METAL CONSTRUCTION ASSOCIATION

Metal Roof Installation Manual

Chapter 16: Panel Installation

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BUILD LEGACIES METAL

Chapter 16: Panel Installation

Chapter Contents

16. INTRODUCTION

Installers perform many different activities during an installation, but they all relate to, or focus on, the installation of the roof panel. Each roof installation is unique and requires different installation details relating to fasteners, clips and hardware, sealant, and similar items.

This chapter discusses activities which are a part of every panel installation. For example, every panel should be installed straight over a clean, even plane. However, every panel and roof has variations. How much variation is acceptable, and how are variations addressed and corrected?

It is common practice, especially in new roof installations, that work by other trades is performed at the same time as the roof installation. Coordination and sequencing with the other trades is essential for the safety, quality, and professionalism of the work being performed.

16.1 Coordination and Sequencing with Other Trades

Coordination and sequencing with other trades is an activity which needs to be performed prior to and throughout every phase of roof installation (Figure 16-1). Failure to properly perform and coordinate this activity can quickly cause costs to skyrocket and schedules to crumble.

Figure 16-1
Coordination and Sequencing with Other Trades

Installation issues to address prior to and during the earliest stages of a roof installation were covered in Chapter 11, *Delivery, Receipt, Storage, and Handling of Materials*. Remember that work performed during this stage not only involves other trades, but may involve additional installation team members who are less skilled and experienced. There must be clear communication, and an understanding by those performing the work of such things as where to locate and stage the material and proper handling techniques.

If an installation involves new cement and masonry work, it is best if this work is completed and cured prior to roof work being performed. Wet, uncured masonry is highly corrosive and damaging to metal roof material. Nearby roof material should be protected from any contact with curing cement products. Even dried cementitious products can scratch, mar, and stain panel surfaces (Figure 16-2). When co-activity with such work is unavoidable, be sure to cover and protect any nearby surfaces, especially material which may already be installed. If possible, and if the roof area is large enough, consider focusing work on other areas of the roof until masonry is completed. Proper and thorough clean-up after masonry work is completed is essential to avoid tracking and spreading of dirt and abrasive materials.

Figure 16-2
Cooperation with Masonry Work Being Performed

Work involving electrical and HVAC trades may take place during any phase of a roof installation. Additional work and time can be avoided by coordinated efforts, such as running cabling, locating and installing openings prior to roof installation, or allowing other trades to perform their work on portions of the roof completely or partially installed. The key to success in this area is communicating and cooperating with the other trades. Knowing their deadlines and scope of work, and them knowing the roof work necessary will help both parties achieve success. (Figure 16-3)

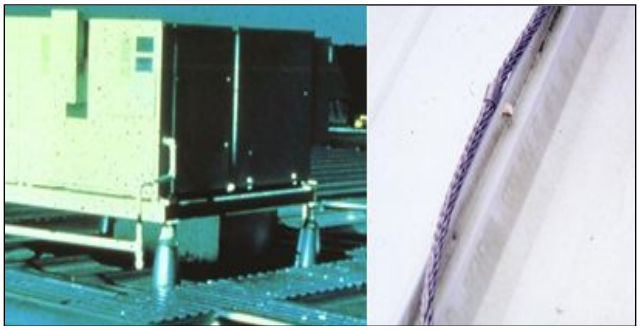


Figure 16-3
Cooperation with the Electrical and HVAC Trades

It is important to remember that the work performed by these trades can be damaging to the roof structure, such as soldering, welding, and drilling, and that many of the materials used in the electrical and HVAC trades are harmful to most metal roofs. Materials such as copper, pressure treated wood, and HVAC cleaners are all highly corrosive to the material of metal roofs.

16.2 Checking the Structure – Substructure

Prior to starting the installation, the installation area needs to be inspected, and any deficiencies reported to the proper parties. This is best performed by an installer who is actually on-site and can evaluate the conditions in light of the requirements of the roof system to be installed. This is a best practice procedure for any installation.

16.2.1 Squareness

The squareness of the structure and roof support system has a major effect on the roof panel installation. Squareness and straightness are not the same. Straightness relates to the variation along a single edge of an object, like a straight line. Squareness is the relationship of one edge to another edge. A square edge indicates the edges should be 90°, or perpendicular, to each other. Most roofs are designed to be square. Roof panels normally have square ends and sides.

When an object is square, the measured distance between opposite corners will be equal. An installer can measure the roof distance between diagonal corners. If the measured distance is equal, the roof is considered square. This method is illustrated in Figure 16-4. When the roof is not square, it is not possible to properly align the roof panel with the roof edges.

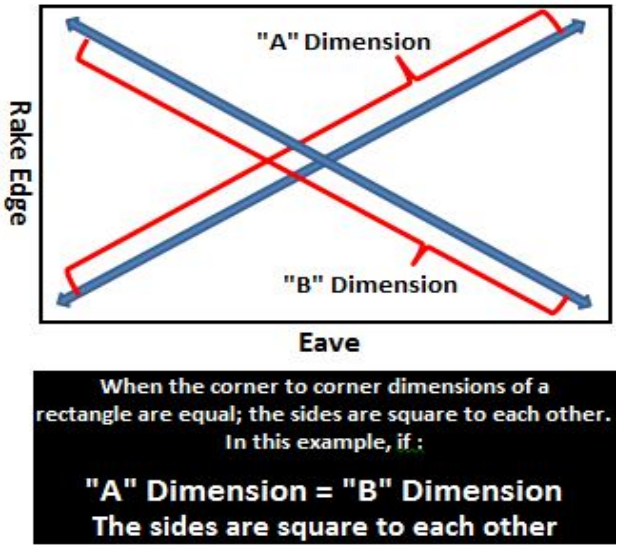


Figure 16-4
Checking Roof Squareness

When this happens, adjustments must be made. It is critical to the overall installation that the first roof panel is installed square to the roof edge, normally the eave. When installing a square roof panel on a roof that is not square, installers often use the 3-4-5 method to ensure that the first panel is secured squarely.

The 3-4-5 Method

When the roof is *not* square, there must be a method which will enable an installer to install a panel "square" to the eave of the roof. A method common to the construction trades uses a measured triangle; it is commonly referred to as the 3-4-5 method. This method is easily learned, and provides a reference line on any surface which is square (perpendicular) to another surface edge, as shown on Figure 16-5.

