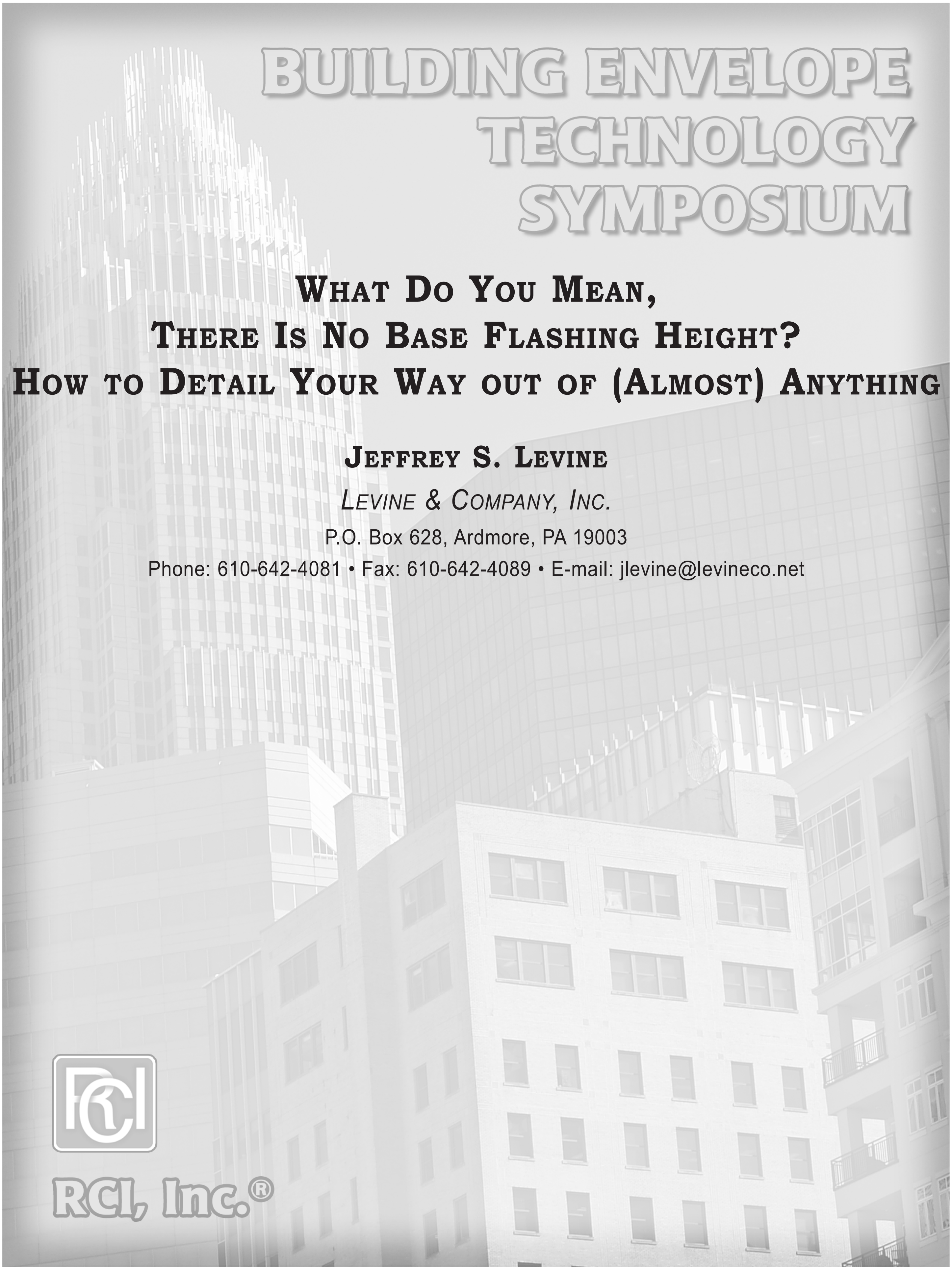

BUILDING ENVELOPE TECHNOLOGY SYMPOSIUM

WHAT DO YOU MEAN, THERE IS NO BASE FLASHING HEIGHT? HOW TO DETAIL YOUR WAY OUT OF (ALMOST) ANYTHING

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ABSTRACT

Low base-flashing heights at parapet walls, the intersection of a flat-seam copper gusset and copper built-in gutter liner, weathervanes with square iron rods, batten ends within the zone of potential ice damming, the inner wythes of parapet walls reconstructed of CMU, valleys that form an obtuse angle, worn gutter outlet tubes: How do you flash those? How do you keep such elements watertight over the long term? This paper is based on the author's 23+ years of experience and is intended to assist design professionals and contractors with the detailing of steep-slope roof systems via specific examples, the ideas and concepts of which can be applied more broadly.

