fasteners is overlaying an existing metal roof system with a nesting panel system.

furring system (first layer of furring runs up the roof slope and a second layer of furring runs across the roof slope; see *Photo 2*), or a single furring system that is precut to nest within the existing metal roof panels. Both of these furring systems are anchored to the existing purlin systems through the metal roof panels. The double furring system does allow for variable furring locations and easier retrofit to older buildings in Florida because of the high wind-uplift forces generated at the roof edge and corner zones. Until recently, older preengineered buildings often required additional purlin framing due to the wind uplift forces that made use of precut single-furring system difficult. One company has recognized this shortcoming and has created a system to accommodate this by having a preengineered, two-way furring system that could be installed at the corner zones of the building and the edge zones, if necessary, within the same limited height as the remainder of the single horizontal furring system.

A replacement system that seems to be unique to utility panels with exposed fasteners is overlaying an existing metal roof system with a nesting panel system (as shown in *Photo 3*). Although very little guidance is available from the roof panel manufacturers with regard to this panel installation method, it can be very cost-effective. Initially, all the existing exposed fasteners at several roof panels are removed, a separator sheet is applied, a new utility roof panel is nested over the existing panel, and new exposed fasteners with neoprene-backed washers are then driven through both roof panels into the underlying steel purlins. The difficulty we have sometimes encountered with this replacement method is finding a new roof panel that will properly nest within the existing roof panel.

METAL ROOF REPLACEMENT ALTERNATES

Replacement of an existing architectural metal roof system over a structural deck with an alternate roof system is relatively simple: Remove the metal roof system and install a modified-bitumen, shingle, single-ply, or other roof system. The deck may need to be checked for additional dead load and wind uplift capacity by a structural engineer, especially if a nail board needs to be added for anchorage of the new system.

Re-covering of a metal panel roof system with alternative systems is more complex. Over the years, we have installed shingles, modified bitumen, and single-ply membrane roofing over an existing structural metal system. Which one of these alternate roof systems should be selected is dependent on the owner's goals, but also on the building structure. All of these systems will impose additional weight on the roof structure, and some more than others. Installing an asphalt shingle would add the most weight because of the required underlayment and a nailable sheathing such as pressure-treated plywood. Modified bitumen would represent less weight added than asphalt shingles; because no nailable sheathing is needed, rigid insulation with or without a cover board could be used. What has proven to be the most successful for us is the installation of a single-ply membrane over rigid insulation on the existing metal roof system due to the light weight of the system, minimal equipment, speed, and ease of installation.

All of these alternate systems would start with the application of precut rigid insulation as a filler board between the standing seams of the existing metal roof, followed by a cover board, which could be rigid insulation, gypsum roof board, or nailable sheathing. In Florida, hail is a design consideration, so we typically use a gypsum cover board as part of the system, but in other areas of the country, rigid insulation could be an acceptable cover board. The increased insulation value of the roof system is a "fringe" benefit.

METAL ROOF REPAIR OPTIONS

In our practice, we have also been exposed to several repair systems for metal roofs and many of their eventual failures in our Florida climate. The most obvious is elastomeric coatings, which we have used ourselves as a protective coating for a deteriorated metal roof surface. We believe this is the proper and intended use of this product and that its use represents the introduction of a periodic maintenance item into the roof system. Unfortunately, elastomeric coatings have been oversold as being able to accommodate panel movement, seal flashing conditions, and for use at limited or isolated areas, which has led to many of the failures we have observed.

Sprayed polyurethane foam has also been applied to many metal roofs in Florida; but on the projects we have observed, due to Florida's heat and high humidity, the foam surface is often very inconsistent and porous, requiring heavy applications of elastomeric coatings at short intervals. We have also observed extensive damage from seagulls and other coastal birds attacking the foam roof systems due to the creaking sounds made by the foam during thermal expansion in the morning sun. This damage and the uneven surface have led to water intrusion beneath the sprayed foam roofs, which has caused severe corrosion to the underlying metal roofs, resulting in structural failure.

Photo 4 – New roof at Broward County school.

EXAMPLE PROJECTS

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In Broward County, FL, we were involved with five sister schools that were all constructed within a few years of each other; three were even built by the same contractor. (See example of new roof in *Photo 4*.) These mill-finish Galvalume steel roof systems were approximately 12 years old, so they were nowhere near the end of their service lives based on the weathering capabilities of the metal itself. These schools had all been plagued with leaks since their initial construction, so the owner had tried several different repair options over the years. All repair attempts—including bituminous roofing cement, elastomeric coating, and sealant—had been unsuccessful.