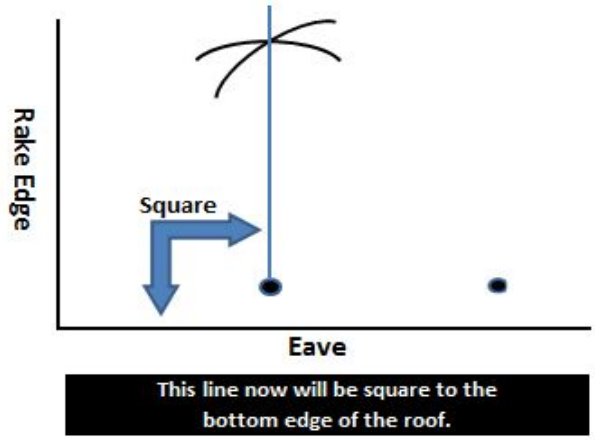
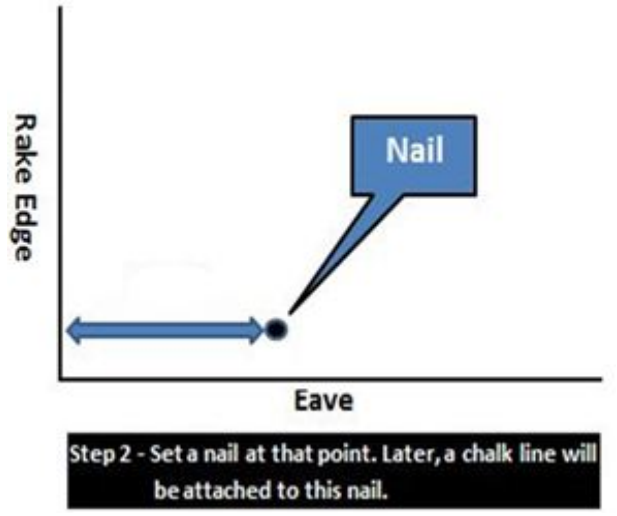
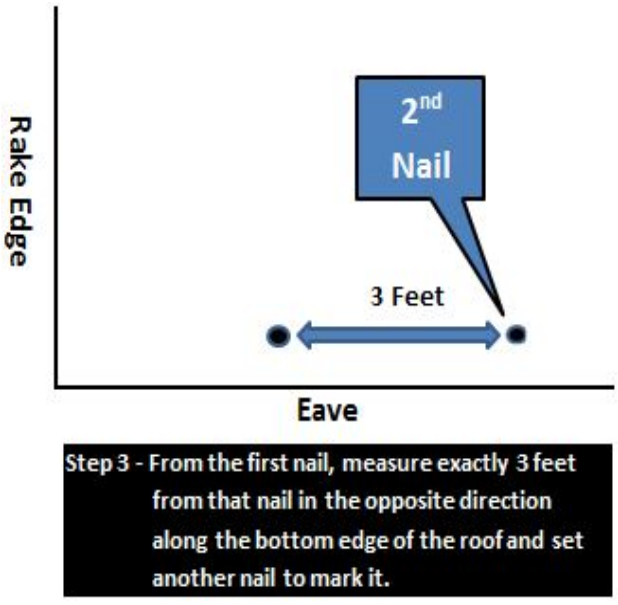
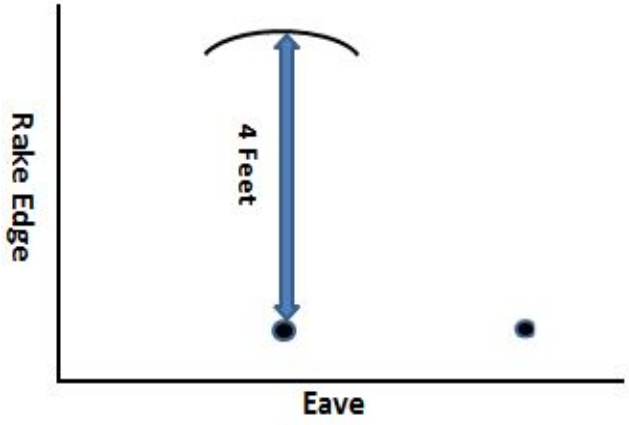


Figure 16-5
A Reference Line for Squareness of an Installation

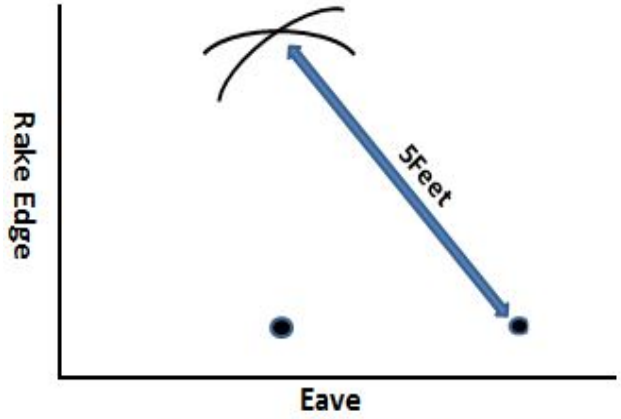
The only tools required are a tape measure, chalk line, and hammer, plus two nails. The steps are illustrated as follows:



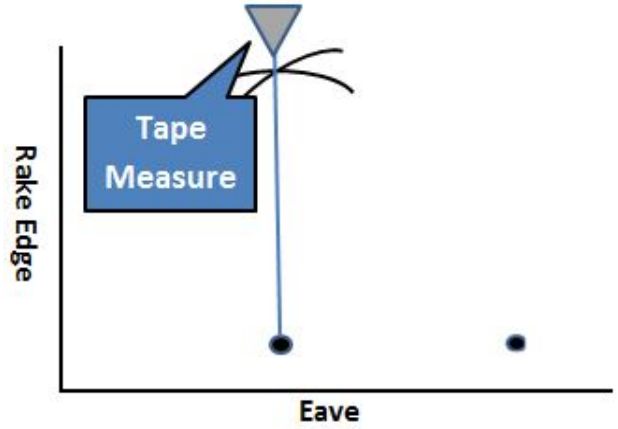




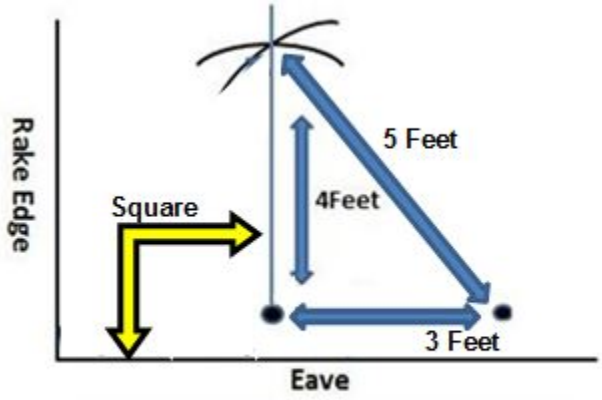
Step 4 - From the first nail, measure exactly 4 feet straight up the slope of the roof and draw a small arc.



Step 5 - Measure from the second nail exactly 5 feet and draw an arc that intersects the first arc.

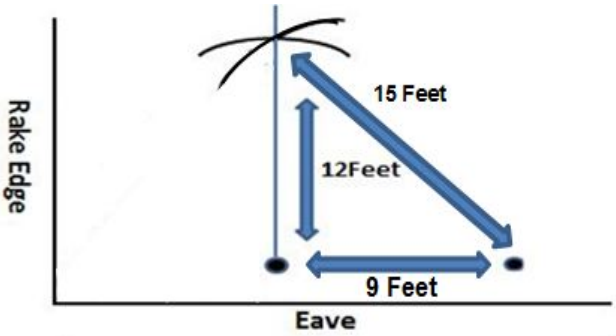


Step 6 - Attach a chalk line to the first nail, extend it up the slope so it passes through the intersection of the two arcs.



Step 7 - Now, snap your line. This line now will be square to the bottom edge of the roof.

On larger roofs, this method works on multiples of 3-4-5, such as 6-8-10, 9-12-15, and so on. This is illustrated in Figure 16-6.



On larger roofs, this method works on multiples of 3-4-5, such as 6-8-10, 9-12-15, and so on.

Figure 16-6
Applying the 3-4-5 Method on Larger Surfaces

16.2.2 In-Plane Alignment

A roof can be installed square, straight, and flat, and ***still*** not be installed correctly. If the roof is not installed "in-plane" with the rest of the structure and other roof planes, it will not "look right," and performance may be jeopardized.

When all surfaces are "in-plane," the roof and wall surfaces "look normal" as shown in Figure 16-7.