SPEAKER

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JEFFREY LEVINE is president of Levine & Company, roof consulting and architectural conservation, Ardmore, PA. He has served as project manager for over 240 restoration and rehabilitation projects, preservation plans, and maintenance programs for a large variety of building types, including academic, commercial, and ecclesiastical buildings. Levine has an MA in historic preservation planning from Cornell University; has written numerous articles on steep-slope roofing, including *Preservation Briefs No. 29*, published by the National Park Service; and is a founding director and current president of the National Slate Association.

WHAT DO YOU MEAN, THERE IS NO BASE-FLASHING HEIGHT? HOW TO DETAIL YOUR WAY OUT OF (ALMOST) ANYTHING

UNIQUE DETAIL DESIGN WORK

Low base-flashing heights at parapet walls, the intersection of a flat-seam copper gusset and copper built-in gutter liner, finials and weathervanes with square iron rods, batten ends within the zone of potential ice damming, the inner wythes of parapet walls reconstructed of CMU, valleys that form a flat obtuse angle, loose gutter shanks, worn gutter outlet tubes: How do you flash these? How do you keep such elements watertight over the long term? These and other challenging steep-slope roofing problems associated with existing structures will be addressed herein. This paper is based on the author's 23+ years of experience and is intended to assist design professionals and contractors with the detailing of steep-slope roof systems via specific examples, the ideas and concepts of which, it is hoped, can be applied more broadly. Why “almost anything?” Well, there are some things that just should not be done on a roof, and some of these will be identified as well.

LOW BASE-FLASHING HEIGHT AT PARAPET WALL

Quite often with historic buildings in the Gothic Revival style, base flashing heights at gable end walls are low. This is especially true at the bottom end of the gable, where the parapet changes direction and turns horizontal. Here, base-flashing heights can be well below the standard 4 in. The limiting factor is the height of the bed joint of the coping stones above the roof deck. Deteriorated wood decking and framing suggest that something more than 1 or 2 in of base-flashing height is needed.

One solution is to cut a new reglet into the inside face of the coping stone. But there are times when even this action will not allow for sufficient base-flashing height, whether that be the standard 4 inches or something greater to accommodate concentrated rainwater flows near the roof eave. A solution is to cap the two bottommost coping stones with a solderable sheet metal. This allows for the vertical leg of the base flashings to be extended upward, past the bed joint of the coping stone, and onto its sloping top surface. The trick then becomes how to terminate the top end of the new coping cap. It should not simply be let into a reglet cut into the top face of the second coping stone from the bottom, as such reglets tend to leak. It is far better to turn the coping cap down into the cross joint at the top end of the second coping stone from the bottom, then below the third coping stone, 6 to 8 in. Counterflashings in the bed joint of the coping stones then lap on top of this 6- to 8-in flange.

Photo 1 shows a finished installation. The dashed line shows the location of the coping stone's bed joint at the bottom end of the parapet and the original base flashing height. To limit the visual impact of the new coping cap, the second coping stone from the bottom was cut to create a new cross joint into which the new coping cap could turn down (arrow in *Photo 1*). Otherwise, the coping cap would have had to extend to the next higher joint.