Our firm was initially retained to review and investigate the existing conditions, determine what the various available options were and the probable cost of each, and recommend repair options. The school board leaned towards removing the metal roofing and installing asphalt shingles, but a structural analysis indicated the added weight of the shingles and a nail board would require significant reinforcement of the building structure. In spite of the owner's having five failed metal roof systems, our recommendation to remove and replace all five roof systems with a properly designed and installed architectural standing-seam metal roof system was financially sound. We had determined, due to the complex roof configuration, that the root cause of the roof failures was a combination of poor workmanship and inadequate detailing. As seen in the photographs, the roof configuration was very complex, with multiple cupolas, dead valleys, and walkways, all of which had to be properly detailed to install the new metal roof systems.

All five of these roof systems were designed and successfully replaced prior to the numerous hurricanes that hit Florida in 2004. All five of the roof systems survived those storms (which had maximum wind speeds below those for which they were designed) without any damage other than from windborne debris, and they have remained leak-free to this day. Prior to the roof replacement, the water intrusion associated with the roof system had been extensive enough that repairs were warranted for several steel structural members and numerous cast-in-place concrete columns with integral roof leaders.

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This library in Broward County incurred storm damage from a hurricane in 2006. Attempts to perform temporary repairs to secure the metal roof system caused permanent damage to the system to the extent that repairs were no longer feasible. (See example of roof in *Photo 5*.) Exposed fasteners were used to secure metal roofing and flashing that had been dislodged by the high winds, which made metal roof replacement necessary. This project involved the straightforward replacement of both the architectural metal roofing in "like kind" and a modified-bitumen roofing system over a structural deck.

The significant architectural element of this project was recognizing that the two roofing systems installed have different service lives, and some provision should be make to allow each roof system to be replaced without necessitating disassembly of the other roof system. This was done by using a cleat at the lower edge of the metal roofing system that also acted as a counter-flashing receiver for the modified-bitumen roof system. A second design element was recognizing that a narrow metal roof area

Photo 5 – Roof at Imperial Point Library.

Photo 6 – This pre-engineered structural metal roof system over purlins incurred storm damage during Hurricane Charlie.

(approximately 12 ft. wide) was dead level and an inappropriate application for metal roofing. This was converted to a modified-bitumen roofing system.

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This building is a pre-engineered metal building with a structural metal roof system over purlins, which incurred substantial storm damage during Hurricane Charlie in 2004. (See *Photo 6*.) Significant portions of the perimeter and corner zones were lost during the hurricane, which made roof replacement necessary.

In this case, the obvious choice was to reinstall a new structural metal roof panel system because of the building type, building use, and the minimal roof slope. Due to the lack of an intermediate purlin at 2½ ft. from the roof edge, which is needed in our area to adequately resist wind uplift, it was advantageous to leave the existing metal roof in place as a working surface and to install a double metal furring system. A single furring system, cut to fit the existing metal roof panels, was not feasible because additional uplift resistance was needed in the perimeter and corner roof zones; therefore, the first layer of furring was run vertically and anchored directly to existing purlins. The second layer of furring is run across the slope and attached to the first layer of furring, which allows it to be spaced as appropriate for the metal roof system selected. During design development, the existing building structure was evaluated to ensure adequate capacity to support the newly imposed loads. While submission of engineering for the metal roof and furring system by the installer was a project requirement, new gutters, downspouts, blocking, and edge metal with increased depth to accommodate the roof on the double furring system were installed.

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This was a pre-engineered metal building with an exposed-fastener metal utility roofing panel. The building had ongoing water intrusion problems at the exposed fasteners and the head laps and various other conditions throughout the roof. Our initial analysis indicated the roof system had followed the typical evolution in this type of panel: The sealants and neoprene gaskets at the fasteners had broken down over time, which had caused minor widespread leaks. As a response to those problems, the owner had previously applied elastomeric coatings at selected areas, fasteners, and head laps, which had also deteriorated with age. This was allowing the widespread water intrusion to recur as shown in *Photo 7*.

As a result, we designed a typical metal roof refurbishment project that included replacement of sealants, flashing boots, fasteners with neoprene washers, and isolated treatment of surface corrosion. Corrosion treatment consisted of abrasive cleaning, treatment with a corrosion neutralizer (such as "Ospho"), then priming and painting with a corrosion-resistant finish to match the existing roof panels.

When this refurbishment began, it was discovered that as the elastomeric coatings aged, water had been allowed to enter and become trapped underneath the elastomeric coating and within the head laps of the roof panels long enough to corrode the top edge of the lower roof panel, to the extent that it was no longer supported by the

Photo 7 – Deteriorated elastomeric coatings allowed widespread water intrusion.

Photo 8 – The darker existing metal roof panel can be seen downslope of the exhaust fan; some building wrap is seen along the edge of the new white roof panel that has been installed.

underlying purlin. Walking on the roof panels downslope of the head lap, which was no longer supported, would cause the lower roof panel to collapse and open the head lap. In simple terms, we no longer had a structurally viable roof system to repair or to use as a roof deck in a re-cover system. The refurbishment work was stopped, and alternate roof systems were considered. Several options were quickly eliminated due to cost or the lack of a structurally viable roof deck. We were stuck with a 70,000-sq.-ft., badly leaking building that was partially disassembled and a minimal budget available for the project.