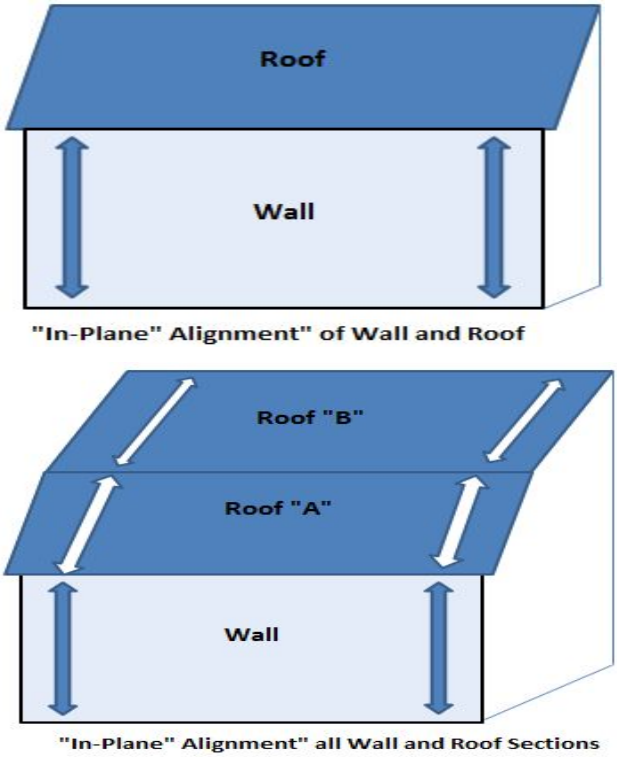


Figure 16-7
"In-Plane" Alignment of Roof and Wall Sections

However, when the roof and wall surfaces are not "in-plane," as illustrated in Figure 16-8, this is often referred to as a "crooked roof," even though each roof and wall surface is straight; just not to each other.

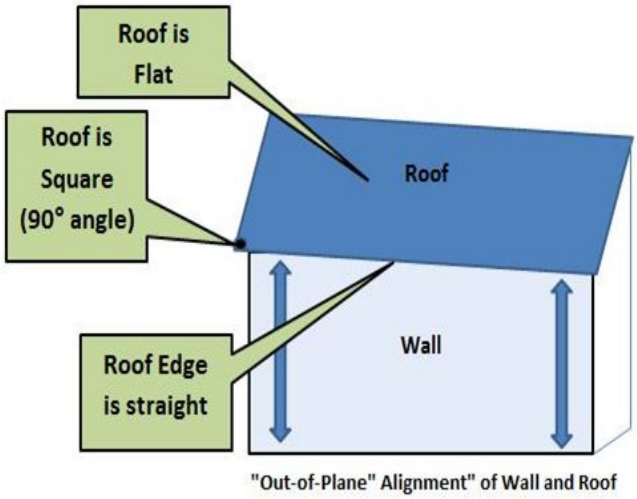


Figure 16-8
Incorrect Alignment of Roof and Wall

This misalignment can also occur at the intersection of different roof sections and transitions (Figure 16-9).

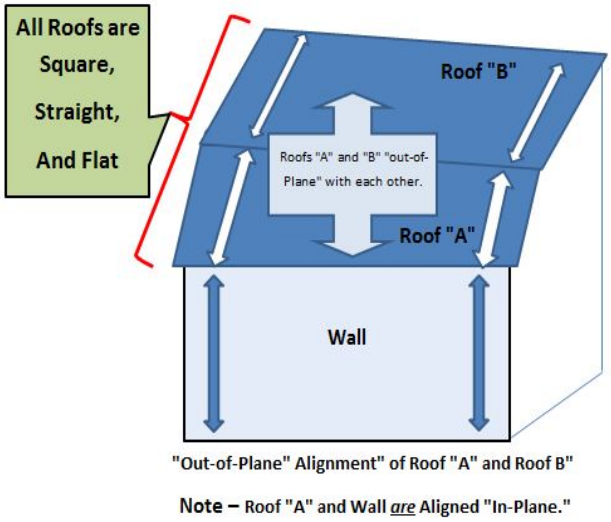


Figure 16-9
Incorrect Alignment of Roof Sections

When roof surfaces are not installed in the proper "in-plane" alignment, it will not only look "crooked" but also present performance issues. Gaps and voids are often created which will leak and weaken the roof.

16.2.3 Flatness

There is often confusion between the flatness and the straightness of an object. Both are important to the installer, and it is necessary for installed roof panels to be both straight *and* flat. A panel can be installed perfectly straight, and not be flat. Straightness deals with the edges of an object, while flatness deals with the wide, open surfaces of an object. This area of the panel is often referred to as the flat, or pan, section.

The metal roof problem of "oil-canning" is a direct result of panel surfaces which are not "flat." This specific issue, shown in Figure 16-10, is discussed in great detail in Section 10.8, *Oil Canning*.

Figure 16-10
Oil Canning Is a Flatness Related Issue

Alignment problems with other roof structure members can cause the roof panels not to lay flat. For example:

- Decking is not flat due to warped panels or misaligned seams.
- Purlins, roof joists, and supporting members are twisted, warped, or "pre-stressed."

Pre-cambered objects have a curve added to their profile which is designed to "flatten out" when supporting a predetermined load.

Pre-Cambered Roof Members

Traditional roof support members are often pre-cambered, but when used with metal roof systems, fail to "flatten out" due to the light weight of the metal roof material in comparison to traditional roofing material. This sometimes happens on a re-roofing application when the old roof (with pre-cambered support members) is removed prior to installing a new metal roof. This may also happen on a new installation if pre-cambered members are installed, and the final installed weight of the roof was not factored into the design considerations of the structural members. Depending on the style of the roof panel, this loss of flatness may be very visible, but not until *after* the roof panels are installed.

Pre-cambered structural members and similar causes are not specifically the installer's fault, and are out of the installer's control. When noticed, the situation should be brought to the attention of the appropriate authorities immediately.

Flatness will not make a panel leak; however, when a panel is not installed flat, it can create areas of standing water or direct runoff to areas not designed to handle the additional water. These areas may eventually leak.

Carelessness by the installer can cause a panel not to lay flat. Physical items like dirt and debris beneath the panel, excessive sealant, improper fastener type, or under-driven fasteners keep a panel from lying flat. Improper installation can also add panel stresses, twisting, or inhibit thermal movement, which will disrupt and distort the flatness of the panel.

These distortions can cause permanent damage and even puncture the panel if, for example, someone steps on material which was trapped beneath the panel.

16.3 Determining Direction and Sequence of Installation

The direction and sequence of panel installation may vary from installation to installation based on geographic factors such as prevailing wind direction; roof design factors like panel types, seams, and profiles; and structural characteristics, including building length and width.

The direction of installation will affect where the installation starts, as well as how materials are distributed on the ground or pre-loaded onto the roof structure.

Installation considerations like these are necessary in order to successfully schedule and integrate the various trades. On large projects, finish trades will often be engaged

inside the building before the roof is completely finished. Trades like electrical, pipefitting, framing, and drywall can commence in the dry interior, but management must know what area will be dry *first* in order to schedule such work.

As shown in Figure 16-11, not every metal roof installation is on a new construction project. Occasionally, roof tear-off is involved on renovation projects. Roof tear-off and re-roofing are usually done in stages to minimize the exposure of the building interior.

Figure 16-11
Re-Roofing of a Metal Roof Is Often Done in Stages

In such cases, it is vital to know and communicate the direction of the installation so that appropriate sections of roof are demolished in the proper sequence. Other re-roofing considerations are covered in Chapter 20, *Re-roofing*.

16.3.1 Prevailing Winds

Start applying panels vertically at the lower corner of the roof edge, *downwind* or away from the prevailing wind. This is done so that wind, rain, and snow blows *over*, not under, the side lap seam joints. This condition is illustrated in Figure 16-12.

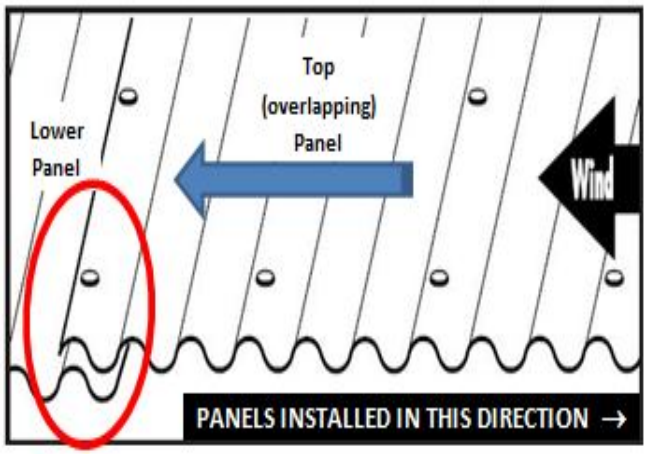


Figure 16-12
Desirable Panel Installation in the Proper Relationship to Prevailing Winds

Care should be exercised when installing these panels. Some panel types are reversible, while others must only be installed in one direction. Panel layout is important.

16.3.2 Panel Layout

The profile and seam layout of the metal roof panel may determine if it is to be installed left-to-right or vice versa. There are also panels having directionally applied coatings, which require them to be installed in the same way directionally, or color variations will be visible. The eave-to-ridge length of the roof also creates situations where an installer may be required to make changes during an installation. If a single roof panel reaches from eave to ridge, end lap joints are avoided and the installation normally proceeds from rake to rake. When the eave-to-ridge length requires more than a single panel, there may be a different installation pattern. Lap joints may need to be staggered and other alignment issues occur.

Proper planning of the panel layout can save material, time, and labor, as well as provide a more pleasing and higher performing roof covering. If the roof has penetrations it may be possible to start the first panel such as that a panel's rib does

not land at a penetration, valley, or dormer. Refer to section 16.4.3.2 Aesthetics of Alignment for further discussion and examples.

16.3.2.1 Single Panel Eave-to-Ridge

When the eave-to-ridge length of a roof can be covered by a single length panel, several factors and dimensional tolerances must be maintained by the installer. Panel straightness and flatness are critical, and must be within acceptable tolerances. Certain aesthetic considerations must be understood and planned out *prior* to the start of the installation. These issues are discussed and clarified for the installer in Section 16.4*, Maintaining Panel Modularity and Alignment*.

16.3.2.2 Multiple Panels Eave-to-Ridge

When the eave-to-ridge length of a roof requires more than a single length panel, additional factors and alignment tolerances must be maintained during the installation. In addition to the single length considerations, the alignment of the lapped panels must be maintained to avoid "Dog Legs" of the panels installed. These considerations are detailed and explained from the installer's perspective in Section 16.4, *Maintaining Panel Modularity and Alignment*.

When multiple tiers or rows of panels are installed, the manufacturer's installation directions and patterns should be followed. Note the difference in sequencing of the panels in Figure 16-13. Seldom can an entire row of panels be installed prior to installation of the higher, up-slope tier of panels.

Installer Safety Note

During some installations, temporary attachment of panels to the substructure may be necessary. Never step onto a roof panel which is not attached securely to the structure.

16.4 Maintaining Panel Modularity and Alignment

Panel modularity is the relationship of the installed roof panel to other installed roof panels, other roof structure members, and the structure the roof rests upon. This modularity has an impact on the strength and performance of the roof, as well as the aesthetic (appearance) factors of the finished installation.

Each of these considerations relates directly to the installation of the metal roof system. Improper attention to any of these issues by the installer may create problems.

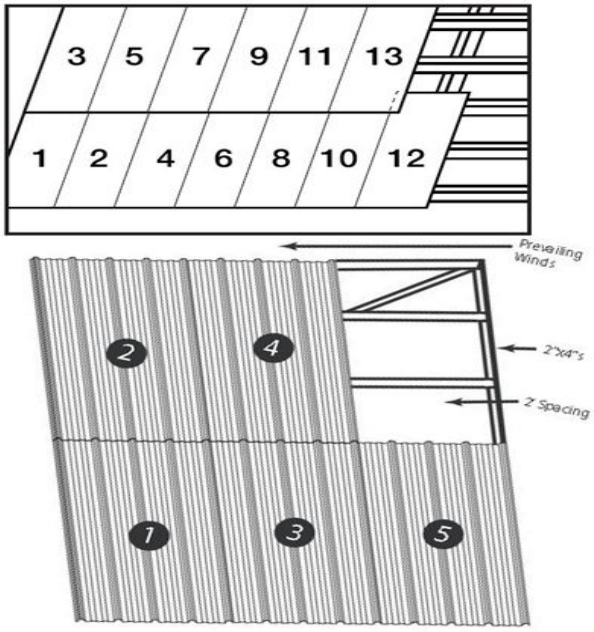


Figure 16-13
Not All Roof Panels Are Installed
in the Same Sequence

Some of the problems may appear during the installation, while others may not be

detected until long after the installation is complete. This section should be studied and understood in its entirety and applied, as it is appropriate to the roof system being installed at the time.

16.4.1 Starting Square to the Eave

Starting square to the eave impacts the performance and appearance of the finished roof. Starting the first panel square to the eave also establishes a baseline and reference for the remaining panels to be installed. When the first panel is not square, all remaining panels will also be out-of-square when attached. When this difference is significant, it will become visible, even to the untrained eye, as seen in Figure 16-14, and will cause problems at the eaves, ridges, peaks, and valleys, of the installation.

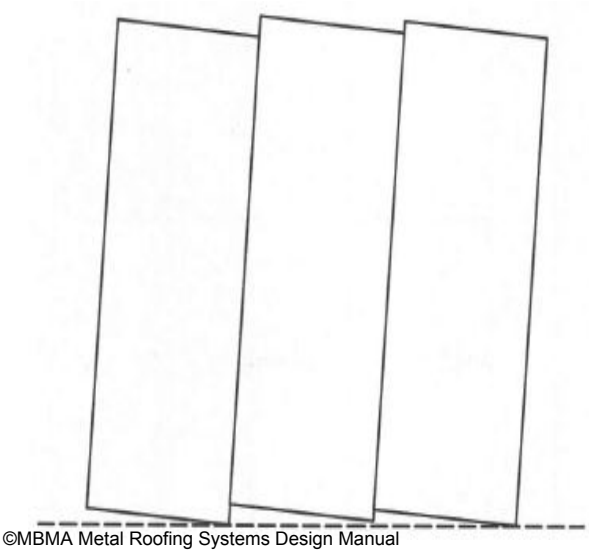


Figure 16-14
Improper Panel Alignment to Eave

Attempts to correct this issue after the installation is underway will likely cause sideseam and sealing issues, as well as an even more noticeably visual mismatch.

An easy and certain method to ensure a straight first panel is to use the 3-4-5 method prior to installing the panel. This method is explained in Section 16.2.1, *Squareness*. When this method is used with an out of square roof, the non-rake edge of the first panel now becomes the reference edge for checking squareness. This is illustrated in Figure 16-15.

16.4.2 How to Measure and Check During Installation

While the selection and design of a roof and its materials are done by others; the measurement and checking of the roof itself, its members, and conditions during the installation of the roof are performed by the installer. Some checks and measurements are only performed once, such as when the material arrives, while others are done perhaps hundreds of times, such as checking each clip or fastener as it is installed.

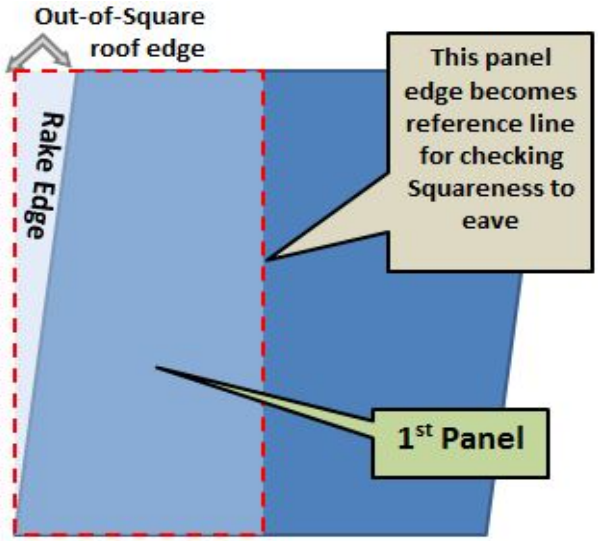


Figure 16-15
New Squareness Reference after 3-4-5 Method Is Used to Square First Panel

When checking and maintaining **squareness**, once a square edge has been verified (as explained in Section 16.2.1, *Squareness*), distances should be measured from, and compared to, this established reference. This new reference line is illustrated in Figure 16-15.

Installer Note
Measurement Tips

Variation between measuring tools is normal, and the acceptable tolerance is ± 1/16th of an inch. This means two different tapes can measure an object and each tape could be off by 1/16th of an inch. If this variation happens to be in opposite directions, the net result is an error of 1/8". To avoid this problem, always use the same tape when measuring the same dimensions. If someone else takes a reading to confirm a measurement, make sure they use the same tape which was used during the initial measurement.

Another factor for an installer to remember is that small errors grow over distance. If a 100 ft. long panel is off-square by 1/16th of an inch 10 feet from the eave, the overall error will grow to 5/8" at the ridge, 100 feet from the eave. Even if this error may not be visible, it will present installation problems.

Straightness can be measured and checked using the basic tools every tradesman carries: a hammer, chalk line and/or string, plus a nail or two. This procedure is illustrated in Figure 16-16. By tacking a nail at each corner, attaching a tight chalk line, or string, between the nails, any variation of the straightness of the roof edge can be detected, measured, and marked. It must be remembered that this surface, no matter how much variation is present, will still have to be covered by the roof system.

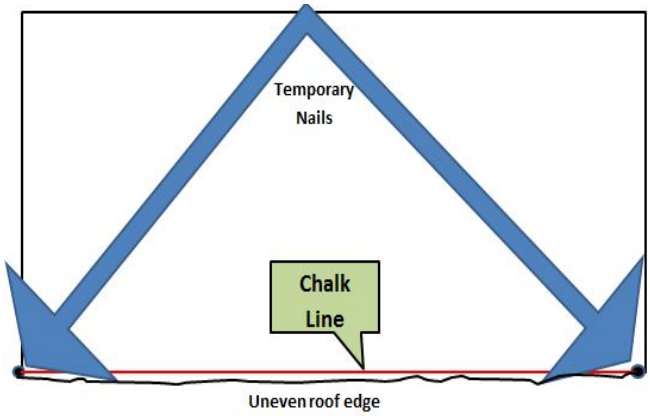


Figure 16-16
Checking the Straightness of an Edge

16.4.3 Results of Failures

During the roof installation, all areas of the roof system assembly must be frequently inspected to ensure the correct assembly in accordance with the erection drawings and the manufacturer's instructions. Failure to install the roof system correctly will result in roof performance problems that may require costly corrective work, roof replacement, and performance and damage claims, etc. Also, incorrect installation may void the performance and material warranties. Special attention should be given to the following areas.

16.4.3.1 Sawtoothing at Eave, End Laps, and Ridge

When panels are not installed square *to the roof edge*, normally the eave, sawtoothing of the panel edges will occur. This is illustrated in Figure 16-17 and will be problematic at the panel ends such as eaves, ridges, and end laps. If the panels are severely out-of-square, the roof will be visibly distracting also.

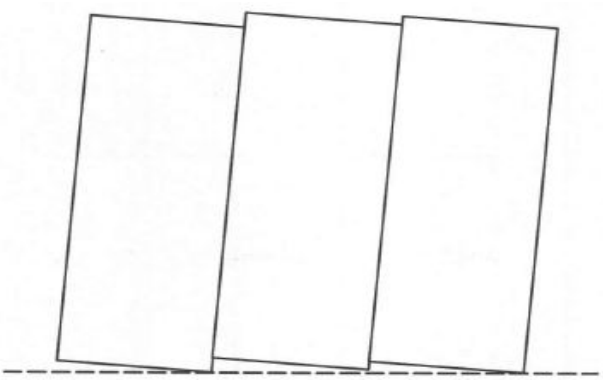


Figure 16-17
Sawtoothing of Roof Panels

A similar problem occurs when multi-tiered panels are installed and are not square *to each other*. This problem is called dog-legging and is illustrated in Figure 16-18.

The installer can eliminate or greatly reduce the risk of sawtoothing, or dog-legging, by making sure the first panel is square to the appropriate roof edge and aligned to panels of other tiers.

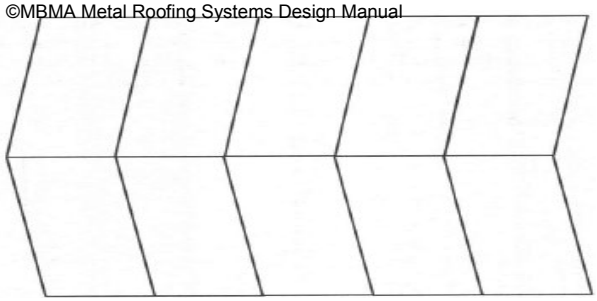


Figure 16-18
Dog-Legging of Multi-Tiered Roof Panels

16.4.3.2 Aesthetics of Alignment

Dimensional tolerances are discussed in Section 16.4.4, *Tolerances*, but the aesthetics, or visual aspect, of the roof installation also must be considered. In many metal roof installations, the finished appearance of the roof is nearly as important as the actual "performance" of the roof. Factors like color matching (Figure 16-19), and balance/alignment of seams and ribs to other roof features (Figure 16-20) may not affect the performance of the roof, but will impact the visual attractiveness of the finished installation.

Figure 16-19
Often the Visual Factors of a Roof Are as Important as the "Performance" Factors of the Roof

In other cases, installation alignment will affect both the visual appearance ***and*** the performance of the roof as seen in Figures 16-21 (roof jack over seams) and Figure 16-22 (blockage of runoff at roof jack).

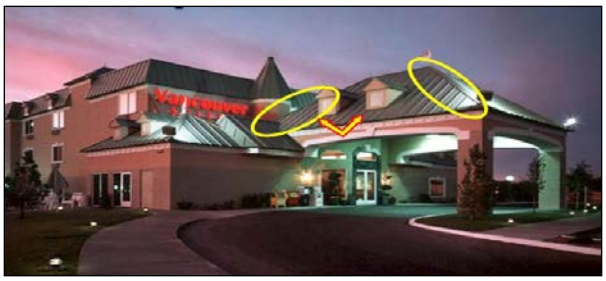


Figure 16-20
Roof Areas Where Visual Alignment and Balance are Critical

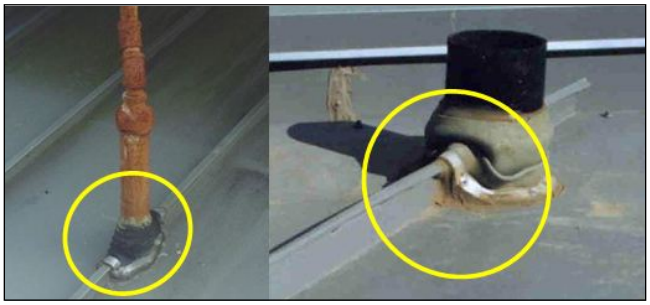


Figure 16-21
Poor Planning of Panel Installation
Creates Areas Prone to Leak and Also Looks Bad

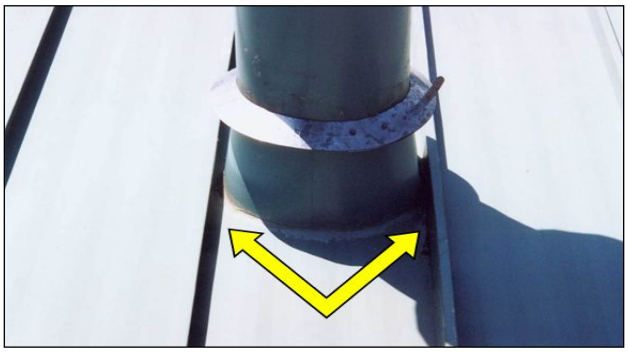


Figure 16-22
Poor Planning of Panel Installation
Creates Drainage Problems

Proper planning *before* installation begins will usually create workable solutions which are visually acceptable and maintain system performance. Examples of such solutions are shown in Figures 16-23 (proper roof jack installation), and 16-24 (clearances for roof runoff).

Figure 16-23
Proper Planning Avoids Roof
Jacks over Seam Joints

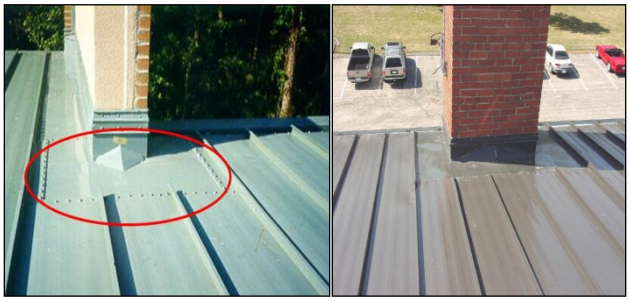


Figure 16-24
Proper Planning Allows Enough
Clearance for Runoff

While installing the roof panels, do ***not*** wait until the next-to-last panel to measure over to the finishing rake. Measure when the panel installation is still approximately 50 feet away from the end of the tier. Slightly adjust each panel module in order to hit at a panel seam. If this is not possible, a partial, field-bent panel may need to be formed as the last panel in the tier.

Layout and Symmetry Planning Installation Example

The following example demonstrates how to evaluate, plan, and layout panels on a roof in order to maintain symmetry and visual balance. Two solutions are given. It is important to note that the same amount of material is required for each solution, but the installation steps are quite different.

Example

A roof plan has a length of exactly 20 feet, from rake-to-rake, and the panel used has coverage of 18 inches. The roof will require 13 full panels, and one fractional panel (20 divided by 1.5 = 13.333 panels).

If the installation begins with a full panel at the starting rake (with seam at rake line), at the opposite end, the roof will have the last seam 6 inches from the roof edge (the 0.333 fractional panel). *This would cause a conspicuous visual imbalance in the aesthetic of the finished roof.*

If on the other hand, a partial panel is used at the starting rake, with the first panel 12 inches in width, at the finish end the same dimension (12 inches) will result, and the panel installation is symmetrical. To the eye, it is balanced.

There are two ways to accomplish this symmetry when laying out a job. One method is to locate *a seam* at the centerline of the roof. The other is to locate *the centerline of a panel* on the centerline of the roof.

Given the same example, the first method (seam at centerline) will result in a 12-inch dimension at each rake as mentioned above. The second method (centerline of panel on centerline of roof) will result with a 2-inch dimension at each rake instead. (Remember the coverage width of the panel is 18 inches in the example)

After evaluating this information, the decision can be made as to which method to use. That decision may be based, at least in part, on details of the rake termination, the rake flashing profile, and so on.

The same rules of symmetry may apply in other ways. Suppose, for example, that a roof has two dormers in its plane. The same kind of balance would be desired between and adjacent to those visual registration points. It might also be based upon the location of skylights, roof jacks, and accessories, and where the seams fall relative to these items.

In either case, the job requires the same amount of material. In the latter example, a portion of a panel is used on the start rake, and its off-fall is retained for installation at the finishing rake.

Often, symmetry in one area must be compromised to achieve it elsewhere, and sometimes this symmetry is more important than others. If the roof in the example (above) was 200 feet in length rather than 20 feet, symmetry would be much less important, because the two rakes do not register visually at the same time on such a long geometry. Because some discretion is necessary in this area, the installer will normally use shop drawings which show these layouts. Such drawings are normally submitted to the project architect who then approves or rejects them.

16.4.3.3 Finish Rake Issue

- ✓ Check that the proper termination trim is correctly assembled with the splices oriented for downhill watershed. If there are roof panel endlaps, check that the endlap sealant marries the termination trim sealant, or that a pigtail of sealant is applied for that purpose.
- ✓ Check that the sealant is in the correct position above and below the roof panel.
- ✓ Check that the termination trim sets fully on the sealant, and that the sealant is in complete contact with the roof panel and the trim without any voids or gaps. Confirm that the roof panel and trim pieces are clean and dry during installation, and that the sealant was not wet or contaminated.
- ✓ Check that the termination fasteners penetrate the center of the sealant and into the rake.
- ✓ Check that the fasteners are not loose or stripped, and immediately replace any fasteners in question.

16.4.3.4 Thermal Movement Issues

Most thermal movement issues are created during the initial installation of the roof system. The two most common causes of thermal problems are double-pinning of the roof panels, such as fastening at both the eave and ridge ends of a panel, and issues

causing panel clips to bind and not adjust to the thermal movement of the panel. An installer should:

- ✓ Check the panel fastening method being used. Confirm that it matches the erection drawing, or manufacturer's instructions, and that all installation team members are familiar with the requirements.

- ✓ Confirm that installation of any accessory or modification does not create a double-pinning situation, as shown in Figure 16-25.

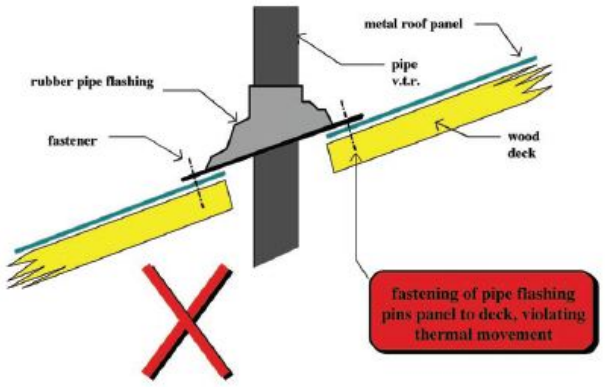


Figure 16-25
Accessories Can Accidently Add Thermal Movement Problems Due to Double Pinning

- ✓ Check and confirm sealant requirements around any clips. Make sure that fasteners designed for thermal movement (Figure 16-26) are not damaged and freely move as designed.

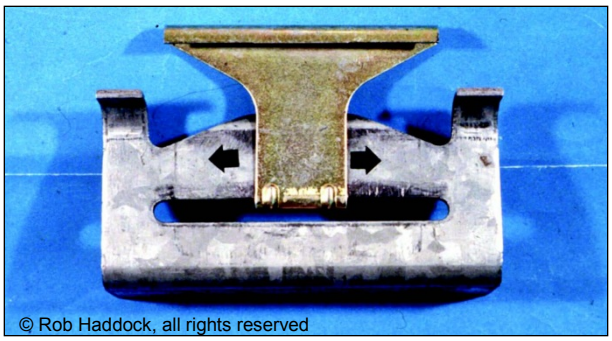


Figure 16-26
Clips Must Allow for Thermal Movement after Installation

Some thermal issues, especially those involving double-pinning, are created by other trades during the performance of *their* required work. When this work is done at the same time as the roof installation, it will benefit the installer to do a quick assessment of any work which appears to jeopardize the integrity of the roof system, and report it to the proper authority for further action.

There is little an installer can do, however, when the work by other trades is performed after the roofing team has left the job. Attention to *all* work being performed on the roof, during an installation, can be very beneficial.

16.4.3.5 Sealant Issues at End Laps, Eaves, and Ridges

Sealant issues at the panel ends, whether at the eaves, ridges, or over-lapping another tier of panels, should be checked and corrected as each panel is installed. Correcting any errors later is difficult and will not perform as well as a proper initial installation.

End Lap Seals

Proper sealing of end laps is necessary to avoid water being driven "upslope" or where lapped joints may experience periods of standing water or become submerged.

- ✓ Check that the roof panel endlaps are correctly assembled and that the lapping panels are tightly nested without visible gaps.

- ✓ Check that the sealant is in the correct position and is in complete contact with the lapped panels without any voids or gaps, especially at any radius between the panel flat and the vertical legs of the panel. Confirm that the panels are clean and dry during installation, and that the sealant is not wet or otherwise contaminated.

- ✓ Check that the pigtail of sealant is in the correct position and seals any endlap seam notches.
- ✓ Check that all endlap fasteners, if used, penetrate through the *center* of the sealant and are properly secured. Immediately replace any fasteners in question.
- ✓ Check that panel surfaces above and below the endlap are not bowed. Depressed panel areas may create ponding and standing water.

Eave Seals

Proper sealing of the eave area of the roof is critical for several reasons. First, it is the lowest point on the roof and must handle any runoff from the upslope portions of the roof. Secondly, it is the portion of the roof which often interfaces with the gutter or drainage system of the roof. Thirdly, and related to the other two reasons, is that this area often floods and becomes submerged if the gutter system clogs, ice dams occur, or periods of high precipitation take place.

- ✓ Check that the eave sealant is in the correct position on top of the eave trim, and that any eave pigtail sealants are correctly placed.
- ✓ Check that the eave fasteners penetrate the center of the eave sealant and into the eave plate.
- ✓ Check that the fasteners are not loose or stripped. Immediately replace any fasteners in question.
- ✓ Check that the eave sealant and any closures are in complete contact with the roof panel and eave trim without any voids or gaps. Confirm that the roof panel and eave trim are clean and dry during installation, and that the sealant is not wet or otherwise contaminated.

Ridge Seals

Even though the ridge is the highest point of the roof, proper sealing of this area is critical. Any leakage at the ridge will drip or run under the installed roof system, or into portions of the structure which are to be protected.

- ✓ Check that all end dams, and closures are correctly assembled.
- ✓ Check that the sealant is in the correct position and is in complete contact with end dam, closures, and the roof panel; without any voids or gaps. Confirm that all surfaces are clean and dry during installation and the sealant is not wet or contaminated.
- ✓ Check that all end dam fasteners penetrate through the center of the sealant and securely fasten.
- ✓ Check that the fasteners are not loose or stripped, and immediately replace any in question.
- ✓ Check that sealant is installed along the back of the end dam, or closure, as necessary to seal any voids around the panel seam area.

16.4.4 Tolerances

Note: Indented paragraphs in this section are reprinted with permission from the MBMA Metal Roofing Systems Design Manual).

Tolerances allow us to answer the questions:

"How good is good enough?"

"How close does it have to be?"

and

"What is acceptable?"

Variation is present in everything, from the manufacturing of the panels, to the

application of sealant, and installation of the fasteners. A tolerance states an acceptable amount of variation from the desired target. For example, if a piece of trim should be 12" long; is 11-15/16" acceptable? How about 11-1/2" or 12-1/8"? The acceptable difference from the desired 12" is known as the tolerance. It is understood that as long as an object is "within tolerance," the variation does not affect the expected appearance or performance of the object.

As common roof tolerances are explained in this section, understand that these tolerances may vary based on the type of roof system, panel connection styles, and other design considerations. Always refer to the manufacturer's tolerances, or those on the construction drawings for the job being installed as the "final authority" on tolerances.

Fanning

Metal roof panels have two width dimensions which are very important to an installer: the actual width of the panel and the "coverage width." Most metal roof panels have a tendency to either gain or lose some of their covering dimension during installation. This variation is called "fanning" and is illustrated in Figure 16-27. The installer must monitor and control this aspect of the panel installation.

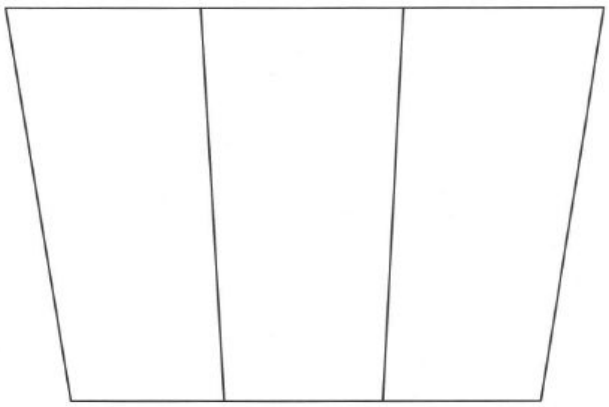


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Figure 16-27
Fanning of Panel Width During Installation

There is no assurance, other than the care of the installer, that a panel will cover its intended dimension. Most panels tend to gain dimension, not lose it.

However, over certain roof deck material, most notably rigid board insulation, the reverse may be true. If not controlled, it is not unusual to see panels gain (or lose) as much as 1/4" each (e.g. the panel is intended to cover 24", but covers 24-1/4"). Such an error can cause a myriad of problems at panel interfaces, especially when the error accumulates.

Such installation errors can result in rib separation at the eave, creating gaps and voids in critical seam-end sealants. When this happens on trapezoidal rib profiles, closure components will not fit properly at the eave and may create sealant gaps and voids at the closure interface.

For example, most ridge or expansion joint details involve closure components of pre-manufactured dimensions. The proper fit of such components is critical to the weather integrity of the finished roof. Mislaid panels which do not match with the dimensions of these components will cause the closures to either not fit at all, or leave gaps and other alignment problems in the interface.

Oftentimes, when a roof involves pre-manufactured equipment curbs, they have inside or outside closure components integrally welded into the curb walls or flanges.

If the coverage width of the installed panels is not held to tolerance, then proper fit at critical curb areas is also not possible.

Finally, off-module installation will usually result in seam alignment problems, since the error in installation module is rarely consistent at both the upslope and down-slope ends of the panel(s), as well as interfaces at walls and other terminations.

It is vital and incumbent upon the installer to maintain the proper panel dimension when installed, and there is help available to prevent fanning during installation. Many manufacturers offer "spacer" tools, or "module makers" as they are sometimes called, to help control the coverage dimension during installation. An example of such a tool is shown in Figure 16-28.

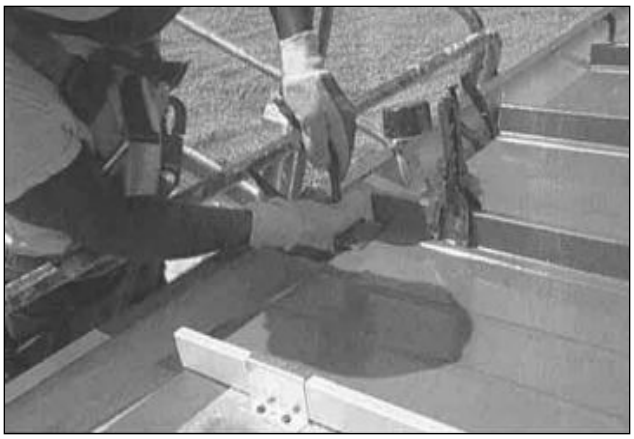

Figure 16-28
Spacer Tools Help Hold Panel Module

Such tools can also be fashioned by the contractor from simple and readily available materials. The best such tools are adjustable so that the installer can intentionally "stretch" or "shrink" a panel at will. This facilitates a recovery from installation error, should one occur.

Acceptable Tolerances

As mentioned earlier, some installation tolerances are product or system specific, and must be provided by the individual product manufacturer. Such data will supersede the tolerances within this section.

The following information is sufficient for general reference purposes, and where the manufacturer's proprietary practices and instructions do not conflict.

Most vertical rib panel profiles will tolerate an installed coverage width error of +1/16" (from true) individually without difficulty. ("A" in Figure 16-29)

Most trapezoidal panels will tolerate an installed coverage width error of +3/32". ("A" in Figure 16-29)

Trapezoidal standing seam panels are particularly susceptible to spreading or shrinking depending on where the worker is standing when putting down the clips. If the upslope worker is standing on the panel and the eave worker is not, then the panel may spread more at one end than at the other end causing accumulating problems. Spacer tools are critical when installing this type of panel.

Accumulated error in panel coverage for either profile, however, should not exceed +1:500. In the case of fanning,
(Figure 16-29, left and center) the total deviation from true between the plus and minus dimensions should not exceed 1/500 of L (L=Length). That is to say that combined errors A and B (Refer to Figure 16-29, center) when added together should not total more than 1/500 of L (L=Length).

In the case of dog-legs, all combined errors A, B, and C when added should not total more than 1/500 of L (L=Length). (Refer to Figure 16-29, right)

While any error within these tolerances is generally not cause for rejection, there may be exceptions:

- If for some reason the error compromises weather integrity, or threatens to do so, it may be deemed unacceptable.

- If the error interferes with some critical roof layout detail, such as the exact placement of an expansion joint, or critical location of mechanical equipment, roof penetration, or similar scenario, it may be deemed unacceptable.

If the roof is steep-sloped, or is used in a highly visible, architectural presentation, then other tolerance restrictions may be given. Further consideration is given in Section 16.4.3.2, *Aesthetics of Alignment*.

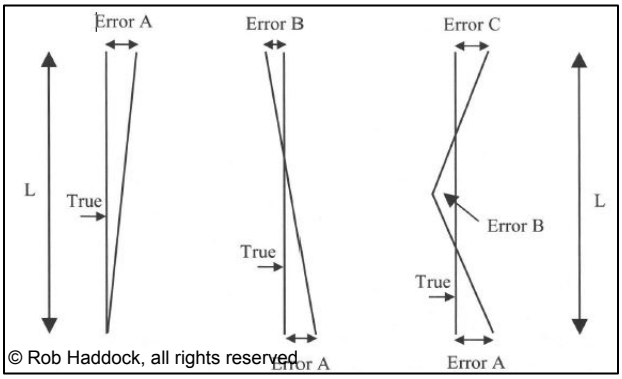

Figure 16-29
Reference for Allowable Tolerances

16.5 Field Operations

Not all roof installation work is done on the roof surface itself. One operation often performed on the ground at the job site is the brake forming of certain panels, related trim, and other roof components. The brake, as show in Figure 16-30, is detailed in Section 12.8, *Brake*.

Figure 16-30
On-Site Brake Forming of Roof Material

16.5.1 Field Cutting of Panels and Trim

Every installation will require some trimming and cutting of panel and trim pieces. Failure to properly cut metal roof materials can jeopardize both the appearance and performance of a roof system.

A few rules when field cutting sheet metal should be followed. First, abrasive or other blades which heat the metal and create heavy burrs should be avoided. This is particularly true when cutting coated steel. Such cutting operations exceed the melting temperature of the metallic coating, and melt it away from the cut edge, causing a corrosion site. The effects of abrasively cutting panels, premature corrosion, and rusting, can be seen in Figure 16-31.

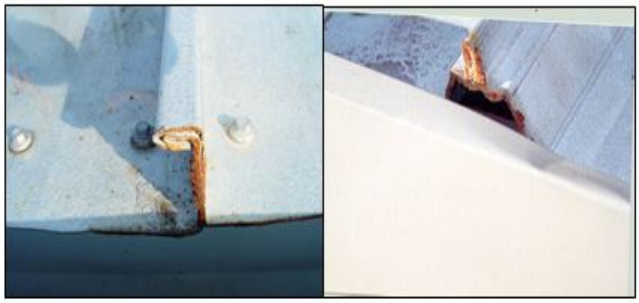

Figure 16-31
Premature Corrosion and Rust Due to
Abrasive Cutting of the Panel

When cutting panels, a lot of steel bits, commonly referred to as swarf, gets scattered and thrown onto adjacent surfaces. If not thoroughly and promptly cleaned up and removed, this swarf will cause potential corrosion or heavy staining as shown in Figure 16-32.

Electric circular saws have typically been eliminated from use. Currently, new circular saw blade products have emerged on the markets which claim no damage to metallic coatings. If in fact such claims *are* validated, these special saw blades may be deemed acceptable to use, but the installer should remain suspect.

Figure 16-32
Failure to Remove Cutting Debris (Swarf) Quickly Causes Panel Corrosion and Rust

Approved methods of cutting include aviation snips, sheet metal hand shears, electric sheet metal shears, and pneumatic or electric nibblers. Most of these tools will be discussed in more detail in Chapter 12, *Tools and Field Operations*. Properly using these tools will deliver the cleanest cuts, cause the least damage, and leave a minimal burr.

Plan the installation

When possible, locate the field cut away from the weather. For instance, if a roof panel has to be trimmed to length, trim the top of the panel, where the cut will be hidden from the weather with a ridge flashing. This is shown in Figure 16-33. When it is necessary to cut an eave flashing to length, put the field cut end ***beneath*** the factory cut end of the adjacent section.

Figure 16-33
Properly Cut Panel End Protected by Ridge Cap

In some cases, the cutting tools described above will not be adequate or practical. An example of this happens after panels are installed and it becomes necessary to cut through multiple layers of sheet metal in the area of a folded seam. In such instances, a hack saw or reciprocating saw is preferred.

However, an abrasive saw or plasma-arc ***may*** be used in such an area under the following carefully controlled circumstances:

1. The nature of the cut must be such that it will be permanently protected from the weather (for instance beneath a curb flange)

2. Adjacent materials and surfaces must be protected from hot sparks and shrapnel (swarf) during the cutting procedure.

16.5.2 Brake Forming

Sometimes, it is necessary to bend metal panel, trim, and flashing material on the job using equipment such as a portable brake. Here's how to do this task:

- Mark and set the metal squarely into the jaws of the brake.
- Clamp the jaws down using the jaw-lock handle.
- Pull the folding handle using even pressure until the metal is at the desired angle.
- Release the jaw-lock handle and carefully remove the formed piece.

While not difficult, brake operation does require practice and attention to details. New employees, and those unfamiliar with the brake, should receive proper training before attempting to form materials. Using scrap as practice material provides a cost effective and convenient practice opportunity.

Similar forming tools such as hand-folding brakes and tongs are used in a similar way.

Summary

Panel installation is arguably the most noticeable activity in the roof installation process. It is also a key activity, and correct panel installation is essential to the proper look, performance, and long life of any roof.

It does require the use of tools and other on-site activities that will affect this activity. In order to correctly install any panel, an installer must also be familiar with the material in the following chapters:

- Chapter 9, *Safety Issues*
- Chapter 11, *Delivery, Receipt, Storage, and Handling of Materials*
- Chapter 12, *Tools and Field Operations*
- Chapter 13, *Sealants*
- Chapter 14, *Fasteners*
- Chapter 15, *Seam Joining*

Notes: