

Standing Seam Metal Roofing

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History

Standing seam metal roofing has been in use for hundreds of years. For early roof projects, the preferred material for standing seam roof panels was a soft, malleable, long-life material such as copper, lead, or zinc. Roof panels were relatively small in size and hand tools were used to form and join the panels. To prevent leaks, roof pitches (slopes) were very steep and details were designed to shed water quickly. Early standing seam roofs were often used when protecting building contents was extremely important. The standing seam roof was chosen for its longevity, beauty, and weathertightness. Standing seam roofs can still be seen on many cathedrals and government buildings in Europe.

Current Technology

The modern incarnation of the original standing seam metal roofs has been in use since early 1969. The theory of placing the panel sidelap joints (seams) above the lowest part of the panel is one of the few remnants of the early standing seam roofs. Modern standing seam roofs have individual panels in widths from less than a foot wide to almost three feet wide. The most common panel widths are between 12 and 24 inches. Panel lengths can vary from a few feet to well over 100 feet. Panel widths and lengths are normally controlled by design, installation, handling, and/or shipment considerations. The ribs (sides or edges) of a panel are joined together to form the standing seam. The height of the seam above the "panel flat" or low point can vary with different systems and manufacturers. The height, shape, type, and frequency of ribs determine the panel system's design strength and watertightness characteristics.

Modern standing seam metal roof panels are initially formed into their shape with a roll forming mill. The roll forming mill typically has multiple hardened steel forming stands or rolls to gradually 'cold-form' the panel into the desired shape. The quality of the formed panel is directly related to the quantity of roll stands and the amount of forming done with each stand. Portable roll forming machines typically have fewer roll stands and do more forming per stand than fixed, permanently mounted rolling mills. Some mills

can have 20 or more roll stands. A portable rolling mill normally costs in the tens of thousands of dollars, while a fixed rolling mill normally costs in the hundreds of thousands of dollars. In this case, cost equates directly to quality, uniformity, and consistency in the forming process. The fit-up, ease of installation, and installation quality of the standing seam roof system is in large part dependent on the quality of the components. Since standing seam roof panels are the weathering membrane, they are critical components of the system.



This is a retrofit of a school library. The original hand-made copper roof had a radius of approximately 103 feet. 3-3/4"-deep hat sections were spaced at five feet on center over the old roof with fiberglass blanket insulation and a Butler MR-24 Roof System in a green patina (weathered copper-color) Kynar paint finish.

Summary of Common Parameters for the Modern Standing Seam Roof System

Material	Steel(carbon or stainless), aluminum, or copper
Coating	<ul style="list-style-type: none"> • Carbon steel with metallic coating or paint finish over metallic coating • Stainless steel in mill finish or with terne coating • Aluminum in mill finish or with paint finish, copper in mill finish, or lead-coated copper
Gage	<ul style="list-style-type: none"> • Steel in 26, 24 or 22 gage, aluminum in .032, .040 or .050 inch thickness • Copper in 16 oz. (26 gage), 20 oz. (24 gage) or 24 oz. (22 gage)
Design	Structural (spanning) or non-structural (fully supported)
Type	Water shedding (hydro-kinetic) or watertight (hydro-static)
Panel Rib	Flat, vertical, trapezoidal or other.
Rib Height	0.125" (flat seam) to over 3" tall.
Seam	Double lock, crimp, snap, batten.
Pitch or Slope	Minimum 1/4" per foot to vertical.

Table 1

Modern standing seam roof panel seams or edges are joined in a variety of ways, using many different techniques. Some of the most common panel sidelap joining methods are: interlocking, pre-formed panel edges; forming panel edges with a portable, self-propelled, seaming machine; snapping panels together or snapping on external battens. A self-propelled seaming machine can form panel seams from a simple crimp up to a Pittsburgh double lock. Pre-formed panel edges can be snapped together, interlocked, or secured with snapped-on or machine-crimped battens. These methods contrast with the early hand forming of the panel edges. In some cases a combination of seam-joining methods may be utilized. Panel edges might be interlocked and the final seam formed by a portable, self-propelled seaming machine.

This article will focus on the discussion of structural, watertight, standing seam metal roof systems made from coated steel. Their design (utilizing United States standards), usage and installation will be examined.

Usage Considerations

Standing seam metal roofs (SSMR) give the user (roof specifier/designer) the ability and flexibility to create unique roof solutions. Slope (steep or low), texture (rib height and frequency), panel color, and roof shape are all design tools available with the SSMR. However, many owners, architects, consultants and specifiers have never specified or used a

Reasons to Consider Using a SSMR

1. To improve or change appearance (aesthetics) of the roof or building
2. To create, change, and/or redirect the slope of the roof.
3. To eliminate interior drainage.
4. To eliminate the tear-off and disposal of troublesome materials (i.e. asbestos, bituminous materials, insulation boards).
5. To attain a longer life or better cost benefit roof system
6. To take advantage of the low relative weight of the system - approximately 2.5 psf for 24 gage panels, fiberglass blanket insulation, and light gage steel structural build-up.
7. To add architectural features such as shape, color, or texture to the roof (texture can be achieved by varying the size, shape, and spacing of the panel ribs).

Table 2

standing seam metal roof. The reasons vary, but the most common are

1. Lack of knowledge or information on details and design requirements of SSMR.
2. Confusion between exposed fastener metal roofs and newer SSMRs.
3. Lack of comfort with the design and installation of support structurals.
4. Insufficient cost (initial and life-cycle) comparison data on SSMR vs. other roof types.
5. Comfort level with other types of roof systems.
6. Bad experience with a particular SSMR system or manufacturer.

Design Considerations

Standing seam metal roofs (SSMR) in their most basic representation are formed sheets of metal joined together into a single monolithic membrane. The sidelap seams are formed above the plain of the roof—hence the name “standing seam.” The seam joints can be formed in various ways and into many shapes and configurations. Each type of seam varies in strength and watertightness. The seam joint is critical, both from a wind uplift or gravity load standpoint and from a shear or differential movement between panels aspect. The tighter formed the seam, the better the shear resistance. The tighter formed seam will also allow a panel to resist wind uplift and gravity forces without becoming “undone,” allowing panels to become disconnected or “un-seamed” from each other. As discussed earlier, the sidelap seams can be formed with a powered, portable roll former; snapped together; secured with an external batten; or even soldered. Between panels, in the panel sidelap seams, attachment clips or cleats are typically present. The clips or cleats attach the roof panels to the underlying structural members or deck and, in some cases, allow movement of the roof to handle thermal expansion and contraction. The attachment clips/cleats are very important structural elements in the SSMR system. The clip/cleat can be made up of one, two or more individual parts. The clip/cleat design, attachment and integration with the panel system are critical components for the uplift performance of the SSMR.

Uplift Tests

The actual strength of a SSMR can be difficult to predict from just the panel width, gage, yield strength, shape, and seam type. Since their inception, SSMRs have been evaluated with various wind uplift tests. Some of the early tests developed by Underwriters Laboratory and Factory Mutual were used to help insurance company underwriters develop loss data comparisons between various SSMR systems. These

early tests, conducted on 10 foot by 10 foot roof assemblies, gave limited "real life," usable performance data.

The latest tests from Factory Mutual and ASTM give designers and specifiers a more accurate comparison between various systems than the old 10 by 10 foot tests. Although wind uplift tests can give a relative comparison between similar-type SSMR systems, even the newer FM and ASTM tests do not give a "real life" performance guide to designers and specifiers. The tests only deal with the roof panels, panel clips, and structural support spacing and type. They do not address the roof edge trims, penetrations, or other roof conditions that can affect uplift performance of the entire roof system.

Standing seam metal roof panels and light gage (under 10 gage) support structurals are required to be designed in accordance with the latest edition of the AISI (American Iron and Steel Institute) Cold-Formed Steel Design Manual. The design requirements from AISI vary greatly from the more commonly known AISC (American Institute of Steel Construction) design requirements for hot rolled steel members. Following AISC design requirements, member section properties are calculated based on the shape and thickness of the member. AISI cold-formed design takes into account not only the shape and gage of the member, but also the presence of or lack of stiffening lips (edges). The effective section properties and/or allowable stresses are reduced or modified based on the lack of stiffening lips or edges.

The actual performance of cold-formed members can vary greatly from the calculated section properties used to develop load tables. The section properties for the panel or structural member are calculated based on the non-deformed (unloaded and undeflected) shape of the member. Since cold-formed members can experience major deformation and deflection without failure, the calculated section properties do not accurately reflect the shape or strength of the members when carrying the required live or uplift loads.

Light gage structural members and roof panels can deform substantially under loading and return to their original shape without any permanent deformation. Permanent deformation is the criteria used to judge failure of the structural member or roof panel when tests are conducted. Cold-formed members are flexible, yet strong. This can be a real advantage that metal roof systems have over many conventional roof systems. However, this advantage can also cause unpredictable performance problems. Panel seams, endlaps, and closures are a few of the details that can become compromised under loading and deformation. The SSMR designer and specifier should look at other factors beside calculated roof panel allowable load span tables when designing with a SSMR. The long-term performance of the SSMR system depends on the properties summarized in Table 3.

The model building code (UBC, SBC, BOCA,

Panel Elements and Properties and How They Influence Roof System Strength

1. Panel material gage—the thicker the material, the stronger the panel.
 - Typical gage is 24 (0.0235" minimum thickness).
2. Panel material yield strength—the higher the yield strength, the stronger the panel.
 - Typical yield strength is 50 KSI.
3. Rib/corrugation shape—the higher the corrugation the stronger the panel.
 - Typical corrugation height is 1 to 3 inches.
4. Seam shape/type—the tighter the seam, the stronger the panel sidelap seam.
 - Typical seams are roll-formed, crimped, snapped, or battened.
5. Panel width—the narrower the panel, the stronger the panel.
 - Typical panel width is 12 to 24 inches.
6. Clip/cleat spacing—the closer the clips/cleats, the stronger the system.
 - Typical clip/cleat spacing is a few inches up to 5 feet or more.

Table 3

MBMA, etc.), state code, or local code specifies the required design loads, their magnitude, their combination, and their application. Modern codes require wind uplift loads to be applied in different magnitudes in roof corners, roof edges, and the field of the roof. In some cases, these loads can be severe and require proper design to ensure the longevity of the roof installation. The required design loads are normally compared to the calculated allowable design loads of the panel system or the mph wind speed rating from a wind uplift test. Remember that allowable design loads are calculated by using the calculated section properties using the non-deformed (unloaded and undeflected) panel shape, panel material yield strength, and span (distance between clips or structural members).

Structural vs. Non-Structural Systems

The SSMR must be fastened to something to give it structural support and attachment for wind uplift resistance. This could be a solid substrate such as a roof deck or structurals such as bar joists or Z-purlins. Properties of the two predominant types of SSMRs are:

Some of the Available Wind Uplift Test Standards

- UNDERWRITERS LABORATORY**—UL580 test procedure.
- Test apparatus is 10' by 10' with tests normally run at the U. L. facility
 - Panel edges are restrained in the test box. Test is suction/pressure combined.
 - Ratings are UL class 30 (lowest), UL class 60, and UL class 90 (highest).
- FACTORY MUTUAL**—FM 1-90 ("one" 90 is the current test; old test was FM I-90, using the confusing Roman numeral for "one").
- FM4471 test procedure (new). Ratings for wind uplift, fire, foot traffic, hail, and air and water infiltration.
 - Test apparatus is 12' wide by 24' long with tests normally run at the FM facility.
 - Wind ratings range from 1-60, 1-75, 1-90, 1-105, 1-120 and higher.
- AMERICAN SOCIETY OF TESTING AND MATERIALS**—ASTM E-1592-95
- Currently under revision - new procedure will likely be ASTM E-1592-99
- Test procedure is based on panel width, span, and edge conditions (restrained, unrestrained, or restrained one end). Minimum 4 panels wide by 3 to 5 spans long. Requirements are given in a chart.
 - "Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference"

Table 4

The Structural SSMR:

1. Panel spans up to 5 feet between structural members.
2. Can be installed over solid decking (metal, wood, concrete, etc.).
3. Clips/cleats are attached to structurals or deck and spaced up to 5 feet apart.
4. Panel material thickness is 24 or 22 gage.
5. Slopes as low as 1/4 inch per foot are typical.

The Non-Structural SSMR:

1. Installed over/supported by a solid deck (metal, wood, concrete, etc.).
2. Clips/cleats are attached to the deck and spaced up to 5 feet apart. Typical panel clip/cleat spacing is from 2 to 3 feet.
3. Panel material thickness is 26, 24, or 22 gage.
4. Slopes as low as 2 or 3" per foot are typical. Most systems require a secondary waterproofing material. Some systems allow lower slopes with, and a few without, the secondary waterproofing.

Summary

Standing seam roofs are one of the oldest roof systems and have been in continuous use for hundreds of years. Current technology and improvements in materials and coatings

have allowed the state of the art of standing seam roofs to be advanced to today's quality-controlled, factory roll formed, field-seamed systems. The roof designer has a multitude of standing seam roof systems available to address the aesthetic, performance, and design requirements of almost any project. Contact a metal roof trade organization such as the Metal Roof Systems Association (MRSA) at (216) 241-7333, a subsidiary of the Metal Building Manufacturers Association (MBMA), for the names and phone numbers of various standing seam metal roof manufacturers.

About the Author

Raymond K. Heisey, Jr., P.E., RRC earned a degree in civil/structural engineering from Lehigh University in 1978. He is National Sales Manager for Butler Roof Division, where he has worked for almost 20 years. Ray was awarded two U.S. patents and numerous foreign (including Japanese) patents on metal roof system components. He is a registered Professional Engineer licensed in the state of Missouri and obtained his RRC designation from RCI in 1993.

Ray has won six awards in an eight-year period for high performance in exceeding sales goals at Butler.

Heisey presented a report on standing seam roof clip design to the American Society of Civil Engineers - Structural Congress and has taught at seminars and given presentations to architects and roof consultants on various roof-related subjects.



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Software Crackdown Hits A/E Firms

The Business Software Alliance (BSA), a software industry watchdog whose members include companies such as Microsoft, Autodesk, and Bentley Systems, is targeting the construction industry, and architectural/engineering firms in specific, for illegal software use.

A recent survey of A/E firms for the BSA showed one-fourth of such firms were using software illegally. Settlements and fines were paid or assessed against 200 construction-related firms by BSA in the last five year, with many reportedly reaching "six figures."

The survey, by Zweig, White & Associates, showed that 25 percent of the firms surveyed have no policies prohibiting users from installing software on their workstations without proper licensing.

Individual software companies also are pursuing independent prosecution.

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