Due to the budget limitations, it was determined that a new metal utility roof panel system needed to be used, and if the cost of a furring system could be avoided, roof replacement for the entire building would be feasible with the money available. The existing metal roof panel was no longer manufactured in the U.S., but after an extensive search, a specific roof panel was discovered that would nest properly over the existing roof system. This allowed us to adopt an approach to roof replacement for which the manufacturer could offer very little guidance—a nested overlay of the existing metal roof panels with new roof panels. We knew that due to corrosion, some separation between the new and existing roof panels had to be created; therefore, a building/house wrap was used as a separator sheet. The construction process was to remove all the existing fasteners at several roof panels, apply the separator sheet, lay down the new utility roof panel, and install new exposed fasteners with neoprene-backed washers through both roof panels into the underlying purlins (*Photo 8*).

During this process, we also removed unneeded and abandoned roof penetrations to "clean up" the roof system, such as the integral fiberglass skylights and agricultural-style ridge vents that remained from this building's previous use as an unconditioned warehouse. This turned out to be a unique and inexpensive process but an appropriate solution for this client that allowed us to reroof the entire 70,000-sq.-ft. building with the minimal funding available. In order to accomplish this goal, the client was willing to accept the future maintenance consequences of using an exposed fastener metal roof panel system, such as possible water intrusion at the exposed fasteners in the future as the neoprene sealing washers age.

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The roof system at this school consisted of Bermuda-style metal shingles installed on felt underlayment over gypsum board and rigid insulation on a sloped metal deck that was experiencing ongoing water intrusion problems. (See *Photo 9*.) Roof leaks were widespread throughout the field of the roof, but primarily at some angle walls, against and along which several roof areas drained. The owner elected to remove the

Photo 9 – Roof leaks were widespread throughout the field of the roof, but primarily at some angle walls, against and along which several roof areas drained.

Photo 10 – This architectural standing-seam metal roof with a snap-on seam cap was experiencing water intrusion problems, primarily along an angled wall flashing.

metal shingles and correct the flashing problems, install a modified-bitumen underlayment over a new nail board sheathing secured to the underlying metal deck, and install an asphalt shingle roof system.

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At this sister school to Wiles Elementary, the architectural standing-seam metal roof with a snap-on seam cap was experiencing water intrusion problems, primarily along the same angled wall flashing as the other school. (See example of conditions in *Photo 10*.) But at this school, it was decided that the roof areas associated with the problem areas would be removed, which would allow us to correct the transition wall flashing conditions. At these seven roof areas, a modified-bitumen underlayment was installed over the gypsum board on metal roof deck, followed by the unusual approach of reinstalling the existing metal roof panel system. This was determined to be possible due to several unique characteristics: The roof panels were simple pans with a friction-fit seam cap that was easily removed, there were no sealants in the seams or the field of the roof, the roof panels were the full length of the slope with no head laps, and the roof panels were "fixed" at the ridge. Also during reinstallation, gutters were replaced, and the drip edge and ridge cap configurations were revised to require a shorter roof-panel length to avoid existing holes and sealant along the top of the roof panels. At the remaining metal roof areas, seals and flashings were refurbished, and the leaking gutters were replaced to correct all of the roofing functional concerns as to the roofing at this campus.

You may have also noticed in the photographs of this project a significant adhesion problem with the factory-applied "Kynar" coating on the existing metal roof panels, the result of problems with the coil-coating process prior to panel manufacture. The existing metal roof system was prepared as recommended by the manufacturer, followed by the application of a high-performance industrial paint/coating to the entire metal roof system to refurbish the appearance of the roof and the school itself.

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Ever since the original construction approximately 18 years earlier, this school had experienced ongoing water intrusion problems at the numerous complex flashing conditions, as well as areas of corrosion—both on the panel surface and causing penetration fully through some of the panels. Initially, replacement of the metal roof panels was considered but determined to be too expensive for the available budget; therefore, we decided to perform selected repairs, limited reconfiguration, and application of an elastomeric coating as a means of extending the service life of the metal roof system. (See *Photo 11*.) We believe that elastomeric coatings should be used to protect the panel surface and seal static joints, but they have limited ability to tolerate the movement that a metal roof will experience. We therefore elected to correct the metal flashing and roof configuration problems prior to the application of the elastomeric coating.

This school campus was designed during an era when the state of Florida was experimenting with providing natural ventilation within the classrooms and had created more than 30 rooftop cupolas to ventilate every classroom. (See examples during construction in *Photos 12, 13,* and *14*.) This may have seemed like a great idea in the late 1980s, but it was determined to be ineffectual, and use of the cupolas for ventilation had long ago been abandoned.

