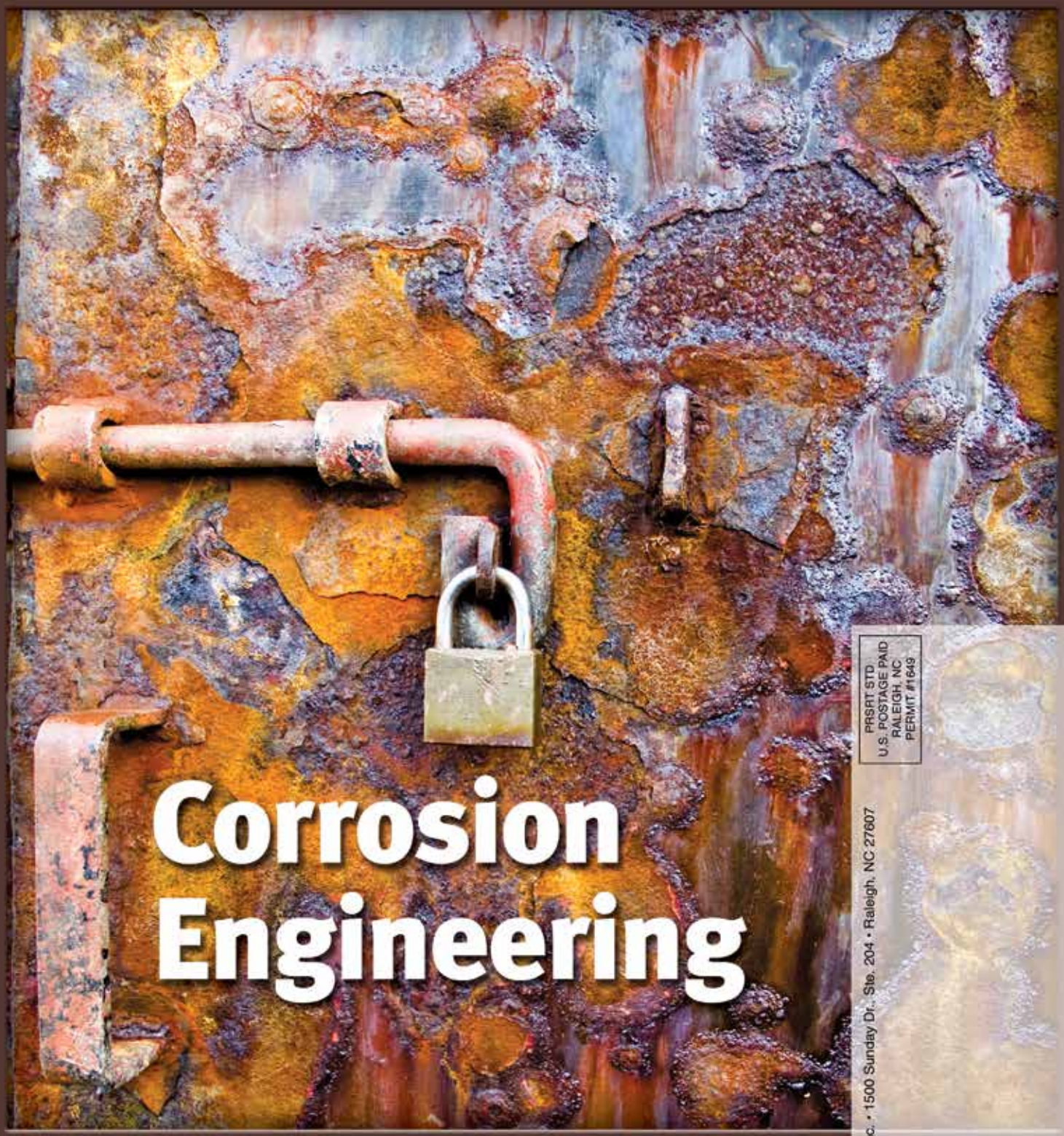
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In This Issue: We explore the concepts of corrosion engineering and their effects on building envelope consulting.

On the Cover: This photo was taken of a lighthouse door at Ardrishaig on the Crinan Canal in Scotland. By "Perspicacious."



Thomas W. Gernetzke,
RRC, RWC, REWC, RBEC, RRO
President

Use of RCI Credentials by Industry Members



Use of RCI registrations by Industry members is a contentious issue. There have been multiple proposals for addressing the situation. Suggestions such as modifying credentials for Industry members or suspending previously earned credentials for Industry members have been unofficially discussed in various circles.

While our credentials are not professional licenses such as those of architects and engineers, I propose these licenses should be used as a standard for comparison. When architects, engineers, landscape architects, etc. take employment with a vendor, manufacturer, or contractor, they do not surrender their licenses. They are, however, still bound to maintain the same ethical and moral standards their licensure demands if and when they utilize their licenses during their employment with contractors or manufacturers.

My concern with modifying or suspending credentials based solely on employment status is simple. In my opinion, our credentials will be significantly diminished or impaired if we withdraw, modify, or suspend them based on who a registrant's employer is. Our credentials would then become membership to an exclusive club—not defensible, respected credentials our industry has come to accept and understand.

RCI has clearly established standards for ethical behavior and professional conduct. All members and registrants are bound by both the agreement signed during the registration process and RCI's code of ethics, signed upon becoming a member of RCI and upon membership renewal.

We have a defined complaint process regarding ethical conduct. I strongly recommend familiarizing yourself with the agreement signed during the RRC, RWC, and REWC application process, as well as the Code of Ethics. If you encounter a registered individual who has acted in possible violation of either of these documents, gather any notes or documentation you may have and submit them to RCI Executive Vice President and CEO James Birdsong. Jim will forward the original complaint to the Ethics Committee for initial review. The Ethics Committee will then make a recommendation to the Executive Committee and Board of Directors. This is the only instance I am aware of in which you are encouraged not to send any information or comment to the Executive Committee.

RCI is working to refine and streamline our ethics complaint and review process. Changes, if and when they occur, will be published in *RCItems* and *Interface*.

The bottom line: If you know of a registrant who you believe has violated the standards of our ethical conduct, file an ethics complaint. If you have any specific questions, please contact James Birdsong at RCI headquarters by phone at 1-800-828-1902 and by e-mail at jbirdsong@rci-online.org.



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CORROSION:

What's Eating at Your Metal?

By Cris Crissinger, CCS, CCCA, ASQ

This article will be published in two parts. Part I describes basic corrosion principles and galvanic reactions. Part II will discuss why some metals are more corrosion-resistant than others.

This discussion will focus on the corrosion of the common metals, such as aluminum, copper, lead, and variations of ferrous metals, including stainless steel, that are used in construction.

Most structural components, from the time of their erection, are under continual corrosive attack by the environment. How well they repel this assault is the designer's responsibility. The information presented and the recommendations suggested are not all-inclusive but are intended to make design professionals aware of potential corrosion problems and to offer some proven suggestions that will provide a foundation for solving issues.

Corrosion is like a disease. In order to prevent or control it, the designer should have a basic understanding of what corrosion is and what causes it. Of the many forms of corrosion—including stress, pitting, fretting, intergranular, and microbiological—the focal point of this article will be corrosion from galvanic action and the atmosphere.

Corrosion is a very complex process, and the ion exchange between metals and their compounds can get very messy. Numerous detailed publications have been devoted strictly to metallurgy and corrosion theory. Some readers may be well versed in corrosion principles, while others may not. The author's intent is to simplify the corrosion process and to provide information that will be beneficial to designers. For those who feel attracted to chasing positive and negative ions, the National Association of Corrosion Engineers (NACE) reference publications at the end of Part II of this article will provide plenty of exercise.

DEFINING CORROSION

The NACE defines corrosion as the deterioration of a substance (usually a metal) or its properties because of a reaction to a substance. Physics says it is the process of a metal returning to its natural oxide state. The author's mentor accurately professed that corrosion occurs when a metal is put in an environment where it should not be.

Most metals (with the exception of precious metals such as gold and platinum) do not occur naturally in their metallic form. Instead, they exist as ore, such as iron ore (ferrous oxide or iron oxide) and aluminum ore (aluminum oxide). The ore must be processed to separate it from the metal in order to make something useful such as steel. As an ore, these metals are considered to be in a stable, low-energy state. When the ore is processed into a metal, that metal is then considered to be in an unstable, high-energy state. Precious metals such as gold and platinum exist naturally in their metal state, have intrinsic electrochemical stability, are not prone to corrosion, and are referred to as noble metals.

When corrosion occurs, the corroding metal tries to revert from its high-energy, processed, and metallic state to its low-energy and more natural state, which we commonly call ore. When an ore is processed into metal, the refining process transfers its latent energy to the ore. When this energy is transferred to the ore, the ore is converted into metal. As the metal receives this energy, the metal is elevated to a higher-energy state, which means its electrochemical stability decreases. Corrosion occurs when a metal that is in a high-energy state reverts to its low-energy (ore) state.

Some metals, such as copper, form oxide films that are porous; while other metals, such as ferrous metals, form oxide films that buckle and flake off. In both cases, the underlying metal is subject to a continued oxidation process and results in metal loss. However, there can be an upside to oxide films. Most metals that form a tightly adhering layer of surface oxides are much more corrosion-resistant because the adhering

GALVANIC SERIES TABLE	
Metal	**Standard Volt Potential**
Potassium	-2.922
Magnesium	-2.340
Aluminum	-1.670
Zinc	-0.762
Chromium	-0.710
Iron	-0.440
Nickel	-0.250
Tin	-0.136
Lead	-0.126
Hydrogen	**-0.000**
Copper	+0.345
Silver	+0.800
Platinum	+1.200
Gold	+1.680

Table 1

layer—known as the passivation layer—offers significant protection by isolating the metal from the corrosive environment. Aluminum and copper are such metals. It has been said that "passivity can be considered as when a metal does not corrode when it should."

CAUSES OF CORROSION

Anyone who has been exposed to construction or construction design should be familiar with the statement, "Separate dissimilar metals to prevent galvanic action." Galvanic action caused by dissimilar metals is the basis for a significant part of the corrosion.

Just as a cold offers subtle symptoms at its onset, such as a runny nose, slight cough, lump in one's throat, chills, and fever, corrosion also offers clues at its beginning that include discoloration, pitting, flaking, distortion, changes in size or shape, and invisible cracks.

HOW CORROSION WORKS

Until designers start putting buildings in a vacuum or until the laws of electrochemical properties of metals are repealed, there will be corrosion. The four conditions that must exist for corrosion to occur:

- There must be an anode (the corroding component) and a cathode (the protected component).
- There must be an electrical potential between the anode and the cathode such as that created by dissimilar metals.
- The anode and cathode must be immersed in an electrolyte, which is an electrically conductive fluid.
- The anode and cathode must be connected by a path of low resistance.

GALVANIC REACTION

Galvanic action is probably the most common type of corrosion that affects metals and is based on the grouping of metals together on a scale called the Galvanic Series Table. *Table 1* shows the position of some common metals in the electromotive series.

A metal's position relative to the other metals on the scale is based on its electrical potential. The strength of this electrical potential, when compared to other metals in the series, determines the probability of a reaction. The position of a metal on the scale also determines the severity of that reaction when the metals are exposed to a common and suitable environment. The common and suitable environment chosen to determine the galvanic scale is seawater because of its abundance and consistency.

The metals that are the most negative tend to be the most reactive and are considered anodic. The metals that are the most positive are the least reactive and are considered to be cathodic. This is why dissimilar metals are those that have significantly different electrical potential (large separation). For example, based on the galvanic table, a metal should be protected by a metal that is higher on the list (more negative electrical potential than a metal below it). The farther apart the metals are on the scale, the higher the probability for corrosion. The voltage difference creates the current flow and increases the rate of corrosion; and the greater the difference, the faster the corrosion. Hydrogen is considered to be neutral.

The Galvanic Series Table reveals several useful bits of information:

1. Metals high in the series are active and less corrosion-resistant.
2. A metal will replace another metal in solution if the metal in solution is lower in the series.
3. Whether a metal will be corroded by an acid. Metals above hydrogen are usually attacked by acids.
4. An indication of the bond strength between combined cells based on electromechanical potential. The larger (less negative) the combined voltage potential in metals is, the stronger the bond will be. Thus, the -2.432-volt bond between aluminum and zinc (-1.670 + -0.762 = -2.432 volts) is stronger than the -1.325-volt bond between aluminum and copper (-1.670 + +0.345 = -1.325 volts).

ELECTROLYTES

Water in some form is probably the most common electrolyte. It can originate from tap water, weather, oceans, lakes, cleaning solutions, etc. However, all water is not pure. The pH of a solution is one of the most important factors that can determine the aggressiveness of water.

The pH scale in *Table 2* shows the acidity (red end) and the alkalinity (blue end) of

Classification	pH	Color	Common Item
	0		Battery Acid
	1		Gastric Acid
	2		Lemon Juice
More Acidic	3		Vinegar
	4		
	5		Coffee
	6		Milk
Neutral	7		Distilled Water
	8		Baking Soda
	9		Sea Water
	10		
More Alkaline	11		Milk of Magnesia
	12		Ammonia
	13		Bleach
	14		Lye

Table 2

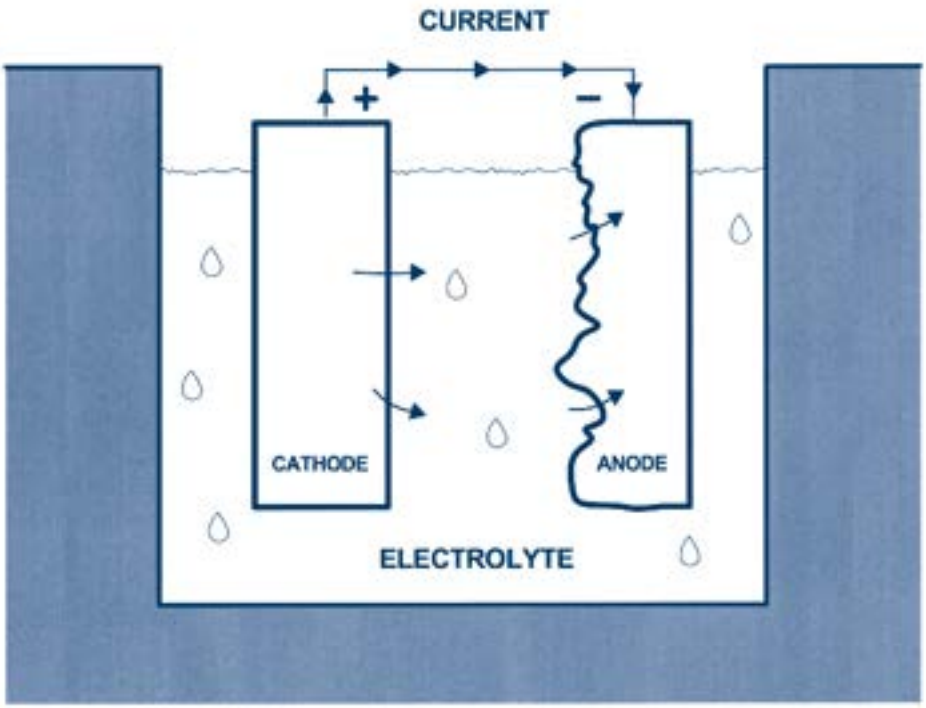


Figure 1 – Galvanic reaction, separated metal.

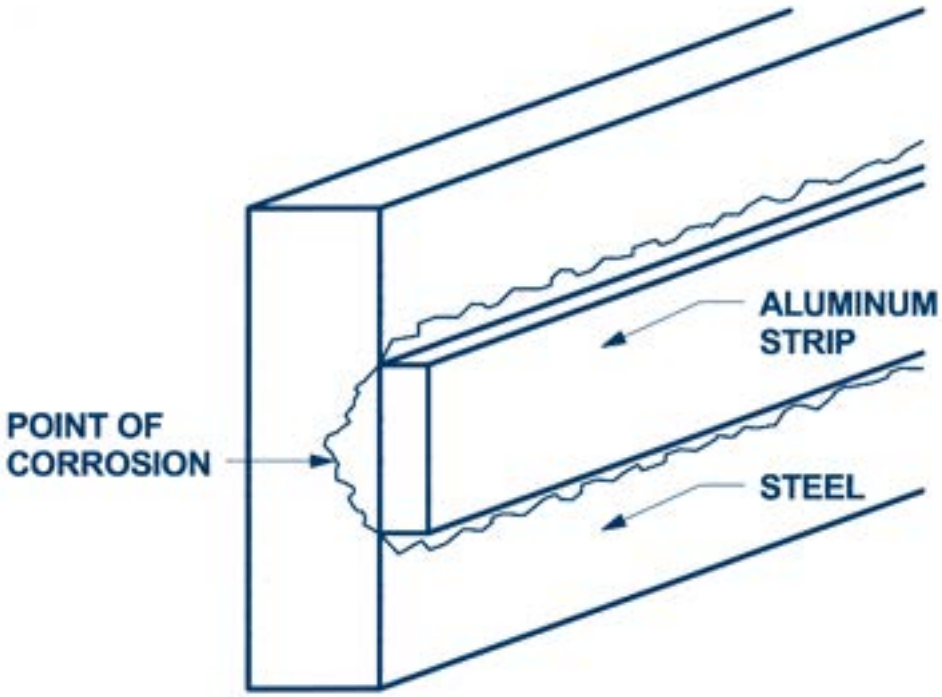


Figure 2 – Galvanic reaction, contacting metal.

common solutions for comparison. The pH is measured on a logarithmic scale beginning at the top from 0 to 14, with 7 being neutral. This means that an electrolyte with a 6 pH is 10 times more acidic than a 7 pH, and a 5 pH is 100 times more acidic than a 7 pH. Small changes make a big difference! Electrolytes with a pH at the extreme ends of the scale tend to be more corrosive than those toward the center, and those at the acidic end tend to be the most corrosive.