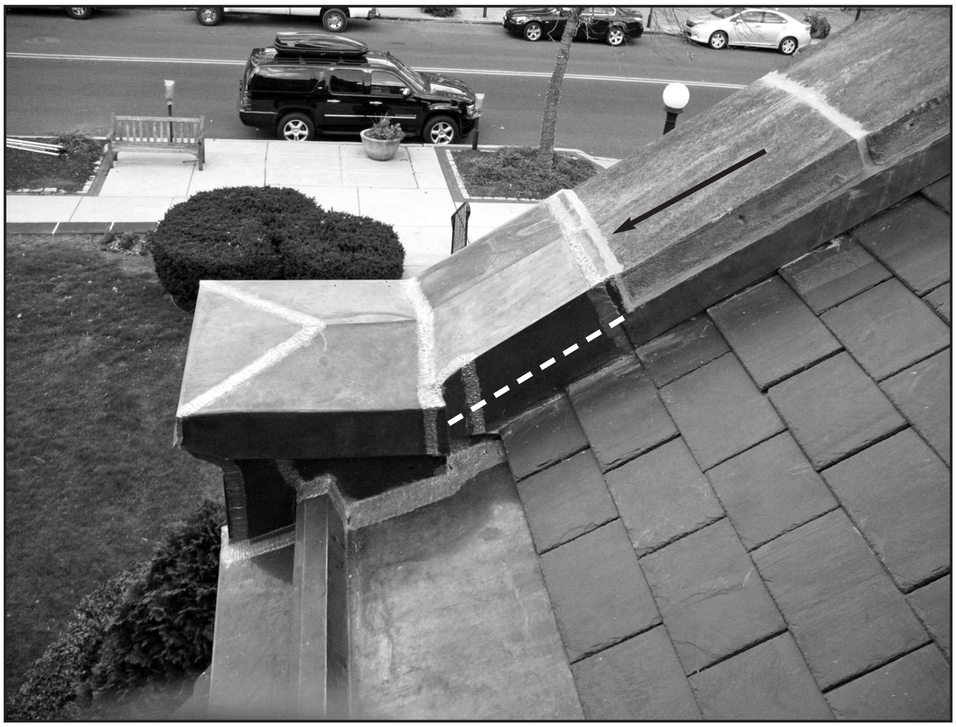

Photo 1

INTERSECTION OF A FLAT-SEAM COPPER GUSSET AND COPPER BUILT-IN GUTTER LINER

Building additions are sometimes constructed without much regard for roof drainage. Where flat-seam copper gussets are forced to interface with built-in gutters running perpendicular to the gusset, significant stress can be placed on the soldered seams at the point of intersection. If the point of intersection is also a low point with an outlet tube and downspout, the potential for catastrophic leakage is pretty high.

The recommendation is to accommodate the stress as much as possible but also plan for failure (e.g., a cracked soldered seam). Stress imparted by thermal movement can be accommodated by 1) constructing the gutter of flat-seam pans rather than 8- or 10-ft long pans oriented longitudinally and 2) installing a new expansion joint nearby in the gutter to both accommodate thermal movement and the transition between flat-seam pans and longitudinally run pans. Planning for failure involves: 1) resloping

Photo 2

Photo 3

EPDM gasket and stainless steel hose clamp, painted black. Lap sealant at interface of EPDM gasket and iron rod not yet installed.

Stainless steel rain hood, painted black

Copper finial base

the gutter away from the point of intersection of the gusset and gutter, 2) installing ice dam protection membrane below the copper pans in the area of the point of intersection, and 3) installing a double outlet tube (a tube within a tube) in order to provide a point of drainage for any water that might reach the ice dam protection membrane.

Photo 2 pictures the type of area in question. The arrows show the direction of water flow. The upper section of gutter has been resloped to flow away from the gutter/gusset intersection. The visible outlet tube serves the gutter and gusset. Below this outlet tube (not visible) is an outer outlet tube that serves the ice dam protection membrane underlayment located below the gutter and lower portion of the gusset.

FINIALS WITH SQUARE IRON RODS

Round roof penetrations of any size are fairly easy to flash in a steep-slope roof. Small, square penetrations associated with historic, character-defining elements, such as finials and weathervanes, can be difficult to flash, especially if they are constructed of wrought iron, cast iron, or some other unsolderable metal.

For the finials and weathervanes in question, a “belt-and-suspenders solution is advisable. Isolation membrane is first wrapped around the iron rod to protect against the potential for galvanic corrosion stemming from the copper flashings. Within the copper base of the finial, a copper ridge flashing is made watertight by stripping-in the square rod's penetration of the ridge flashing with self-adhering ice dam protection membrane. The top end of the square shaft of the copper finial base is first made watertight with sealant. A second line of protection can be added by fabricating and installing a stainless steel rain hood to counterflash the top end of the finial base (*Photo 3*). The rain hood consists of a custom-fabricated hood set in epoxy around the square shaft of the finial. A 1-in-thick, disk-shaped EPDM gasket with a square hole cut in its center is then installed over the top end of the rain hood and secured using a stainless steel hose clamp. Finally, the interface between the EPDM gasket and iron rod is sealed with lap sealant.

BATTEN ENDS WITHIN THE ZONE OF POTENTIAL ICE DAMMING

Batten seam roofs often terminate at a built-in gutter located at the building's eave. Traditional batten seam end caps consist of flanged, trapezoidal-shaped plates that get loose-locked to the batten seam pans and batten seam caps. When located within the zone of potential ice damming, these end caps can leak, even when the loose locks are filled with nonskinning sealant.

One way to improve this situation is to fabricate 8- to 10-in-long end caps with all of their seams soldered watertight and with the batten end plate left recessed such that

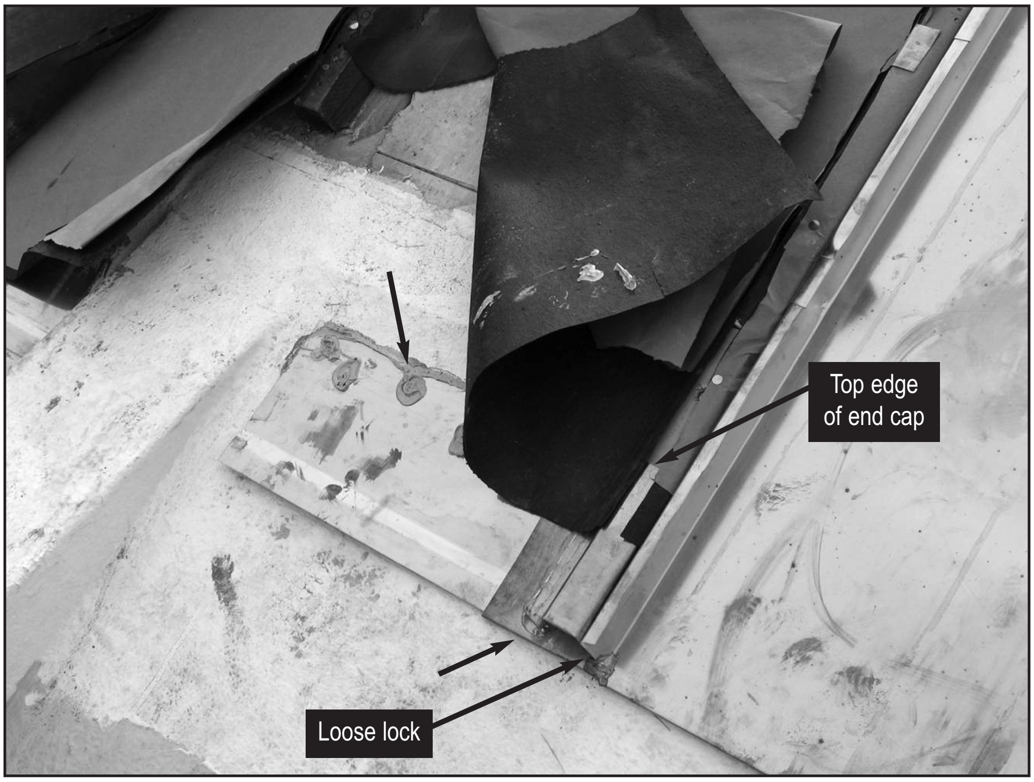

Photo 4

the batten seam pans and cap can still be folded around and loose-locked to the end cap (*Photo 4*). In *Photo 4*, the end cap is loose-locked to a stainless steel continuous cleat (bottom arrow), the top end of which has not yet been stripped-in (in this case, with a fluid-applied membrane waterproofing system, shown at the left arrow).

INNER WYTHES OF PARAPET WALLS RECONSTRUCTED OF CMU

When the parapet walls of older buildings need to be rebuilt, often the inner wythes of masonry are replaced with reinforced and grouted concrete masonry units (CMU). The CMU on the inside (roof side) face of the parapet should not remain exposed to the weather. A common solution is to install stucco or a cementitious parge over the CMU.

A more durable solution, and one less prone to leakage, is to install a ventilated rain screen in front of the CMU (*Photo 5*). The rain screen is held off the wall by furring strips, thereby allowing air flow between the CMU and rain screen, and protects the CMU from direct rainfall. The rain screen itself can be constructed of various materials, including exterior siding, standing-seam roof panels, and various sheet metals. The rain screen shown in *Photo 5* is constructed of copper-coated stainless steel panels, selected for their durability and for being more rigid than cold-rolled copper. The panels are joined with vertical slip seams. Copper screening tack soldered at the bottom of the panels (*Photo 6*) and a proprietary corrugated plastic venting strip at the top of the panels allow for air flow and keep insects out of the air space between the panels and parapet wall. As can be seen in *Photo 5*, the rain screen has been integrated with the roof system's counterflashings and the parapet wall's coping caps.

VALLEYS THAT FORM A FLAT OBTUSE ANGLE

Roof planes typically come together at valleys to form obtuse angles. In the occasional odd situation, the roof planes come together at a “flat” obtuse angle, not due to low roof slopes but rather to the roof planes coming together at an angle much greater than 90° (think of the ridges meeting at,

Photo 6

Photo 5

Photo 7

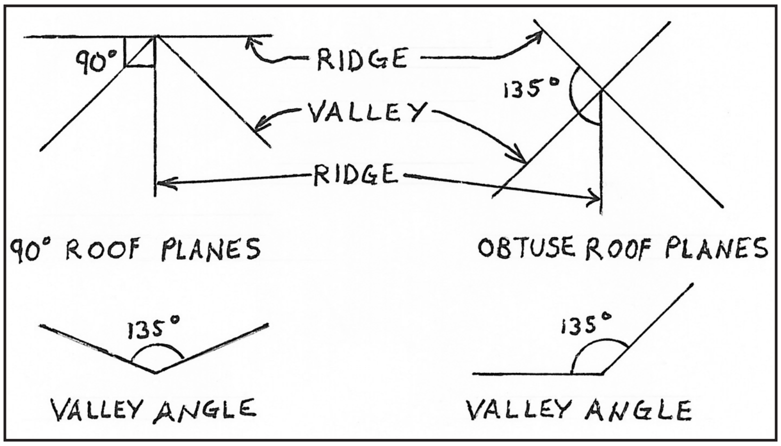

Figure 1

say, 135°, as is the case for the roof shown in *Photo 7*; see also *Figure 1*). When this occurs, water from the steeper slope will have a tendency to flow across the valley and below the shingles on the opposite side (dashed arrow in *Photo 7*).