Photo 11 – The school s existing condition shows the dead-level valley with the internal gutter and several ventilation cupolas.

Photo 12 – The new framing used to extend the existing rooflines and eliminate this problem valley.

Photo 13 – Just prior to the coating application with the dead-level valley and ventilation cupolas eliminated.

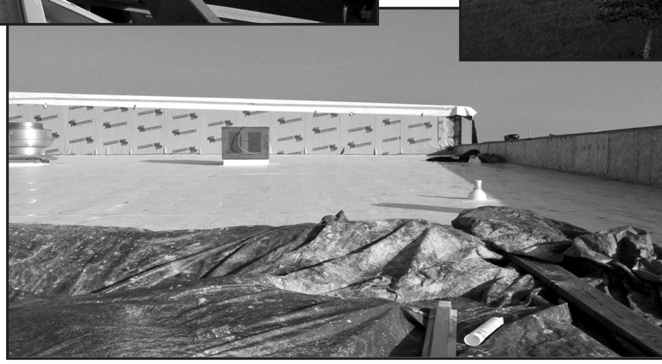

Photo 14 – The application of a single-ply membrane over a standing-seam metal roof on the cafeteria to eliminate numerous equipment flashing problems.

As mentioned earlier, metal roofs are more appropriate when used with simple roof configurations; therefore, we elected to remove the existing cupolas and extend the existing roof planes to the ridge of the building to greatly simplify the roof configuration of the buildings. The campus had two dead-level valleys between buildings with internal gutters that had had ongoing water intrusion problems ever since the construction of the school. All previous repair attempts had been unsuccessful. We elected to change the configuration of the roof system. Additional metal framing and metal roof panels were installed over the existing structure prior to the application of elastomeric coating to extend existing roof planes and eliminate the dead-level valleys. Three very-low-roof-slope areas with numerous pieces of rooftop equipment were also converted to thermoplastic single-ply roof membrane, which was more appropriate for those specific roof conditions.

This school was a prime example of the inappropriate use of a metal roof system, although the repair project has proven successful and will soon need its elastomeric coating reapplied.

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This school district had a series of four nearly identical sister schools built in the early to mid-1980s that had two distinct roof systems installed at the school—an aggregate-surfaced, built-up roof and an architectural standing-seam metal roof system. Based on our investigations, it was determined that all four schools shared many of the same water intrusion problems and the same basic scope of repair work. The goal was to resolve the known problems and extend the service life of the existing roof systems.

To do so, we performed three distinct tasks: isolated and limited repairs of the aggregate-surfaced, built-up roof; replaced the defective metal roofing; and refurbished the remaining metal roof areas. The replacement of the existing metal roof at the Media Center (*Photo 15*) was deemed necessary due to a long history of leakage problems at the central cupola, which affected the entire roof system. The waterproofing problems exposed at this building involved the cupola wall construction, the clerestory windows in the cupola, and the metal roof flashing at the cupola. For this limited roof area, it made more sense to disassemble the roof and cupola, perform the proper waterproofing (including removal and replacement of cupola windows and their sill flashing), reapply the EIFS, and reinstall the metal roof. The remaining metal roofs on campus were refurbished, which included replacement of pipe flashing boots; sealing the ridge, rake, and hip conditions; correction of flashing problems; securement of loose rake and drip edges; and repairing of seams at gutters. All of the existing metal roof areas and the newly installed Media

Photo 15 – A portion of the media center s refurbished roof.

Center roof system were prepared by high-pressure washing and priming as recommended, then inspected and accepted by the manufacturer's technical representative. After adhesion testing, all the metal roofs (new and existing) were field-painted with a high-performance, automotive-grade polyurethane enamel coating. This mixture of tasks within the scope of work of these projects was recognition of what problems could be repaired and addressed and what problems needed to be disassembled and corrected by replacement.

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This school district had a series of four nearly identical sister schools built in the mid-to-late 1980s, all with an architectural standing-seam metal roof system, with a factory-applied polyvinylidene fluoride (PVDF-"Kynar") finish. Based on our investigations, it was determined that all four schools shared many of the same water intrusion problems to varying degrees and had similar scopes of repair and refurbishment work. The goal was to resolve the known water intrusion issues and address the aesthetic issues present at each of the existing roof systems.