Electrolyte temperature tends to have an effect on corrosion. Corrosion seems to increase in tropical seawater where water surface temperatures are often above 85°F. Water temperatures above 140°F have produced a noticeable increase of corrosion in hot-water heaters. Conversely, the exploration of steel ships sunk in deep, cold ocean water shows corrosion to be extremely slow.

If two dissimilar metals are immersed or otherwise exposed to an electrolyte, they may or may not corrode by themselves if left separated in the electrolyte. But when they contact each other and a galvanic (electric) couple is created, the corrosion rates of the individual metals change. The corrosion rates change because one of the metals becomes the anode and corrodes faster than it would by itself. The other metal becomes the cathode and corrodes slower than when by itself. The difference in electric potential causes a current to flow from the anode to the cathode. This electrical circuit causes the anode to lose some of the metal in the form of ions. This process slowly consumes the anode and effectively strengthens the cathode against corrosion. The metal removal is the corrosion. As the electrons flow across the low-resistance, metallic path to the cathode, the electrical potential of the cathode is reduced enough to stop the formation of metal ions. When the metal is not in a positively charged ionized form, it is much less reactive. This is why the cathode develops an inherent protection from metal loss to corrosion. *Figure 1* is a simple cell showing galvanic reaction of separated metals and how a current leaves a metal (the anode) and enters an electrolyte. The electrolyte conducts the current to the metal surface (the cathode) that receives the current. A wire connecting the anode to the cathode completes the circuit, allowing the current to return to the anode. The anode is the portion of a metal that corrodes. Pit ladders and off-shore oil platforms are examples. *Figure 2* shows similar conditions, except that the metals contact each other, eliminating the connector wire.

Oxygen is frequently involved in the corrosion process because most metals in their ore state are oxides. Copper, on the other hand, is typically found as copper sulfate, meaning that in the presence of sulfur, copper will readily react with sulfur to return to its natural state of copper sulfate. Among steel, aluminum, and copper, copper is the most cathodic or noble, and is typically less affected by galvanic reactions. However, copper does not get a free ride regarding corrosion. When used in contact with more noble metals, such as nickel, Type 316 and 304 stainless-steel alloys, or titanium, it will corrode by galvanic action just as easily as steel or aluminum.

If the electrical potential of a metal is the most important factor in determining the potential for galvanic action, then the cath-

ode-to-anode size ratio is probably the second most determining factor. A large mass of the more reactive metal tends to lessen the potential for a reaction. For instance, similar masses of stainless steel and structural steel will produce a galvanic reaction. However, when stainless steel fasteners (a smaller and less reactive mass) are in contact with structural steel (a larger and more reactive mass), the reaction is negligible. Stainless steel fasteners with aluminum windows (a larger and more reactive mass) produce similar results. Conversely, aluminum screws (a small and reactive mass) in a steel or stainless-steel assembly (large and less reactive mass) can produce severe corrosion. Early American metalsmiths understood this relationship very well as shown in *Photo 1* of an old copper pot with iron handles. Even though slight traces of rust bloom are visible on the iron handle, the mass ratio of the iron handle to that of the copper pot is large enough to prevent a severe



Photo 1 – Old copper pot and steel handle.



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TABLE 10—GUIDELINES FOR SELECTION OF FASTENERS BASED ON GALVANIC ACTION

Base Metal ↓ / Fastener Metal →	Zinc & Galvanized Steel	Aluminum & Aluminum Alloys	Steel & Cast Iron	Brasses, Copper, Bronzes, Monel	Martensitic Stainless Type 410	Austenitic Stainless Types 302/304, 303, 305
Zinc and Galvanized Steel	A	B	B	C	C	C
Aluminum and Aluminum Alloys	A	A	B	C	Not Recommended	B
Steel and Cast Iron	AD	A	A	C	C	B
Terne (Lead-Tin) Plated Steel Sheets	ADE	AE	AE	C	C	B
Brasses, Copper, Bronzes, Monel	ADE	AE	AE	A	A	B
Ferritic Stainless Steel (Type 430)	ADE	AE	AE	A	A	A
Austenitic Stainless Steel (Type 302/304)	ADE	AE	AE	AE	A	A

Key:

A. The corrosion of the base metal is not increased by the fastener.

B. The corrosion of the base metal is marginally increased by the fastener.

C. The corrosion of the base metal may be markedly increased by the fastener material.

D. The plating on the fastener is rapidly consumed, leaving the bare fastener metal.

E. The corrosion of the fastener is increased by the base metal.

NOTE: Surface treatment and environment can change activity.

Table from Designer Handbook – "Stainless Steel Fasteners – A Systematic Approach to Their Selection" published by Special Steel Industry of North America

Table 3

galvanic reaction. Also, notice the slight green passivation layer that has formed on the copper where the iron handle is connected to the pot. This is the protective layer that prevents further corrosion of the copper.

Since using the wrong fastener can cause corrosion, *Table 3* shows expected reactions with various metal combinations.

The galvanic corrosion process has led to using metals in the galvanic series for cathodic protection. Cathodic protection uses galvanic reaction principles in a positive way to prevent corrosion of a desired component. There is still corrosion, but the corrosion is controlled so that a predetermined metal is sacrificed. Galvanic protection is generally used when metal components are buried in earth or immersed in water, such as ships or offshore drilling rigs. Magnesium, zinc, and aluminum are metals often coupled to steel. For example, electrically connecting buried steel pipe with zinc, which is more anodic, allows the zinc to corrode before the steel. It is offered up as a sacrificial anode and limits the corrosion of the steel pipe until all of the zinc is consumed.

Impressed cathodic protection is usually a modified procedure. For instance, for a ship, anodes are strategically positioned on a ship's hull and emit an electrical current that suppresses current flow from the anodic areas of the hull. This converts the ship's hull to a cathode, removing/reducing any damage from corrosion—hence the term "impressed-current cathodic protection." The system continuously monitors and controls the impressed current output to provide optimum corrosion protection.

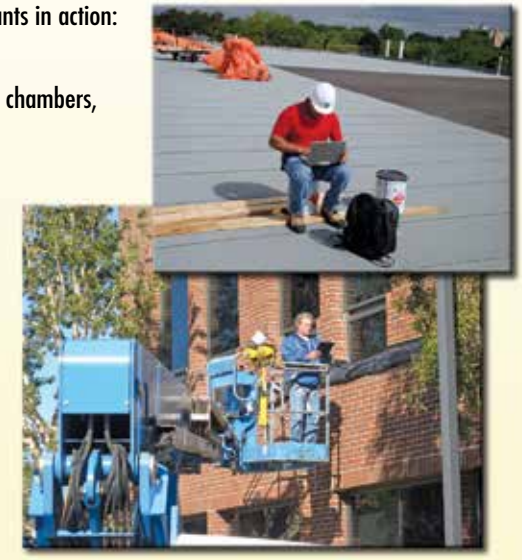
ATMOSPHERIC CORROSION OF STEEL

Salts are probably the most common components that affect electrolytes. Several

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Photo 3 – Salt on vehicle.



Photo 2 – Salt on a highway.



Photo 4 – Corroded fire escape.



common sources of salts found in electrolytes are deicing salts and coastal salts. Road salts (most commonly sodium chloride) can become airborne on both wet and dry highways; and heavy, fast-moving traffic can send salt mist airborne like an aerosol spray. *Photos 2* and *3* show a mixture of deicing salt and sand on the highway and salt residue on a vehicle.

Prevailing winds and thermals can carry these airborne salts hundreds of feet and deposit them on unprotected structures. Once deposited, they remain dormant until moisture from rain, melting snow, fog, and condensation create an electrolyte or carry the salts to the structure's interior where, unobserved, they perform their destruction. The height that airborne salts can be carried up the building façade will vary depending on building shape and orientation, topography, landscaping, prevailing winds, etc. Regardless of the distance traveled, they can cause damage to improperly protected materials. *Photo 4* shows a corroded steel fire escape along a busy metropolitan street.

Sodium chloride, calcium chloride, and magnesium chloride are salts common to coastal environments that may also be found in deicing salts and may affect corrosion in multiple ways. For instance, since salt is considered to be hygroscopic (able to absorb moisture in the air) and does not have to wait for rain to begin its destructive path, it can simply absorb whatever moisture (including humidity) is in the surrounding air. A salt's chemistry can breach the protective oxide barrier that some metals, such as aluminum and zinc, form when exposed. Salts also act as a catalyst to an electrolyte, which increases the electrolyte's conductivity. As previously mentioned, during galvanic action, the rate of corrosion is directly proportional to its conductivity, and the atmosphere near the seashore is more con-

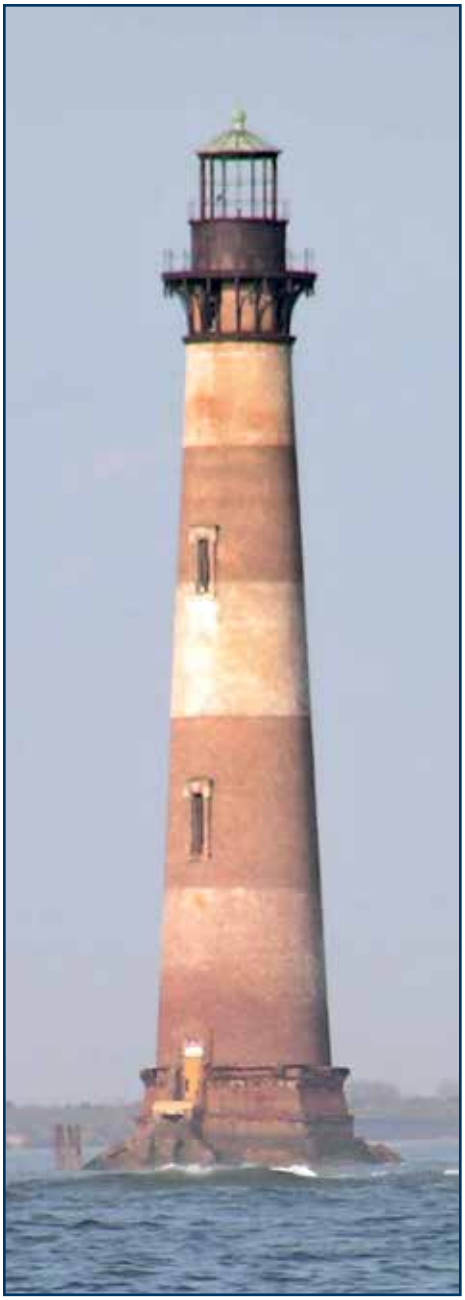


Photo 5 – Corroded lighthouse.

ductive because of the associated salt and is, therefore, more corrosive than inland. Similarly, condensate near the seashore is more brackish and thus is more conductive and a better electrolyte than an inland condensate. Steel typically corrodes or rusts rapidly in moist environments, and the rate of corrosion accelerates significantly if that moisture is salty, as shown in *Photo 5,* a coastal lighthouse.

Although this author is not aware of definitive tests or experiments to confirm or refute the supposition, it is possible that mixing sand with deicing salt, as is done in some localities, increases the airborne tendencies of the salt. This is because the salt particles can cling to the sand and are not absorbed by the concrete and are available to become airborne.

As previously discussed, ferrous oxide forms on the surface of iron or steel during the initial corrosion process and acts as a passivating layer. However, in the presence of water, oxygen, sulfur dioxide, and carbon dioxide solutions, the protective ferrous oxide layer becomes nonprotective rust, due to the formation of magnetic iron oxide called magnetite. Once this protective layer flakes off at the surface, fresh metal is exposed to corrosion. This process continues until either all of the iron or all of the oxygen, water, carbon dioxide, or sulfur dioxide in the system is removed or consumed.

Smokestacks often have a metal liner that can corrode when the furnace is shut down and the stack cools. As the stack cools, the surface temperature can fall below dew point, causing condensation to form on the surface. The condensation can react with carbon and sulfur deposits that may have accumulated on the stack lining from burning fossil fuels. This reaction can produce corrosive sulfurous acid that will drain down the lining and start a corrosion process with unprotected metal that is susceptible to corrosion.

Look for Part II of this article in an upcoming issue of Interface.

Joseph ("Cris") Crissinger, CCS, CCCA, ASQ



Joseph ("Cris") Crissinger, CCS, CCCA, ASQ, is semi-retired and is a construction specifications and materials consultant in Spartanburg, SC. His responsibilities include construction specifications, materials analysis, field investigations, and facility assessments. Crissinger is a Certified Construction Specifier and a Certified Construction Contracts Administrator. He is a member of the Construction Specifications Institute, the Building Performance Committee of ASTM, and the Design and Construction Division of the American Society for Quality. He is a two-time recipient of RCI's Richard Horowitz Award. He also serves in the community on the Construction Board of Appeals for Spartanburg, SC, and is a U.S. submarine veteran. Crissinger may be reached at specalyze@reagan.com.

Amarillo Hail Storm Costs $400 Million

Insured losses from a May 28 hailstorm that hit Amarillo, Texas, are expected to reach $400 million, according to the Insurance Council of Texas. In a statement, the council said the storm damaged an estimated 35,000 vehicles and thousands of homes as it passed through the center of the city, dropping hail as big as baseballs.

The statement cited comments from local roofers who described the damage as the worst they'd seen in the area in their experience. Because of the May storm's size, the resulting losses are expected to exceed those from a June 2004 hailstorm that held the previous record for the largest losses from such a storm in Amarillo at more than $175 million. This latest storm was in the same line as the recent string of severe weather affecting Oklahoma.

One roofer, Brandon Roberts of West Texas Roofing, says high-end roofs and the highest class of impact-resistant asphalt shingles were "totaled out" by damage from the storm.

Texas experiences the highest number of hail events of all states most years, suffering from 795 such events in 2012—almost twice the number of the closest "competitor," Kansas, at 426, according to the National Weather Service.

— propertycasualty360.com

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PREMATURE METAL ROOF DECK CORROSION:

Difficult to Detect and Diagnose

By Mark H. Hopmann, PE
and Kimberly Steiner

INTRODUCTION

Recent studies by various parties have examined premature corrosion of metal roof decks where fiberboard insulation was directly attached to the top surface of the metal deck and/or where ferrous mechanical fasteners were placed through the fiberboard to anchor it to the deck[1] (*Figures 1* and *2*). At present, fiberboard roof insulations are manufactured using both hardwoods and softwoods, although in the past, at least one facility produced cane-based (bagasse) products. The corrosion conditions associated with fiberboard roof insulation should not be confused with the phenolic insulation board corrosion problem identified in the 1980s. Often undetected by property owners, managers, and tenants, this new condition weakens the roof deck to the point that it presents safety concerns for rooftop equipment and workers. The corrosion can also decrease the capacity of the metal deck's connection to the structure, making the roof deck susceptible to damage from high-wind events. The National Roofing Contractors Association (NRCA) has reported cases in the southern, southeastern, and northeastern areas of the country; however, the extent of the problem across the nation is not yet known. No written requirements to manufacturers have been mandated, and ASTM C208, *Standard Specification for Cellulosic Fiber Insulating Board*, has not yet changed its language to address the issue of corrosion resulting from exposure of metal to the insulation.

In an article entitled "Roof Deck Quickly Corroded by Insulation," published



Figure 1 – Roofing membrane and insulation board removed to expose metal decking. Note corrosion occurs at both "peaks" and "valleys" of metal decking.



Figure 2 – Metal deck samples with corresponding section of fiberboard insulation.



Figure 3 – Small red rust spots (left arrow) and white rust (right arrow) developing on bottom side of roof deck.

Figure 4 – White rust starting on bottom side of roof deck looks like deposits from water droplets.



in the January 2011 issue of *Interface*,[2] the authors stated their opinion that the corrosive agent came from chloride-containing chemicals that were used by the manufacturer to kill mold and mildew in cane-based products prior to fabrication of the boards. (It is our understanding that the sole bagasse-based fiberboard insulation factory in the United States has been closed.) While that mechanism may explain some instances of corrosion associated with cane-based products, this article shows that other corrosive agents can come from the fiberboard material itself.