A raised, inverted “V” placed on the low side of the valley (as opposed to the centerline of the valley) will help prevent water from flowing across the valley. The “V” in *Photo 7* is 1¾ in high. Three other details were incorporated into the valley to further decrease the potential for leaks. First, the valley tapers drastically, from 4 in wide at its top end to 24 in wide at its bottom end. Second, valley pans lap 10 in rather than the standard 8 in, and the top ends of the valley pans are stripped-in with ice-dam protection membrane. Third, to capture any stray water that may wander laterally, ice-dam protection membrane was lapped 4 in onto the lower edge of the valley and extended a little over 5 ft below the slate shingles (dashed line in the photo). The solid arrow in *Photo 7* indicates the primary direction of water flow on the low side of the valley. Although the roof area on the steeper side of the valley pictured in *Photo 7* is significantly smaller than the roof area on the lower sloped side of the valley, other flat obtuse valleys on the building had roof areas of equal size on either side of the valley centerline. It was therefore decided to treat all of the flat obtuse valleys similarly.

LOOSE GUTTER SHANKS

Loose gutter shanks, often resulting in hanging gutters that are bowed or bent outward, are a callback that can be easily avoided.

First, each of the screws used to secure circle to shank should receive not one but two nuts. This will help prevent loosening of the nuts and disengagement of the circle's nib from the shank. To further prevent loosening and rotation of the circle, the second most closely aligned pair of fastening holes in the shank and circle can be drilled out and a second screw and double-nut assembly installed.

WORN GUTTER OUTLET TUBES

The outlet tubes associated with built-in and pole gutters tend to wear a bit quicker than the gutter liners themselves due to the concentration of water and particulate matter at the outlets. Premature failure in the form of wear holes can be avoided by specifying a thicker or heavier-weight material for the gutter outlet tubes. Thus, if 20-oz copper is specified for the gutter liner, 24-oz or 32-oz copper can be specified for the outlet tubes. For an even longer service life where 24-oz or 32-oz gutter liners are

Photo 8

Photo 9

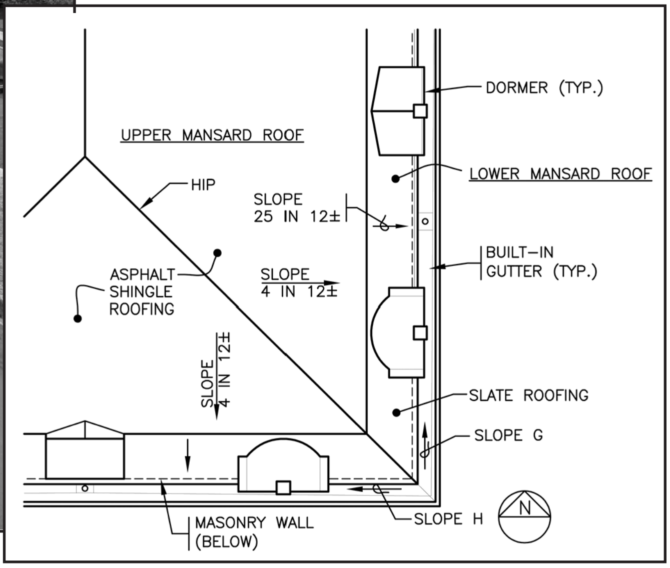

Figure 2

required, or where the outlet tube passes through an exterior wall rather than a cornice positioned outside the wall, drain waste and vent (DWV) solid copper drainage tubing can be specified. Four-in diameter DWV tubing has a wall thickness of approximately 0.058 in, nearly 80% thicker than 24-oz copper sheet. Another advantage of DWV copper tubing is that it has no longitudinal seams to leak or burst apart. Joints between adjacent lengths of DWV copper tubing are sweated with solder like copper plumbing pipes. Emery cloth is used to clean the mating ends, and a torch is used to sufficiently heat the copper.

DORMER WINDOWSILL FLASHING

It is sometimes necessary to cap a wood windowsill with sheet metal, either because the wood itself is in dubious condition or because the sill cannot be made sufficiently watertight by sliding a flashing beneath it. Due to the added material, installation of metal capping can sometimes interfere with the operation of the window sash, especially when casement, awning, or center pivot-type windows are present.

One way to minimize the thickness of the sill cap is to use 12-oz copper, the availability of which is not widely known (*Photo 8*). In *Photo 8*, the apron flashing is constructed of 16-oz copper. The bottom edge of the 12-oz copper sill flashing locks to the apron flashing. All seams in the sill flashing are soldered watertight. At the wood window mullions, the sill flashing turns directly into a small reglet cut at an upward angle.

BUILT-IN GUTTERS WITH LARGE GIRTHS

What material should be used to line gigantic built-in gutters, measuring more than 9 ft in girth? Multiple soaking-wet, asphaltic, and coal-tar pitch built-up roofing systems at a recent project, totaling approximately 4 in thick, suggested that bituminous membrane systems had been put to the test and failed. EPDM, although a common “go-to solution, is not really designed for gutter troughs, does not handle all of the inside corners and changes in plane very well, and rarely lasts more than ten years in such locations. Flat-seam copper could be a technically feasible choice with the benefit of a 50-year service life, but at a very high cost.

A fluid-applied membrane waterproofing system (*Photo 9*) is a practical solution. The advantages of a fluid-applied system are many:

- No seams: The system is seamless, a critical feature in an application where there are numerous changes in plane and where past failure was due, in large part, to open seams and fishmouths in traditional membrane roofing.
- Cost-effective: Although more expensive than a traditional built-up or modified-bitumen membrane system, fluid-applied systems are far less expensive (about half) than flat-seam copper.
- Durable: Fluid-applied systems have an expected service life of about 20 years, after which they may be cleaned, primed (reactivated), and recoated to further extend their service life another ten to 15 years.
- Warrantable: Unlike EPDM and modified-bitumen systems, most fluid-applied membrane system manufacturers will provide a 20-year warranty, despite the fact that the membrane is being installed in a gutter.
- Self-terminating: Fluid-applied systems are self-terminating, eliminating the need for termination bars and associated fasteners.
- Laps inside outlet tubes: Fluid-applied membranes turn directly down into the gutter outlet tubes, with no seams or lippage to impede water flow. This feature allows the outlet tubes to be installed first, with their flanges slightly recessed in the wood gutter sheathing, thereby further reducing lippage in the waterproofing membrane. The same is true where roof drains are present in the gutters in lieu of outlet tubes.

Fluid-applied membrane systems can also be specified where obstructions would prevent proper accommodation of thermal movement in a metal gutter liner. For instance, the dormer windows in a mid-nineteenth-century academic building at a northeast university projected so far into the gutter trough that they would have effectively acted as stops, impeding thermal expansion and contraction of a new metal gutter liner (*Figure 2*). In fact, open seams and fatigue cracks in the existing metal gut-

Photo 10

ter liner attested to the severity of the problem. A new metal gutter liner could have been made to work with the addition of numerous expansion joints and 18 additional downspouts. A far more practical solution was the installation of a fluid-applied membrane waterproofing system that required no expansion joints and no additional downspouts.

BOX GUTTERS WITH STRAPS THAT INHIBIT MOVEMENT

Box gutters often rest on shelves at the top of exterior masonry walls and are further supported by metal straps that extend from the top outside edge of the gutter to the roof deck, beneath the roofing material. The straps are typically screwed or nailed to the roof deck (often through the roof flange of the gutter) and secured with machine screws and nuts through the outside edge of the gutter, thereby effectively constraining the gutter as it moves with changes in temperature (*Photo 10*). In *Photo 10*, alternating straps are fastened through the rear vertical leg of the gutter, below the high water line, further restricting thermal movement. Fatigue cracks and open seams frequently occur.

There is a better way that acknowledges the fact that the metal gutter liner is going to experience significant thermal movement and that this movement cannot be stopped but rather must be accommodated. The solution is to use a strap that allows the gutter to move longitudinally while simultaneously preventing outward movement of the top outside edge. The strap requires that the top edge of the gutter be changed from one with right-angle bends (much like a K-gutter; see *Photo 10*) to one with a top roll (much like a half-round gutter) reinforced with a stainless steel rod. The outside end of the strap must be bent in such a way that it wraps more than halfway around the top roll of the box gutter (*Photo 11* and *Figure 3*). The opposite end of the strap is fastened to the roof deck, above the top edge of the roof flange of the box gutter.

EXPOSED FLUID-APPLIED GUTTER LINERS

The use of fluid-applied membrane waterproofing systems to line built-in gutters was mentioned earlier. Sometimes, rather than rely solely on its self-terminating properties, it is desirable to not see the outside edge of the membrane from grade and/or to counterflash the fluid-applied membrane. The trick becomes how to

Photo 11

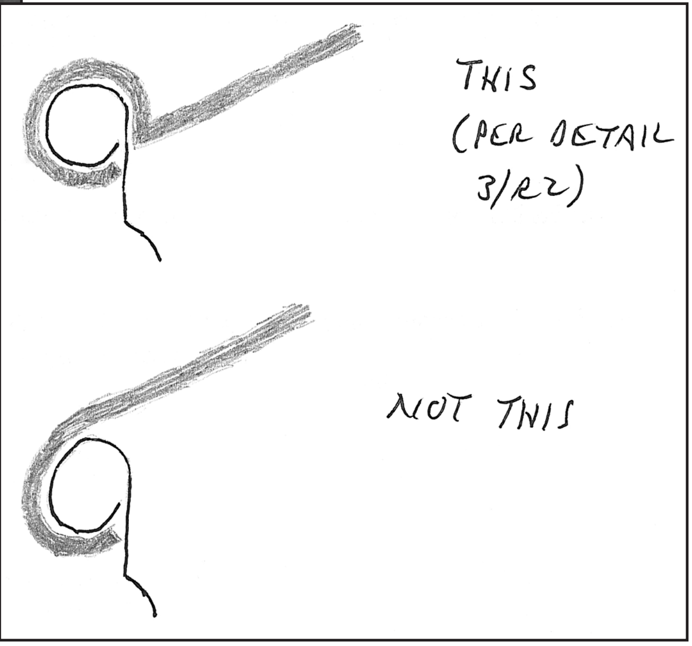

Figure 3

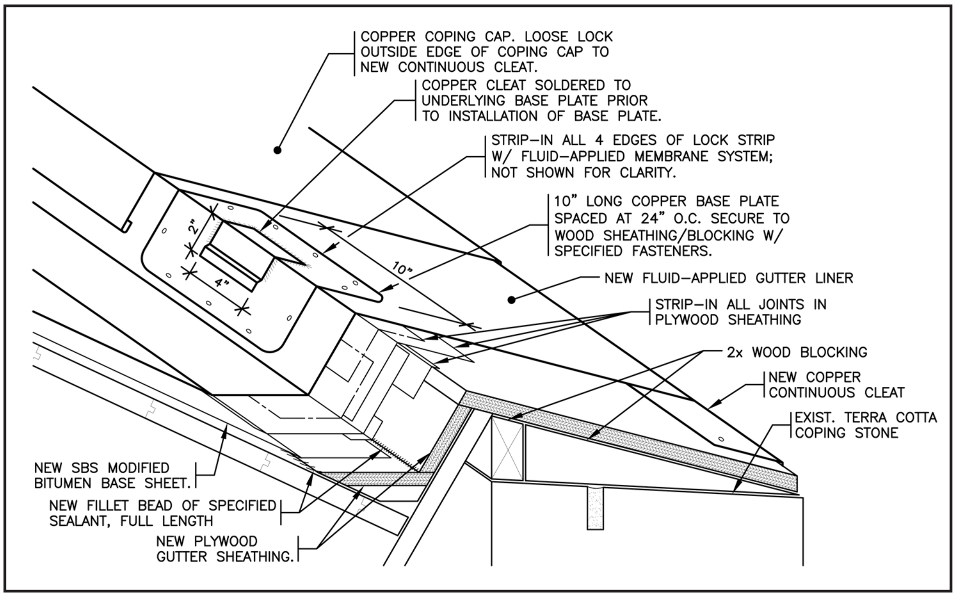

Figure 4

secure a metal coping cap without leaving exposed fastener holes in the new membrane gutter liner.

One solution is to install metal plates spaced at, say, 18 to 24 inches on center, to which a continuous cleat has been soldered. The plate then can be fastened through the gutter liner and stripped-in with the fluid-applied membrane waterproofing system, thereby eliminating exposed fasteners and the inside edge of the new coping cap loose-locked to the continuous cleat (*Figure 4*).

LIGHTNING PROTECTION SYSTEM ATTACHMENT METHODS

Lightning protection systems are often installed by separate tradesmen towards the end of a project. Left to their own methods, lightning protection contractors will sometimes secure their conductor cables and rods with fasteners set directly through roof shingles and copper flashings. This, of course, is unacceptable.

Two ways to help secure lightning protection system components without leaving exposed fastener holes in the roof are as follows: First, copper or tinned soft bronze straps can be notched along their top ends, slid below the shingles, and hooked onto the nails used to secure the shingles. The bottom end of the strap is then either wrapped around the conductor cable and held tight with a machine screw and nut or fitted with a standard loop that, in turn, holds the cable (*Photo 12*); The second method applies to copper flashings and coping caps. Here, a copper base plate with a stainless steel pan head machine screw projecting through its center can be riveted and soldered to the flashing. A standard loop then can be secured to the projecting machine screw (*Photo 13*). Similar fastening devices can be used to secure conductor rods and other lightning-protection system components in place (see *Photo 13*).

SOME THINGS ARE DIFFICULT TO DETAIL WELL

There are many things that should not be done on a roof that are done anyway. Two of the more common problems for which there is no elegant, durable detailing solution are built-in gutters at the eaves of flat-seam copper roofs, and shingle installations on very-low-sloped roof surfaces.

It is difficult to detail the interface of a small copper built-in gutter or pole gutter at the eave of a flat-seam copper roof. The dif-

Photo 12

Photo 13

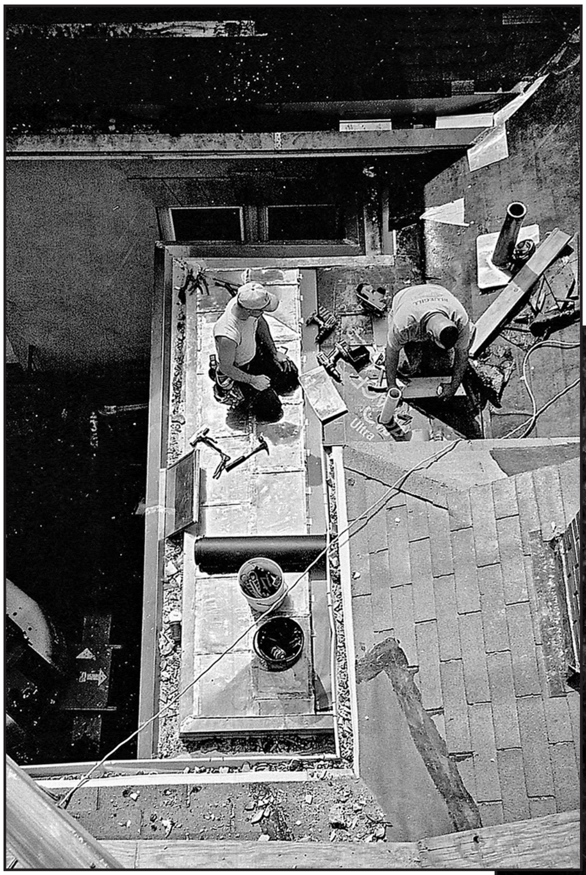

Photo 14

ficulty arises because the gutter pans, being longer, will expand and contract more than the relatively smaller flat-seam pans. On small roofs, such as the one pictured in *Photo 14*, the differential movement and consequent stress on the seams will be comparatively small. On larger roofs with long lengths of eave, expansion joints in the gutter and a loose lock between the flat-seam pans and gutter pans will be virtually impossible to keep watertight due to the low slope of the roof. About all one can do is shorten the length of the gutter pans and hope for the best or switch to a different waterproofing system, such as a fluid-applied membrane. Where the gutter trough is relatively wide and able to accommodate flat-seam pans (*Photo 15*), the problem goes away as both roof and gutter are now constructed of similar-sized small pans and will, therefore, move similarly in response to changes in temperature.

Attempting to install asphalt shingles on slopes less than 3:12 and slate shingles on slopes less than 4:12 is really pushing the limits of the functionality of the shingles. These are water-shedding products. The lower the roof slope, the greater the potential for lateral migration of water, especially during windblown rain events. Some say that a robust underlayment system, perhaps consisting of APP modified-bitumen membrane roofing or multiple plies of ice-dam-protection membrane, will offer enough secondary protection to prevent leakage. Maybe. Maybe not. Whether installed directly atop the underlayment or a batten or batten/counterbatten system, the fact remains that the underlayment will be peppered with fastener holes, each and every one of which must be sealed well against water entry. One possible out is to install an engineered grid of pedestals that can be readily flashed and to which roof framing and/or decking can be secured. A minimum of about 9 to 12 in of vertical clearance would be needed to attempt such a roof, including 4 in of base-flashing height in the shingled roof. This seems like an awful lot of effort to expend when other, more reliable low-slope roof system alternatives are readily available.

Photo 15

WATER RUNS DOWNHILL

Some challenging design detailing situations were presented herein. There are probably others, but those mentioned seem to crop up most often. Regardless, the design principles to keep in mind are the same and can be applied more broadly: Water runs downhill; the lower the roof slope, the greater the tendency for rainwater to migrate laterally; thermal movement in metal flashings and gutters cannot be stopped but rather must be accommodated; and the potential for ice damming during winter months must always be considered, even when design work is taking place on a beautiful spring day. These principles are, of course, to be considered in conjunction with the normal checklist of roof design issues, including geographic location of the project, annual rainfall for the location, roof ventilation, structural loads, roof insulation, wind uplift, building codes, the potential for debris accumulation on the roof due to overhanging trees, characteristics of the roof covering, water discharge from adjacent and upper roofs, and, where appropriate, historic preservation considerations.