Two of the schools had experienced severe corrosion at isolated locations. At one school, the finish coat was flaking off of the existing metal roof panels, and one school had experienced severe and uneven fade. All four projects were approached as metal roof refurbishments due to budget concerns and included new pipe flashing boots; correction of expansion joint systems; sealing the ridge, rake, and hip conditions; correction of flashing problems; securing of loose rake and drip edges; and repair of seams at gutters. At several of the schools, the metal fascia panels were sitting in a "J" bead that collected water, resulting in severe corrosion along the bottom edge of the fascia panels. In lieu of wholesale replacement, the bottom 6 in. of the roof panel was removed, and new metal banding was provided to remove the severely corroded conditions. Flashings were corrected at transitions onto other roofs and walkway canopies and at lightning protection penetrations, and limited roof panel replacements at skylight and smoke hatch locations were performed.

Upon completion of all the metal repairs and corrections, the entire metal roof system and associated flashings were painted with high-performance industrial paint /coating. Use of a field-applied PVDF-"Kynar" coating system was considered, but due to budget constraints, a high-performance, automotive-grade polyurethane enamel was selected for application at all four campuses, which were refurbished over the course of four years (*Photo 16*).

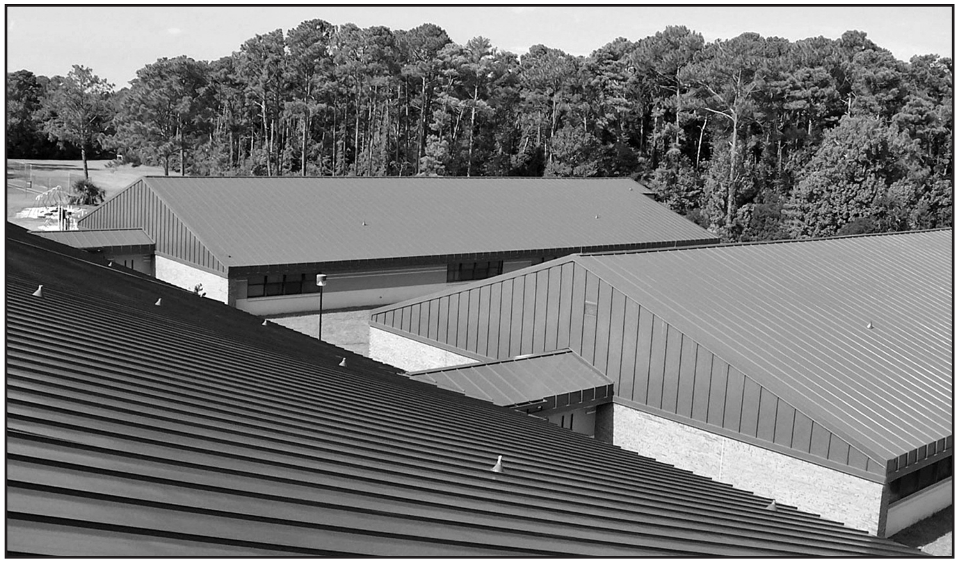

Photo 16 – Portion of completed roof.

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This school had a mill-finish Galvalume® structural panel typical for a pre-engineered metal building. Although there was no intent to change the appearance of the building, specific problems existed that needed correction. (See example in *Photo 17*.) The school had experienced numerous roof leaks along the outside wall. Due to the age of the exposed fasteners with sealing washers, these were replaced with new fasteners that were one screw size larger; at that time, panel corrosion was also addressed by properly preparing and treating the panel with zinc-rich coating. Questionable flashing conditions were identified and corrected throughout the campus. Of note was the hip and ridge condition, which would trap water at the edge of the ridge cap that was held between two "J" channels. All the ridge and hip caps were

Photo 17 – This school had a mill-finish Galvalume® structural panel typical for a preengineered metal building.

removed, modified, and replaced. Many of the gutters were the original Galvalume steel and had rusted through; these were replaced with stainless steel. The Galvalume® roof and fascia panels had been in place for several years and weathered to a dull gray, but the zinc-rich repair paint was bright silver; therefore the repair paint was coated with a gray spray paint to match the appearance of the existing panels. Between two building wings was a dead-level valley that was problematic. We considered reconfiguring the roof system to eliminate the valley, but due to a short construction period, a seamless metal cricket to provide positive drainage of ¼-in.-per-ft. slope to each side was installed to eliminate the dead-level valley.

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As anyone involved in this industry knows, any water intrusion from above is identified as a "roof leak," of which this project was an example. The metal roof called into suspicion by the owner for water intrusion problems was, in fact, functioning correctly. Over the convention center and ballroom at the Swan Hotel is a 160-ft.-wide barrel volt that utilizes a structural standing-seam panel that is mechanically seamed as a single piece for the entire roof width. The 80 feet from the ridge was draining into a concealed internal gutter at the top of the wall that was 4 in. wide and 6 in. deep. Considering that the design rainfall in central Florida is 4½ inches an hour, this gutter size was inadequate. During heavy rains, the gutter would fill, but because the outside edge of the gutter was higher than the drip edge of the panels, water was being forced back through the panel seams above the edge metal and entering the building. The solution was not to replace the roof but to create a larger gutter. This was accomplished by removing the wall extension that concealed the gutter by utilizing the additional width of that parapet wall. A 14-in.-wide, 4-in.-deep gutter that could adequately handle the amount of rainfall was created. This gutter depth allowed the outer edge of the gutter to be an inch lower than the drip edge of the roof system. The aluminum roof panels remained unchanged. The gutters were fabricated from heavy-gauge aluminum to avoid corrosion problems, minimize brackets and straps, and allow all components of the gutter system to be welded.

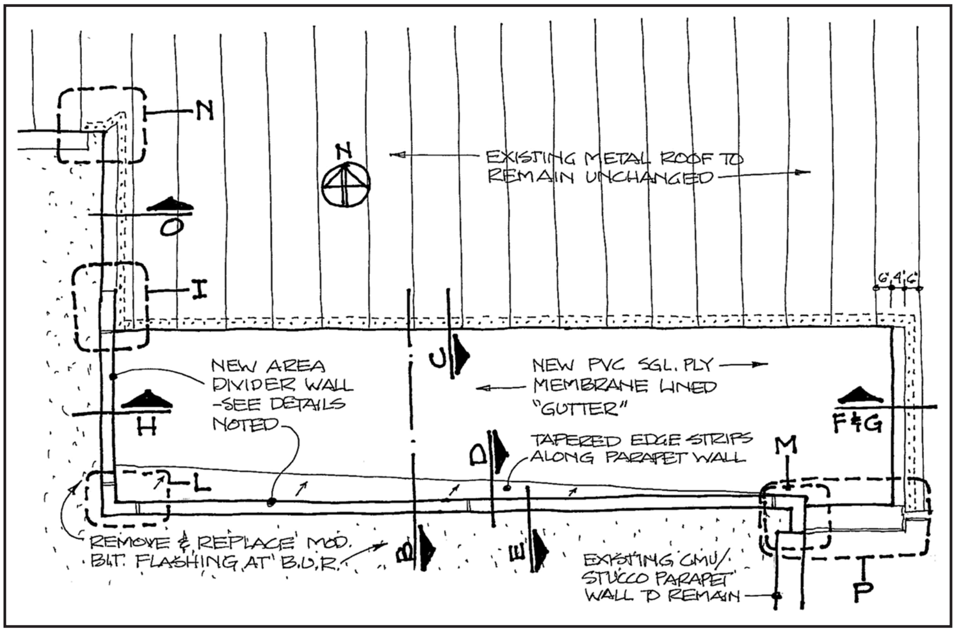

Figure 1 – Plan of the problem roof area.

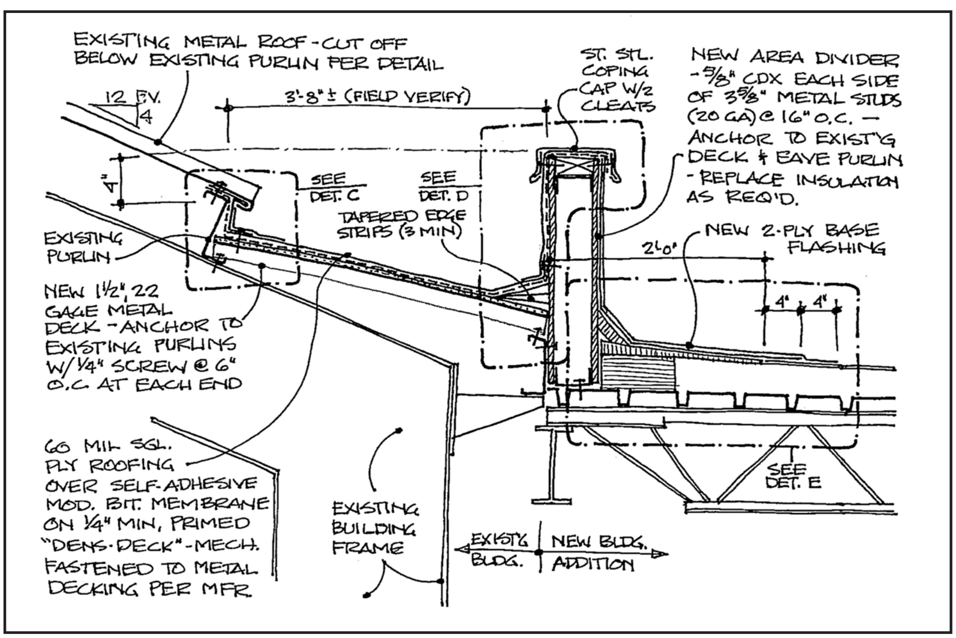

Figure 2 – This section through the roof repair area illustrates the basic concept.