Other facilities are known to have been affected by this problem, but this article focuses on the field and laboratory evaluation of two facilities in Texas, both of which were affected by cane-based fiberboard insulations. This paper will list several hypotheses regarding the cause of the problem and will describe chemical analyses and the related findings behind them. Finally, recommendations for property owners, managers, and tenants are provided explaining how to perform initial checks and observations to determine if their facilities may be subject to this condition.

GENERAL DESCRIPTION OF FACILITIES AFFECTED

Although the range of construction dates exhibiting this problem is not fully known, the facilities addressed in this article were constructed between 2000 and 2005. Affected structures are typically industrial warehouses, often with conditioned office space in front and unconditioned spaces with large roll-up overhead doors in the rear. In these facilities, the bottom side of the roofs' metal decks may be exposed to view or covered by interior insulation and/or ceiling finishes, making their condition more difficult to assess. This type of structure can also present varying environmental conditions (temperature and humidity) within the spaces.

Roof deck corrosion at these facilities was typically discovered accidentally, within several years of original construction, when roof decks were exposed for modifications to rooftop equipment for new tenant requirements. Levels of corrosion were typically quite significant—much more than would be expected from a minor roof leak over many years of service life for this type of roof. Roof leaks at isolated locations had been reported and repaired but were not necessarily associated with the areas of significant corrosion observed.

EVALUATIONS AND STUDIES

As a safety measure, visual surveys (first from the entire underside of the roof deck) should be conducted, looking specifically for signs of metal decking distress. Simple probing and up-close inspections can be performed from manlifts to check for signs of corrosion and "soft spots" in the decks. These areas need to be marked on roof plans and then on the roof surfaces. Temporary support of the roof deck around these areas may be required before conducting condition surveys and testing on the top side of the roof. Because there does not need to be a significant amount of water present for this type of premature corrosion to occur, it is important to evaluate areas that are prone to roof leaks as well as those that are not.

Distress can appear as common small red rust stain spots but can also appear as white rust spots (which look like dried deposits from water droplets) or "wrinkled" surfaces (*Figures 3* and *4*). White corrosion



Figure 5 – Lines of white rust on top of metal deck at spot welds.

is often found at the spot-weld locations where the metal deck is connected to the open web bar joists. Because some specifications call for the coating of these spot welds and some contractors provide it as best practice, white rust can be mistaken for an applied coating (*Figure 5*). Material testing can determine if the white material is a coating or a form of corrosion.

HYPOTHESES CONSIDERED

When dealing with premature corrosion, it is critical to identify the source of the corrosive agent so that proper corrective action may be taken. Several sources of potential corrosive agents were considered, including:

- Presence of acid rain
- Presence of elevated levels of air pollution related to nearby elevated expressways
- Material installed in wet conditions, trapping water in the roofing system
- Moisture ingress through openings in the metal decking from interior spaces underneath the roofing system
- Excessive roof leaks
- Corrosive agents within the roofing system itself
- A combination of these factors

LABORATORY TESTING

Extensive laboratory testing was undertaken by Wiss Janney Elstner Associates Inc. (WJE) to determine the source of the corrosion.

Testing of the Corrosion Product

The first place to look for evidence of the corrosive agent(s) is within the corroded

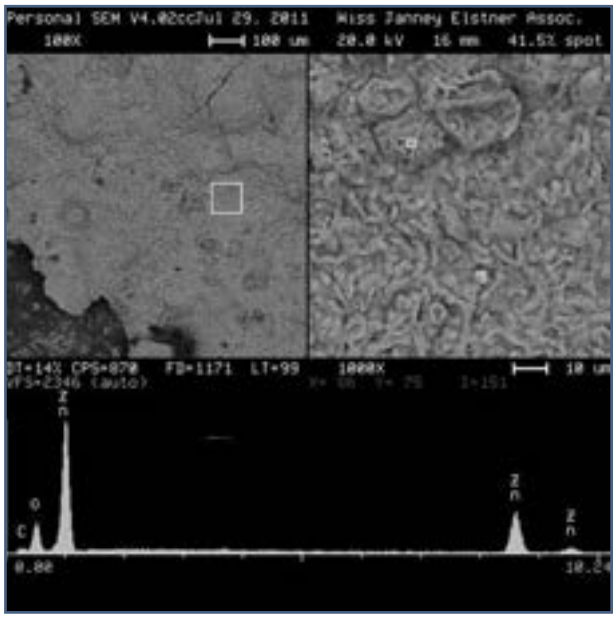


Figure 6 – SEM/EDS analysis of corroded galvanized steel roof deck. Note that the analysis found the presence of zinc, oxygen, and carbon only.

material itself, as many corrosion products retain a chemical signature of the corrosive agent. Corrosion product from the galvanized steel roofing was analyzed using three techniques. Scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM/EDS) identifies elemental composition (of elements heavier than boron) on a microscopic scale; Fourier transform infrared spectroscopy (FTIR) provides information about certain molecules, particularly organic (carbon-chain) molecules; and X-ray diffraction (XRD) identifies the crystalline (regularly ordered atomic arrangement) component.

SEM/EDS analysis of several corroded roof deck specimens from multiple locations indicated the presence of zinc, oxygen, carbon, and—where red corrosion product was present—iron (*Figure 6*). Typical corrosion accelerators—such as chlorine, indicating the presence of chloride; sulfur, indicating the presence of sulfate; or nitrogen, indicating the presence of nitrate—were generally not found. The elements observed (zinc, iron, oxygen, and carbon) would be present from typical moisture-induced corrosion or might indicate an organic component. FTIR analysis indicated the presence of a low-molecular-weight carboxylic-acid salt, such as an acetate or formate. In this case, a likely source of these chemical compounds is bagasse/sugar cane or other wood fibers used in the production of the fiberboard insulation. As discussed below, the source of the acetate and formate was the fiberboard insulation. XRD analysis of the corrosion products—particularly water extracts of the corrosion product where only water-soluble components were analyzed—indicated the presence of zinc acetate and sometimes zinc formate, along with other typical corrosion forms (zinc oxide, zinc carbonate hydroxide, iron oxide) in several samples of corrosion product.

The absence of typical corrosion products (chloride, sulfate, or nitrate) and the presence of unusual corrosion products (acetate and formate) helped to rule out several potential hypotheses: 1) acid rain contains sulfurous acid, which would leave traces of sulfur in the corrosion product; 2) air pollution, which contains elevated levels of CO_2 and SO_x, would leave traces of high levels of carbonate and sulfate; and 3) elevated levels of moisture from the installation of wet materials or roof leaks (solely) or 4) moisture ingress from unconditioned spaces (solely) would have each led to the presence of oxide and hydroxide corrosion products, but no others. The data indicated that the source of corrosive species must be within the roofing materials, possibly in combination with another factor.

To confirm that the source of the corrosive species was within the roofing system itself, testing of materials sampled from the roofs under investigation was performed. The roofing system consisted of the galvanized steel deck and fiberboard insulation with an asphalt coating on its top side. The fiberboard insulation was subjected to two types of chemical analysis and exposure testing to observe the degree of corrosion of galvanized steel exposed to insulation specimens.

Testing of Components in Roof System

Anion analyses were conducted on water extracts of insulation samples using ion chromatography (IC) or chloride analy-



Anion	Anion concentration (mg ion/kg insulation) (7 samples tested for chloride, 3 sample tested for other anions)
Acetate	1422 - 15,938
Formate	Nd - 590
Chloride	160 - 2,020
Nitrite	Nd - 314
Sulfate	105 - 405

Nd = Not detected

Table 1 – Water-soluble anions extracted from insulation samples.

Carboxylic Acid	Concentration (7 samples tested)
Acetic Acid	Nd - 5974
Formic Acid	Nd - 26

Nd = Not detected

Table 2 – Vapor-phase carboxylic acids produced by insulation samples at elevated temperatures.

sis to determine the types and quantities of water-soluble anions (negatively charged ions) that may participate in corrosion reactions. The quantity of anions detected in the samples ranged significantly from specimen to specimen, even among those collected from the same building. Acetate, formate, chloride, and sulfate were typically detected in the insulation samples, all of which are associated with accelerated corrosion of zinc and steel (*Table 1*).

Vapors (particularly carboxylic acids) emitted by the insulation at elevated temperatures were analyzed. Insulation moistened with deionized water was heated to 160°F. Nitrogen gas was passed through and over the wet insulation, and water-soluble components were collected. Using IC, the water was then analyzed for anion content. The conjugate bases of acetic and formic acids—acetate and formate—were typically detected. The amount of the acids was calculated based on the quantities of conjugate base and the pH of the water solution. As with the anion analysis of the water extracts, the quantities of acetate and formate in the collected vapors varied from specimen to specimen, even those removed from the same building (*Table 2*).

Exposure Testing of Insulation Board

A final set of tests to evaluate the corrosivity of the insulation involved exposing noncorroded portions of the galvanized steel deck to the insulation under controlled conditions: 1) exposing the galvanized steel to moistened insulation in direct physical contact with the galvanized steel substrate, 2) exposing the galvanized steel to vapors produced by moistened insulation, and 3) exposing the galvanized steel to vapors produced by dried insulation. The purpose of these tests was to evaluate the relative effects of exposure to 1) the water-soluble ions in the insulation (moistened insulation by direct contact), 2) acetic and formic acid vapors produced by moistened insulation,



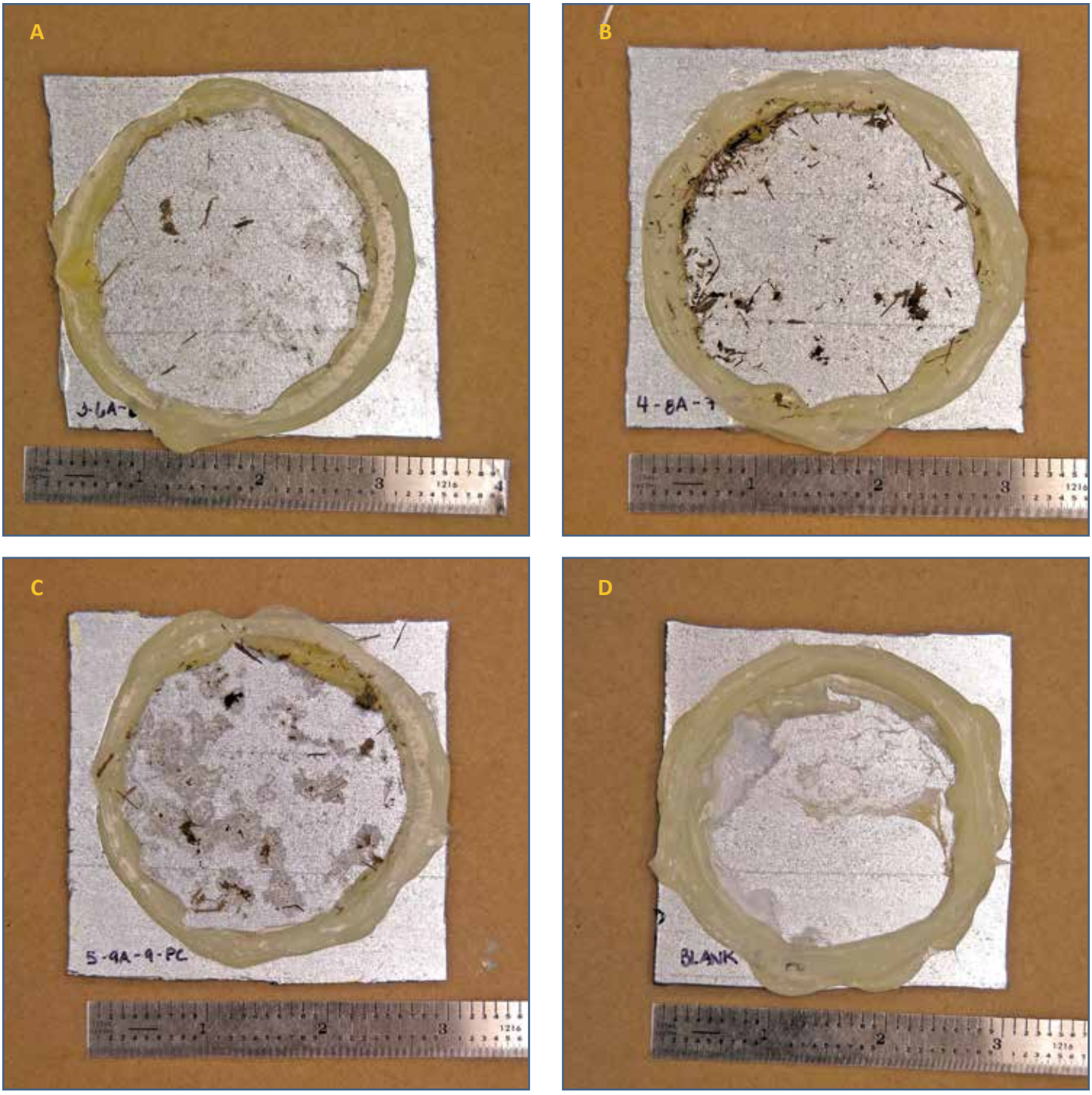


Figure 7 – Physical contact exposure test samples after eight days of exposure at 160°F to different moistened insulation samples. Levels of water-soluble anions detected on a separate portion of the insulation samples used for exposure tests were as follows: A) 16,000 mg acetate/kg insulation, <1 mg formate/kg insulation, 1,080 mg chloride/kg insulation, 314 mg nitrate/kg insulation, and 405 mg sulfate/kg insulation; B) 1,400 mg acetate/kg insulation, 420 mg formate/kg insulation, 160 mg chloride/kg insulation, <1 mg nitrate/kg insulation, and 105 mg sulfate/kg insulation; C) 5,800 mg acetate/kg insulation, 590 mg formate/kg insulation, 499 mg chloride/kg insulation, <1 mg nitrate/kg insulation, and 206 mg sulfate/kg insulation; and D) no insulation used for blank test.

and 3) vapors produced in the absence of moisture in the insulation. For all conditions, the controls were exposure to deionized water or laboratory air that was sealed into the exposure test system.

Although expected to lead to significant corrosion because of the levels of water-soluble chloride and sulfate in the insulation, exposure to moistened insulation in direct physical contact with the galvanized steel produced little to no corrosion compared to other exposure tests and a control of exposure to deionized water (*Figure 7*). This correlated well with the absence of detectable chlorine or sulfur in the corro-

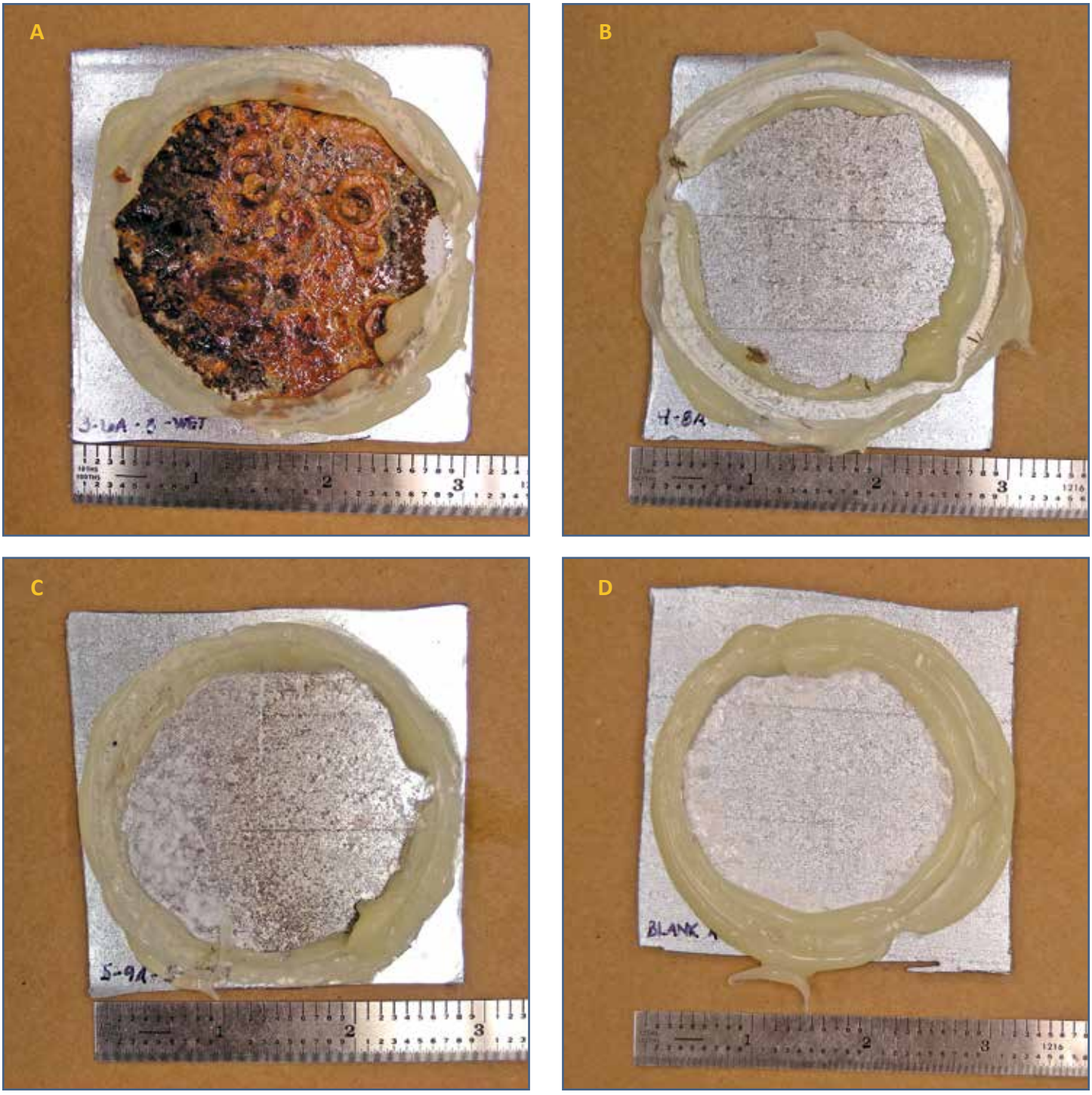


Figure 8 – Vapor phase exposure test samples after eight days of exposure at 160°F to different moistened insulation samples. Levels of volatile acetic and formic acids detected on a separate portion of the insulation samples used for exposure tests were as follows: A) 5,980 mg/kg insulation, B) <1 mg/kg insulation, C) 2,850 mg/kg insulation, and D) no insulation used for blank test.

sion product of the samples removed from service. If water-soluble chloride or sulfate were causing the premature corrosion, a chemical signature of chlorine- or sulfur-containing compounds would be expected in the corrosion product itself.

