

WHITE PAPER



Part 5: Metal Roofing From A (Aluminum) to Z (Zinc)

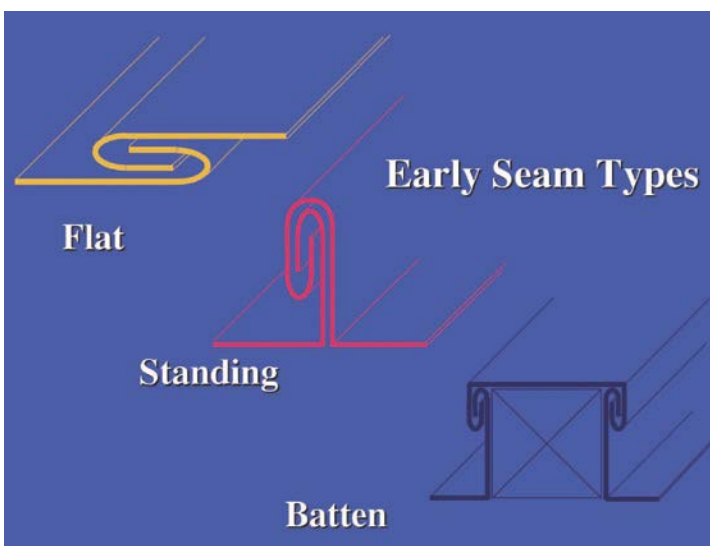
Profiles and Profiling Equipment

The original shapes of metal panel profiles were quite simplistic, as were the tools used in their making. Smiths hammered out small plates of brass, copper or gold more than 2,000 years ago. They were then folded at their edges and interlocked one-to-the-next to form the “flat-locked” or “flat seam” style roof. The anchorage was accomplished with a small cleat folded into the joint area during installation. This style is believed to be the original metal roof type and is still popular today, especially for irregular shapes, like domes and onion domes. With the advent of soldering in the mid-to-late 1800s, these roofs could be used dead flat with soldered “hydrostatic” joints.

At some point, more than 1,000 years ago, craftsmen learned they could fold the adjacent edges of a flat plate up at 90 degrees and then fold the uppermost portion of the upstanding edges together into a tightly formed 360 degrees, creating a double-folded lock. This resulted with the joint being raised above the drainage plane of the plate

an inch or so, hence it was more water-resistant. The joint was now standing up in a vertical orientation, rather than lying flat—hence “standing seam” was an appropriate designation to differentiate from the earlier “flat seam.” Once again, the anchorage was accomplished via a small cleat nailed to the structure and folded into the seam. At this stage of evolution, the plates were also growing in length—more like longitudinal “panels.”

When the craft migrated from the Middle East to Europe during the Crusades, metal-panel profiles were adapted to the styles of architecture and climate prevalent in western Europe and Scandinavia. Steep roof areas and “tiered” architecture (roofs above lower roofs) would dump snow and ice, damaging fragile standing seams below. A strip of wood inserted between the upstands of adjacent panels would support the seam area, increasing the durability of standing seams and creating a new style—the “batten seam,” so called because of the wooden batten strip.

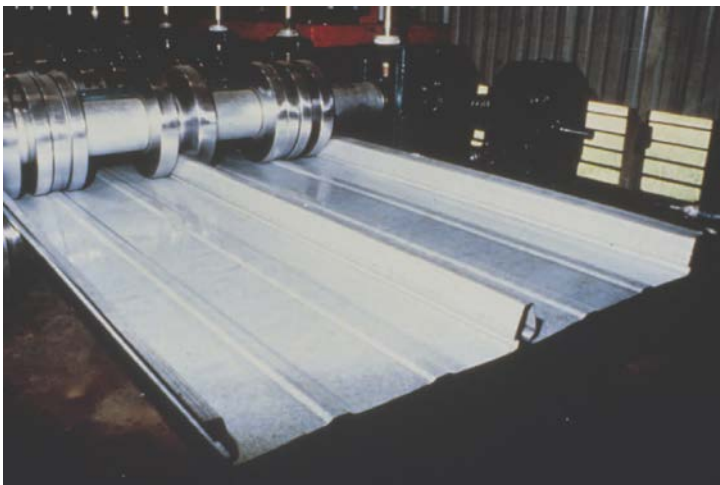


▲ The earliest seam styles (above, left) were simple and fabricated by hand with malleable metals and hand tools. The first profile in history—the “flat seam”—was also the first “hydrostatic” metal profile type when soldering came along. It is still used today (above, right) and is a popular profile for covering irregular shapes, like domes. *Illustration courtesy of Metal Roof Advisory Group, Ltd., Colorado Springs, CO. Photo courtesy of Rob Haddock.*

A significant nuance was the introduction of a separate joining component—the batten cover that locks into two twin up stands and completes the joint. This was a departure from the other profiles that used a “male” and “female” seam edge, which were then interlocked with each other. A modification of the batten seam is the “batten roll.” This profile uses a raised “lap seam” (no separate batten cover) and was developed with and for lead roofing to provide more gentle radii for this unique material.

All these styles were fabricated at the point of installation and with very simplistic tools—mallets; small anvils; tongs; hand and foot brakes; and later, simple pan formers. The metals used were soft, malleable materials and could be meticulously formed, folded and jointed using these tools, shapes and techniques. And so was the craft of metal roofing for centuries of time. It was installed by highly skilled (and highly compensated) copper and silver smiths, and remained relatively unchanged for nearly a thousand years until the Industrial Revolution. Until that point, a metal roof was the finest and most expensive roof that could be had, thus its use was limited to prestigious structures, like palaces, castles and cathedrals.

▼ Rollforming technology brought on a host of changes and represented real mass production.



▲ Tools became more sophisticated. From the top, an early wooden brake, circa 1860. Next, a variety of early hand tools, including hand shears, spades and malleting anvils. Next, an early pan former for lead “batten roll,” circa 1840. *Photos courtesy of Rob Haddock.*

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The Effects of Changing Fabrication Equipment

With improvements in mining and milling techniques, as well as innovation in fabrication tools and equipment, new styles of metal roofing began to emerge. New materials were coming onto the scene, as well. The steel industry was making huge strides into the commercialization of sheet goods in the early and mid-1800s. The harder, less-expensive material could be fabricated in a newfangled contraption called a “leaf brake.” This device had a long jaw and a hinged apron that could clamp the material and fold a perfect, straight bend far more quickly and accurately than the old (and much shorter) hand and foot brakes. This new equipment made any metal roof style more affordable, saving much time by “pre-bending” standing- and batten-seam profiles in a production environment by less-skilled workers rather than on the roof.



Photo courtesy of New Tech Machinery, Denver

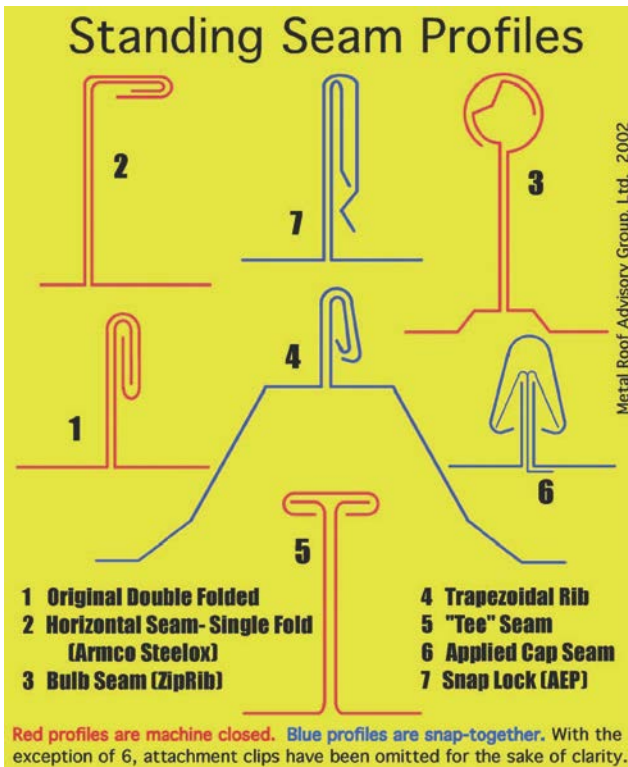
▲ Rollforming technology brought on a host of changes and represented real mass production.

Corrugating

Another interesting development around the turn of the 20th century was a process called “corrugating.” Steel producers found they could take a very thin sheet of galvanized steel and press lengthwise wrinkles into it by passing it beneath a “corrugating drum.” The wrinkles stiffened the sheet such that the metal could now span over open supporting structural members without benefit of a continuous deck. Thus a “structural” covering would fulfill the function of deck and roof membrane with one material.

The corrugating of steel panels was the first real mass-manufacturing process for metal cladding, and the resulting products made metal an economical roof material for the first time in history. Whereas metal had always been the most expensive roof, now it could also be the least expensive, making the quantum leap from castles to barns and industrial buildings.