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We often see problems created in situations when the use of multiple roof systems is attempted and the different roof systems are not properly interfaced or separated. At the Kennedy Space Center's Media Broadcast Building, due to additions and expansion over time, there was an aggregate-surfaced, built-up roof; a single-ply membrane; and a standing-seam metal roof installed and interconnecting on this building. After several attempts by the NASA facility staff to stop the water intrusion over the broadcast studio, we were contacted to resolve the water intrusion problems associated with this condition.

Often, the solution is not how roofing systems are put together but how to separate them properly so they can function correctly. A metal roof on a pre-engineered metal building section was draining onto a single-ply membrane with inadequate flashing heights and no elevation change, which was stripped into the built-up roof. In order to address the water intrusion problem, it was decided to separate these three roof systems with raised area dividers, as opposed to continuing to try to interconnect the three roof systems. By doing so, the single-ply and built-up roofs could be properly terminated and function correctly, but a method needed to be provided for storm drainage from the metal roof. The solution for this problem was to remove the first span of the existing metal roof panels from the eave purlin to the first "Z-purlin," which was approximately 5 ft. We then installed a metal deck panel (and gypsum roof board) bearing on the lower flange of the "Z-purlin" and, therefore, created a height difference between the existing metal roof and this new deck area. In effect, this created a 4½-ft.-wide gutter with a depth of the purlin height minus 2 in. Within this gutter area, we then installed a thermoplastic single-ply roof membrane with coated metal flashings and a properly sized roof drain system for the storm drainage from the metal roof. This separation of the roof systems and the unusual gutter system successfully solved the water infiltration problems at this building. (See *Figures 1* through *4*; photos were not allowed on NASA-Kennedy Space Center property.)

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This is a small fire station on the east coast of central Florida that was constructed using a pre-engineered metal building system with a mansard and raised parapet around a central, low-sloped roof condition. The existing central low-slope roof was constructed using structural metal roof panels over purlins, which sloped two ways to drain into two internal gutters.

There are certain things that designers and pre-engineered building suppliers do with their building systems that we believe are inappropriate; one is use of internal gutters. Because of a pre-engineered metal building's components and erection methods, these gutter systems are invariably sealant-dependent, and once the sealants start to deteriorate and fail, the leaks begin. When this occurred and we were asked to correct the problem, we intended to convert the central roof to a thermoplastic single-ply roof system. This design concept would allow us to install the proper crickets for drainage, drain the roof using a standard roof drain, eliminate any dependence on sealants, and provide the owner with a 20-year manufacturer's warranty.

As part of the design development phase of this project, fastener withdrawal testing was performed on the existing metal roof panels, and the building structure was analyzed in regards to the additional dead load a roof re-covering system would impose on the building structure. This was accomplished by installing rigid insulation between the standing seams of the metal roof panels as filler over which we installed a ½-in.-thick gypsum roof board to create a smooth substrate, followed by a single-ply membrane roof system mechanically fastened to the underlying metal roof panels. With this design concept, there is a slight addition to the dead load on the roof framing system, which most building structures can typically absorb successfully, but it may provide a viable alternative to a problematic metal roof.

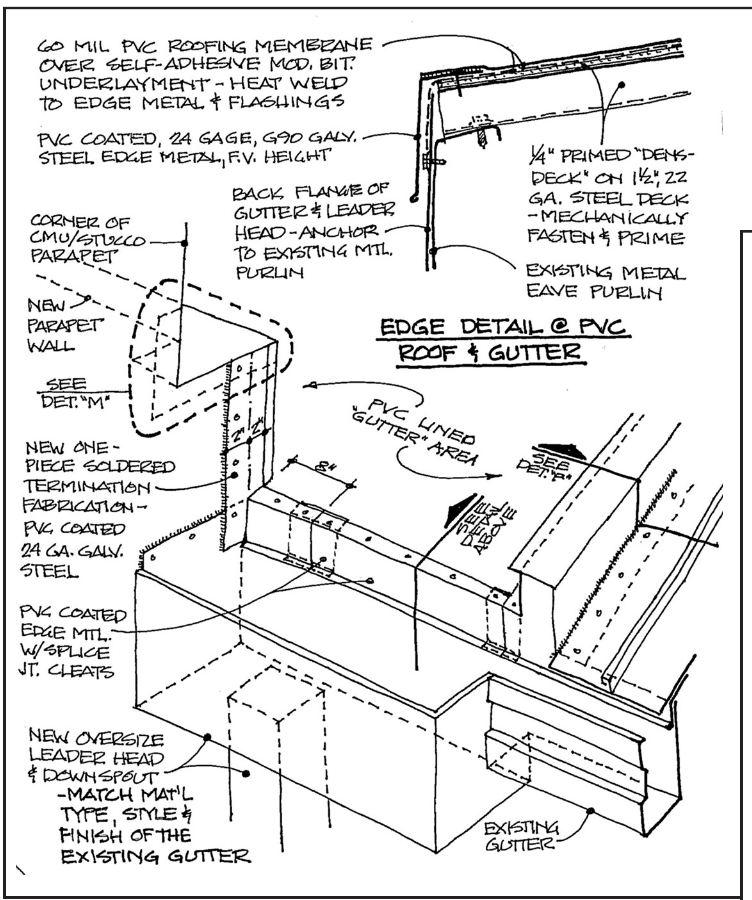

Figure 3 – Detail of the transition from the sloped metal roof to the newly created, single-ply lined gutter.

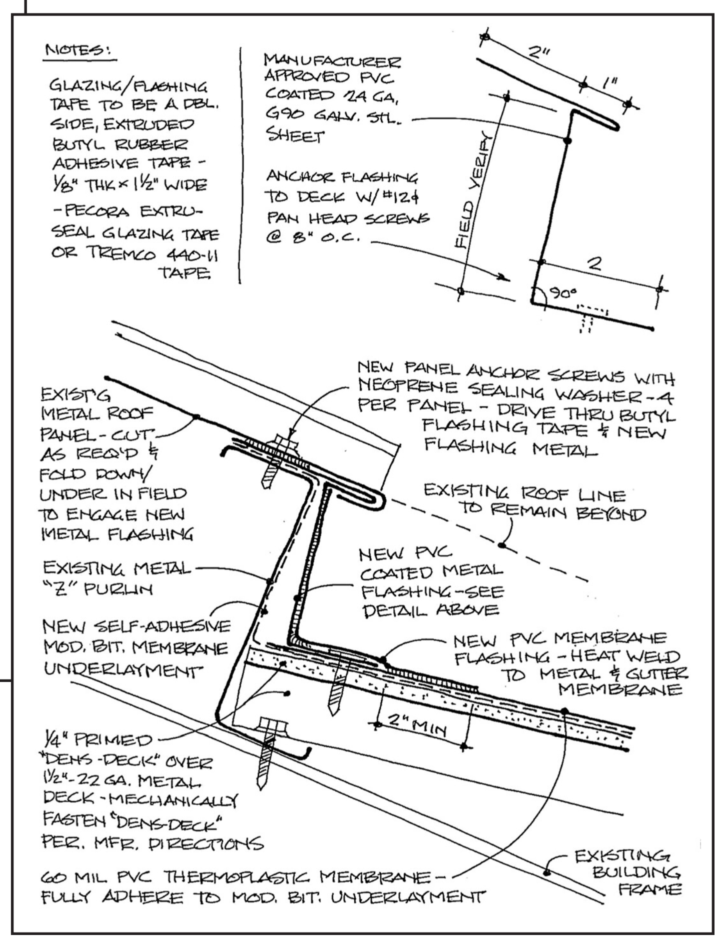

Figure 4 – Detail of discharge from the "gutter at the roof edge.

SUMMARY

To summarize some of what we have seen, metal roof systems can be replaced through removal and replacement, which are easiest when dealing with architectural panels over solid substrates. New roof systems can be installed over furring systems, which allow the existing roof systems to remain—certainly advantageous for structural systems. Metal roof systems can be replaced with an alternate roof system. Shingles, single-ply systems, and modified-bitumen systems are all viable options. There is a wide range of repairs that can be done to an existing metal roof to avoid total replacement.

Many times, specific flashing conditions are a source of problems for a metal roof. Those flashing conditions can be repaired or replaced without total replacement of the existing metal roof. These could typically be gutters, additional flashing, drip edge, valleys, hips, and ridges.

As you can see, we can also run into refurbishment issues. As I mentioned earlier, Florida is a rough climate on metal roof systems. We have a lot of metal roof systems that were prefinished when installed 15 - 20 years ago that are certainly showing their age. Often, the owner would like to refresh the look of the building without having to go to the extent of roof replacement; this is where coatings become a viable option.

We tend to use elastomeric coatings for an extension of service life or high reflectivity as opposed to aesthetics. In our opinion, based upon the installations we have observed, these coatings have only minimal ability to cure leaks and seal openings, especially when associated with flashing conditions that experience significant and repeated movement. They seem to have a limited service life of six to eight years in Florida and tend to collect algae due to the textured surface that they present. We have used industrial coatings, such as polyurethane, and enamels to refurbish metal roof systems. Although these have no waterproofing capabilities, they do provide a better long-term finish than the elastomeric coating. When flashing conditions need to be corrected, one must apply new sealant and make sure the roof system is a waterproof system prior to the application of the coatings. More expensive than the polyurethanes and enamels would be field-applied PVDF ("Kynar") coatings, which have a longer service life and color retention over time, but they are significantly more expensive. They, too, are a variety of paint, so one is working with the same preparation and corrections of the roof system prior to application that one would with acrylics and polyurethanes.