METAL CONSTRUCTION ASSOCIATION

Metal Roof Installation Manual

Chapter 7: Panel Connections

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BUILD LEGACIES METAL

Chapter 7: Panel Connections

Chapter Contents

7. INTRODUCTION

The panel connections are "what keep the roof on the roof." When the proper tools and materials are used, the installer is the most critical factor of the installation. Knowledge of various panel connections, and understanding the reasons *why* certain fasteners, tools, or materials are used, will enable the installer to deliver a roof system that performs as one unit.

Panel connections not only secure the roof during normal use, but are designed to withstand any "worst case" situations involving the wind and weather, seismic activity, thermal effects, and roof loading. A brief look at these issues now will lay a foundation for understanding. These topics are detailed in later chapters, especially Chapter 10, *Roofing Design*; Chapter 13, *Sealants*; and Chapter 14, *Fasteners*.

7.1 Wind Effects

As air flows across the roof, the metal panels making up the roof surface act like an airplane wing. This creates a "lift" or suction force. During periods of moderate or high winds, this effect becomes quite exaggerated, and the entire roof can be lifted, or "sucked," off the structure as shown in Figure 7-1. The frequency and strength of the panel connections is vital to roof survival during a wind storm.

Table 7-1
Metal Roof Damage Due to Wind Effect

Panels are attached with either exposed or concealed fasteners. Installing ribbed panels with exposed fasteners involves directly fastening the panel to the deck. This attachment method provides increased wind protection, but has the obvious disadvantage of penetrating the panel.

Concealed fasteners, or clips, do not penetrate the panel. Instead, they are installed along the outside edges of the panel. However, during high winds, the center of the panel remains unsecured, and may flex as lift is developed. This flexing stresses the panel, rotating the seam, which may deform the panel and clip, and cause the joint to fail. Panel clips are unique and designed specifically for certain panels. They will only function properly when installed using the specific fastener and panel for which they were designed. Always check with the manufacturer for the proper installation information.

7.2 Water Shedding

The primary function of a roof is to shed water and protect the shelter from the environment. The metal panels making up the roof surface can only leak at the seams, where there is a puncture, or where an opening has been cut into the panel. A panel's joint configuration, fasteners, and sealant (when used) are key factors in a leak-proof installation.

Properly installed fasteners (Figure 7-2) are necessary in order to provide and maintain a tight seam capable of shedding water. Any exposed fastener that is not completely secured, is crooked, or has a defective seal will eventually leak. Common fastener faults, as shown in Figure 7-3, are caused by an installer under or over-driving the fastener while securing the roof panel.

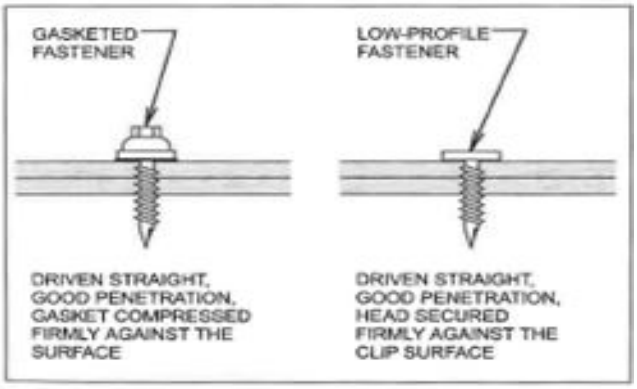

Figure 7-2
Properly Installed Fasteners Provide
Strong Leak-Proof Panel Connections