This corrugated metal was attached with exposed fasteners. It was, in other words, “face-fastened,” or “through-fastened,” meaning the weathering surface was pierced with nails (and later screws) to secure the product in place. Early applications located the nails in the “high corrugations,” but later weather-sealing washered screws came into use, as well. Side-seams were joined in overlapping style, as with the earlier “batten roll” methods of roofing.



▼ In this sample of shapes, 5 and 6 utilize twin male components with a female cap. The others are male-female interlocks. Many variations of all these profiles are available. For instance, combining a 1 seam type with a 4 rib geometry creates Butler Manufacturing’s “MR-24,” MBCT’s “Double-Lok®” or VP Buildings’ “SSR.” Combine a 6 seam type with a 4 rib geometry for Behlen’s standing seam. Add a small hook to the 2 seam type for McElroy’s “Maxima.”

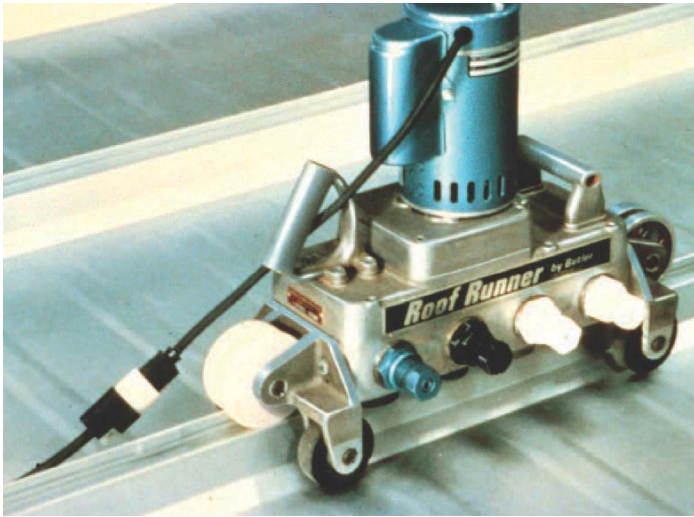
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▲ Butler Manufacturing introduced “MR-24®” in the late 1960s. It utilized the original double-folded standing-seam profile (see standing seam profile previous page) atop a trapezoidal rib shape and closed the seam with an electric machine—in essence, a miniature 4-stage rollformer. *Photo courtesy of Rob Haddock.*

Rollforming

Innovation continued throughout the next half century, and the leaf brake helped birth a few new profiles, including the integrated batten seam; the button punched standing seam; and another structural panel, the “trapezoidal rib.” But the most significant advancement in manufacturing did not come along until World War II when “rollforming” technology was invented. This approach to making a profiled sheet was the first departure from a one-at-a-time manufacturing mentality. The progressive roll tooling of such a mill could produce a finished profile in a continuous process rather than step-by-step bending or sheet corrugating one-by-one.

Another benefit attributable to this new manufacturing method was the precision with which panels could be formed. One end of the panel would be dimensionally consistent with the other—within thousandths of an inch! This had never been possible with leaf braking. The rollforming process also opened the spectrum of available metal panel profiles, allowing intricate shapes, lines and bends never before possible or affordable. This equipment today can operate at line speeds of up to 600 feet per minute, automatically measuring and cutting

panels to length with amazing accuracy at the same time.

The concept of continuous manufacturing—dealing with an endless strip of material—now pervades almost every aspect of production and fabrication, including painting, profiling, curving, seam closing, slitting, leveling and even sealant injection. The rollforming process has found its way from large in-plant mills to smaller, portable “on-site” forming machines, as well as electric seam-folding machines. Whenever long, parallel bend lines are found on metal panels, it is a reasonable bet the profile was made by this process.



▲ The concept of roll-tooling and continuous feed are also utilized by other material-handling equipment, including levelers (that stretch and flatten material), cut-to-length lines, slitters and curving machines. *Photos courtesy of Rob Haddock.*

Sometimes press-forming is used in tandem with rollforming to produce still different effects, like some of the popular tile facsimiles available in the marketplace for “crimp curving” or to break a profiled (rollformed) sheet over the ridge area. Press forming is also used for the manufacture of individual shingles or tiles and other textured shapes that are not characterized by long panels with parallel bend lines.

Of course, rollforming technology has made a whole host of new profiles possible and the manufacture of the old ones much more cost-effective. Another new concept to come along in panel profiling within the last few decades was the creation of snap-together seams and snap-on caps. This method uses the spring action of harder and higher-yield metals along with the dimensional consistency of modern rollforming equipment to develop locks and joints that do not require field folding or crimping.

Profiles and Joints for “Structural” Panels

The use of standing-seam joints and profiles on structural steel and aluminum panels is a trend that started with Armco Steel pre-1950. The concept was boosted with Kaiser’s introduction of a product called “Zip-Rib” in the 1960s. This was a “bulb seam” design held in place with concealed clips, and it was popularized worldwide. Also in the 1960s, a sheet-metal craftsman and consultant from Sweden (Ola Svensson) invented an electric rollforming machine that could perform the labor-intensive, double-lock standing-seam folding—automatically. Meeting with rejection in his home country from the trades who relished hand methods, he brought his machine to the U.S. and showed it to Butler Manufacturing in the late ’60s.

Around 1970, owing to Svensson’s invention, Butler Manufacturing™ introduced MR-24 in the U.S.: the first standing-seam joint used in conjunction with a trapezoidal rib panel profile, all machine folded with Svensson’s contraption. It was a curious blend of old and new. A 1,000-year-old joint on a relatively new material and pro-file—then used atop

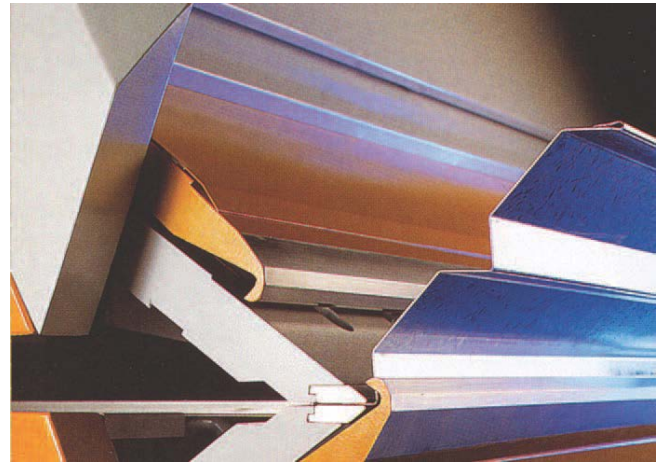
pre-engineered metal buildings and with the addition of factory-applied seam sealant. This revolutionized the metal-building industry and, since then, every major U.S. manufacturer of pre-engineered steel buildings now offers a structural standing-seam alternative.

There seems to have emerged from within the metal-building industry two panel geometries: the flat pan and the trapezoidal rib. Two different types of joints also have emerged: male-female interlock and applied cap. With applied-cap profiles, the cap is the female component of the assembly, and the panel edges are mirrored male components. Additionally, either of these joint types (interlock or applied cap) may be snapped together or mechanically crimped or folded. It seems that recent trends are more toward mechanically folded seams—probably because they are generally more durable with respect to wind resistance. Clearly, snap-together-type seams are less labor intensive to install. For that reason, they will always remain popular.

Which Is Best?

There is no clear answer to the question: “Which seam and profile is the best?” Everyone has biases, and there are pros and cons to any profile and seam type. My personal favorites are generally folded seam profiles that involve no void within the panel’s cross-section.

Profiles that have void areas within the seam are cumbersome shapes to deal with at panel termination points, especially when those points are skewed, like at hips or valleys—enlarging the void, which must be somehow closed and sealed. But on the other hand, if the job does not involve such conditions, the trapezoidal profile (having the largest void area of any shape) may offer cost efficiencies not enjoyed by other profiles because it has such a material-efficient shape.



▲ Modern state-of-the-art sheet-metal brakes can handle hard metals and are veritable fabrication centers with computerized controls and automated processing. Photo (above, left) courtesy of Roper Whitney, Rockford, IL. Photo (above, right) courtesy of RAS Systems, Peachtree City, GA.

All things considered, it is hard to beat the original double-folded standing seam. It has been around for more than 1,000 years and is sure to be around for a very long time to come.

New Technology Brings New Challenges

Prior to the advent of rollforming, panel lengths were generally limited to 8 or 10 feet—the length of a traditional leaf brake. With the rollforming process, panel lengths grew longer and longer, not being limited by fabrication equipment, but only by transportation restrictions. This makes sense because longer panel lengths mean fewer end-to-end joints that are expensive to execute and can be problematic.

As the panel lengths increased, however, we also began to experience roof failures associated with thermal effects. With increasing panel lengths, panel-attachment methods had to gain sophistication to accommodate the increased effects of thermal cycling.

In the next segment, we will look at dealing with thermal-cycling characteristics of metal panel systems.

Rob Haddock is president of the Colorado Springs, CO-based Metal Roof Advisory Group Ltd. He is a consultant, technical writer, training curriculum author, inventor and educator. In 2012 he became a charter inductee of Modern Trade's "Metal Construction Hall of Fame" for his many contributions to the industry.

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