Exposures to vapor produced by moistened insulation generally produced the most corrosion of the galvanized steel, although the level of corrosion varied dramatically from sample to sample (*Figure 8*).

Exposure to vapor produced by dried insulation resulted in no corrosion product (*Figure 9*). The results of the exposure testing of the oven-dried insulation, compared to that of the moistened insulation, indicated the role of moisture in the corrosion reaction. Moisture is essential for any corrosion reaction to occur, and the laboratory tests indicated that moistened insulation leads to corrosion at a greater rate than oven-dried insulation.

LITERATURE SEARCH

A literature search was undertaken to determine if fiberboard insulation has been associated with corrosion. Numerous sources discuss the emission of acetic acid vapors from hemicellulose-containing products, including wood- and cane-based materials. Fiberboard insulation, specifically cane-based fiberboard produced by a single manufacturer, has been used in storage containers of nuclear material. Reports published by the Department of Energy indicated corrosion in some of these containers due to emission of acetic acid vapors from the insulation and water-soluble chloride in the cane-based insulation.[3,4,5,6,7,8,9] Other literature describes the emission of carboxylic acid vapors from wood.[10,11] The quantity of vapor emitted depends on the species of wood and whether the wood material has been exposed to elevated temperature and humidity for extended time periods, in which case the quantities of acetic and formic acids were typically substantially increased.[11] In addition, specifically for a bagasse product, variations during the processing of the sugar cane into bagasse affect

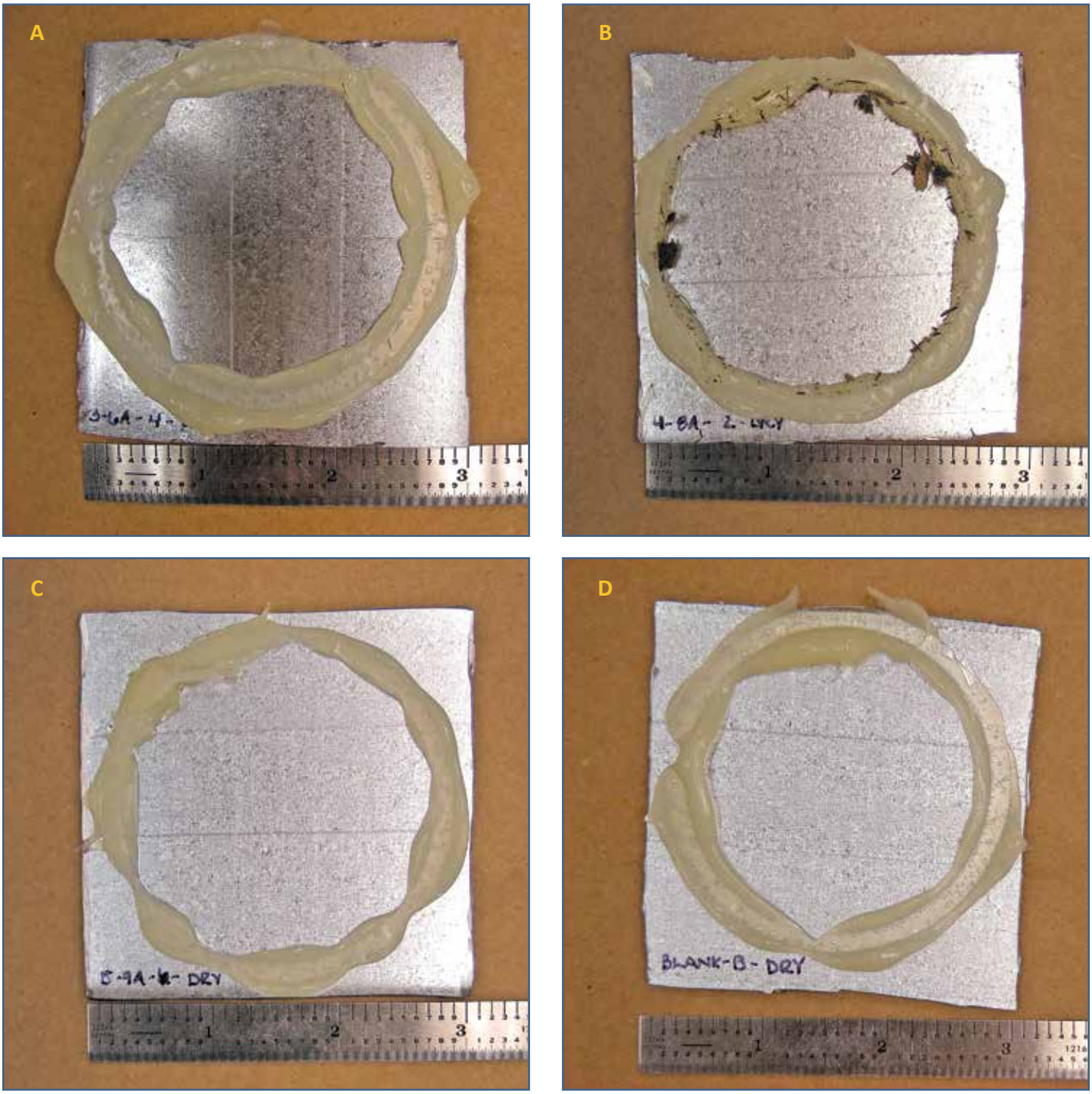


Figure 9 – Vapor phase exposure test sample after eight days' exposure at 160°F to oven-dried insulation. The sample in 9D was exposed to laboratory air only. The other samples were exposed to different insulation samples.

quantities of carboxylic acids emitted from the material.[12,13,14] The production of corrosive vapors from wood-based materials is also well-studied within the museum and conservation industries, which involve storing artifacts in wood-based cabinets where they can be susceptible to corrosion from vapors.[15] No literature was found describing corrosion related to wood-based fiberboard insulation used in the roofing industry.

CONCLUSIONS

The range of laboratory tests performed indicated that a primary source of corrosion was vapors (particularly carboxylic acids) emitted from the cane-based fiberboard insulation itself, particularly if the insulation was in a somewhat moistened condition. The source of the moisture was not determined, but the insulation was not noticeably wet when sampled, and areas of severe corrosion were not related to roof leaks. Neither high levels of water moisture nor direct physical contact of the tested fiberboard insulation with the metal decking was necessary to cause this type of corrosion. Even in the absence of corrosive vapors, the insulation contains water-soluble chloride, nitrate, and sulfate, which can lead to corrosion of galvanized steel. The other potential sources of corrosion previously listed were ruled out.

Our literature review indicates material containing hemicellulose, including wood- and cane-based products, has the potential to emit acetic and formic acids upon exposure to elevated temperatures and moisture.[3,4,5,10,11] Previous roofing industry publications have linked this problem specifically to bagasse (sugar cane-based) insulation. However, as the published literature referenced above suggests, wood-based roofing fiberboard insulations, to our knowledge, have not yet been tested to be able to definitively state if they do or do not produce similar corrosive environments. The amount of carboxylic acid emission has been shown to be affected by the processing of both cane- and wood-based materials.[11,12,13,14]

It is also possible that manufacturing processes led to conditions in which the fiberboard is more likely to break down and emit acetic and formic acids than fiberboard of a similar composition but processed differently. In addition to concerns about vapor emission, the presence of water-soluble chloride, nitrate, and sulfate in the insulation are also expected to lead to corrosion, although minimal evidence was observed that these ions were involved in the corrosion reactions examined within this investigation. The quantities of water-soluble anions and carboxylic acids emitted varied substantially from specimen to specimen, and the specific mechanism of corrosion may also be variable.

RECOMMENDATIONS

Difficulty in detecting and diagnosing premature corrosion presents a safety concern. Steps should be taken by facility owners and managers to identify its presence, and designers and contractors should be aware of the potential problem.

For Owners and Property Managers:

- Identify the type of roof materials used on your facilities. If fiberboard insulation materials have been used, the method of attachment to the metal deck and the manufacturer should be identified. This can possibly be done by reviewing the specifications and/or the approved submittals for the facility. It can also be done by contacting the architect of record and/or roofing and general contractors for the building. If the fiberboard insulation material was applied directly to the deck or if metal screws were used to attach the fiberboard insulation to the metal roofing deck material, condition surveys of the roofs should be performed as described below.
- Make general observations of the bottom side of the roof deck to determine if there are visible signs of decking distress as described earlier in this article. If such conditions are identified, the next step should be to perform simple probe tests (or metal thickness testing) to see how significant the corrosion of the metal deck is. All distressed areas should be documented on roof plans. The roof condition survey should also include locating all roofing penetrations (such as rooftop units, vent stacks, etc.), previous roof repairs, and/or leaks so that correlations between leak and corrosion areas can be made, if present.

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- Have the roof investigated by an RRC or an architect or engineer knowledgeable of this particular type of roofing problem if the characteristics of the roof align with those of premature roof corrosion described in this paper. The extent to which the roof needs to be repaired depends greatly on the extent of the corrosion, both in area of the roof and in thickness of corrosion in the metal deck. To address this condition properly, the entire roof system (including the metal deck) may have to be removed and replaced. If the corrosion is minor, the metal deck may be able to be cleaned and coated, and then a new roofing system placed on the repaired metal deck. Care must be taken to use a new roof system that does not overload the existing roofing support members and allows detailing of penetrations and edge conditions, similar to the original roof details.

For the Roofing Design and Construction Industries:

- Create and maintain a database of information on roofs with significantly corroded metal decking where fiberboard has been used.
- Perform testing specifically on wood-based products used in the roofing industry to determine if they can cause significant corrosion in materials of roof deck systems. Test various manufacturers' fiberboard insulations to determine if they contain carboxylic acid or other corrosive chemicals such as water-soluble chloride.
- Define sampling and testing methods for determining the actual cause of corrosion. This could result in the adoption of an ASTM test method requiring manufacturers to conduct testing and publish the results in their product literature.
- Have professional roofing and design organizations address the issue in their publications and standards.
- Do not use fiberboard insulation in direct contact with metal decking or ferrous anchors (with no anti-corrosive coating) unless it is shown that the fiberboard does not contain chemicals that could cause corrosion with metal decking and fasteners. Details (such as separation materials) can be used to keep the metal deck from being exposed to the fiberboard.

FOOTNOTES

1. The conditions being discussed in this article have been described in NRCA's publication *Professional Roofing* (March 2012 issue), in an article entitled "A Concern with Fiberboard Insulation: Corrosion of Metal Components Poses Safety and Performance Issues" by Mark S. Graham. In that article, manufacturers who have been identified as having this problem with their fiberboard insulation products are listed. The problem was also announced in a Steel Deck Institute (SDI) position statement in May of 2012. NRCA's Technical Operations Committee has met with representatives of the North American Fiberboard Association (NAFA) and fiberboard manufacturers to begin to better understand this corrosion issue.
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Mark Hopmann is a professional engineer registered in Texas. In 1997, he established the Houston office for Wiss, Janney, Elstner (WJE), where he has been involved with the evaluation and repair design of structures and building enclosure systems. Prior to joining WJE, he worked for Law Engineering, for a general contractor involved with the construction of the Menil Museum (designed by Renzo Piano), and for Haynes Whaley Associates, a structural engineering design firm.



Kimberly Steiner

Kimberly Steiner is a chemist specializing in failure analysis of construction materials. She has expertise in many different types of laboratory analyses as well as field observation. Prior to joining WJE, she was a research scientist specializing in ceramic materials and coatings for Applied Thin Films, Inc. and Northwestern University.

Oklahoma Prohibits Sole-Source Specs on Public Construction

Oklahoma Governor Mary Fallin (R) recently signed Oklahoma Senate Bill 630 into law, which prohibits sole-source specifications on all public construction projects in the state. The legislation, authored by Sen. Clark Jolley (R-OK, District 41) and Rep. Jason Murphey (R-OK, District 31), passed the Oklahoma Senate and House 43-0 and 85-1, respectively. SB630 is designed to stop unfair bidding practices that can significantly inflate the cost of public construction projects.

Recent news reports found that the lack of competition in some Oklahoma school districts had resulted in costs that were up to 60% higher than if a competitive bid process had been followed. The new law will ensure competitive pricing and the protection of Oklahoma taxpayers' dollars in several different ways:

- For public construction projects, at least three equivalent items from more than one manufacturer and more than one supplier or representative must be included in the bidding specifications.
- Any sole-source bid proposal cannot set a geographical boundary from which the material must be obtained.
- Any bid submission on a public project that substitutes an item with one that is alike in quality and design or that meets the required specifications must be considered and shall not be prohibited.
- Any competitive bid submitted under the Public Competitive Bidding Act of 1974 to a school district, county, or municipality for furnishing of goods or services must be accompanied by a sworn noncollusion statement that states, among other items, that neither the bidder nor anyone subject to the bidder's direction or control has been a party to any efforts or offers with state agency or political subdivision officials or others to create a sole-brand acquisition or a sole-source acquisition in contradiction to the new law.

— Coalition for Procurement Reform

Restoration and Maintenance of Architectural Metals

By Jim Ryan



This clear anodized aluminum building in Grand Rapids, MI, is in the process of being cleaned.

Real estate managers and building owners recognize that well-maintained buildings increase tenant satisfaction and building image. Buildings are assets, and the value to the owners and tenants increases with the use of durable materials that can be economically maintained, such as anodized aluminum, stainless steel, and coil-coated aluminum. Architects are fond of incorporating these architectural metals into curtain wall design; and, as a result, they are commonplace in contemporary architectural design.

The use of anodized aluminum and stainless steel in exterior building design dates back to the 1960s, when metal curtain wall designs became popular with architects and developers. Some of the most renowned buildings in the United States utilize metal prominently in their curtain wall, including the John Hancock building, the Inland Steel building, and the Willis Tower (previously Sears Tower) in Chicago; the Westinghouse building in Pittsburgh; and the Equitable building in Atlanta, to name a few.

Proper maintenance is the only assurance that the metals incorporated into these curtain



Close-up of painted aluminum cleaning contrast.



Restoration is progressing from both corners of the façade on this anodized aluminum Century City high-rise.

Demarcation between restored and unrestored areas of this clear anodized aluminum building is apparent.



walls maintain their intended appearance and luster. All surfaces exposed to the atmosphere collect soil, dirt, and atmospheric pollutants, depending upon the geographic area, environmental conditions, and location of the building. In extreme cases, heavy surface oxidation, surface roughening, and iridescence can develop. The accumulation of surface soils and atmospheric pollutants increases the surface roughening, staining, and discoloration of the finishes. The decorative metallic appearance of these finishes can only be maintained by periodic cleaning. If left unmaintained, the oxide coating of anodized aluminum will be attacked by these chemical deposits; and in the latter stages of unmaintained aluminum, corrosion in the form



Painted composite panel restoration after.



Painted composite panel restoration before.

of pitting can develop. With respect to stainless steel, these same contaminants can create corrosion in the form of red rust spots. It is generally believed by building managers that stainless steel cannot rust; however, lesser grades of stainless steel will corrode in the presence of atmospheric pollutants and moisture.

Maintenance should be figured into the life cycle costs or operations budget of each and every building in which architectural metals are used in the configuration of the curtain wall. Proper maintenance, initiated from the beginning, will prevent permanent damage caused by neglect and ensure maximum life expectancy of the finish. Material and finish information should be obtained from the metal supplier or finisher to ensure that the metal is cleaned properly for a material of its type. Cleaning procedures should be initiated as soon as practical after construction or installation to remove construction soil and accumulated environmental pollutants. Alkaline building materials such as concrete or mortar should be removed from the architectural metals and glass to prevent staining, corrosion, or etching of the metal and glass.

In the event that a building façade incorporating architectural metals is neglected for a period of years, it will be necessary to employ restorative techniques to return the metal finish to its intended appearance. In the case of anodized aluminum and stainless steel, these methods generally require the use of abrasive materials and procedures to remove heavy soil buildup, oxidation products, and tenacious pollutants from the neglected metal panels and extrusions. With the advent and extensive use of Kynar finishes in the 1980s, a new cleaning challenge was presented to building managers, owners, consultants, and contractors alike. Abrasive cleaning methods should not be utilized on coil-coated



Painted curtain wall restoration cleaning in progress on a Chicago building.



A marked contrast is apparent after cleaning of a stainless steel building in Denver.



Note contrast before (top) and after (bottom) restoration of black anodized aluminum.

aluminum or painted finishes, due to the likelihood of scratching or abrading the coating. Extra care must be taken in the cleaning of these sometimes delicate finishes. The use of strong chemicals or acid-based cleaners should not be permitted under any circumstance, regardless of material. These cleaners will very likely permanently damage the finish of the architectural metals and glass on a curtain wall in the form of corrosion, discoloration, or etching. Adjacent landscaping will also likely be damaged due to runoff of these aggressive cleaning solutions.

The American Architectural Manufacturers Association's (AAMA's) 609 specification for the cleaning and restoration of architectural metals outlines basic procedures for the cleaning and maintenance of architectural metals, with emphasis on anodized and coil-coated aluminum. Although the AAMA specification provides guidelines for cleaning, the selection of a contractor with specialized knowledge and experience in the field of the restoration and maintenance of architectural metals is imperative to ensure optimal results. The AAMA cleaning specification in the hands of three or four inexperienced contractors could result in three or four very different interpretations and results. There are many documented cases in which the local window cleaner convinced a property manager that he had the know-how to clean or restore a metal curtain wall system, only to fail miserably and/or permanently damage the appearance and finish of the expensive curtain wall materials.

There are numerous cases in which buildings were neglected for extended periods of time, and restorative cleaning techniques did not

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restore the finish to an acceptable level of appearance. Also, negligent cleaning procedures implemented by inexperienced contractors have created these very same situations: The metal could no longer be restored. In these cases, the application of field-applied architectural coatings may provide the desired result. Though this process is far more costly than restorative cleaning, it does have advantages in the selection of virtually any custom color available. When it is at all possible, the original factory finish should be retained, as these finishes are far more durable and lasting than air-dry field applications of architectural coatings.

No less important, the contractor selected for this specialized work should have extensive experience and certifications in access solutions as they relate to the use of scaffolding, swing stages, aerial equipment, and related safety requirements. Every building is different with respect to roof suspension systems, tiebacks, roof access, and overall building design. This experience is equally as important as the knowledge that the contractor has in the area of the cleaning and maintenance of architectural metals.

Consultants—with the assistance of the manufacturers, finishers, and fabricators of these curtain wall systems—should be able to provide guidance to building owners, property managers, and contractors to ensure that these expensive assets are maintained to safeguard a long, productive service life.

Jim Ryan

Jim Ryan has been engaged in the curtain wall restoration field for more than 25 years. In 1997, he founded Alumitec Ltd., of Chicago, IL, and is its president. The company specializes in the restoration, cleaning, and maintenance of architectural metals and curtain wall systems. Ryan previously served as vice president for the Midwest region for AMS Architectural Technologies for 13 years.



NRCA Recommends Polyiso Be Specified by Thickness, Not LTTR

The National Roofing Contractors Association (NRCA) recommends that designers specify polyisocyanurate (polyiso) insulation by its desired thickness, not R-value. It also maintains that designers should specify polyiso using an in-service R-value of 5.0-per-inch thickness for heating conditions and a 5.6-per-inch thickness for cooling, based on the predominant condition for the building use and climate.

Long-term thermal resistance (LTTR), which is used by the Polyisocyanurate Insulation Manufacturers Association (PIMA) in its reporting of R-values, may be more appropriate for laboratory analysis and research comparisons rather than for roof system design, the NRCA opines.

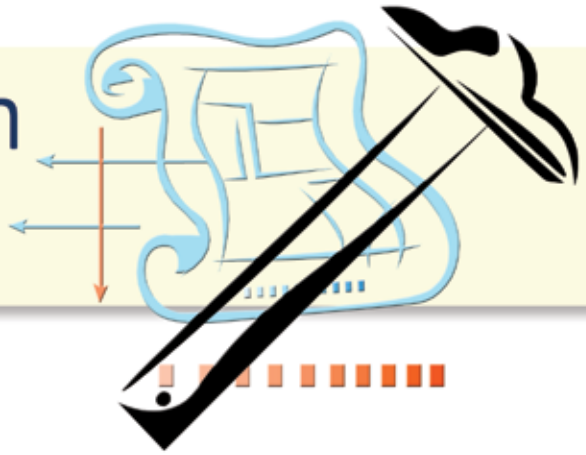
CPI Expands Emissions Calculating Tool

The Center for the Polyurethanes Industry (CPI) of the American Chemistry Council (ACC) has expanded its Regulatory Compliance Assistance Program (RCAP) by upgrading the interactive tool designed to help manufacturers, processors, and other users of diphenylmethane diisocyanate (MDI) and polymeric MDI (PMDI) in calculating emissions. This tool aids users in complying with mandatory reporting to the U.S. Environmental Protection Agency (EPA) by estimating emissions from typical process applications and activities. Users who exceed the threshold limits set by EPA are required to submit a Form A or Form R to the EPA and the designated state agency by July 1 each year.

The RCAP can be used by companies in their Toxic Release Inventory (TRI) reporting. CPI expanded the tool in its "diisocyanates" category to address 12 additional examples of emissions from various applications, including the manufacture of air filters, appliances, trucks, automobiles, boats, doors, mobile homes/motor homes, packaging, rebond foam, spray foam, spandex, and water heaters.

The interactive tool is available free of charge on CPI's website. To learn more about this tool and for more information about MDI emissions, visit http://www.americanchemistry.com/polyurethane.

RCI Document Competition Project $ Cap Adjusted



By Catherine Moon

The RCI Document Competition Subcommittee, chaired by Steve Alberico, AIA, has agreed to adjust the delineation mark between the Small and Large Project entries for the 2014 competition from $500,000 to $750,000. The decision was made after receiving minimal entries in the Small Project category for the last two years.

The annual competition consists of three entry categories: Reports, Small, and Large roofing, waterproofing, and exterior wall construction projects completed and delivered to the client after September 30, 2010, and before September 30, 2013.

Small and Large Projects will be judged based on:

- Appropriate cost-effective solution
- Technical merit
- Drawing format
- Drawing content
- Specification format
- Specification content
- Complexity (relative to others)
- Thoroughness (limited change orders and problems)
- Overall professionalism

Reports shall be entirely related to an evaluation or investigation of roofing, waterproofing, or exterior walls. Reports will be judged based on:

- Providing of meaningful information
- Thoroughness
- Readability
- Grammar
- Conclusions
- Recommendations
- Complexity (relative to others)
- Technical merit
- Overall professionalism

The competition is open only to RCI Professional and Quality Assurance Observer members who acted as the project manager for the document entry. Two entries in each category per firm are permitted. Winning entries will be awarded in the name of the entering RCI Professional or Quality Assurance Observer member. All entries and the entry forms must be postmarked on or before October 31, 2013, to be considered. For more information about submittal requirements and to download competition entry forms, go to the RCI website at http://www.rci-online.org/document-competition.html.

There is no fee for entries. Please complete an entry form for each entry submitted and send them to RCI at 1500 Sunday Drive, Suite 204, Raleigh, NC 27607.



Publish in *Interface*

Interface journal is seeking submissions for the following issues. Optimum article size is from 1,500 to 2,500 words, containing five to ten graphics. Articles should not serve commercial interests. Articles on subjects that do not fit into any given theme issue may be submitted at any time.

ISSUE	SUBJECT	SUBMISSION DEADLINE
November 2013	Bituminous roofing	August 15, 2013
December 2013	Weather issues	September 13, 2013
January 2014	Walls	October 15, 2013
February 2014	Safety	November 15, 2013
March 2014	Technology	December 13, 2013
April 2014	Concrete	January 15, 2014

Submit articles or questions to Executive Editor Kristen Ammerman at 800-828-1902 or kammerman@rci-online.org.

2013 DOCUMENT COMPETITION WINNERS

RCI President Chip Ward presented plaques to the winners at the Awards Luncheon in Orlando.

REPORT WRITING



1ST PLACE
Joshua J. Summers, REWC, SE, PE
Building Technology Consultants, PC

2ND PLACE
Kamran Farahmandpour, FRCI, RRC, RWC, REWC, RBEC, PE
Building Technology Consultants, PC





3RD PLACE
David Willers, RRC, RRO, PE, LEED AP
Rooftop Systems Engineers, PC

SMALL PROJECTS



3RD PLACE
Michael Hoecherl, RRC, RRO
Building Exterior Solutions, LLC

2ND PLACE
Richard L. Cook Jr., FRCI, RRC, RWC, REWC, RBEC, CCS, CSRP
ADC Engineering Inc.





1ST PLACE
Joseph E. Baker, RRC, RRO
ADC Engineering Inc.

LARGE PROJECTS



1ST PLACE
Kamran Farahmandpour, FRCI, RRC, RWC, REWC, RBEC, PE
Building Technology Consultants, PC

(The owner of this property has declined to have it highlighted in *Interface*.)

2ND PLACE
Matthew Farmer, PE
Wiss, Janney, Elstner, Associates Inc.





3RD PLACE
Bill Conley, RWC
Conley Group Inc.



Joshua J. Summers, REWC, SE, PE
Building Technology Consultants PC

Anchor Bank

Madison, Wisconsin

Exterior Façade Evaluation

The Anchor Bank is contained in a nine-story concrete frame structure completed in 1963 (Original Building) with a nine-story addition completed in 1975 (1975 Addition). The building's exterior façade consists of exposed aggregate precast components, including flat panels, horizontal sills, and vertical fins. The precast vertical fins are made of a C-shaped rigid steel frame encased in reinforced concrete and are connected to concrete spandrel beams at the building perimeter. The precast horizontal sills are reinforced concrete slabs connected to the vertical fins with seat angles welded to embedment plates in the sills.

A displaced sill, its connection to the adjacent fin on the right having failed.



Overview of the Anchor Bank, Madison, WI.



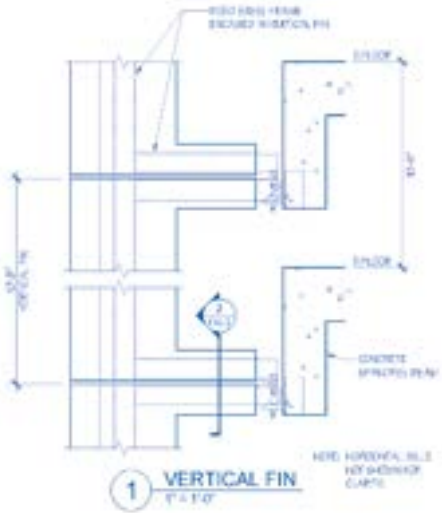
Concern regarding the building façade was initially expressed due to significant displacement of one of the horizontal sills. An up-close review of this sill revealed that the connection between it and one of the adjacent vertical fins had failed due to corrosion of the embedded connection hardware. This sill was stabilized with external structural steel to prevent it from falling from the building. Review of a few other sills in the vicinity of the displaced sill revealed similar connection failures, even though significant displacement had not yet occurred. These sills were also stabilized in the same manner.

Based on the observed conditions at the failed sill locations, an up-close evaluation of the entire building façade was commissioned to determine the overall condition of the precast façade components and to assess whether repairs were practical or recladding was necessary. This evaluation consisted of a visual review, hammer-sounding of concrete surfaces, and exploratory openings at precast connections.

The evaluation indicated that the façade of the Original Building was in very poor condition. Exploratory openings at the sill-to-fin connections revealed significant corrosion at all openings and failure of the connection at many of the openings. Other observed deterioration included significant freeze-thaw damage, cracking, spalling, and delamination. Stabilization was performed at failed connections.

The façade of the 1975 Addition was found to be in fair condition. However, evidence of deterioration similar to that on the Original Building was observed. Since the materials and façade attachment configuration were also similar to those of the Original Building, the 1975 Addition was found to be highly susceptible to future façade deterioration.

Based on the evaluation findings, several options were developed to address the observed deterioration. These options included make-safe repairs, comprehensive conventional repairs, and recladding. These repair options are currently under consideration.



Detail of vertical fin.



Detail of sill-to-fin connection.

Kamran Farahmandpour, FRCI, RRC, RWC, REWC, RBEC, PE
Building Technology Consultants PC

Highland Park High School, Bldgs. B and C

Highland Park, Illinois

Exterior Façade Evaluation

REPORT WRITING
2nd PLACE

Constructed in the early 1900s, Buildings B and C at Highland Park High School are solid masonry structures with a combination of various interior framing systems. Both buildings were constructed with steep-slope roofs and punched windows. The roofing systems and windows at both buildings have been replaced within the past 25 years. The building exterior walls were constructed with brick masonry and limestone accents.

Water-related damage to interior finishes on exterior walls has been an ongoing problem at the buildings. In addition, evidence of water leakage and related deterioration in the form of efflorescence has been observed at some locations. The high school district was considering the viability of rehabilitating the buildings versus demolishing them and building new ones. As such, an evaluation of the building envelope was commissioned. Its objective was to provide an opinion regarding the overall existing condition of the building envelopes and the viability of repairing them. The findings of this evaluation were used by the school district to make informed decisions regarding future use of the buildings.

The evaluation included the following:

- Review of the buildings' history
- Review of the buildings' interior areas
- An up-close visual review of the exterior façade and roofs
- Calibrated spray-rack water testing, Rilem tube testing, and ASTM C1601 chamber water testing on masonry walls
- Calibrated spray nozzle water testing on windows



Overall view of one of the subject buildings.

Prior to performing some of the water tests, interior finishes were removed to assist in identifying paths of water leakage.

After completion of water testing, several exploratory openings were made through the interior and exterior faces of the exterior walls to evaluate the extent, significance, and cause of observed deterioration. Concealed deficiencies that allowed water penetration were uncovered during exploratory openings.

Field observations and test results were analyzed to evaluate the overall condition of the exterior façades and roofs, as well as the extent of repair work required to return the façades and roofs to a serviceable condition. Several repair options were developed. For each repair option, advantages and disadvantages were analyzed. In addition, anticipated service life, initial costs, and future maintenance costs for each option were estimated. Based on these estimates, a life-cycle cost analysis was performed to properly compare financial ramifications of each repair option.



Calibrated spray nozzle testing.



Exploratory opening revealing partially filled head joints.



Deteriorated sealant between limestone coping units.

REPORT WRITING

3rd PLACE

David Willers, RRC, RRO, LEED AP

Rooftop Systems Engineers, PC

East Carolina University Neurosurgical and Spine Center

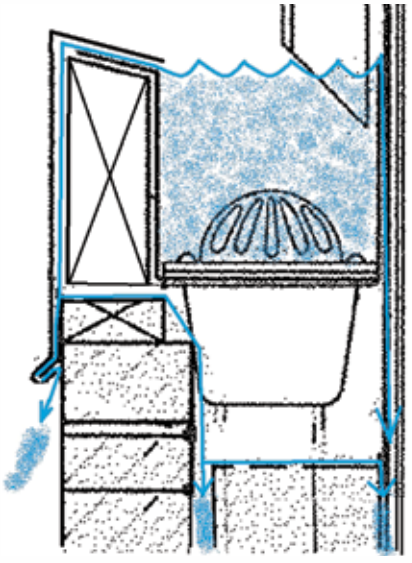
Greenville, North Carolina

Building Envelope Assessment



Partial overview showing single- and two-story building areas.

Building occupants reported water damage at window corners and ceiling areas adjacent to the perimeter walls at the Neurosurgical and Spine Center of East Carolina University. Rooftop Systems Engineers, PC was asked to identify construction defects allowing water entry into the building. The company performed the following: 1) visual examination of the building's roofs, gutters, exterior brick walls, and windows and 2) water testing of selected windows and gutters in combination with 3) destructive examination of the same windows and adjacent exterior brick walls.



A section of the built-in gutter. Blue lines show how water overflows and infiltrates the building's interior.

Building construction took place in two phases totaling 18,900 sq. ft. The majority of the structure is single-story; however, a small portion is two-story. It is wood framed with brick veneer and typically has a steep-sloped standing-seam metal roof with built-in gutters. However, the two-story portion has a single-ply membrane, low-slope roof. The exterior brick veneer is unique, with two brick wythes above and between windows and at building corners. Downspouts at the original building are within wall construction, but at the addition, they are on the exterior.



Spray rack testing in progress.

After performing a visual evaluation, four different window locations were selected for water testing and destructive examination. The test protocol was as follows: 1) remove interior drywall above and below windows and adjacent to internal downspouts; 2) water-test each window via spray rack; 3) watertest selected gutters; 4) remove windows, examine, perform repairs, and reinstall them; 5) remove masonry above and below the windows, examine the wall cavity, and reinstall the masonry; and 6) perform follow-up testing of repaired areas.

Numerous construction defects were found. Primary sources of water infiltration included defective windowsill pans and built-in gutters, which, when filled to capacity, would overflow into the building. Windowsill pans were sloped into the building; were missing end dams; or, in some cases, had holes in the end dams or were secured with nongasketed unsealed fasteners. In some cases, water from gutters would infiltrate the attic or below window corners through joints in the wood sheathing.



The windowsill pan is missing (red oval) an end dam and is sloped to drain into the building.

Secondary construction defects included lack of through-wall flashing (TWF) at many locations or missing end dams where TWF was present, missing/sealed weep holes, mortar bridging, and missing building wrap. Additionally, steel brick lintels were clad with sheet metal that directed water into the building and created mortar bridging.

Obtaining this information has enabled the owner to move forward and obtain a design to correct these construction defects and effectively serve the center's patients.

Joseph E. Baker, RRC, RRO
ADC Engineering Inc.

Byrd Hall, The Citadel Military College

Charleston, South Carolina

Building Envelope Repairs





Exterior during repairs.

Exterior after repairs.



ADC Engineering, Inc. was contracted by The Citadel, the military college of South Carolina located in downtown Charleston, under an open-end contract for building consulting services. The project's scope encompassed the implementation of building envelope repairs based on the recommendations of an investigation and written report.

The field investigation included gathering additional data necessary to provide a detailed design of all wall areas. The design project for The Citadel's Byrd Hall incorporated hardcopy drawings, specifications, and project construction administration. A prebid conference, preconstruction conference, milestone inspections, and prefinal inspection were also included.

The facility is a four-story educational building with walls consisting primarily of a direct-applied three-coat stucco system over masonry. It has aluminum storefront windows with cast-stone balusters and coping with cast-stone decorative bands surrounding it.

The construction documents included detailed elevations identifying various selective levels of cracking and damaged sections of cast-stone decorative bands, the repair/replacement of cast-stone balusters and copings, the repair of existing expansion joints, stucco repair/replacement, crack repair, sealant replacement, complete application of fluid-applied waterproofing on all elevations, and repairs to various fenestrations and penetrations.

Specifications included standard front-end requirements to the owner's unique instructions. All State-of-South-Carolina documentation was properly prepared and coordinated with the design documents. Quality control procedures for the design process focused on a system of regular multidiscipline review meetings with the owner. The drawings and specifications were reviewed and coordinated during each scheduled design process. Numerous quality assurance checks were performed in regard to the documents, using guide checklists in an effort to prevent discrepancies that could impact client expectations and prevent costly change orders. Although ADC Engineering, Inc. has an extensive library of standard isometric details, the project's details were tailored to specific needs. The construction phase was completed within the project budget. A change order was requested by the contractor to perform additional stucco repairs and additional silicone-tape system application.



Decorative band-pinning CAD detail.



Richard L. Cook Jr., FRCI, RRC, RWC, REWC, RBEC, CCS, CSRP
ADC Engineering Inc.

North Greenville Hospital

Greenville, South Carolina

Roof Replacement and Repair



Before.

After.



ADC Engineering Inc. was contracted by the Greenville hospital system under an open-end contract for building envelope consulting services. The project's scope encompassed the implementation of select roof replacement and repairs to the North Greenville Medical Hospital in Greenville, SC.

The investigation included field measuring, core samples, asbestos sampling, deck analysis, wind uplift, fire ratings, drainage issues, documentation of existing conditions, and review of the overall building envelope. The design project incorporated drawings, specifications, project administration, and project coordination with the owner. To ensure that the function of the facility was maintained, issues regarding safety, security, and sequence of work were addressed. Prebid and bid openings were conducted and followed by a preconstruction conference, weekly meetings, and final inspection services.

Although the initial scope focused on roof replacement, the initial field investigation determined that repairs were viable for one large section of roof and that added through-wall flashing would be required in some locations; therefore, this work was also integrated into the project.

Quality control procedures for the design process focused on a system of regular multidiscipline review meetings with the owner. Numerous quality assurance assessments were performed in regard to the documents, using guide checklists in an effort to prevent discrepancies that could impact client expectations and result in costly change orders. The project's details and specifications were tailored to specific needs.

Detailed drawings of the existing conditions, which included all terminations and penetrations, were developed based on field surveys and measurements. Drawings that were completed included existing roof plans, new roof plans, tapered roof plans, and a roof repair plan.

A series of customized isometric details were developed specifically for roof replacements and repairs, indicating the existing conditions and defining the extent of work. These details were then modified based on actual field conditions. The construction phase was within budget and completed on time. The facility had to remain operational at all times; thus, specific requirements for safety, scaffolding, protective fencing, and defined material storage areas were included for the due to the function and location of the facility.

Complete close-out documents were provided to the owner—both in a three-ring binder and on CD. A roof information card was posted on the interior of the penthouse door.



Workers doing final touches on the roof.

Michael Hoecherl, RRC, RRO
Building Exterior Solutions, LLC

University of Houston Moody Towers Dining and Commons

Houston, Texas

SMALL PROJECTS
3rd PLACE

Reroof

The University of Houston (UH) requested that URS Architects (URS) retain the services of one of the university's approved consultants for the reroof of the Moody Towers Dining and Commons project. Through the proposal process, Building Exterior Solutions, LLC (BES) was selected by URS as its roofing consultant.

BES performed a condition assessment on the existing roofs. During this assessment, BES discovered that the existing roof had a slope of 3:12 and that the existing roof deck was structural concrete with cast-in-place internal gutters.

URS and BES met with the university to discuss reroofing requirements and options for this building. Students would be utilizing the building, so the use of hot asphalt or torching was eliminated. UH had reservations about TPO membranes, so they were eliminated, as well. Since the sloped roofs would be visible, UH wanted the color of the roof to be as close to "Cougar red" as possible. (UH's mascot is a cougar and its team color is "Cougar red.") The final requirement was that the roof must meet a UL Class A Fire Rating and have a wind uplift rating equivalent to a Factory Mutual 1-120 system.

University of Houston Dining and Commons.



Moody Commons roof, close-up.

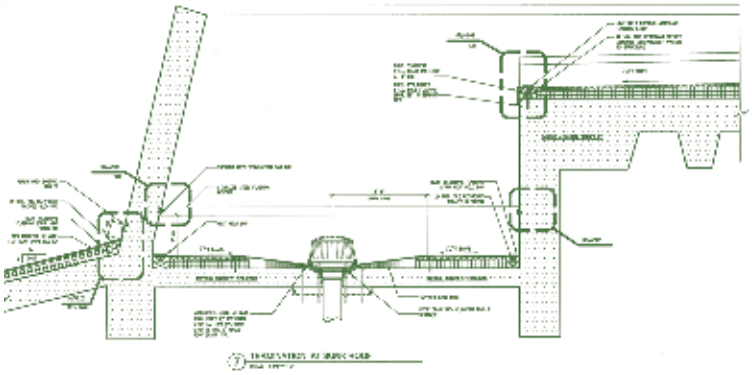


Working with these requirements, BES chose a 60-mil, custom-colored PVC membrane from IB Roofing Systems. The system used a water-based bonding adhesive that eliminated odors during installation and helped to achieve the UL Class A fire rating. BES chose to adhere the roof insulation and cover board with low-rise foam adhesive to eliminate mechanical fastening noise. It also provided the required wind uplift pressures equivalent to a Factory Mutual 1-120 system.

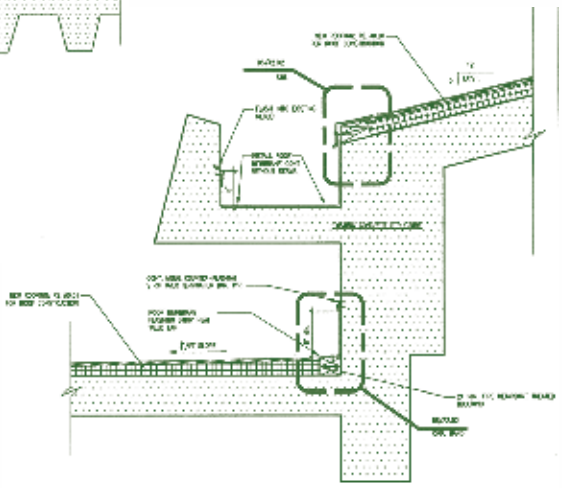
BES assisted URS with specification and detail reviews that included redlines, written recommendations, sketches, and custom drawings.

After several weeks of collaboration, URS put this project out for bid. BES attended the prebid conference to assist with questions. After the bidding process, BES assisted URS and the University of Houston with contractor selection; and once the contract was signed, BES attended the preconstruction conference to answer questions.

After work began, BES conducted quality assurance observations during the reroofing process. BES also assisted URS during the construction phase by reviewing requests for information and payment. When the roof was complete, BES performed a final roof observation.



Detail of termination at sunk roof.



Detail of flat roof flashing.



Matthew Farmer, PE
Wiss, Janney, Elstner Associates Inc.

The Cathedral of Mary Our Queen

Baltimore, Maryland

System Assessment, Roof Replacement, and Stone Repairs

This project involves one of the largest cathedrals in the United States. Built in the 1950s, the exterior walls of Mary Our Queen Roman Catholic Cathedral in Baltimore, MD, are limestone-faced brick masonry bearing walls. The roof structure is composed of reinforced, cast-in-place concrete slabs, joists, and beams, decoratively painted and exposed to the interior. The roof structure is supported by 14 limestone-faced masonry arches that are approximately 30 in. thick.

In 1972, a limestone fragment fell from a 90-ft.-high limestone masonry arch to the sanctuary floor. Wiss Janney Elstner's investigation revealed that concerns regarding limestone failure had originally been raised just 10 years after the original construction.

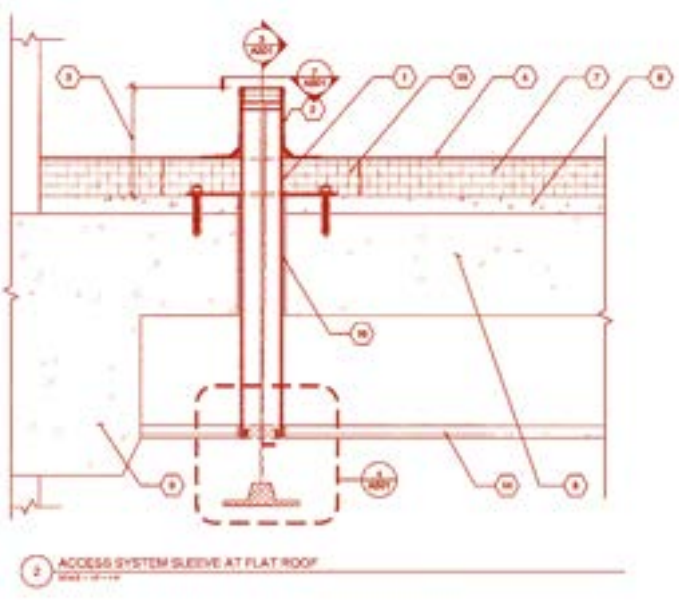
It was determined that control joints in the concrete roof structure were located right over the arches, and the concrete members were placed directly in contact with the limestone arches without any ability for the arch masonry to accommodate the inevitable volume changes and movements of the roof structure. These differential movements between the concrete structure and the limestone arches have caused substantial damage to the limestone masonry and the concrete roof structural members, threatening the overall stability of both. The objective of this project was to stabilize the limestone arch masonry and reduce the potential for future distress by disengaging the roof structure from the arches to the greatest extent possible without critically compromising bearing of the roof structure on the arches. This challenge led to a series of targeted modifications to the concrete roof structure to overcome the damage it has sustained, and stone masonry repairs to isolate the roof structure's influence on the arches.



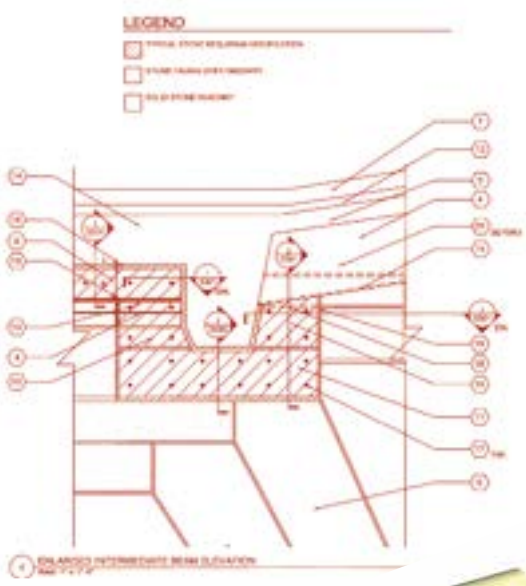
Mary Our Queen Cathedral.



Typical limestone arch distress.



Access system sleeve at flat roof.



Enlarged intermediate beam elevation.

Bill Conley, RWC
Conley Group Inc.

DFW International Airport Business Center North

Dallas, Texas

Roof Replacement



This project required an integrated design and construction phasing plan to systematically relocate and upgrade cell phone equipment and related utilities for five cell service vendors with a roof removal and replacement project on 18,600 sq. ft. All cell phone service equipment serving Dallas/Fort Worth International Airport (DFW) was installed on nine equipment skids and four equipment platforms on this eight-story structure. The phone equipment, cell antennas, and over 8,000 linear feet of cable were installed on rooftop support skids and cable trays that prevented roof system maintenance and replacement. Maintaining continuity of cell phone service and related emergency and DFW Airport security and operational communications were critical to the success of the project.



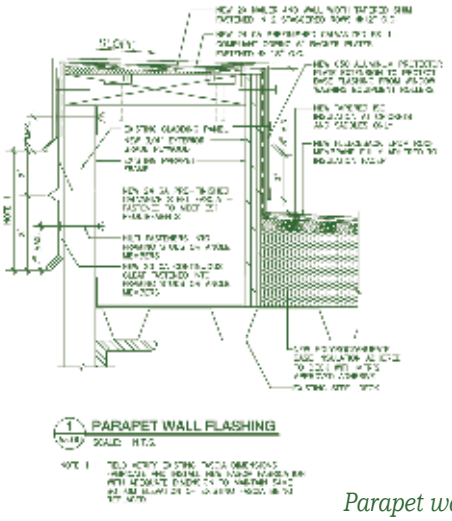
Business Center North roof prior to replacement.

Conley Group worked over the course of two years with the DFW Airport Project Team and the five cell service vendors to plan, budget, refine, design, bid, and manage the project through completion. Our approach included a three-phase project plan to:

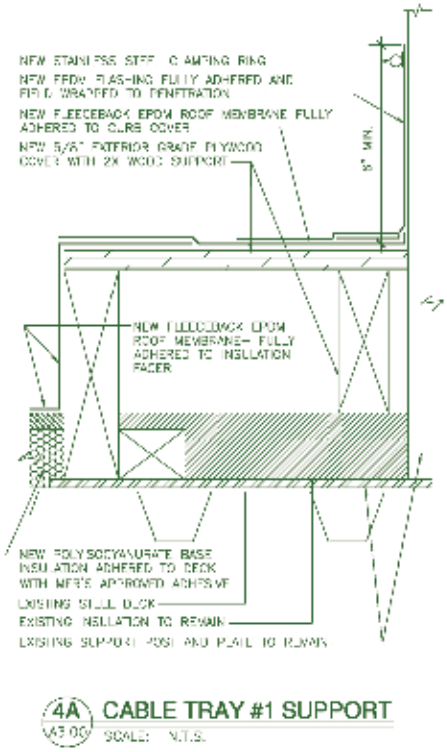
1. Fabricate and install 31 new structural support posts with 380 linear feet of new modular spanning beams and access catwalks for cell antennae and cabling placement.
2. Coordinate concurrent nighttime migration of cell antennas, cabling, utilities, electrical services, and grounding systems with five cell service vendors to a new perimeter support structure, and maintain the weathertight condition of DFW administration offices located on the top floor of the building.
3. With full-time, onsite project representative, manage the roof system replacement project, which included code and drainage upgrades with a new 135-mil, fully adhered, fleece-back Energy-Star-rated single-ply roof membrane with a 30-year warranty, including 100-mph wind speeds and 3-in. hail coverage. The design included ES-1-compliant copings, parapet flashing protection, new structural catwalk, and cross-over stairs for cell service and roof system maintenance access.

The project planning and execution was complicated by:

- Building location (at the epicenter of DFW Airport, bound by the eight-lane north/south access parkway through the airport without any ground-based staging area)
- Roof height/access and safety (117 ft. above grade, with the only staging area being on the top floor of an adjacent parking garage with one spiral access ramp with load restrictions)
- Operational/safety/income stream risks (all cell phone service and all associated operation, security, emergency response, and public safety communications for DFW Airport is provided by equipment on this roof).



Parapet wall flashing detail.



Cable tray support detail.

ASHRAE 189.1 – 2011: WHAT THE "GREEN STANDARD" CAN MEAN TO UPCOMING PROJECTS

BY DAVID HAWN, RRC, CEM, FRCI

The 2012 International Green Construction Code (IgCC) was published in March of 2012. It is an overlay code, which does not circumvent or overrule, but may enhance or modify, the code adopted by any given jurisdiction. While some jurisdictions have not yet adopted the 2009 International Building Code (IBC), they may have already adopted the 2012 IgCC. Initially, interpretations will be requested frequently; and responses are likely to be varied, even within the same jurisdiction. As a companion option (not just a referenced standard), IgCC ANSI/ASHRAE/USGBC/IES Standard 189.1 – 2011, *Standard for the Design of High-Performance Green Buildings*, may cause some confusion. ASHRAE 189.1 is published as both a stand-alone ASHRAE document and also as an appended document to the 2012 IgCC.

There are several issues within ASHRAE 189.1 – 2011 (189.1) on which study and review by roof and building envelope consultants could be of value. Note that 189.1 is written in mandatory language and can be enforced as such. The extent of enforcement should be verified with the local code enforcement official(s).

Also note this standard is continually updated, unlike code versions that are periodically updated and subject to change. In fact, recently, reflective roof requirements were being considered for Zones 4a and 4b in addition to Zones 1, 2, and 3; but after industry input, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) held off on recommending that modification. RCI was one industry entity that offered input to ASHRAE at the time. Still, this continual updating process should receive consultants' attention to ensure there are no changes to the versions they are using.

As of April 2013, there is an open public comment period for an addendum. The addendum being considered would allow the California Air Resources Board's (CARB's) Suggested Control Measure for Architectural Coatings (SCM) as an alternative compliance path to SCAQMD Rule 1113 for the volatile organic compound (VOC) content requirements of paints and coatings.

Requirements worth noting include these:

ROOFING AND EXTERIOR WALLS

Thermal insulation values required are increased. Tables 5.5, 1-8 (and 5.5.3.1) from 90.1 – 2010 are being changed by 189.1 (see Tables A-1 to A-9 in 189.1).

The minimum R-values required (continuous insulation above the roof deck [ci]) for the most part are enhanced from ASHRAE 90.1 – 2010 as included in the 2012 International Energy Conservation Code (IECC). As an example, for Zone 4, the minimum acceptable R-value in 90.1-2010 is R = 20ci, but in 189.1, it is R = 25ci. The changes vary from zone to zone, but most insulation value requirements are enhanced by about 20%. The change may be even more significant, depending upon the existing adopted code and for exterior walls.

ROOFING

Zones 1, 2, and 3 require reflective roof surfaces. The exceptions allowed are similar to that in 90.1-2010.

PROMOTION OF VEGETATIVE ROOFING TO MEET SITE REQUIREMENTS FOR PERVIOUS SURFACES

A percentage of the entire site must incorporate a means to reduce surface drainage by providing pervious surfaces. One of the ways to achieve this requirement is to include a vegetative roof with a minimum growing medium depth of 3 in. There are other methods listed, and some exceptions are allowed. Still, the roof footprint is often a good and perhaps easy place to help achieve this requirement.

This requirement may emphasize the inclusion of vegetative roofing and require changes to the building and roof to meet the site requirements.

PROHIBITION ON POTABLE WATER FOR VEGETATIVE ROOFS

The use of potable water for roof spray systems to thermally condition the roof is prohibited. Also, the use of potable water for irrigation of vegetative (green) roofs is prohibited once plant material has been established.

In certain climates with long drought cycles, this may be an issue for plant health. Most of the plants utilized are hardy and selected for the climate expectations. Still, unusual weather occurs, as well as other events that affect plant health. Water is essential to plant health and reestablishment. This provision requires that any initial potable watering systems be removed once the vegetation is established. Other water sources may be necessary to maintain a strong root system during an extreme

weather event or to reestablish a damaged vegetative roof system.

TOPLIGHTING (SKYLIGHT) REQUIREMENTS

Daylighting by toplighting requires minimum standards for buildings of certain types as defined by interior lighting and use of building requirements. Minimum standards for the amount of toplighting or skylights are also called out. There are some exceptions listed as well.

The result of this is that more skylights are likely to be included on buildings constructed in compliance with 189.1. The standard does not discuss how the inclusion of toplighting affects the requirement for continuous insulation for the roof's thermal barrier.

SHADING OF FENESTRATIONS

There is a requirement for shading of fenestrations; and for many buildings, this may result in more envelope penetrations, as shading devices are attached to the structure through the exterior skin, including most, if not all, barrier layers (air, weather, and thermal). An example of a shading feature that adds penetrations through the exterior skin, air, and thermal barriers is shown in *Photo 1*.

CLOSING COMMENTARY

Understanding these issues and others within ASHRAE 189.1 – 2011 will help consultants be prepared as the 2012 IgCC is adopted. ASHRAE 189.1 is available through ASHRAE or can be found in the 2012 IgCC publication.

This article is not intended to provide an exhaustive listing of ASHRAE 189.1 – 2011 requirements. Instead, it notes key items worthy of attention and perhaps further study by building envelope consultants.

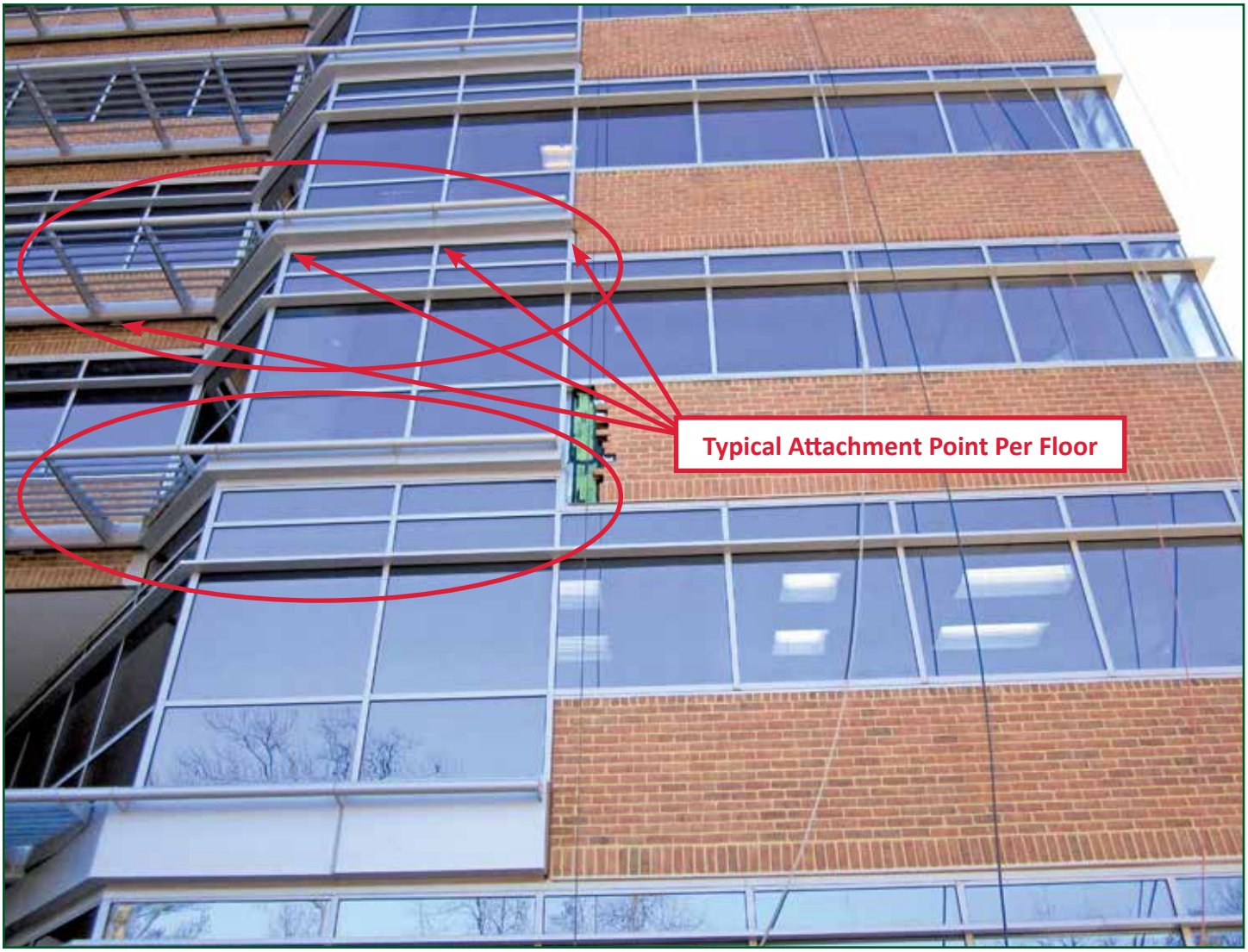


Photo 1 – Shading fenestration attachment requirements have changed with the 2012 IgCC.



Where to Find the New Jobs in Construction



By Ken Simonson

Over the 12 months ending April 30, Hawaii has gained the largest percentage of construction jobs (a rise of 11.5%, or 3,300 jobs), while California added the most jobs (44,800, for a 7.7% increase). Vermont lost the highest percentage of construction jobs (11.3%, or 1,700), and Illinois lost the most jobs (12,900, or 6.8%). After ten consecutive months of increased construction employment nationwide, construction dipped by 6,000 in April, still totaling a gain of 154,000 jobs from April 2012 to April 2013. Total hours worked in construction increased by 3% over 12 months, implying that contractors are lengthening working hours and also hiring new workers. The unemployment rate for jobseekers who last worked in construction dropped to 13.2% from 14.5% in April 2012 and a high of 21.8% in April 2010.

OIL AND GAS CONSTRUCTION

The growing production of crude oil and natural gas in the U.S. is leading to new investments by ports and other facilities. The Energy Department recently approved exports of liquefied natural gas from a terminal in Quintana Island, TX, although construction must be approved by the Federal Energy Regulatory Commission. "Targa Sound Terminals will invest at least $80 million in a Port of Tacoma terminal to receive crude oil brought by railroad from Montana, at a site where a container terminal was once planned," the *Puget Sound Business Journal* reported. "Several other projects to handle crude oil brought in by rail are planned in Washington."

CONSTRUCTION COSTS

Construction costs (materials, labor, and equipment) have increased 2% from April 2012 to April 2013, according to the RS Means Historical Construction Cost Index released by Reed Construction Data. The index represents the average of costs in 30 cities.

Compensation costs for construction rose 0.7% in the quarter and 2.0% year-over-year, the fastest yearly gain since December 2008.

CONSTRUCTION OFFICES

The Census Bureau has released "County Business Patterns: 2011," (www.census.gov/econ/cbp/) providing detailed information on employment-size classes (e.g., number of establishments with one to four employees) and legal forms of organization (e.g., corporations and partnerships). Construction showed the largest decline in establishments, losing 24,946 (3.7%) in 2011, down to 657,738 overall. An establishment is a fixed business location, not a job site; most construction firms have just one.



Ken Simonson

This series on the economy and its impact on the construction industry is published monthly in Interface. *The column is prepared by Kenneth D. Simonson, chief economist for the Associated General Contractors of America (AGC). Simonson is also the 2012-13 president of the National Association for Business Economics. He may be reached at simonsonk@agc.org.*

Roof Technology and Science I



e-LEARNING PROGRAM

The new Roof Technology and Science I course is designed for roof consultants, building owners, architects, and engineers who want to better understand roof construction, materials and performance.

TOPICS INCLUDE

- Roof decks and drainage
- Thermal and moisture design, calculations, and materials
- Bituminous systems, including bitumens, reinforcements, BUR membranes and surfacings for bituminous systems
- Single-ply roofing systems
- Spray-applied polyurethane roofing systems
- Protected-membrane roofing systems

PROGRAM GOAL

The purpose of this course is to offer students a greater understanding of roofing principles and materials so that they may become more effective as systems designers, quality assurance observers, or owners/managers. Roofing Technology and Science I is the first program in a two-part series.

RCI, Inc. **800-828-1902** **Enroll today @ rci-e-learning.org**

Roof Technology and Science II



e-LEARNING PROGRAM

This course is designed for practicing roof consultants, architects, engineers, building owners, and manufacturers' technical personnel who desire to become more knowledgeable about the science and technology of roofing.

TOPICS INCLUDE

- Wind design for low-slope roofing
- Fire characteristics of roofing
- Cold fluid-applied roofing and waterproofing
- Roof flashings
- Roof surveys
- Moisture surveys
- Life-cycle costs
- Maintenance and repair
- Steep roofing – asphalt shingles, concrete, and clay tile
- Metal roofing

PROGRAM GOAL

It is reccommended that students first register for Roofing Technology and Science I. Many of the concepts from that course are expanded upon in Roofing Technology and Science II.

RCI, Inc. **800-828-1902** **Enroll today @ rci-e-learning.org**



Industry News

To submit an industry news item to *Interface,* e-mail it to kammerman@rci-online.org or mail it to RCI, *Interface* Journal, 1500 Sunday Drive, Suite 204, Raleigh, NC 27607. Note: News must fit journal requirements in order to be published.

CSRP Designation Recognized by Colorado

Roof Integrated Solar Energy™ (RISE™) Inc.'s Certified Solar Roofing Professional™ (CSRP™) designation will be recognized by the state of Colorado to fulfill the requirements set forth in Colorado Revised Statute 40-2-128, "Solar Photovoltaic Installations." With the help of DOW Solar, a business unit of The Dow Chemical Co., Midland, MI, the regulation was amended to include the CSRP designation as equal to the North American Board of Certified Energy Practitioners certification already cited within the statute. RISE was created by the Center for Environmental Innovation in Roofing and the National Roofing Contractors Association.

CRCA Honors Baskaran



Bas Baskaran

Bas Baskaran, a group leader at the National Research Council of Canada (NRC) and adjunct professor at the University of Ottawa, was presented with the 2013 Frank Ladner Award by the Canadian Roofing Contractors' Association (CRCA). The award is given in honor of the association's first technical director and recognizes technical contributions to the roofing industry. Baskaran, a professional engineer, is vice chair for RICOWI; a member of RCI, ASCE, SPRI, ASCE, ICBEST, and CIB committees; and has authored over 200 research articles in the area of wind effects on buildings.

Owens Corning Buys Thermafiber Inc.

Thermafiber, Inc., a producer of mineral wool insulation products, has been purchased by Owens Corning (NYSE: OC). Thermafiber, based in Wabash, IN, and founded in 1934, was acquired in 2007 by Altus Capital Partners, L.P.

James Cowell Retires



James Cowell

James "Jim" Cowell has announced his retirement after 46 years in the roofing industry. From 1959 to 1972, Cowell sold building supplies for Borchers Brothers, San Jose, CA, and later for Viking Materials Company. He was then hired by Monray Roof Tile (later Monier and Boral Roofing) as a district and general manager. He served on the technical committee responsible for writing the first edition of the Canadian CSA A220 Standard for Concrete Roof Tiles, published in 1991. Following retirement from Monier, he was regional sales manager for TRA Snow and Sun, Inc.

Leonard Honored by RCMA

William "Skip" Leonard, Henry Company, has been awarded the Roof Coating Manufacturers Association's (RCMA's) Industry Statesman Award. The award recognizes special efforts on behalf of the association in advancing the roof coatings industry. Leonard joined Henry Co. in 1999 as its director of technical services. Prior to that, he served as regional commercial sales manager for TAMKO Roofing Products and sales manager at Gulf States Asphalt Company and GS Roofing Products. He is currently a consultant to the Henry Co. and vice president of RCMA.

Chenoweth Starts New Business

David Chenoweth, RRC, RRO, recently opened Roof Service Specialties, LLC, in Three Rivers, MI, to provide rooftop expertise, as well as testing and field services to design professionals. He was previously with Wallace & Associates Testing and Consulting and is a Professional member of RCI. For more information, visit www.roofservicespecialtiesllc.com.

Powers Joins Flynn Canada

John Powers, RRO, was recently hired by Flynn Canada, Ltd., Kelowna, BC, as service manager for roofing, architectural metal, glazing, and cladding installation. Powers is an Industry member of RCI and has over 25 years of experience in the roofing industry.

Kemper Promotes Younger



Jeff Younger

Jeff Younger has been named account executive for the southeast by Kemper Systems. He will be offering workshops and AIA-credited lunch-and-learns based out of Murrells Inlet, SC. Younger has 15 years of experience with Kemper as an independent representative based in the mid-Atlantic area.

Lemay Promoted at Groupe ABS Toiture

Mirja Lemay has been promoted to the position of coordinator of roofing in the Montreal bureau of Groupe ABS Toiture. Lemay has 15 years of experience in the roofing industry in project management, including the new McGill University Health Centre.

ABC Supply Gets Seventh Workplace Award

For the seventh consecutive year, building products distributor ABC Supply Co. Inc. has been honored with the Gallup Great Workplace Award, recognizing the best-performing workforces in the world. The company is one of only 32 worldwide to receive the 2013 award and one of only three to have received it every year since its inception. The award is based on multiple criteria, including response rates, overall engagement levels, and evidence of engagement's impact on performance.



Industry News

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NFRC Seats Board Members

The National Fenestration Rating Council (NFRC) has seated its newest board members for the 2013 term. Seated as three-year board members were Sneh Kumar, Jeff Baker, Mahabir Bhandari, and Gary Curtis. Named to the executive committee were Chair Steve Strawn, Vice Chair Jeff Baker, Secretary Steve Farrar, and Treasurer Sneh Kumar.

IRE to Return to Las Vegas

The International Roofing Expo (IRE), sponsored by the National Roofing Contractors Association (NRCA), is returning to Las Vegas, NV, from February 26 to 28, 2014, at the Mandalay Bay Convention Center. The U.S.'s largest roofing show, targeted mainly to contractors, is expected to draw 450 exhibitors and 9,000 attendees.

Tapco Purchases Kleer Lumber

The Tapco Group® has purchased Kleer® Lumber, Inc., a manufacturer of cellular PVC trimboard, molding, and decking products. Kleer's Massachusetts-based fabrication center will be the fifth in Tapco's nationwide production and distribution network.

Garland Acquires DryDog Barriers

Garland Industries, Inc. has acquired DryDog Barriers, LLC. The DryDog line of waterproofing products will be integrated into GMX, Inc., a wholly owned subsidiary of Garland.

Red Pointe Roofing Launched

Aaron Martin and John Patterson, LEED-AP, have partnered with Newport Beach, CA-based Labrador Capital to launch Red Pointe Roofing, a commercial roofing firm. Martin was previously president of DRI Commercial of Irvine, CA, while Patterson managed that company's business development and marketing activities since 2003. Prior to that, Patterson was VP of business development for Southern California Roofing of Downey, CA. Martin will be president of the new firm and Patterson will be vice president.

LS3P Gives to Community on 50th Anniversary

On May 1, more than 200 LS3P employees donated their time as part of a "Day of Engagement" to mark the 50th anniversary of the architectural and planning firm with offices in Charleston, Columbia, and Greenville, SC; and Charlotte, Raleigh, and Wilmington, NC. Employees visited hospitals and read a book to young children that was written and illustrated by the creative team at LS3P and inspired by the firm's founder, Frank Lucas.

RPM Posts Quarter Loss Ahead of Settlement

Ohio-based RPM International Inc. (NYSE: RPM) posted a net loss of $42.36 million for the first quarter, ahead of an expected $68.8 million settlement with the Department of Justice (DOJ) and the U.S. General Services Administration (GSA). The anticipated settlement is the result of an investigation into past roofing contracts between RPM's Building Solutions Group (which includes Tremco) and the GSA, specifically, the compliance with pricing terms and conditions of GSA contracts under which Tremco sold goods and services to the federal government. RPM International, which also makes coatings, sealants, and paints, stated that its Building Solutions Group is cooperating fully in an effort to resolve the investigation and is in settlement talks with the DOJ and GSA. RPM has taken an adjustment for the anticipated $68.8 million settlement; however, the actual total of RPM's loss remains subject to approval by the DOJ.

Monier Wins Class-Action Suit

Monier, Inc., a concrete roof tile manufacturer, recently won a 128,000-member class action suit alleging violations of the Consumer Legal Remedies Act (CLRA) and the Unfair Competition Law (UCL) in California. The suit charged Monier with failing to disclose that the color composition of its roof tiles would erode away well before its represented 50-year life. The court ruled that the plaintiffs did not prove their case.

ITW Polymers Sealants Merges Companies

The ER Systems, Schnee-Morehead, and TACC business units are combined to form ITW Polymers Sealants North America, Inc. Effective April 1, 2013, the aforementioned business units are one legal entity. ITW Polymers Sealants North America, Inc. has six facilities operating in Texas, Georgia, Massachusetts, Minnesota, Arizona, and California. Division headquarters are in Irving, TX. Illinois Tool Works (NYSE: ITW) is a Fortune 200 diversified industrial manufacturer with $18 billion in revenue, operating in over 50 countries worldwide.

Sika Sarnafil Opens New Center

Sika Sarnafil has opened a 63,000-sq.-ft. warehouse and distribution center in Cypress, CA, after having outgrown its old facility there. The increased warehouse size will allow the company to transport an additional 450 truckloads of roofing membrane and accessories by train rather than by truck over the next five years.

Architectural Testing Opens New Facility

Architectural Testing, Inc. (ATI) announces the opening of its new location at 2658 Electronics Way, West Palm Beach, FL. Designed to replace the company's Riviera Beach location, the test facility offers 20,000 sq. ft. of indoor space with 24 ft. of ceiling clearance, a 128- by 40-ft. outdoor mock-up wall, and state-of-the-art equipment. The new location is one of 14 strategically placed full-service laboratories across the United States and Canada offering air, water, structural laboratory and field testing; impact and cycling testing; full-scale performance mock-up testing; and non-structural and structural roof uplift testing.

More Industry News
continued on page 44



Industry News

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Jasper Hires Goering

Baton Rouge-based Jasper Contractors Inc., a residential roofer with offices in 12 markets, has named Richard Goering, formerly of Shingle Corp., LLC, as its VP of West Coast operations. He will be based out of Jasper's Denver, CO, office. Jasper plans to open its 13th office in Omaha, NE, this summer.

Carlisle to Establish TPO Operation

Carlisle Construction Materials (CCM) has announced plans to establish a TPO membrane manufacturing operation at its Carlisle, PA, campus. The facility is expected to be completed in the fourth quarter of 2014, will be CCM's fifth manufacturing line, and will create an estimated 30 new jobs.

ABC Purchases Lee Wholesale Supply

ABC Supply Co., Inc., Beloit, WI, has acquired substantially all of the assets of Lee Wholesale Supply Inc., a distributor specializing in steep-slope roofing, siding, and windows, with four locations in the Michigan communities of Livonia, Macomb, New Hudson, and Port Huron.

ABC has also acquired the inventory and equipment of J.B. Supply Company, a distributor of roofing and exterior building products in Flint, MI.

CertainTeed to Build Shingle Plant

CertainTeed Corporation has selected Jonesburg, MO, as the home for a new asphalt roofing shingle manufacturing and distribution facility. The company is planning to invest $100 million in the new 60,000-sq.-ft. factory and a 150,000-sq.-ft. warehouse to serve as its Midwestern distribution site for all of the company's roofing products. CertainTeed operates ten asphalt shingle plants, one low-slope commercial roofing facility, and three stand-alone granule production plants throughout the U.S.

DEATHS

Thomas John Gilmore Jr.

Thomas John Gilmore Jr., AIA, LEED GA, of Greer, SC, died suddenly at his home April 11, 2013. He was 61. A registered architect with 40 years' experience in the business, he was the president and managing partner of MGFA/Spiezle Architectural Group in Greenville, SC, and earned his RRC this year.

Sidney I. Sontz

Sidney I. Sontz, former president of the Northeast Roofing Contractors Association (NERCA), died February 14. He was president of Max Sontz Roofing Services of Lynn, MA. From 1992-94, he served as the president of NERCA.

Mark E. Moore

Mark E. Moore, 55, a senior principal with Wiss, Janney, Elstner Associates, Inc., based in Atlanta, GA, died suddenly on February 25 while on company business in Washington, DC. Moore was a 34-year WJE veteran and was involved in many of the firm's most significant structural investigation assignments.

LOOKING FOR A FEW GOOD PICTURES



Like to see a picture of your company's project gracing the cover of *Interface*? Give your company industry-wide exposure!

We are looking for attractive, four-color, high-resolution, vertically oriented shots to illustrate our monthly themes.

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Got Industry News?

Hired by a new company? Started a new business? Opened a new branch of your business or hired new consultants?

Get your news in front of the industry.

Send us your company news for publication in *Interface* and/or *RCItems*. Send to: kammerman@rci-online.org. Write "Industry News" in the subject line. Make sure we have your contact information in case we have questions.



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Calendar of Events

Red print: RCI Educational or Registration Opportunity
Blue print: RCI Leadership Event
Green print: RCI Region or Chapter Meeting
Black print: Industry Event

Bold-faced items indicate two or more RCI events scheduled consecutively for convenience.
Calendar subject to change without prior notice.
Visit **www.rci-online.org** for schedule updates.

JULY 2013

5 *RRC app. due for 10/5/13 exam*
12 *RWC app. due for 10/12/13 exam*
13 Executive Committee meeting
17 Puget Sound Chapter meeting
Kent, WA
18-20 FRSA Convention and Trade Show
Orlando, FL
Info: floridaroof.com
26 North Texas Chapter meeting
Irving, TX

AUGUST 2013

2 Region II meeting
Atlanta, GA
8 Ontario Chapter outing
Toronto Pier, ON
9 *RRO app. due for 11/9/13 exam*
13 Roof Asset Management
Pensacola, FL
Del. by RCI N. Gulf Coast Chapter
15 Mid Atlantic Chapter meeting
Richmond, VA
16 *RRO app. due for 11/16/13 exam*
23 North Texas Chapter meeting
Irving, TX
26-27 Metal Roofing
Atlanta, GA
Delivered by RCI Georgia Chapter

SEPTEMBER 2013

TBD RCI Board of Directors meeting
5-6 Exterior Walls Tech. & Science
Houston, TX
Del. by RCI Gulf Coast Chapter
9 *RRC app. due for 12/7/13 exam*
10-11 Stucco and Exterior Finish Cladding Systems
San Francisco, CA
12-13 Masonry Wall Systems
San Francisco, CA
14 REWC exam *(app. due 6/14/13)*
San Francisco, CA
13 Ontario Chapter meeting
Brampton, ON
13 Chicago Area Chapter meeting
Oak Brook, IL
16 North Texas Chapter golf tourney
Irving, TX
19-20 Rooftop Quality Assurance
Chicago, IL
Del. by RCI Chicago Chapter
21 RRO exam *(app. due 6/21/13)*
Chicago, IL
23-35 Polyurethanes Tech. Conference
Phoenix, AZ
Info: americanchemistry.com
25-27 Construct 2013 and CSI Conv.
Nashville, TN
Info: www.csinet.org
26-27 Metal Roofing
Atlanta, GA
Delivered by RCI Georgia Chapter
27 North Texas Chapter meeting
Irving, TX

OCTOBER 2013

1-3 MetalCon International
Atlanta, GA
Info: metalconstruction.org
4 Region I meeting
Baltimore, MD
2-3 Professional Building Consulting
Dallas, TX
4 Roof Systems Thermal & Moisture Design
Dallas, TX
Del. by RCI North Texas Chapter
5 RRC exam *(app. due 7/5/13)*
Dallas, TX
10-11 Exterior Walls Tech. & Science
Waukesha, WI
Del. by RCI Wisconsin Chapter
Info: rci-wisconsin.org
10-11 Waterproofing
Houston, TX
12 RWC exam *(app. due 7/12/13)*
Houston, TX
17-18 Leadership Devel. Workshop
Raleigh, NC
18 Ontario Chapter meeting
Waterloo, ON
20-24 SMACNA Annual Convention
Maui, HI
Info: smacna.org
23-25 MRCA Convention
Chicago, IL
Info: mrca.org
25 North Texas Chapter meeting
Irving, TX

NOVEMBER 2013

7-8 Rooftop Quality Assurance
Seattle, WA
Del. by RCI Puget Sound Chapter
9 RRO exam *(app. due 8/9/13)*
Seattle, WA
8 Chicago Area Chapter meeting
Oak Brook, IL
14-15 Symp. on Bldg. Envelope Tech.
Minneapolis, MN
14-15 Rooftop Quality Assurance
Orlando, FL
Del. by RCI Florida Chapter
16 RRO exam *(app.due 8/16/13)*
Orlando, FL
17 Puget Sound Chapter meeting
Seattle, WA
21 Roof Systems Thermal & Moisture Design
Toronto, ON
22 RRC Review & Update
Toronto, ON
Del. by RCI Ontario Chapter
23 RRC exam *(app. Due 8/23/13)*
Toronto, ON
22 North Texas Chapter meeting
Irving, TX

ADVERTISERS' INDEX

Advertiser	Phone Number	Website	Page
American Hydrotech, Inc.	(800) 877-6125	hydrotechusa.com/rci	7
Carlisle Syntec	(800) 4-SYNTEC	carlisle-syntec.com	45
GAF Materials Corporation	(800) 555-1852	gaf.com	Cover 4
Premier Rail Systems	(913) 677-4700	premierrailsystems.com	15
Prosoco	(800) 255-4255	prosoco.com	21
RCI Foundations	(800) 828-1902	rcifoundation.org	20
Seaman Corp.	(800) 927-8578	seamancorp.com	11
Sika Sarnafil, Inc.	(800) 576-2358	sarnafilus.com	3
Siplast	(800) 922-8800	siplast.com	47
Situra, Inc.	(888) 474-8872	situra.com	Cover 2



With **NVS**, you bring a permanent insulation solution to your next re-cover project.

Siplast's **NVS Lightweight Insulating Concrete System** was developed to solve reroofing problems economically. NVS combines the unique properties of aggregate-based lightweight insulating concrete and premium expanded polystyrene foam insulation board.

Once a Siplast NVS System is poured in place, it stays there a long, long time. Unlike disposable rigid polyisocyanurate insulation, NVS can be reroofed indefinitely, which dramatically reduces both the environmental cost of filling landfills with discarded polyisocyanurate and the life-cycle cost of the roof. Siplast Lightweight Insulating Concrete is truly sustainable.

Learn more about how your next re-cover project can include a permanent insulation solution. For information on **Siplast NVS Lightweight Insulating Concrete Systems,** please call **1-800-922-8800,** or visit our Web site at **www.siplast.com**. Or, scan the QR code below to visit the site or see a video on NVS Lightweight Insulating Concrete.

video

www.siplast.com

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Would You Look at That!

So Much for Those Slow Children...



We encountered this unusually creative remedy to a missing flue cap in Baltimore, Maryland. An old street sign secured with duct tape makes a fine cap. Necessity is truly the mother of invention.

Submitted by
Doug Fields
CRS Roofing Services
Bladensburg, MD

Readers running across situations that would catch the attention of other building envelope consultants are asked to submit representative photographs and a maximum 150-word summary to Kristen Ammerman, Director of Publications, "Would You Look at That!" column, RCI, 1500 Sunday Drive, Suite 204, Raleigh, NC 27607 or via e-mail to kammerman@rci-online.org.

Building Envelope

Technology Symposium 2013



El Paso Energy – Building Envelope Solutions for 1960s Vintage Construction
Jerry Abendroth, RRC, RWC, RRO, CDT – Building Exterior Solutions, LLC, Houston, TX

The Last Few Feet – Parapet Design, Issues, and Repairs
Matthew Novesky, RA – Wiss, Janney, Elstner Associates, Inc., Chicago, IL
Logan Cook – Wiss, Janney, Elstner Associates, Inc., Chicago, IL

Creative Solutions for Challenging Curtain Wall Conditions
Derek B. McCowan, PE – Simpson Gumpertz & Heger Inc., Waltham, MA
Joshua B. Kivela, PE – Simpson Gumpertz & Heger Inc., Waltham, MA

Thermal Improvement of Existing Masonry Envelopes Using Prefabricated, Highly Insulated Curtain Walls
Christoph Buxbaum, PhD – Carinthia University of Applied Sciences, Spittal/Drau, Austria

Air Barrier Performance
Laverne Dalgleish – Air Barrier Association of America, Inc., Washington, DC

Evaluating As-Built Properties of Masonry Wall Systems Using Investigative Laboratory and In-Situ Testing Techniques
Kenrick J. Hartman, LEED® AP BD+C – Wiss, Janney, Elstner Associates, Inc., New York, NY
Thomas C. Kuczynski – Wiss, Janney, Elstner Associates, Inc., New York, NY

Developments in Wind Testing of Building Envelope Systems
Peter Irwin, PhD, PEng – Florida International University, Miami, FL

On the Edge? Defensive Strategies for Roof Perimeters
Wilma Leung, CEng, LEED® AP – Williams Engineering Canada, Edmonton, AB
Gordon Rajewski, RET - Williams Engineering Canada, Edmonton, AB

Does My Wall Assembly Have to Comply With NFPA 285?
Heather Paschal, AIA, LEED® AP – Henry Company, Highland Village, TX

Monitored Field Performance of Conventional Roofing Assemblies – Measuring the Benefits of Insulation Strategy
Marcus Dell, PEng – Vancouver, BC

Evaluation of a Panelized EIFS Wall Assembly System
Chris Norris, PE, LEED® AP, CEI – Morrison Hershfield, Atlanta, GA
Dominick P. Baruffi, II – Jersey Panel Corporation, Vineland, NJ

Air Barrier Quality Assurance – A New Model for Achieving Success for Your Next Air Barrier Project
Timothy A. Mills, PE, LEED® AP – TAM Consultants, Inc., Williamsburg, VA



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