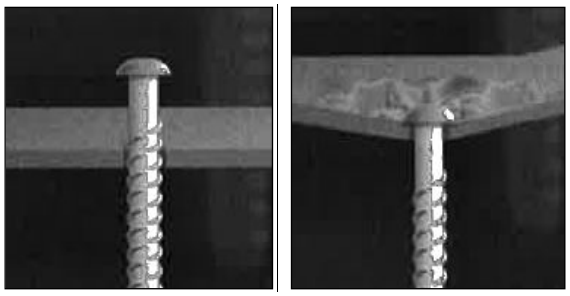

Figure 7-3
Under or Over-Driven Fasteners Will Eventually Leak

Wherever there are overlapping surfaces, there is the possibility of leakage due to what is called "capillary action." Water will be drawn up into the small gap where the two surfaces overlap. To prevent this capillary seepage, many panels have an additional ridge formed into the rib which will cover a seam. This additional ridge, circled in Figure 7-4, "breaks" the adhesion of any water trying to seep back between the panels and provides a drain to the outside.

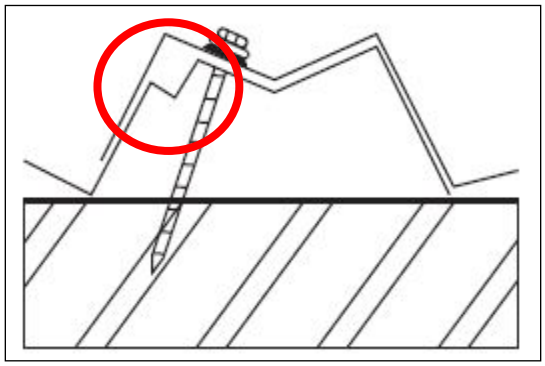

Figure 7-4
Additional Groove Prevents Capillary Leakage

7.3 Sealants

Many panel connections require the use of a sealant. When using a sealant always:

- **Select** the correct **type** of sealant.
- **Apply** the correct **amount** of sealant.
- **Position** sealant in the correct **location**.
- **Check** the **expiration date** of the sealant.

For more details on sealants, refer to Chapter 13

7.4 Seismic and Lateral Movement Effects

A properly designed roof must also adjust to lateral, or side to side, movement and stress. The forces from this type of stress are illustrated in Figure 7-5.

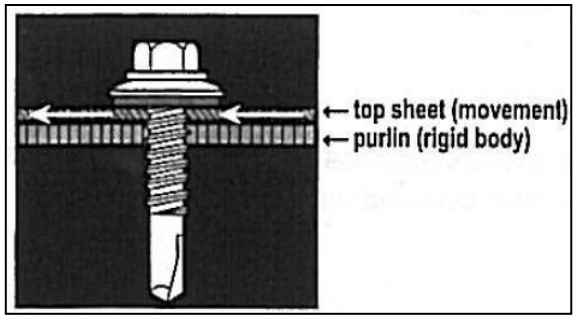

Figure 7-5
Direction of Forces During Lateral Panel Stress

Most ribbed panels are designed to "flex", or adjust to small amounts of lateral movement through their formed ribs. Figure 7-6 illustrates a variety of ribbed panels. These ribs will "flex" during lateral movement of the panel, preventing damage and distortion. Other roof systems accommodate these stresses through parts of the roof system other than the panel connection.

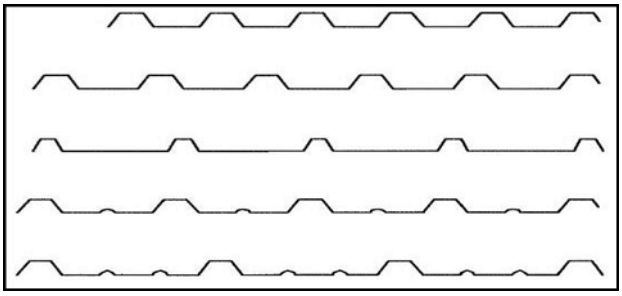

Figure 7-6
These Rib Profiles Will "Flex" During Lateral Stresses

It is important that the manufacturer's instructions are followed carefully so that if, and when, the roof experiences such stresses, the roof system performs as designed.

7.5 Thermal Effects

Metal expands and contracts as temperature changes. Metal roof panels, by the nature of their material, size, and the extreme temperature changes that take place, may experience significant size changes on a regular basis. (Figure 7-7) This is normal.

Figure 7-7
Temperature Extremes Are Normal for Any Roof

The expansion and contraction of the panels must be taken into consideration and addressed during the design and installation of the roof. A detailed look at this issue is covered in Chapter 10, *Roofing Design*, but the installer needs to always remember the following general truths:

- All material expands and contracts as temperature changes.
- Different metals have different amounts of change for the same amount of temperature (see Table 7-1).

Coefficients of Thermal Expansion (inch/inch/°F)

Material	Coefficient
Steel	6.5×10^{-6}
Copper	9.3×10^{-6}
Stainless steel	9.5×10^{-6}
Aluminum	12.8×10^{-6}
Zinc	17.4×10^{-6}
Titanium Zinc	11.0×10^{-6}

Table 7-1
Thermal Expansion of Common Roof Metals

- The following relationships *always* apply:
  - As temperature ↑, length ↑
  - As temperature ↓, length ↓
  - As length of panel ↑,amount of change ↑
  - As length of panel ↓,amount of change ↓

The direct fastening method does not account for this change in panel size, while most concealed fasteners provide for thermal movement through several clip configurations. Clip examples are shown in Figures 7-16 and 7-17, are discussed in the next section, 7.1, and detailed within Chapter 14, *Fasteners*.

7.6 Snow and Ice Effects

In some areas, the effect of possible snow and ice accumulation on a metal roof, as shown in Figure 7-8, requires that additional attention be given to the panel connection during Installation.

Figure 7-8
Possible Snow and Ice Effects Require
Special Attention During Installation

The weight of the snow and ice accumulation acts as a gravity load, sometimes called a "drag load." This weight tends to grab the panel and attempts to slide, or drag, the panel out of place. The amount of force is a function of the snow load, panel length, and roof shape.

When a panel is installed using clips which adjust to panel movement due to thermal conditions, it is also necessary to secure, or "pin" the panel at some point along its length so it does not migrate out of its intended location. An example of damage caused by this type of panel migration can be seen below in Figure 7-9.

Figure 7-9
Adverse Effects of Snow Load on a Metal Roof

Depending on the roof design, metal panels are pinned at the ridge, eave, or midpoint of the panel. It is important that the panel be pinned **at only one point**, in order to accommodate thermal expansion. This "point of fixity," plus additional snow and ice considerations are detailed in Chapter 10, *Roofing Designs*.

7.7 Side Joint Configurations

In addition to the previous considerations, there are other factors closely related to the installation of the roof which affect the exact type and style of the side joint configuration selected for the roof panel.

As mentioned in Chapter 4, low slope roofs are designed with hydrostatic joints; capable of sustaining slow-moving water (Figure 7-10).

Figure 7-10
Low Slope Roofs Must Handle Slow Moving Water

Steep sloped metal roof panels (Figure 7-11) may be designed with hydrokinetic joints; capable of sustaining fast-moving water for periods of time. Each of these slopes requires different design features and unique profiles.

Figure 7-11
Steep Slope Roofs Must Handle
Fast Moving Water Runoff

Exposed or concealed fastener panels have side configurations designed for the type of fastener required.

Panels installed using exposed fasteners often have simple overlap or side-lap type joints. Depending on design requirements, the same panel may require fasteners to be installed on the top of a rib or ridge, while another roof design requires the fasteners to be installed on the pan, or flat valley, portion of the panel. These different fastener patterns are shown in Figures 7-12 and 7-13.

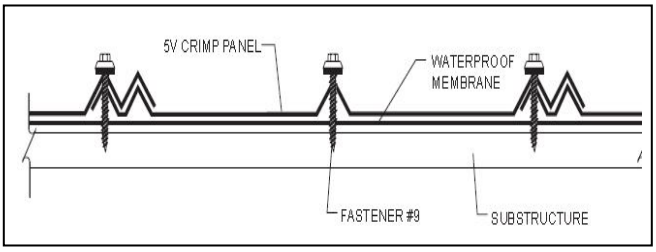

Figure 7-12
Exposed Fasteners Installed at Top of Ribs

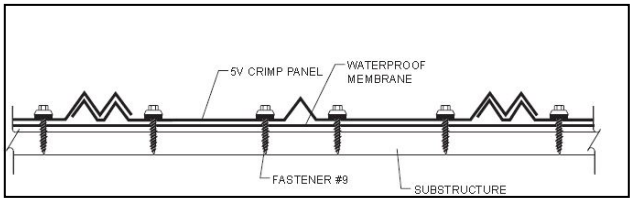

Figure 7-13
Exposed Fasteners Installed on the Pan

Panels installed using concealed fasteners or clips, often have larger side ribs already formed in the panel. These larger ribs cover the fasteners or clips securing the previously installed panel. (Figure 7-14)

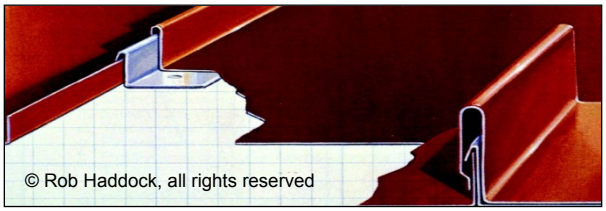

Figure 7-14
Larger Side Ribs Are Used To
Conceal Panel Fasteners

Some panels, though, are designed to use separate fastener covers. These panels will have side-joints configured to accept and lock the separate cover when it is snapped into place. Although similar to a batten-type seam, many varieties and styles of this seam exist. Two examples are illustrated in Figure 7-15.

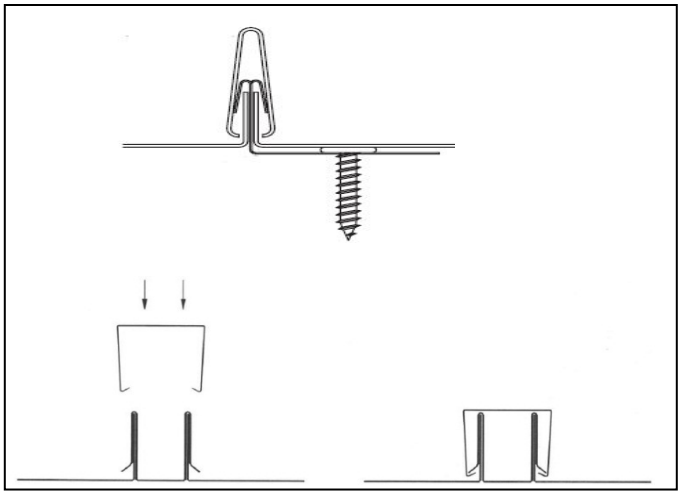

Figure 7-15
Separate Fastener Covers Snap
and Lock Into Place

The simple one-piece clip design shown in Figure 7-16 allows the panel to adjust to thermal movement yet remain firmly attached to the substrate.

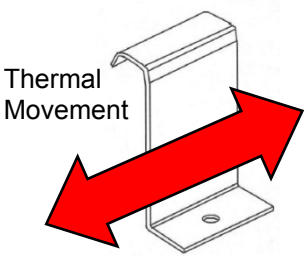

Figure 7-16
Basic One-Piece Clip,
the Panel Moves Under the Clip

However, if a sealant is used on the seam joint, the panel often tears the sealant as it tries to slide along, under the clip, to adjust to thermal differences. In this case, a two-piece clip similar to Figure 7-17 is used to allow use of sealant and still permit thermal movement of the panel.

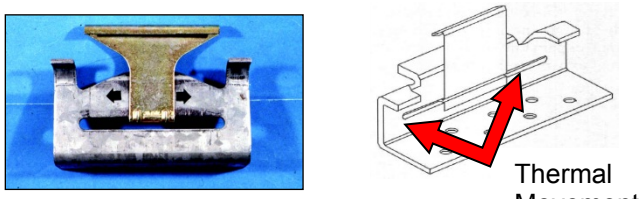

Figure 7-17
Two-Piece Clip,
Panel Movement Is Within the Clip Itself

Proper side-joint installation will ensure that the seam will perform as designed, with no leaks, proper drainage, and allowing adequate panel movement.

7.8 Mechanically Seamed

In addition to the side configurations already discussed, there are panels which require mechanical seaming. Mechanically seamed profiles have portions of the seam formed and folded during panel fabrication, with the final seam being completed on-site after the panels are in place, and usually with an electric seaming machine.

Figure 7-18 shows a typical seam after the panels are installed but *before* mechanical seaming. Notice how the individual pieces are "nested" within each other, ready for final rolling and folding.

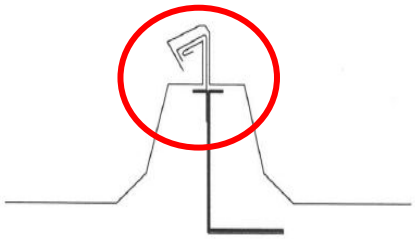

Figure 7-18
Before Mechanical Seaming

Panel seams are finished using a mechanical seamer, usually electric powered, which rolls and forms the final bends of the seam. Figure 7-19 shows the previous seam *after* a mechanical seamer has completed its pass over the rib joint. Notice how a properly adjusted seamer leaves a panel connection which is neat, attractive, consistent and tight, and provides an effective barrier to the environment.

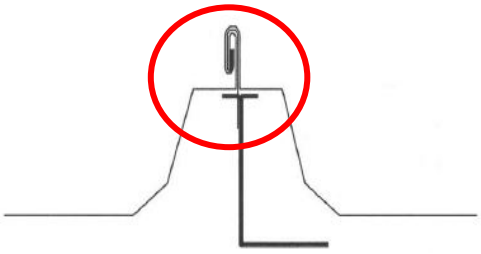

Figure 7-19
After Mechanical Seaming

Mechanical seamers are normally proprietary to each roof system. This means each roof panel type may require a separate seaming machine, as well as separate tooling, set-up, and adjustments. Some require the seaming to be done as the installation progresses, while others require seams to be formed after all panels are installed. A pair of mechanical seamers is shown in Figure 7-20. Note the horizontal ribs on vertical panels, with standing seams.

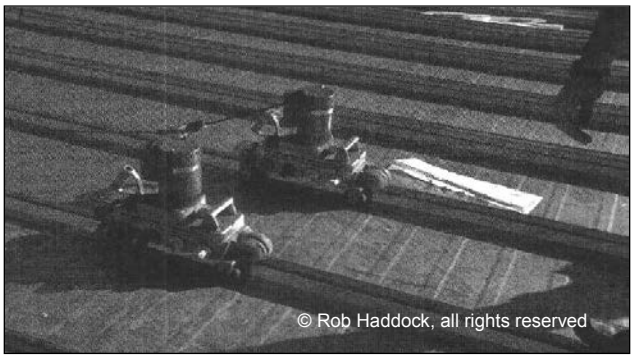

Figure 7-20
Electric Powered Mechanical Seamers
Note: Horizontal Ribs on Vertical Panels

When a roof system involves machine folding of the seams, there are many issues an installer must consider. These include:

- Seamer - correct for the height, seam style, and panel gauge?
- Proprietary tools - purchase, rent, or lease them?
- Work schedule - form seams during or after all panels are installed?

- Will the tool fit on seams located along walls and roof accessories?

These issues, and others relating to mechanical seamers, are detailed in Chapter 12, *Tools and Field Operations*, Section 12.1.9, *Seaming Tool*.

Remember, the panel connection is only one member of the metal roof family of products. It is one link in the roof system chain. Selecting the proper materials and fasteners, using the proper panel connections, and performing the proper installation method will prevent the panel connection from being the weakest link.

Notes: