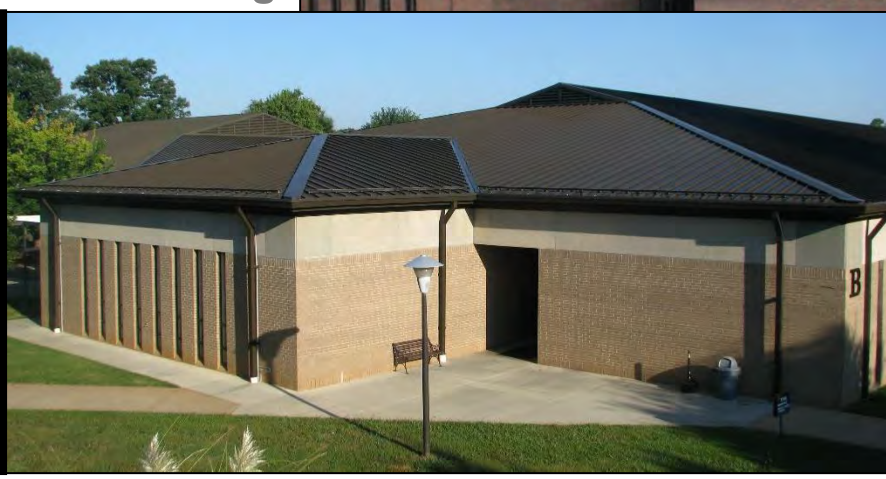
RETROFIT METAL ROOFING

METAL-OVER-FLAT ROOFS

Before & During



After

- Market History
- Fundamentals
- Applications
- Framing Systems
- Assembly Details
- Metal Roofing Systems
- Energy Savings

Metal-over-Metal Roofs

- Fundamentals
- Applications
- Assembly Details

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BUILD LEGACIES METAL

CHAPTER 1

Introduction to Retrofit Roofing

Metal roof systems continue to gain in popularity and are frequently installed to replace or reroof over the top of traditional and conventional roofing systems. It is more important than ever for building owners/managers, design professionals and contractors to understand how these systems work and what are the advantages and benefits in comparison to other methods of re-roofing.

Photo 1-1 Metal-over-Flat Concrete Roof System (Courtesy of McElroy Metal)

Based on recent FMI Management Consultants studies, the metal construction industry continues to gain in roofing market share each year. This is largely due to inherent life service benefits, long-lasting coatings, and high-performance metal roof systems. Some metal roofs are showing service life expectations of 60-plus years based on third-party independent research conducted on behalf of the Metal Construction Association (MCA). (Service Life Assessment of Low-Slope Unpainted 55% Al-Zn Coated Steel Standing Seam Metal Roof Systems", published 10/2018.) In addition, reroofing with metal makes even more sense with the current focus on energy savings through efficiency upgrades and the use of renewable energy technologies in the building envelope. Chapter 3 includes detailed information from Oak Ridge National Laboratories research started in 2005 on dynamic and convective ventilation incorporated into re-roofing assemblies. Illustrations on what is called the "Next Generation of Metal Roofing" have also been included to show where fully-integrated solar hot air and water as well as power generation photovoltaic equipment are being incorporated into new metal roof systems.

Retrofit metal framing systems have been successfully used on existing conventionally constructed buildings since the early 1980's. These systems, called "sloped build-up systems", offer design professionals a multitude of options ranging from low-slope functional systems for discharge or diversion of roof rainwater to steep-slope architectural applications. Retrofit metal roofing represents an economical and functional solution for building owners who want to beautify an existing structure.

Photo 1-2 Metal-over-Flat Roof System (Courtesy of MeElroy Metals)

Design professionals may also employ steeper slopes and use metal roof panels in an attractive array of colors. Finishing touches, hips, valleys, dormers, and other architectural concepts can be created through the use of metal. By adding insulation and installing properly designed ventilation accessories, the retrofit concept is an excellent remedy for energy inefficiencies in older buildings and helps to update performance to the levels required by the U.S. energy policy. In addition (and little known to most), retrofit systems are often employed to correct existing roof geometry with problematic roof drainage. Systems can be designed to remove unwanted conditions found in many older buildings that have facility additions or are undergoing expansion programs that present weather-tight concerns. The sloped build-up systems are discussed in full detail in Chapters 4 and 5.

Photo 1-3 Metal-over-Metal Retrofit System (Courtesy Roof Hugger, LLC

In addition to the sloped build-up systems is a system type of retrofitting referred to as “Metal-over-Metal” retrofit. These systems address aging metal roofs that have exceeded the expected service life. Metal-over-Metal retrofit systems typically include a low-profile (depth of overall assembly) structural sub-framing and in many cases allows a new metal roof to be installed over the existing roof without removal. This type of retrofit is discussed in general in Chapters 6. Some typical construction details have been provided, but please note that installation details may vary widely by manufacturer.

It is important to note that due to the varying differences in performance-based specifications of both retrofit systems identified herewith, this guide refers the reader to those provided by MCA member manufacturers referenced in Chapter 9.

For Architects wishing to learn more about retrofit systems and to obtain CEU credit, visit The Continuing Education website of Architectural Record. This program, as well as many other metal construction related AIA courses, are sponsored by the MCA. If interested in taking the retrofit course, visit this link: “The Metal Retrofit Revolution”.

CHAPTER 2

General Information

This Chapter provides a brief history of retrofit roofing as it that relates to the metal construction industry as well as other information that will be helpful when investigating the feasibility of any retrofit project.

Retrofit Market History

The retrofit market has roots going back to late 1970, when a prominent pre-engineered building manufacturer published the first known technical product manual. The product manual illustrated typical light-gauge cold-formed steel components used to make up retrofit framing assemblies. All of the components were standard members used in the manufacturer's metal building product offering. The assemblies were principally designed for low-slope applications for both thru-fastened and standing seam metal roof systems. Before this recognized product manual, retrofitting an existing building roof was accomplished by using dimensional yard lumber, structural steel sections and some light-gauge members combined to create a jobsite-built system. Many of the projects paid little attention to building codes, design load compliance and adherence to good engineering principles. In retrospect, many of the systems installed did not transfer design loads in accordance with the original intent of the existing building structural system. **Transferring loads is the most important requirement in the design of a retrofit framing system.** Not doing so will subject the building roof to a potential failure or possible collapse.

Overview

This Chapter outlines the various tests used to show performance levels for metal roof systems that are then compared to the required performance defined in the building codes. This chapter will also identify industry defined terms and the roles and responsibilities of the parties involved in metal roof system projects. *Information is generic in nature. Specific roles and responsibilities may vary based on the particular job and negotiated contracts between the parties.*

The current design practice for roofing retrofit work is to utilize cold-formed framing members in cee, zee, channel, and angle-shapes to create slope-framed systems. These systems are also known as slope conversions which support new metal roof systems. These slope conversion systems have a multitude of applications as referenced elsewhere in this manual and are effectively designed to satisfy and comply with the original design intent of an existing building's structural support system.

Existing buildings with flat roofs are subject to ponding water. Consequently, flat roofs have the potential for above-normal moisture gain and possible water infiltration. Flat roofs also have a design considered to be hydrostatic (watertight) and their inability to shed rainwater to the building's outer perimeter may result in a broad range of performance issues. Retrofit metal roof systems most often employ both hydrokinetic (water-shedding) and hydrostatic roof systems depending upon the roof slope. Retrofit metal roof systems are designed to discharge rainwater quickly making them subject to fewer performance issues than a traditional flat roof system.

Of course, the feasibility of any construction project is subject to the building owner's needs and the tasks to be achieved or satisfied. In many roofing situations where retrofit is being considered, the building owner is experiencing roof leaks and, in many cases, several attempts have already been made to eliminate these leaks. In fact, the building owners may have spent enormous amounts of money over the years on constant repair and maintenance trying to address this issue. In some cases, the owners may have already gone to the extreme of a complete tear-off and replacement of the weathering surface and membrane of the roof only to experience a continuation of problems with water infiltration.

Building owners interested in retrofit, typically intend to occupy the building for many years or update the building's appearance for resale. The assurance that a metal roof system provides in long-term performance and weathertightness reliability can be overshadowed by the initial cost of retrofitting. In these situations, the following topics should be discussed as methods to reduce the cost of the retrofit option and/or to amortize the investment over an extended life cycle of the various re-roofing alternatives.

1. If the intent of retrofitting is strictly to shed water from an existing flat roof, a minimal slope framing and a functional standing seam metal roof system should be considered. These low-profile systems reduce the framing material and installation labor and may prevent rework or relocation of existing rooftop equipment.
2. Regardless of the reason for retrofitting, adding fiberglass blanket or loose-filled blown-in insulation onto the existing roof can increase the building's overall energy efficiency. This minimal investment will pay back the owner in reduced energy costs for years to come, offsetting the cost of the retrofit option. Benefits are largely dependent on whether the building is temperature controlled and its occupancy or use.
3. If a building owner is facing a tear-off and replacement to install a new conventional re-roofing system, evaluate the effect of lost time during construction on business operations and/or production. The cost associated with the loss of production/relocation of business operations within the building to another site should be added to the conventional re-roof option.
4. Building owners that are in an existing building with metal roofing have the ability to install a new high-performance metal roof system without removing the existing roof. This option is discussed in Chapter 7.

Other Reasons to Retrofit

Leaky flat roofs and conventional membrane issues are not always the major drivers behind retrofitting an existing roof assembly. Other reasons may abound to create the need and the building owner, with the help of a design professional, can design the project to reap all benefits that retrofit has to offer. These scenarios include:

1. When a building owner is most interested in enhancing curb appeal and architectural appearance, retrofitting with a high-slope system can present many other options into the conceptual picture. High-slope metal roof

systems are available in a multitude of styles and color options. For example, if an older building has been purchased and the new owner wants to upgrade its appearance and increase its monetary value or marketability, a high-slope system is always a good option.

2. Many design professionals have used light-gauge retrofit framing for its economic benefits to construct roof systems over new construction. This application is common when a building is being constructed with structural concrete and the retrofit framing is installed over an "attic" deck/slab. The framing system can be designed to accommodate the installation of electrical/mechanical equipment, ductwork, and, in some cases, provide code-approved attic storage.

3. Many facilities have undergone building expansions that create problematic conditions such as multi-gable or other valley gutter conditions. Retrofit systems offer a sound solution for these detrimental conditions. Figure 2-A illustrates a common condition found in pre-engineered building facilities. Figure 2-B can be applicable to existing conditions or issues caused when a new building is constructed adjacent to an existing building.

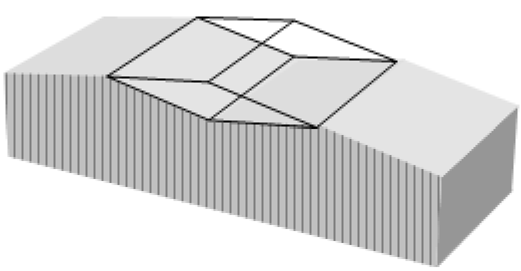

Figure 2-A

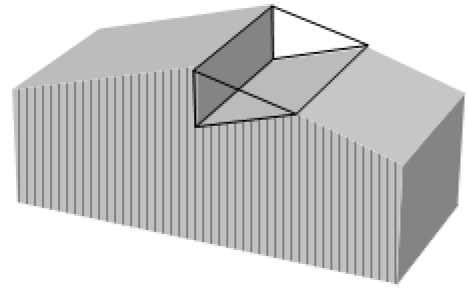

Figure 2-B

Product Testing Descriptions

Design professionals and contractors must have a solid understanding of the specific requirements involved in required metal roof system testing procedures. These tests are conducted to establish product performance values and should not be used as specified independent design load criteria for a metal roof system project.

Underwriters Laboratories (UL-90 Uplift Rating)

This wind uplift resistance test (UL580 test protocol) has become an industry standard to determine the insurability of a roof assembly. Test panel specimens are placed onto a 10' x 10' test chamber and fastened to the tested substrate. The test procedure involves load cycling for a sustained period of 5 minutes at a maximum uplift pressure of 105 pounds per square foot (PSF). Successful completion of this procedure allows an assembly to be classified as a UL-90 rating. Because specimens are not tested to failure and are not similar to an actual roof assembly, test ratings and assemblies should not be used for design purposes. Other ratings exist such as UL-30, UL-60, and UL-120.

Factory Mutual (FM Standard 4471-Class 1 Roof Panels)

This series of tests includes combustibility, wind uplift, foot traffic, hail, and water leakage resistance.

Factory Mutual is a private enterprise that provides testing and approval of various products and assemblies which meet established performance criteria and manufacturer quality control procedures. The wind uplift test involves exposure to wind loads in the field area of the panel (interior) and securement requirements for corner, perimeter, and appropriate roof peaks. The securement requirements are generally higher than the load acting in the field area of the roof. Specimens (12' x 24') are tested to failure based on minimum design pressures. Ratings are 1-60, 1-90, 1-120, 1-150, and 1-180 with the numeric value being equal to the minimum uplift pressure the specimen is subjected to for 1 minute.

American Society for Testing Materials (ASTM E1592 Uplift)

This metal roofing uplift test simulates field conditions because of the large test chamber. The test chamber is usually at least five panels wide by a length adequate to test multiple purlin spacing (usually 25'). Air pressure is applied, and deflections are recorded so the test results can be used for design purposes, unlike UL uplift test results. Because the specimen is tested to failure, this standard test is required for standing seam roof systems for US Army Corps of Engineers projects.

American Society for Testing Materials (ASTM E283 Air Infiltration)

A standard static air infiltration test using an airtight test chamber assembly in the form of a large box. The panel test specimen constitutes one side of the box. Air is forced into, or exhausted from, the test chamber producing a pressure differential across the specimen. The amount of air passing through the test specimen is measured in cubic feet per minute (CFM). (ASTM E1680, is the air infiltration and exfiltration test designed specifically for metal roof systems.)

American Society for Testing Materials (ASTM E331 Water Penetration)

A standard static water penetration test. The test chamber is identical to that used for air infiltration testing. Differential pressures are applied for 15 minutes while spraying water uniformly over the exterior surfaces of the test specimen. The passing requirement for ASTM E331 is that there be no evidence of any "uncontrollable leakage" during the test. (ASTM E1646, a new standard, is the water penetration test designed specifically for metal roof systems.)

Industry Terminology and Party Roles [1]

The metal roofing industry has certain practices and terminology relating to the design, manufacture, and installation of its products. The following descriptions are provided to clarify the responsibilities of each party involved in a project and their specific roles. Also included are definitions of the documents involved in the construction process and their significance

Manufacturer

A party that fabricates, and may actually participate in the design of, materials included in the metal roof system in accordance with the order documents. A manufacturer's responsibility includes:

[1] (TERMINOLOGY ADOPTED FROM *METAL ROOFING SYSTEMS DESIGN MANUAL* (PUBLISHED BY THE METAL BUILDING MANUFACTURERS ASSOCIATION)

1. It is the manufacturer's responsibility, through the manufacturer's engineer, to design a metal roofing system to meet the design criteria used by the roofing contractor in the order documents.
2. The manufacturer is not responsible for making an independent determination of local codes or other requirements not part of the order documents.
3. The manufacturer is responsible only for the structural design of the metal roofing system it supplies to the roofing contractor. The manufacturer or manufacturer's engineer is not the design professional or "engineer of record" for the construction project. The manufacturer is not responsible for the design of any components or materials not supplied by its interface and connection with the metal roofing system.
4. When specified by the order documents, the manufacturer is responsible for supplying adequate evidence of compliance with the specifications, design criteria, design loads, and other specified information necessary for the roofing contractor or design professional to incorporate the metal roofing system into the construction project.

Bid Documents

Documentation, prepared by a design professional, which defines the scope and magnitude of the work at the planning stage. Bid documents include, but are not limited to, project plans and specifications. In the event of a discrepancy in the bid documents, the specifications will govern unless otherwise qualified in the manufacturer's proposal. When specifications do not exist, and project plans do not provide adequate information for interpretation, the manufacturer's proposal will govern. In the event of a discrepancy between annotated dimensions and scaled dimensions, the annotated dimensions govern.

Contract Documents

Contract documents define the material and scope of work to be provided by the general contractor (or the roofing contractor, if acting in this capacity) for a construction project. The contract documents consist of the written agreement defining the scope of work, contract price, schedule, performance requirements and other relevant terms of the agreement. Project drawings completed by the design professional and project specifications will typically be included in the contract documents.

Construction Project

The construction project includes all material and work necessary for the completion of a finished structure ready for occupancy by the end customer. Items included as part of the construction project could include, but are not limited to, site preparation, foundations, mechanical, electrical work, general construction, and finish work. When retrofitting of an existing building, the finished structure shall include only the metal roofing system and any alterations included in the scope of the manufacturer's proposal and order documents. Supply and installation of the metal roof system are generally both elements of the construction project.

Design Professional

The design professional is an architect, engineer, or roof consultant (legally qualified to perform professional design services) retained by the end customer, general contractor, or roofing contractor to assist in the preparation of design specifications and/or drawings for the project. When included in the contract, the design professional will assist in supervising the construction process for compliance with the contract documents. The responsibilities and rights of the design professional and the end customer are defined in a separate agreement for professional services between the parties.

Design Responsibility

It is the responsibility of the design professional to specify the design criteria for the metal roofing system to be used by the roofing contractor and manufacturer, including all applicable design loads. When the end customer does not retain a design professional, it is the responsibility of the end customer to specify the design criteria to be used for the metal roofing system, including all applicable design loads. In any event, it is the responsibility of the roofing contractor to interpret all aspects of the end customer's specifications and incorporate the appropriate specifications, design criteria, and design loads into the order documents submitted to the manufacturer.

Effect on Existing Buildings

The design professional is responsible for investigating the influence of the new metal roofing system on existing buildings or structures. The end customer assures that such buildings and structures are adequate to resist snowdrifts or other conditions as a result of the presence of the retrofit or metal roof system.

End Customer

The end customer is generally the owner of the construction project. The term includes any agent of the end customer, including any design professional or general contractor retained by the end customer. In situations in which the roofing contractor is also the end customer, the relationship to the manufacturer remains that of a roofing contractor, not an end customer. For a specific construction project, the end customer may act as the general contractor. If the end customer purchases "materials only" from the roofing contractor, the end customer has responsibility for the installation of the metal roof system as provided. The end customer's responsibility is:

- In general, the end customer is responsible for identifying all applicable building codes, zoning codes, or other regulations applicable to the construction project, including the metal roofing system. It is the responsibility of the end customer to prepare, or have prepared by a design professional, complete specifications including the applicable design criteria, codes, standards and regulations. All design loads or other requirements that affect the design or installation of the metal roofing system shall be the responsibility of the end customer. The following information must be supplied to the roofing contractor to ensure a successful project:
  1. The building geometric requirements. (Length(s), width(s), height(s), roof shape(s), and slope(s).)
  2. The applicable code or standard that describes the application of design load to the metal roofing system.
  3. The applicable design loads including live, snow, wind, seismic, collateral, and auxiliary loads required by the manufacturer to enter the order. Design loads must be accurately defined in the order documents.
  4. Building end use (occupancy classification) and topographical information.
  5. Site and construction conditions that affect design criteria such as conditions causing snow drifting, including the location of adjacent structures.

6. Building conditions that could cause an increase in internal pressure, such as open wall conditions or accessories that are not wind rated.
7. All information necessary to ensure that the metal roofing system can be designed to comply with the specified code or standards and is compatible with other materials used in the construction project.
8. All serviceability criteria limiting vertical or horizontal deflections.
9. The owner is responsible for providing clearances and adjustments of material furnished by other trades to accommodate all of the tolerances of the metal roofing system.

General Contractor

The general contractor is the party that has the overall responsibility for providing all materials and work for the construction project (including the metal roof system) as specified by the contract documents.

Installer

The party that installs the metal roof system. The roofing contractor, general contractor, manufacturer, or another party pursuant to an agreement with the roofing contractor, general contractor, or end customer may act as the installer. Subject to State and Local licensing requirements.

Order Documents

Order documents are required by the manufacturer for the purpose of entering and processing an order by which the roofing contractor orders the metal roof system from the manufacturer. The order documents consist of the purchase order and/or proposal/contract, the manufacturer's written acceptance, drawings, and specifications or other documents required by the manufacturer in the course of entering and processing an order Unless agreed upon in writing by the manufacturer, specifications and drawings prepared by the roofing contractor, end customer, or a design professional are not part of the order documents.

Roofing Contractor

The roofing contractor is the party that orders and purchases the metal roof system from the manufacturer. The roofing contractor is generally an independent contractor and is not an agent of the manufacturer. For purposes of this description, roofing contractor means any buyer of a metal roof system other than the end customer. In situations where the roofing contractor also meets the description of the end customer, the relationship to the manufacturer remains that of a roofing contractor, not an end customer. The roofing contractor acting only as a material supplier has no responsibility for installation of the metal roof system. In this event, the roofing contractor is responsible for conveying to the general contractor or end customer the engineering data, plans, and other information provided by the manufacturer, if applicable.

Supporting Design

The design professional is responsible for the design, materials, and workmanship of the supporting structure. Anchorage and load plans prepared by the manufacturer are intended to show location only. It is the responsibility of the design professional to verify that the attachment to the existing substructure can perform as required. The manufacturer is responsible for providing to the roofing contractor the location and amount of any load(s) imposed by the metal roofing system on the supporting structure. The design professional is responsible to ensure that adequate provisions are made to determine if the supporting structure can resist the design loads imposed by the metal roofing system.

<u>Special Note for Users of this manual</u>

There is an industry glossary in Chapter 9 of this manual that indicates brief definitions of many common terms used in the metal construction industry including those for retrofitting existing buildings using new structural light-gauge framing and new metal roof systems. Chapter 9 also lists several MCA Member manufacturers that are regularly engaged in supply and installation of retrofit roof systems.

CHAPTER 3

Fundamentals

Overview

This Chapter provides information so readers can begin to evaluate existing roof systems and other pertinent topics related to roof retrofit. Topics include initial design considerations, installation precautions, and an outline detailing the items required during a job site roof inspection. This is followed by information pertaining to the existing roof support system analysis to ensure structural integrity is maintained. Tables are provided that list common building material weights and thermal resistance values. These values are common to older building materials that could be found in aging buildings that may be a retrofit roof candidate. Methods to increase thermal performance, control condensation, and ventilate the new attic space created by the retrofit system also are detailed. Descriptions of conventional re-roof methods along with an application table and cost comparison of these methods versus retrofit metal roof systems appears at the end of this Chapter.

Photo 3-1: Ponded water on flat roof (Courtesy of Retrospec, LLC)

Design Considerations

The design professional and contractor consideration must consider the following during the development of contract documents. Understand that these considerations are common to retrofit system construction and that each project will vary regarding specific requirements.

1. All retrofit framing systems use the existing roof structure to transfer loads to the existing bracing system. Consequently, the existing building must provide a serviceable diaphragm for bracing requirements.
2. Removal of loose gravel or ballast, if applicable, on the existing building roof should be considered to reduce dead weight. When removing ballast, consider environmental regulations and restrictions that may affect the disposal. If the existing roof is a ballasted type, determine if removal prior to new retrofit system completion will create potential problems caused by shrinkage in the existing roof membrane.
3. The space between the existing and retrofit roof, if applicable, should be ventilated to assist in condensation control and dissipation of trapped moisture at the existing roof membrane.

A retrofit project is considered by many building code officials to be classified as renovation. An investigation must be performed to address compliance with the following codes:

1. National Codes established to provide uniformity in regulations to building construction. Examples include the International Building Code (IBC) published by the International Code Council (ICC). Many state and local jurisdictions have a specific local code or have included amendments to the IBC that may affect the requirements for a specific project. Review local code requirements prior to submission of any plans for approval.
2. In 1989 the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) adopted a standard practice code to define minimum levels of energy efficiency in nonresidential buildings. Titled ASHRAE 90.1, this code has been adopted by most states and federal agencies. ASHRAE 90.1 sets forth design requirements for the efficient use of energy in new buildings intended for human occupancy, apart from single and multifamily residential buildings of three or few stories above grade.
3. Life safety codes and/or fire prevention requirements as set forth by the National Fire Protection Association NFPA-101 and any locally adopted performance requirements. These specific local codes may govern many performance requirements pertaining to the existing roof assembly that will remain a component of the retrofit application. Project inspection is always necessary to determine specific performance requirements the project must be upgraded to. Understand that many older roof systems are not compliant with fire resistance and flame spread ratings that may be required in a specific location. One of the significant differences in fire performance between materials can be evaluated by comparing flame spread ratings (Class A is the best performance, followed by Class B, and Class C). Noncombustible materials are either defined as such in the building code or have met the requirements of ASTM E136.

The retrofit system will be anchored to the structural support system of the existing roof. Anchors should be designed using resultant values obtained from actual rooftop-conducted pullout tests with applied safety factors. While performing this testing, the compression resistance of the existing membrane and insulation should be recorded or core testing should be completed to evaluate the positive load effect at the anchorage attachment points. For more information, reference Chapter 4, Anchorage of the Framing System.

Installation Precautions

Photo 3-2: Base Channel being installed (Courtesy of McElroy Metal)

The following are recommended procedures and precautions to consider during installation of a retrofit framing system.

1. The existing roof assembly, including the deck, insulation, and membrane, must be checked for trapped moisture. If moisture is present, the existing roof should be removed entirely or in the affected areas. Check that all anchors penetrating existing roof assemblies have not experienced premature corrosion. These anchors should have a corrosion-resistant coating at a minimum.
2. When a retrofit system is anchored to the existing building, a compatible sealant should be installed at all penetrations through the existing roof assembly. This will help prevent rainwater or other moisture infiltration into the building interior that may occur during the erection and installation of the retrofit system.
3. When continuous base members are included in the manufacturer's erection drawings, the contractor should install a shim beneath each anchor location. Shims help to prevent water damming between the continuous members in the event the project is subjected to rainfall before being fully enclosed with the metal roof system. The composition (metal, wood, etc.) of the shim is determined by the contractor but should be a non-deteriorating, high-compressive strength material. Shim thickness should be enough to allow the base channel to span over the existing roof membrane.
4. To satisfy anchorage requirements and to ensure the retrofit framing and metal roof system stay on the existing roof, the design professional or contractor will need to conduct pullout testing. These tests are conducted by selecting appropriate anchors that are designed for securement into the existing roof's structural system type (steel, wood, or concrete) and physically pulling them from the existing member until they pull out of the roof's structural system. This is accomplished using a calibrated pulling device. Refer to Chapter 5 for more information.

Photo 3-3: Hurricane force wind on metal retrofit (Courtesy of RetroSpec, LLC)

5. The contractor needs to evaluate the compression resistance of the existing roof's substrate and membrane at each retrofit framing system base channel attachment location. It is common for the new imposed load from the retrofit framing and metal roof system to exceed the compressive strength of the existing roof assembly. If this happens, blocking will need to be installed from the existing structural decking to the bottom of the new retrofit framing base member. Refer to Chapter 5 for more information.
6. **Before installing anchors**, the installer should investigate the "under structure" beneath the existing roof decking to assess the presence of electrical, mechanical, and plumbing system components. This knowledge is imperative to prevent anchors from coming in contact with these components and causing harm to the building or the installer's personnel.

Existing Building Inspection

All existing buildings subject to retrofit should be inspected before proposing alternate systems and finalizing the new roof geometry. Existing conditions, rooftop obstructions, and other construction may influence design considerations regarding appearance such as eave elevations, low or high pitches, and hip or gabled ends. When using the roof plan illustration such as shown in Figure 3-A, numeric notations that refer to specific items to be considered in the early stages of design can be identified and located. These notations should be described below the illustration.

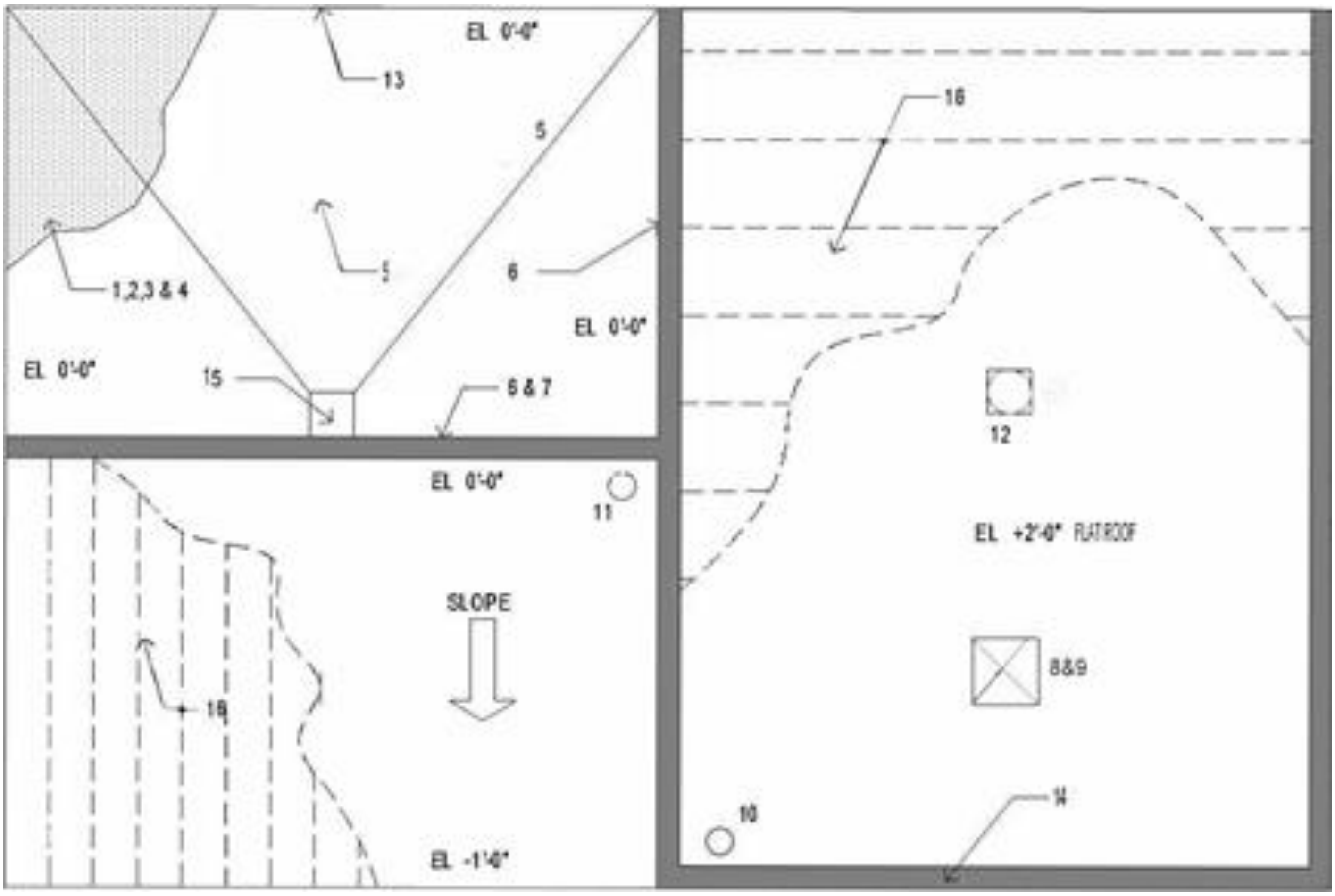

Figure 3-A

<u>Drawing Notations</u>

1. Inspect the existing roof membrane and insulation assembly to determine if any areas are waterlogged or deteriorated. These areas are of concern because of compression resistance and the roof's ability to accept loads from the new retrofit system.
2. Identify the existing membrane type and determine which compatible sealants are required at framing system anchorage penetrations.
3. For existing built-up roofs (BURs) with loose aggregate (gravel), determine if this material should be removed, disposed of or recycled if permissible by local codes and restrictions. Note: Removing this material may expose the existing

membrane to damage during retrofit system installation. Also note the aggregate's current adhesion level and evaluate costs associated with removal (spudding, slitting, stripping, and disposal).

4. For single-ply roofs with ballast, consider the effects to the membrane when the ballast is removed. In many cases, excessive shrinkage has occurred, resulting in damage to perimeter conditions and flashing.
5. Evaluate inconsistencies and slope in the existing roof plane. These can control the geometry of the new roof, especially framing assemblies at eave lines.
6. Identify location of roof steps and internal parapets. These may create requirements for thermal expansion assemblies in the new retrofit framing and roofing systems.
7. Identify location of firewalls located within the limits of the building perimeter. Firewalls must be extended through the new roof creating costly considerations.
8. Note the location and proximity to existing roof edges of rooftop mechanical equipment. This equipment can control the geometry of the new roof and determine the new eave height and its elevation above the existing roof. In addition, it will be necessary to evaluate whether to raise the equipment to the new roof plane or to construct the new roof over the units. Note that in some cases mechanical wells can be designed into the new roof geometry to allow for the equipment to be in a common area, or louvered dormers can be added to the new roof directly over the existing units, allowing adequate operating air-space around them and to provide ventilation if required. A mechanical engineer or contractor should be consulted to assist in this evaluation.
9. As shown in Figure 3-B, note the location of existing exhaust and fresh air intake fan hoods and other smaller equipment that will remain operational. Determine which equipment must be extended to the new roof plane. Any new penetrations should be round, not square, unless a new roof curb is used. This permits proper flashing. Also consider any air movement devices that can be coupled to minimize new roof penetrations and further evaluate routing them to a vertical wall surface, if available, eliminating roof penetrations.

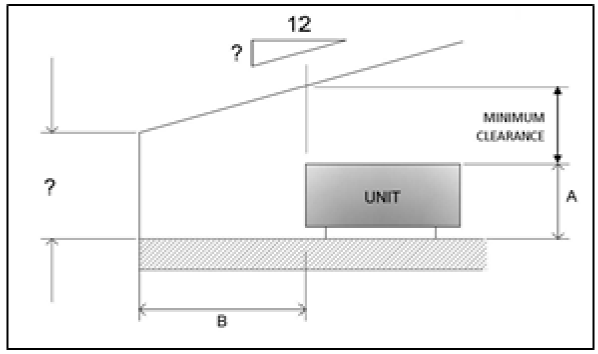

Figure 3-B

10. Note location of existing furnace flues and evaluate extending them through the new roof. Examine for temperature requirements to select appropriate new roof jacks/boots or curbs.
11. Note location of existing sanitary vents and determine if they can be combined into a manifold to minimize penetrations through the new roof. Also evaluate if these vents can be routed to penetrate through an available vertical wall surface.
12. Note location of existing skylights and determine if they will be removed or reused. When reusing, determine feasibility of constructing wells from the new roof to the existing opening that allow light to be transmitted.

13. Note the condition of existing roof edges, fascias, and gravel stops. The condition of these items can control new flashing conditions insofar as extending new flashing to hide old and/or unsightly materials. Record dimensions so new flashing can be fabricated and provide these dimensions to the manufacturer if not being fabricated in-house.
14. Examine existing parapet wall construction to determine whether it is structural or non-load bearing. With structural parapets, evaluate parapet caps to determine if they can receive retrofit framing anchoring devices and loading. Record dimensions so new flashing can be fabricated to hide existing flashings. Provide this information to the manufacturer of any new flashing. With non-load-bearing parapets, the perimeter retrofit framing will require cantilever members to ensure the design loads are transferred to the existing framing system and not on to the parapet. Locate existing roof drains and evaluate their use and the safety measures that should be observed during construction of the new "retrofit" roofing system to ensure rainwater is discharged properly without incident.
15. Identify existing structural roof framing from beneath the roof. As identified see in Chapters 4 and 5, these structural elements control virtually the entire design of the new retrofit framing system. Record and photograph the type of secondary spanning members (bar joist, wood joist, etc.), span direction, and exact spacing. This information will be required to commence engineering and design work.

Take photographs and record perimeter dimensions, roof height changes, and any other information pertinent to the project during the roof inspection. Provide the retrofit framing manufacturer with as much information as possible to ensure the project proposal includes all of the materials needed to satisfy any contractual obligations. Take note of any qualifications on the manufacturer's proposal for excluded items and/or any assumptions made during the estimating phase that require further investigation or confirmation.

Structural Analysis of Existing Roof Systems

Understanding the connection and load transfer between the existing roof structural system and the new retrofit framing system requires fundamental knowledge of how these structural grids work. The existing roof system must be structurally adequate to receive the newly imposed loads created by the new retrofit system.

Due to the added retrofit system, design loads and patterns have changed from the original design and the original structure may be subjected to excessive loading. Roof geometry changes may be the cause for additional snow loads created by drifting at valleys and other conditions. Geometry changes plus the additional weight of the new retrofit system are primary reasons why existing roof systems and their structural components must be analyzed to determine a capability to support the total of the new and existing loads and load patterns.

All roof designs use a structural grid, whether constructed of steel, wood, or concrete. This grid combines primary and secondary load-bearing assemblies that receive positive-acting (downward) loads and ultimately transfers them to the building foundation through load-bearing walls and/or structural columns. For example, a pre-engineered metal building has rigid frames (primary) that are normally spaced 20–30 feet apart. These frames receive the loading from the roof purlins (secondary). Chapter 5 discusses this topic in more detail.

The primary load bearing assemblies will generally be comprised of load-bearing walls, including those at the exterior perimeter of the building; steel or wood girders and trusses; or steel, concrete, and wood beams. Secondary load bearing assemblies can be open-web steel bar joists, steel or wood purlins, and concrete beams including tees used in precast tee systems. Most secondary load bearing assemblies distribute uniform loads to their outer ends where the total tributary load is then distributed (one-half of the total load at each end, with total load being the combination of live loads plus loads produced by construction materials [dead load] and snow) to the primary load bearing assembly. As defined in the glossary, the tributary load is the positive-acting roof design load measured across the member to a distance equal to one-half of its spacing to each adjacent secondary member multiplied by the member's span. For example, if a bar joist in an existing roof is spaced at 5'-0" on center and spans 50 feet, then the tributary is 2'-6" outward from its center line in each direction multiplied by 50 feet, or 250 square feet. If the total load is 28 pounds per square foot (PSF), then the total load carried by the joist is 250 x 28, or 7,000 pounds. Therefore, each joist will distribute one-half of this load or 3,500 pounds (7,000 divided by 2) at each of its ends to the primary load bearing assembly.

To begin the analysis, it first is necessary to determine the required design loading for the roof. The method used to determine specific loading is defined in ASCE 7 and is generally a combination of

- Dead load (weight of materials and fixed service equipment (crane load, HVAC equipment, etc.)
  - For dead loads, the weight of the existing roof assembly must be determined along with the estimated weight of the new retrofit system.
- Live load (load produced by use and occupancy of the building)
- Wind load
- Snow Load
- "Earthquake" Load

To determine the specific dead load of the existing roof, it will be necessary for the engineer to have information available on the existing components of the roof system. More important, this information should reflect the time frame during which the building was originally constructed. It will be necessary to physically identify the existing roof's structural components and then obtain their respective load-carrying capacities. The tables on the following pages provide information that can be used to calculate the weight of the existing roof assembly including ceilings, if applicable, and to identify members. Refer to the publications mentioned in this manual to identify load-carrying capabilities.

Common Construction Material Weights and R-Values

Table 3-1 provides information on the approximate weights of the existing roof assembly materials including various interior building finishes that have been common to the construction industry since the mid 1900's (ceiling, insulation, etc.). This information will aid in determination of the approximate weight of an existing roof assembly with a conventional type roof system. Table 3-2 aids in determining the approximate total thermal value (R) by providing the overall thermal resistance of the existing building's roof assembly. Note: *Both of the Table's values obtained from John Wiley & Sons 1978 Sixth Edition of Architectural Graphic Standards.*

Table 3 – 1 Weights of Older Construction Materials	
Material	**Pounds/SF**
Ceilings	
Acoustic tile	1.2 – 1.57
Suspended	1.40
Lath & plaster (per 1” thickness)	10.50
Roofing	
EPDM adhered	0.28
EPDM ballasted	12.0
Modified bitumen	0.25
PVC foam (per 1” thickness)	0.02
3-ply felt	3.00
3-ply felt with gravel	5.50
5-ply felt	3.50
5-ply felt with gravel	6.00
Decking	
¾” wood	3.00
2” gypsum plank	12.00
20-gauge metal	1.50
22-gauge metal	1.25
LW concrete (per 1” thickness)	3.0 – 9.0
Insulation	
Loose fill	0.5
Poured in place	2.00
Rigid (per 1” thickness)	0.75
Fiberglass batt	0.10 – 0.40
Foam Board (per 1” thickness)	0.16
Tectum (per 1” thickness)	1.75

Table 3 – 2 Thermal Values of Common Construction Materials	
Material	**R-Value**
Ceilings *(insulation above ceilings is not included in value)*	
Acoustic tile	2.38
Suspended	2.28
Lath & plaster (per 1” thickness)	.94
Roofing	
EPDM adhered	0.24
EPDM ballasted	0.37
Modified bitumen	0.75
PVC foam (per 1” thickness)	3.85
3-ply felt	0.24
3-ply felt with gravel	0.33
5-ply felt	0.40
5-ply felt with gravel	0.55
Decking	
¾” wood	0.44
2” gypsum plank	1.80
20-gauge metal	0.0001
22-gauge metal	0.0001
LW concrete (per 1” thickness)	0.3–0.9
Insulation	
Loose fill	2.2–3.5
Poured in place	6.25
Rigid (per 1” thickness)	2.78
Fiberglass batt	4.00
Tectum (per 1” thickness)	5.56
Foam board	6.00

Open-Web Steel Bar Joists

Tables 3-3 and 3-4 are provided as reference on open-web steel bar joist, the most common structural roof support system found on retrofit projects. The data can be used to identify existing joists and match to their proper designation. Refer to the Steel Joist Institute (SJI) load tables to evaluate loading capacity and consideration of future loads to be imposed by a retrofit system. Calculating the weight per square foot and multiplying by the joist's spacing will yield the current load in pounds per lineal foot (LF). Joist tables provide allowable total safe load in pounds per LF based on joist span. It is important to note that in many cases, interior building finishes may have been added to existing buildings that were not originally appropriated for in the design of the existing roof. These finishes can include the addition of ceilings, mechanical/electrical, fire sprinkler systems, and any other materials suspended from the existing roof or its support structure.

Table 3-3 Open-Web Steel Bar Joist Dimensional Data[1]				
Series	**Manufacture Date**	**Std End Depth**	**Available Depths**	**Web Type**
SJ, S, J, H, or K	1930–1952 1952–1972 1972–1988	2½"	8"–16" (2" increments) 8"–24" (2" increments) 8"–30" (2" increments)	Round Bar
L, LA, LJ or LH	1953–1988	5"	18", 20", 24", 28", 32", 36", 40", 44", and 48"	Angle
Deep Span DLJ or DLH	1970–1988	Chords 10–17 = 5" Chords 18–20 = 7½"	52"–72" (4" increments)	Angle

[1] Data collected from the Steel Joint Institute's (SJI's) *60-Year Manual 1928–1988* © 1992, a compilation of specifications and load tables. This manual is available by contacting the SJI by visiting its website at www.steeljoist.com. Note: A more current manual is available on their website.

Table 3-4 Open-Web Steel Bar Joist Chord Sizes[1]—Series SJ, S, J, and H		
Chord ID	**Possible Angle Sizes (inches)**	**Chord Hole Gauge[2] (inches)**
1	¾ x ¾ x ⅛ or 1 x 1 x ⅛	1⅛-1⅜
2	1 x 1 x ⅛	1½
3	1¼" x 1¼" x ⅛	1⅞
4	1½" x 1½" x ⅛	2⅛
5	1½ x 1½ x 5/32 or 1¾ x 1¾ x ⅛	2¼-2½
6	1½ x 1½ x 3/16	2¼
7	1¾ x 1¾ x 3/16	2⅝
8	2 x 2 x 3/16 or 2 x 1 ½ x 3/16	2⅞
9	2 x 2 x 3/16	3
10	2 x 1½ x ¼ or 2½ x 2 x 3/16	3–3½
11	2 x 2 x ¼	Varies due to web dimension

[1] Data collected from the Steel Joint Institute's (SJI's) 60-Year Manual 1928–1988 © 1992, a compilation of specifications and load tables. This manual is available by contacting the SJI by visiting its website at www.steeljoist.com. Note: A more current manual is available on their website.

[2] Gauge is the distance between the centers of the two bar joist chords.

Insulating Retrofit Roofs and Controlling Condensation

In order to increase in the energy-saving efficiencies for older buildings, many industry authorities recommend insulating the space between old and new roofs. The most beneficial placement of insulation has been a debated topic that has caused confusion for design professionals, contractors, and owners for many years. Insulation industry authorities have offered the following positions to resolve questions on the proper location and placement of insulation.

1. To increase thermal efficiency of an existing building, insulation should be placed directly on the existing roof. Thickness of insulation is subject to individual project requirements and level of upgrade desired. Typically, designers will specify the addition of at least 6" of fiberglass insulation to provide an additional R-19. A laminated vapor barrier is not recommended because the existing roof effectively acts a barrier and an additional barrier would restrict moisture dissipation in the existing roof substrate. For projects designed in accordance with ASHRAE 90.1, an R-30 would be required as a minimum total insulation value. After calculating the existing roof's thermal resistance value, additional insulation requirements need to be determined. Note that overall thickness is obviously limited by the cavity depth.
2. Condensation occurs when moisture-laden air meets a surface temperature equal to or below the dew point of the surrounding air. This phenomenon creates problems that are not unique to metal roofing construction and can be found in nearly all types of construction. Many design professionals and contractors will recommend installing minimal-thickness fiberglass insulation laminated to an appropriate and economical vapor barrier directly beneath the new metal roof. This will provide excellent condensation control beyond ventilating the cavity, but it will not effectively increase the thermal resistance of the overall assembly.

Ventilating the Retrofit Attic

One of the most overlooked elements in the design of retrofit systems is ventilation. A properly engineered ventilation system using a gravity exhaust vent at the high points of the roof (ridge, high sidewall, pitch-break, or roof-to-wall) in conjunction with an eave intake air vent strip will provide fresh air movement through the roofing system. Summer heat is released naturally, extending both the life and performance of the roof system. During winter, proper ventilation can assist in the control of condensation and other moisture problems such as rust and insulation deterioration. Typically, it is recommended that the new attic space created between the old and new roofs be ventilated at a minimum ratio based on industry standards of 1:300 (one square foot of free intake and exhaust air movement to 300 square feet of attic space). This value is subject to local codes and regulations.

Conventional Re-Roofing Methods

Various roofing membranes have been commonly used in roofing applications for the past 10 – 40 years. Many new and improved versions of these membranes are still used today. Following are roofing descriptions from publications dating back to the early 1980s. It is more likely that these systems will be involved in retrofit roof systems projects today. These descriptions explain roof membrane materials, physical properties, pitfalls, and limitations. Table 3-5 identifies various re-roofing systems and the acceptable industry practices for roofing over conventional membranes. Table 3-6 compares average life expectancies, associated maintenance costs, and total cost to owners with low-slope and high-slope retrofit applications. Metal roofing's long-term performance and low maintenance cost speak well regarding investment value.

Built-up Roof (BUR)

The flat and low-slope roofs used on commercial and industrial buildings for many decades have been protected with a built-up roofing membrane. The name, Built-up Roofing (BUR) is derived from the construction method used to create the waterproofing cover: Layers or plies of felts made of paper, asbestos, polyester, or glass fibers are embedded in alternate layers of hot- or cold-applied waterproofing asphalt or coal-tar-based bitumen. The surface layer is also embedded in a flood coat of asphalt or coal-tar pitch and is generally topped with aggregate granules or small pebbles. BUR must be protected from ultraviolet exposure with this granule surfacing to ensure long-term performance. The following explains the basic components of a BUR membrane, bitumen, and felts as well as installation characteristics.

Bitumen Roofing

The bitumen in a built-up roof has two functions: to act as a waterproofing layer and an adhesive between the plies of felt. Various types of BUR have specific applications:

- Dead-level asphalt is suitable for roofs having slopes up to 1:12.
- Flat asphalt is suitable for slopes typically up to 3:12, but some manufacturers are limited to 1/2:12.
- Steep asphalt is required for slopes up to 6:12. This asphalt was regarded as an adhesive and **not** considered to be a waterproofing material because of its poor weathering qualities.
- Special steep asphalt was recommended for slopes greater than 6:12. Its weather resistance was the poorest of all asphalts.
- Coal-tar pitch was used on nearly level roofs and considered superior to dead-level asphalt on roofs that experienced ponding. However, coal-tar pitch had several drawbacks.
  - Weatherability was poor and coal-tar pitch had to be protected from ultraviolet exposure with aggregate gravel.
  - Coal-tar pitch was incompatible with asphalt and introduced problems at flashing locations.

Felts

Layers of felt provide strength and dimensional stability to the bitumen. Because bitumen tends to stiffen at low temperatures and become brittle with age, the addition of felts also makes it possible to accommodate thermal movement by helping to avoid the splitting of the membrane.

- Organic felts almost always split along the felt lines unless their directions were reversed during installation. Coated felts exhibit no substantial difference in service from ordinary paper felts.
- Asbestos felts provided the advantage of greater moisture resistance, but their poor tensional values made them less strong than paper or glass-fiber felts. These felts were used in three-ply roofs because of their low

cost, however the sacrifice in strength resulted in a greater tendency for splits.

- Glass fiber felts led the BUR roofing market because of their weathering characteristics. Four types were produced: steam-blown mat, wet process mat, continuous strand mat, and polyester mat. Each type had its own advantages and disadvantages:
  - Steam-blown mats had moderate cross-sectional tensile strength and were not suitable for colder climates.
  - Wet process mat, the most widely used, had very good flexibility, allowing it to conform to configurations that others could not. This mat had poor tear strength and fair durability.
  - Continuous strand mat had a uniform high tensile strength and could be used in all climates. Disadvantages were higher cost and limited uniformity compared to steam-blown and wet-process mats.
  - Polyester mat had excellent elongation characteristics and flexural strength. Disadvantages included an inability to withstand the high temperatures associated with mopping asphalt and polyester mats were mated with cold asphalt or emulsion.
- Installation characteristics: Asphalt must be applied at the appropriate temperature to deliver its waterproofing characteristics. The correct temperature ranges were from 375º F to 425º F. If overheated for any extended period, the physical properties of asphalt are modified, and the integrity undermined. For coal-tar, the appropriate temperature is just as important but was often neglected by installers. If overheated, coal tar becomes thinned and the performance qualities are greatly reduced.

Modified Bitumen Systems

These roof systems included a broad class of materials and blends. Modifiers and additives enhanced the material properties of roofing-grade asphalt and improved performance. This membrane is a composite sheet of two or more materials and additives that closely resemble BUR, but the individual plies are factory-laminated, and the membrane is applied in one layer. These composite sheets can either be self-adhering or heat applied.

- **Self-adhering.** These sheets have a base layer of bitumen that is modified with a plasticizer and a top layer of polyethylene film. The film acts as a protective barrier and a base for any liquid protective-applied coating or gravel adhesive with mineral granules.
- **Heat-applied.** These composite sheets contain a reinforcing layer at mid depth. This reinforcement may be plastic sheeting, polyethylene film, heavy polyester mat, glass-fiber felt or fabric, or a combination thereof. The asphalt may be modified with rubberizers or special plasticizers. Surfacing may be a thin embossed metal, a mineral aggregate, or a special protective coating.
- **Installation characteristics**. Self-adhering sheets have a protective release paper on the bottom that is removed immediately before installation to the substrate. The asphalt and added tack oils create an almost instantaneous bonding. Seams are bonded with mechanical pressure applied with a roller. Heat torching joins reinforced modified bitumen sheets; this is subject to the installer's skills to control the flame and avoid burning through the membrane.

Single-Ply Membranes

During the energy crises in the early 1970s single-ply membranes such as rubber and thermoplastics became popular. Known as elastomeric systems, there are two types of single-ply membranes: thermosetting and thermoplastic. Thermosetting materials solidify when first heated under pressure and cannot be re-melted or remolded without destroying their original composition. Thermoplastic types are readily softened when heated and hardened when cooled, returning to their original characteristics. The membranes typically had good weathering qualities, and some had good resistance to chemical and corrosive environments. Various attachment methods and different membranes that have been available at some point during the last 30 years include:

Single-Ply Installation methods

- Fully adhered – This method glues (adheres) the membrane to an insulation board such as polyisocyanurate, which is attached to the supported deck.
- Partially adhered – The membrane is partially bonded with adhesive and, in some cases, with mechanical fasteners. This method glues the membrane in strips to allow for a specified percentage of nonbonded area.
- Mechanically attached – This method attaches the membrane to the deck through the insulation board, with battens hot welded at the seams.
- Ballasted – This method attaches the membrane at its perimeters with a layer of heavy rock that is spread to hold it down to the insulation and deck. A polyester protection mat is installed over the membrane to protect it from the rocks themselves. The weight of this system can be as much as 12 PSF.

Single-Ply Membranes types

- Neoprene – This was the first commercially produced synthetic rubber. Sheets were available in weathering (black) and non-weathering (light colors) grades. The latter had to be protected from ultraviolet exposure, usually with a coating.
- Polyisobutylene (PIB) – A synthetic rubber sheet classified as an uncured elastomer, composed of isoprene, high-molecular isobutylene, and aging protectors. This membrane had good ultraviolet and weathering resistance.
- Ethylene propylene diamine (EPDM) – A thermoset synthetic elastomer membrane that is glued or fastened to the deck.
- Chlorinated polyethylene (CSP and CSPE) – Rubber-like materials of high molecular weight, low-density polyethylene that are mechanically fastened to the deck. Seams are heat welded. CSP is typically white or gray and CSPE was available in several colors and usually had an asbestos backing. These membranes offered good acid resistance but would swell if exposed to chlorinated and aromatic solvents.
- Polyvinyl chloride (PVC) – A thermoplastic synthetic polymer composed of vinyl chloride that comes in reinforced and nonreinforced versions. Through aging and solar exposure, this membrane can become brittle, which is caused by the loss of plasticizer. It can be protected from ultraviolet degradation with ballast or by adding inhibitors in its composition.

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- Ethylene copolymer bitumen (ECB) – A thermoplastic material mixed with anthracite micro-dust.

Spray-On Coatings

This roofing system comprises a polyurethane foam and various protective coatings. Because of the polyurethane's high thermal conductivity and resistance values, this system offered unique advantages to older energy-deficient buildings. Polyurethane foam is a result of a reaction between two major components: isocyanate and polyol. These two elements, with additives and catalyst, undergo an exothermic reaction when mixed and sprayed onto the subject roof area, causing the material to expand within seconds to 30 times its original volume. A coating to make it watertight and to prevent degradation from ultraviolet exposure must be applied to protect the foam. Various coatings have been used during the last 30 years such as urethane elastomer, elastic acrylics, and silicones. Other coatings have included butyl rubber, chlorosulfonated polyethylene, neoprene, polyvinyl chloride, and vinyl. Some of the coatings are breathable and allow passage of water vapor while others retard it. The performance of this roofing system is highly dependent on weather conditions, quality control of the equipment being used to install the foam, and control of the thickness of the protective coating.

Acceptable Re-Roofing Methods

Because numerous roof types have been used on buildings for decades, Table 3-5 is provided to determine which new re-roofing systems and methods are acceptable regarding application over the various systems.

Table 3-5
New Re-Roofing Protective Membrane

Existing	BUR	Mod-Bit	Single Ply	Spray-On	Retrofit
BUR	1	2	2	4	Acceptable
Mod-bit	2	3	2	4	Acceptable
Single ply	4	3	3	4	Acceptable
Spray-on	4	3	3	4	Acceptable-5

1. Acceptable per roofing industry standards and practices
2. Industry recommends a minimum 1/4:12 slope
3. Acceptable with complete tear-off of existing system to deck and replacing with all new materials
4. Acceptable with tear-off to existing insulation at minimum and replacing with new membrane
5. Recommended to remove foam and coating, dependent on thickness of foam at framing attachment location

Re-Roofing System Cost Comparisons

Table 3-6 is provided to assist users and building owners in evaluating and selecting re-roofing systems. Even though the initial cost of a conventional re-roofing system can be much lower than a retrofit system, a metal roof will by far be the best investment when compared to its counterparts. Due to issues like continuous maintenance expense and shorter life spans on conventional systems, installing a retrofit system can represent a savings of 39% - 70% over the long term where conventional membranes require replacement when they reach their life expectancy. It is important to note that this table uses 25 years as a basis for life expectancy even though metal roofing has proven its superiority for 40 to even 60 years and more dependent on type, coating, and location. For more information on the MCA's Service Life Assessment of metal roofs, visit this link: http://www.metalconstruction.org/Tech-Resources#service_life_assessment

Table 3-6
Cost Comparison of Various Reroofing Systems over 25 Years[1]

Re-roofing System	Initial Roof Replacement[2] based on 10,000 Sq. Ft.	Maintenance Cost Over 25 Years $/SF/YR	Replacement Cost at end of average life	Total Cost Over 25 Years
4-ply BUR Asphalt	$61,400	*$0.17/SF*	*17.2 Years*	$217,575
		$61,981	$101,486	
60 Mil Adhered EPDM	$48,331	*$0.20/SF*	*23 Years*	$209,342
		$72,919	$95,384	
60 mil Mechanically Attached TPO	$46,768	*$0.26/SF*	*20 Years*	$218,738
		$94,794	$84,468	
Mopped SBS Modified Bitumen	$63,418	*$0.17/SF*	*21 Years*	$236,082
		$61,981	$117,975	
[3]Low-slope Metal Retrofit over Flat Roof	$90,000	*$0.02/SF*	*40 to 60+ Years*	$97,292
		$7,292	Not required in 25 years	

[1] Sources: Roofing Communications Network, American Iron & Steel Institute, RetroSpec, LLC Life Cycle Costing Study and RCI 2012 Cost Analysis.

[2] All roof systems have received an initial roof replacement calculated on an averaged basis from independent competitive Texas roofing contractor proposals provided in 2012 to RetroSpec, LLC. The roof replacement costs do not consider the type of existing roof other that it is a flat roof requiring minimal preparation to equalize the system's cost with a metal retrofit application.

[3] Based on a 10,000-square-foot building, calculation includes the initial installation cost and maintenance with replacement of the system at the year-end (rounded up) of the system's average life span. Maintenance and replacement costs include a 3% per year inflation rate but does not include any energy savings from new insulation. Low-slope system includes unpainted trapezoidal standing-seam roof (SSR)-type roof system with maximum framing member height of 36". Not insulated.

CHAPTER 4

Applications and Systems

Retrofit roof framing systems are designed to provide the design professional and contractor with options that can satisfy various building occupancies, conditions and geometry. Building occupancies can range from warehouses to schools and office buildings as well as hospitals and lodging establishments. Regardless of a building's purpose, retrofit systems can be engineered to accommodate an architectural design where a new steep-sloped metal roof is incorporated as a design element to improve the overall aesthetic value. If the building is more of a utilitarian purpose, as in the case of a warehouse or manufacturing facility, a low-slope functional design that simply discharges rainwater from the roof will satisfy those needs. Besides architectural and utilitarian, there are always building complexes that are needing a solution to what the metal industry terms as "Problematic Geometry". In these cases, there may be a building complex with multiple roofs that have created challenges to satisfactorily discharge rainwater. This may be due to internal gutters and other obstacles or because the facility has undergone numerous expansions over time. As illustrated in Figure 4-A, these challenges can include multi-gabled roofs, stepped conditions, parapet conditions that trap excessive rainfall and many others that cannot be corrected by a basic conventional flat or sloped roof replacement. Existing geometry that can be remedied with retrofit systems include:

Photo 4-1: Showing how retrofit framing systems can accommodate various existing and problematic roof geometry even with this double-barrel roof. (Courtesy of MBMA)

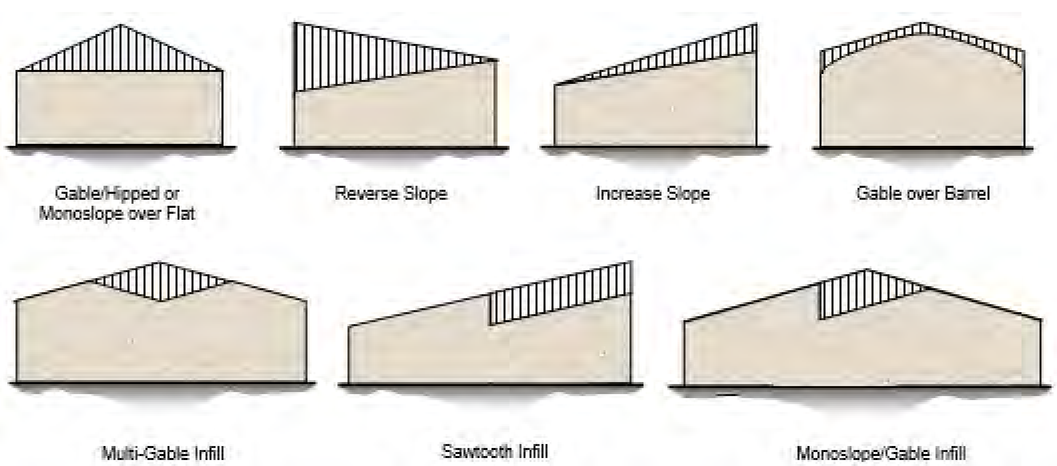


Figure 4-A: Roofing geometries that can be retrofit

Retrofit systems provide enough versatility to provide an ideal solution to virtually any existing building roof. However, it doesn't stop there. MCA member companies engineer retrofit framing to suit new construction projects as well. Light weight and cost-effective retrofit framing systems have been used for newly built hotels and other steep-slope applications. New construction systems are especially suited for pre-cast or poured in place concrete construction where a structural concrete "attic" floor serves as the bearing surface for the new framing system and these systems can be designed to maintain a maximum load in the roof deck at their point of attachment.

Existing Roof Construction

Roof construction is very elementary by design. In the case of retrofitting flat roofs, a series of primary and secondary support systems is utilized with a uniform load bearing deck installed over the secondary members with insulation and a waterproofing membrane added. The secondary members can include open web steel bar joist, steel beams (purlins) and wood joists supported by primary framing members and load bearing walls or a combination of both.

Sloped roofs use similar framing designs as flat roofs, where bar joists, steel beams and wood joists are supported at each end by load bearing walls or primary framing (beams, girders, etc.) of various types as well.

Roof loading is based on specified live, dead; wind and snow loads being transferred into the support structure uniformly through the decking over the entire roof area.

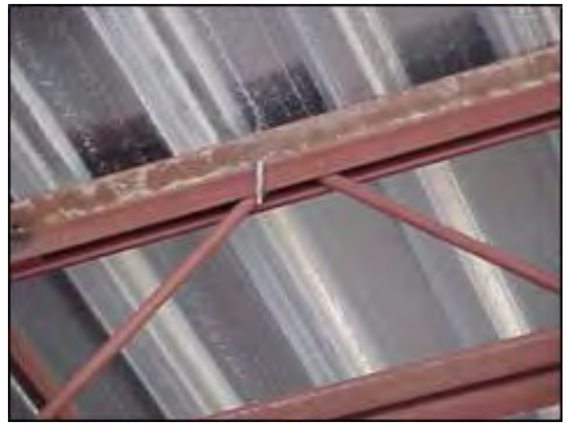


Photo 4-1 – Existing Bar Joist with retrofit framing base member anchor showing at top chord (Courtesy of retrospect, LLC)

Before going into the basics of retrofit framing systems design, it is important to understand two basic terms regarding the attachment of retrofit framing to the existing roof structure. These terms identify the relationship of the new roof's slope direction/orientation to the span direction of the existing roof structure.

- Parallel Framing – The existing structural spans are parallel with the new roof slope, generally allowing the new framing to only require a point loaded type base member (Intermittent Base).
- Perpendicular Framing – The existing structural spans are perpendicular with the new roof slope, generally requiring new framing to require a load-distributing type base member that runs across the existing structure (Continuous Base Member)

Systems are engineered first, based on the project's specified design loads, using the existing roof support system as a map for the retrofit systems framing designer. The existing roof support represents a "grid" system made up of the primary and secondary supports as already explained. This grid can be found in most types of roof construction regardless of the supporting members used (steel, wood or concrete). The spacing of the existing members, typically joists, generally controls the spacing of the retrofit vertical framing members. The structural span direction typically determines the type of retrofit base members.

Low-slope and Steep-slope Systems

There are basically two framing approaches to retrofit framing that require different types of framing based on design intent and the slope/pitch of the new metal roof. These two systems address both low-slope and steep-slope systems.

Perimeter Framing

Figures 4-B through 4-D are three of the most common conditions located at the new low eave of the new roof assembly. Other roof perimeter methods at gable walls, gable purlin extensions and low eave canopies/overhangs are provided in Chapter 5.

Figure 4-B: "Fixed" elevation Low-eave member

Figure 4-C: "Variable Height" low-eave member that accommodates inconsistent roof edge elevations

Figure 4-D: "Elevated" low eave wall

Low-slope Retrofit Framing Systems

The most economical, and most limited framing method is the Low-slope Retrofit Framing System. This system utilizes varying height, press broke, zee-shaped or roll formed members. These members are typically made from 16-gauge steel with web depths of 3-1/2" to 12". The maximum web depth of 12" is what limits the use of this system to narrower buildings. For example, if a new roof slope is 1/4:12, then the ultimate building width would be limited to 48' (.25 X 48 = 12) or 96', for a building with a symmetrical ridge. Although limited, this system is regularly used in conjunction with the Post and Purlin framing systems discussed later in this chapter.

Figure 4-E illustrates how a custom-broke variable height zee-shaped member is used in a parallel condition. Maximum web height of this member is typically no more than 12" which limits slope and width from new eave to new eave. Figure 4-F illustrates a continuous zee-shaped member in parallel or perpendicular conditions. A vertical member will be attached to this member up to the new zee-shaped purlin that can run either direction for both conditions as is explained in Post and Purlin Systems. It is very common for both type member orientations to be used in retrofit framing where the new low-eave elevation is near the top of the existing roof edge.

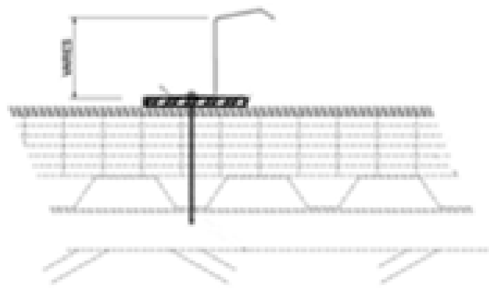


Figure 4-E: "Variable Height" custom base member for low-sloped parallel condition

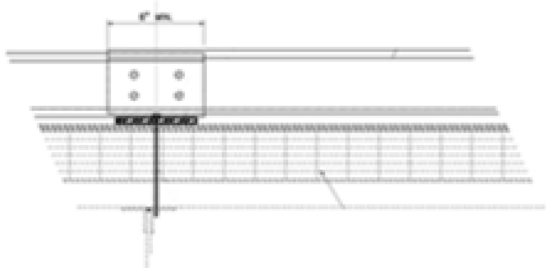


Figure 4-F: "Continuous" zee-shaped base member for steep-slope perpendicular condition

Post and Purlin Systems

Post and Purlin Systems are the most commonly used systems because of adaptability to steel, wood or concrete roof systems. This system uses cee-shaped posts that support zee-shaped purlins. Because of member dimensions and connection requirements, the minimum height of this framing is approximately 8", where overall height (above the existing roof) has been designed to 25' and more using larger vertical members with horizontal struts bracing the system. The type of base member is dictated by the span direction of the existing roof structure as explained in the Low-slope Retrofit Systems and shown in Figures 4-E and 4-F. The illustrations on the following pages show the framing differences with steel, wood and concrete systems. Note the significance in the location of the new cee-shaped vertical posts in relation to the existing roof structure.

Post & Purlin Base Member Types:

Figures 4-G and 4-H depict the various base members employed in post and purlin framing. Each has specific applications that relate to the existing roof's secondary support system span direction as explained previously. In most cases, the post web is attached to the base zee's web making web-to-web connection. It is important to note that the continuous base zee is generally used for all existing roofs constructed with dimensional lumber.

Figure 4-G: Parallel condition bar joist with intermediate base member (Courtesy of McElroy Metals)

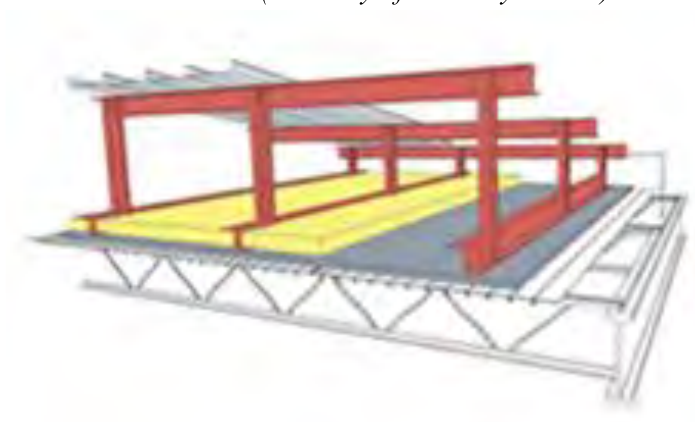


Figure 4-H: Perpendicular bar joist with continuous base member (Courtesy of McElroy Metals)

In Figure 4-G, the new roof is sloping “parallel” to the existing bar joists. In Figure 4-H, the new roof is sloping perpendicular to the bar joists. The difference between the two systems is the change in base members from intermittent base shoes placed directly over each joist in Figure 4-G and continuous zee-shaped members running across the joists in Figure 4-H. All other framing is the same except orientation of the vertical posts. The continuous base member allows the vertical members to be placed at the intervals required to support the metal roof to meet the specified wind uplift and/or snow loads.

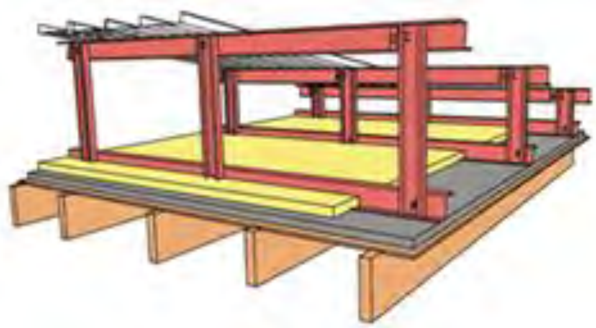


Figure 4-J: Parallel Wood Joist with Continuous Base Members (Courtesy of MeElroy Metals)

All of the systems accommodate steel framed roofs as shown, but also accommodate roofs constructed of wood and concrete. As shown in Figure 4-J, existing dimensional lumber framed roof systems will always have continuous base members. In addition, vertical framing members will be spaced closer together. Both design element location and orientation are predicated on the existing wood structure typically spaced no more than 16” to 24” on center. They do not have the capacity to accept the heavy concentrated loads that a retrofit framing system can impose. There are other types of wood framed roofs, such as heavy timber and glue laminated beam (Glulam) with structural wood decking which may require vertical posts to be spaced 10’ or more apart and positioned directly over the primary supports in lieu of the secondary wood joists.

In this type of retrofit system the new roof purlins will be designed for longer spans compared to those of a bar joist type system.

Concrete framed roofs, Figure 4-K, can either be for pre-cast construction or poured in place structural decking. Note that these systems are not to be confused with bar joist with lightweight concrete decking system. Those system types will require framing similar to bar joist framed systems. In the case of pre-cast concrete tee beam roofs, retrofit framing is designed the same as a bar joist system. This is because the tees are typically spaced no more than 5’ to 8’ feet apart. Framing base members will be intermittent base shoes as shown in Figure 4-K.

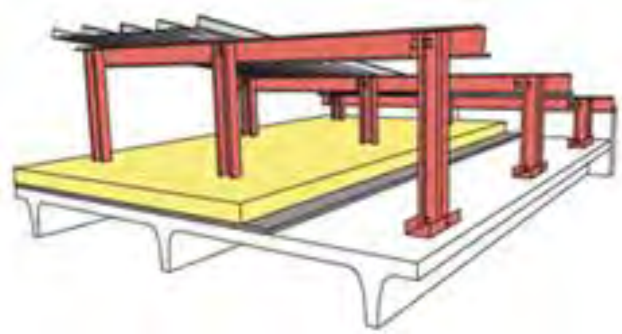


Figure 4-K – Parallel Tee Beam Roof with Intermittant Base Member (Courtesy of MeElroy Metals)

Continuous base members will be used if the new roof slope is perpendicular to the span direction of the tee beam.

Another flat roof system is shown for utilitarian low-slope framing that utilizes varying height zee-shaped purlins to create slope. (Figure 4-L) This system is for minimal sloped applications between 1/4:12 and 1/2:12 roof pitches using standing seam metal roof systems designed for lower roof pitches. As already mentioned, because of the member’s physical height limitations of the purlins used, it is only adaptable to gabled buildings less than 96’ wide or 48’ wide mono-sloped roofs.

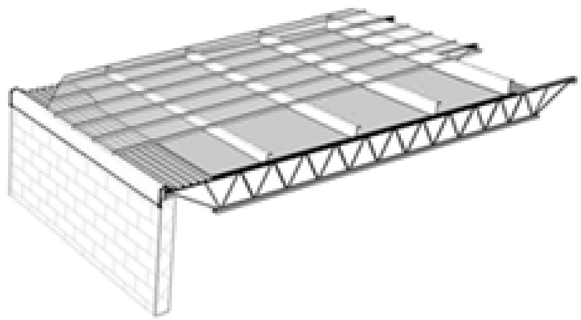


Figure 4-L: Low-slope framing system, parallel application over existing flat roof (existing bar Joist system shown) (Courtesy Metal Sales Manufacturing)

Finally, there are simple sub-framing systems for existing sloped roofs that have conventional membranes. (Figure 4-M) For this system a hat-shaped or other continuous member is designed and placed perpendicular to the roof pitch at intervals to withstand the design wind uplift loads as based on the selected new metal roof.

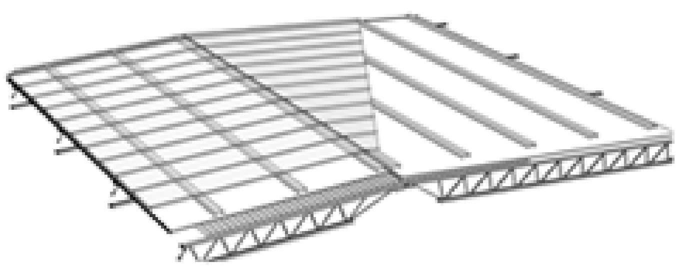


Figure 4-M: Metal-over-sloped conventional roof system (existing bar joist system shown) (Courtesy Metal Sales Manufacturing)

Metal-over-Metal Retrofit Applications

This application may be needed to address any number of reasons including rusted roof panels, leaks caused by excessive thermal expansion and contraction, or corrosive atmospheric conditions in and around the building. Before the introduction of aluminum-zinc alloy coatings in the early 1980s, (Galvalume™, etc.) metal building manufacturers used G-60 and G-90 galvanized coated metal for their roof panel systems. If the roof panels were painted, the older acrylic and silicone-based coating systems lacked long-term performance in color retention, fade, chalk, abrasion resistance and weatherability.

Photo 4-2: Existing exposed fastener that has failed receiving new factory-notched sub-framing for a new metal roof to be installed (Courtesy of RetroSpec, LLC)

One of the most prevalent problems with older metal buildings is the inability of the exposed fastened roof system to allow adequate thermal movement, as evident by elongated screw holes and cracked ridge caps. (Photo 4-3) With today's engineering expertise, the ability to employ a nested factory-notched sub-purlin system into the design of a re-roof framing system over existing metal buildings is available throughout the nation.

Photo 4-3: Existing exposed fastener that has failed due to movement ove the years (Courtesy of RetroSpec, LLC)

In many cases, there may be a need to meet engineering and specification requirements or to upgrade an existing roof structure to current building code compliance with higher wind loads than those used in the original design. In these cases, the design of the sub-framing system may include additional corner and roof edge framing at the perimeter. A common example of this is an existing building built in 1980 that was originally designed for a 90 to 100 or greater mile per hour (MPH) wind speed and now requires a 130 MPH or greater designed wind speed. In addition, it is not uncommon for the local codes to require a minimum 157 MPH wind speed, which is equal to a Category V hurricane. For offshore structures, the design criteria may be as high as 175 MPH. More information on Metal-over-Metal applications with typical construction details is provided in Chapter 6.

Summary on Applications

From the illustrations and information provided, one can see how the existing roof support system controls the design of the new retrofit framing system. It is also easier to understand the difference between parallel and perpendicular framing alignment; why different base members are necessary to accommodate changes of roof supports and/or span direction; and new roof geometry that may create hips and valleys.

Why Conventional Roof Membranes Fail

With retrofitting over conventional roof systems being the most common application, it is prudent to understand why flat or nearly flat roof membranes reach the end of their service life much quicker than metal roofing. Recent technology developments in roof membranes certainly offer a much longer service life than those of the older roofs that are commonly subject to retrofit roof application. These older systems will include:

- Multi-layer built-up asphalt with gravel aggregate (BUR). This membrane system has served the roofing industry for decades and is the most common system available. Currently, BUR is losing market share to the more advanced systems like standing seam metal roofing, elastomeric EPDM and thermoplastic TPO membranes (single ply). The BUR system has an average service life of 17 years.
- Single-ply Systems. This membrane system typically uses elastomeric EPDM and thermoplastic TPO. The average service life is a little over 20 years.

Principle reasons why conventional roofs fail and why they are inferior to metal's service life of 40 to 60 plus years and low-cost maintenance.

Multi-layer BUR Issues:

- Physical damage due to foot traffic
- Building movement
- UV exposure
- Thermal cycling and embrittlement
- Thermal shock (after rainfall)
- Ponding water
- Difficult to maintain and repair

Single-ply Sheet Issues:

- Seam failure and separation
- Prone to punctures
- Infrared exposure
- Shrinkage and swelling due to thermal cycling
- Difficult to maintain and repair

None of these issues are threatening to the integrity of the roof when metal roofing is used. Standing seam metal roofs are designed to accommodate thermally induced stresses and building movement alike, and with minimal affect from ultraviolet or infrared exposure.

Chapter Summary

Earlier in this Chapter, it was noted that roof construction is very elementary in design. What is most important in a successful retrofit application is the design professional or contractor's upfront inspections of the existing roof to identify the structural grid of the roof and whether it will be adequate to support the retrofit roof. Once this is determined, MCA member manufacturers that are reference in Chapter 9 will be able to engineer the retrofit framing and metal roof system. Without this information, potential design errors can lead to an unsuccessful project or even a catastrophic roof failure. The building owner, contractor, design professional and the retrofit manufacturer working together throughout the design and construction process is an ideal recipe for a successful project.

CHAPTER 5

Framing System Design and Layout

Overview

When designing roofs and determining the procedures for proper layout of framing system components including base members, vertical posts and new metal roof supporting purlins, the user must understand that retrofit framing is an engineered system. The assistance of a design professional familiar with and licensed in structural design and cold-form framing is required. The information contained in this Chapter will assist the design professional in specifying the required components to properly complete the project and will provide information regarding anchor quantity and some common pullout values for fasteners often used in retrofit. Each of these is a critical element in preventing potential failures referred to as a "blow off" from happening.

Photo 5-1: Typical Metal-over-Flat roof retrofit system (Courtesy MBCI)

Design Criteria - Past and Present

The design of any roof system considers gravity and wind loading as well as static loads that include the weight of the roof assembly as well as any building service equipment suspended or supported by the roof structure. (HVAC, Electrical, Fire Sprinkler, etc.) In a retrofit roofing application, it is important to understand that the existing roof assembly and its supporting structure were designed based on the occupancy and use of the building at the time of initial construction. It is important to understand that this initial design does not include any installed service equipment that may have been added in subsequent years. The design professional of record for a retrofit project must determine the governing building code at the time of building construction and what loading requirements were used in the original design. The design professional must then account for any changes that had taken place since the building was built. These changes might include the effects of a change in occupancy that resulted in the addition of a fire sprinkler system, a suspended ceiling, lighting and ductwork, or HVAC equipment just to name a few. The original design and these additional loads may impact the ability to retrofit the roof without significant additional structural work being done.

For example; a warehouse built in 1975 was re-purposed in 1995 to an office building and is now receiving a new Metal-over-Flat roof retrofit creating a new sloped roof. The original design loading was a 20 PSF wind load with a 10 PSF snow load, and 5 PSF dead load. When the building occupancy was changed to offices, the weight of the ceiling, sprinkler and other components created an additional 10 PSF of dead load. Unless the renovation addresses the additional dead loading, the building roof support structure could be overstressed. With the proposed changes involved in the retrofit roof, an additional dead load of 3 to 5 PSF from the retrofit framing and metal roof assembly may make the roof support system even more overstressed. In addition to straight loads, the new retrofit roof may very well create some other concerns in the form of additional loads due to snow drift loading.

When a flat roof is retrofitted, from a flat to a sloped roof, the basic geometry of the roof is also changed. Valleys, parapets and other conditions associated with sloped roofs can very well create snow drifting that must be considered in not only the analysis of the existing roof, but in the design of the new retrofit framing system.

These are a few of the compelling reasons why a design professional must be consulted on a retrofit project. The process in determining the complete affects due to structural changes demands a thorough examination of the building and roof system as well as the structural analysis described in Chapter 3.

Understanding Structural Grids

Almost every building roof has been built using a structural grid concept regardless of whether they are constructed with steel, wood or concrete support systems. This structural grid is made up of secondary and primary components that support the overall roof. The secondary supports (joist, trusses, beams, etc) receive tributary live, dead, and snow loads from the roof itself and Transfer the loads to the primary supports. The primary supports (exterior and interior load-bearing walls, girders, beams supported by interior columns, etc.) then transfer the collected loads from the secondary supports into the building foundation. Newly imposed loads from both the retrofit structure (dead loads) and the loads imposed on the retrofit roof (live loads) must be transferred into the existing roof structural grid. Most retrofit framing systems have been developed to satisfy the various conditions that the existing structural grid proposes. Terms "Parallel" and "Perpendicular" have been employed into the retrofit concept to identify the relationship of the retrofit structure to the existing roof structure. As explained in Chapter 4, these two terms dictate the type and direction of the base member and, in some cases, control purlin spacing.

Figure 5-A illustrates an existing flat roof building, originally built with bar joists that transfer load into the primary steel beams and then to the columns and exterior load-bearing walls. In this case, since the bar joists are parallel to the proposed new roof slope, continuous base zee members are not required to distribute the load. A standard intermittent base shoe would be used to receive the new (retrofit structure) purlin supporting posts. This base shoe would be located directly over and attached to the existing joists. The new (retrofit) purlins are spaced transversely from eave to ridge based on the new metal roof system design capacity for snow, wind and new equipment loads.

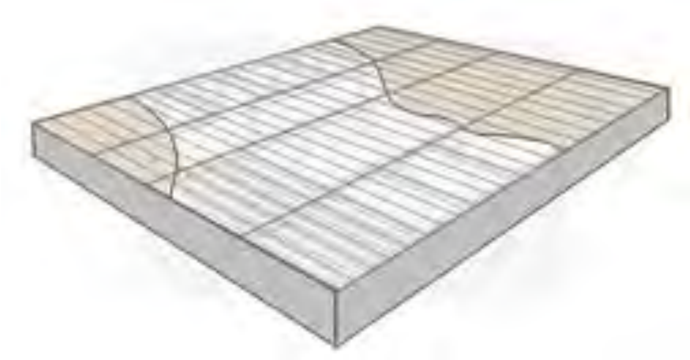


Figure 5-A: Flat roof on bar joists

Figure 5-B illustrates the same roof as Figure 5-A with the new retrofit framing system partially installed for clarity purposes. The posts (represented by the vertical lines) are shown located directly over the existing bar joists.

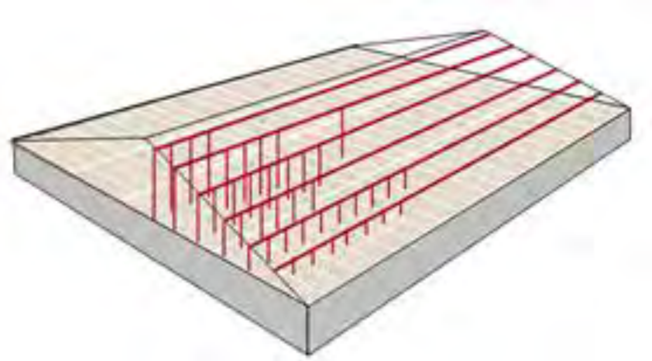


Figure 5-B: retrofit support structure

Figure 5-C is a different roof footprint that will utilize both types of base members. Base shoes are required in the parallel areas and continuous base zee members at the perpendicular areas (shaded). This is because the building has hipped ends, where the purlins in the hip and valley areas begin to run the same direction as the existing bar joists. Notice that the base zees extend past the hip and valley lines to the next bar joist. This permits a post to be located near the hip or valley centerline.

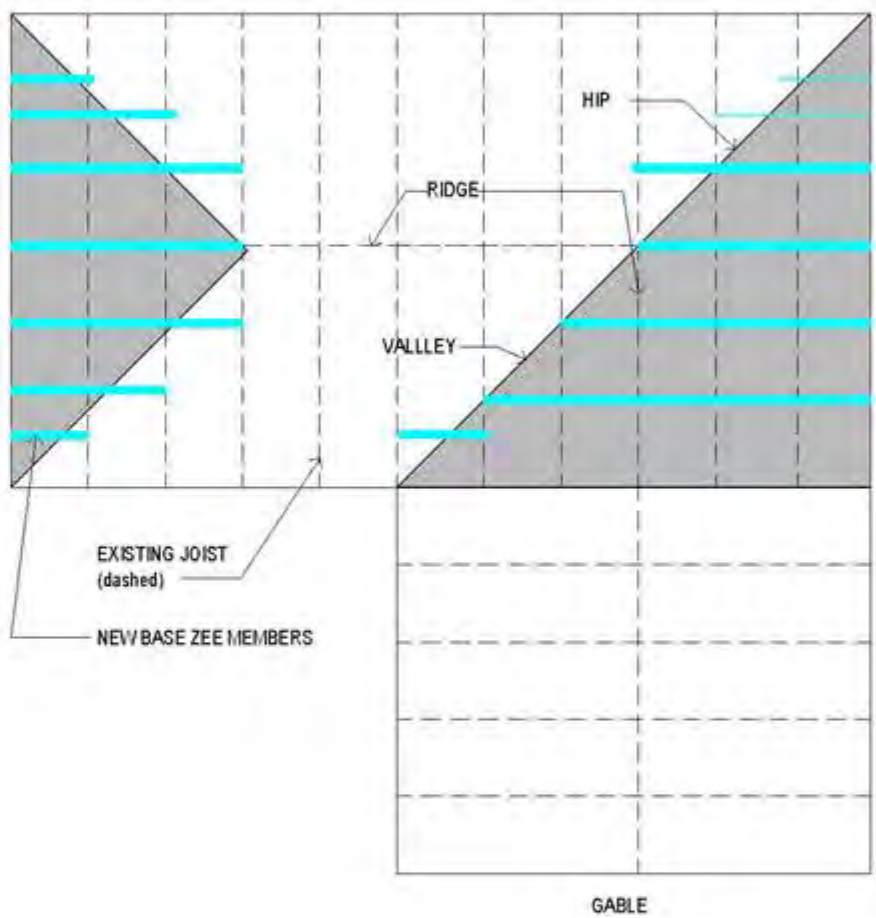


Figure 5-C: Retrofit support structure for a roof with Hips and Valleys

Figure 5-D shows some posts from the retrofit support structure with new purlins. Note the base shoe and posts that are in the parallel areas and that the posts are attached to a continuous base zee member at the perpendicular hip/valley areas.

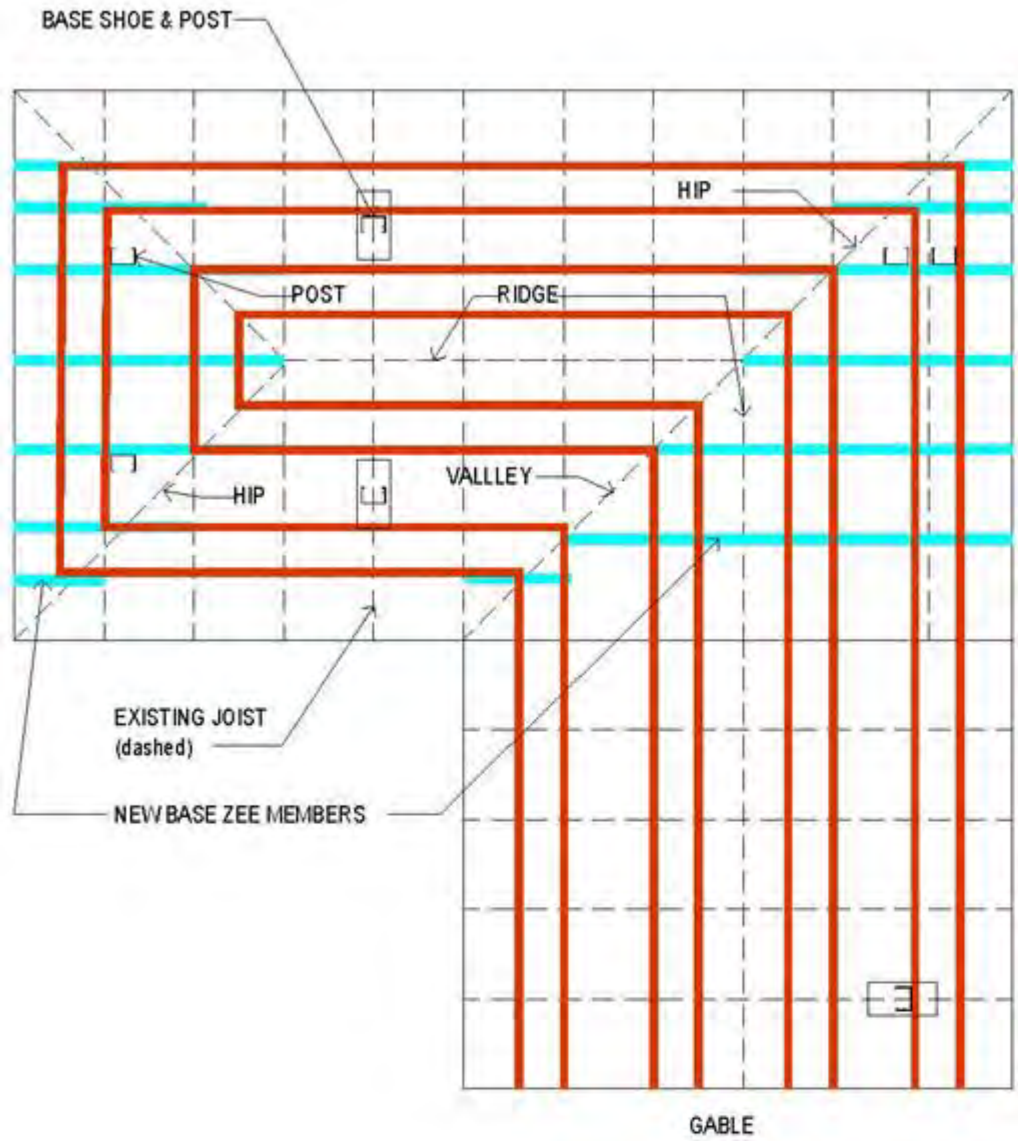


Figure 5-D: Typical location of base shoes and posts

Figure 5-E illustrates the base zee members, base shoes, and posts required to frame a valley (similar at hip). Note that it will be required to install short base members that span from one joist to an adjacent joist to provide attachment of vertical posts in order to support the valley purlins.

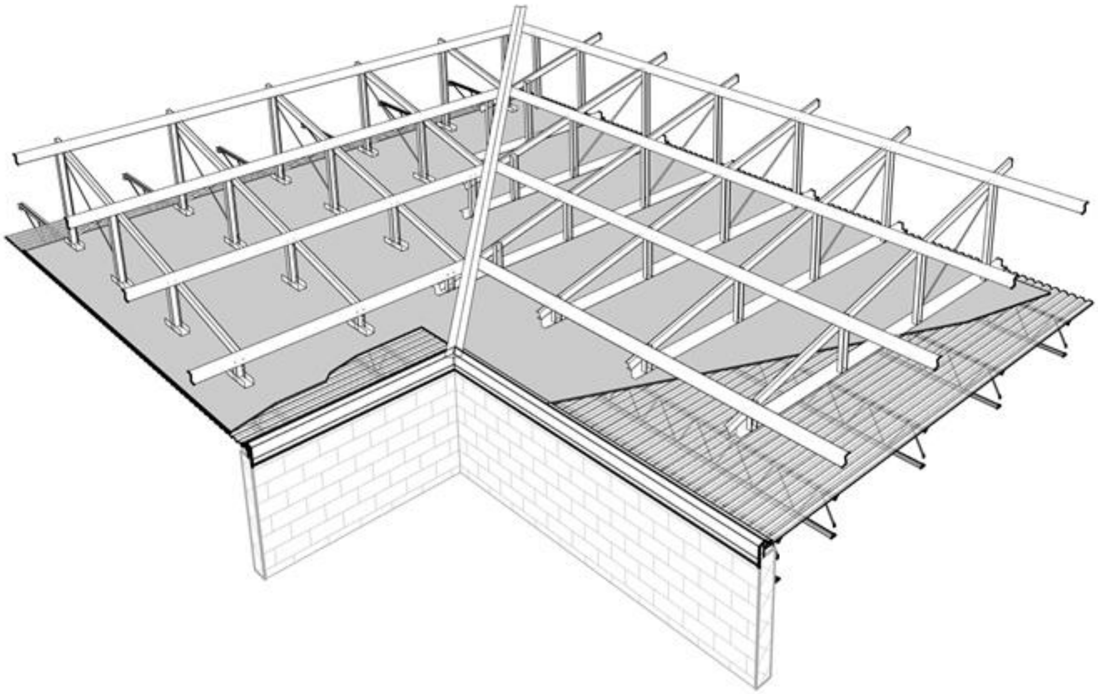


Figure 5-E: Illustration of valley framing

Anchorage of Retrofit Framing Systems

Pullout tests must be performed at the jobsite on the existing roof to determine the load capacity of installed anchors. These tests are conducted by selecting appropriate anchors, which are compatible to the structural components of the existing building. Multiple tests should be performed at different areas of the overall roof to collect enough pullout values to establish an average pullout load to be used in the structural calculations. After installing a test anchor, the pullout tester (Photo 5-2) pulls the anchor until it fails, generally by stripping out the threads. At the point of failure, a value is recorded from the tester's calibrated gauge and the average of these values are used to define the anchorage design.

With pullout values established, a calculation is performed to determine the quantity of anchors required at each attachment location.

Photo 5-2: Pullout Test being performed on existing BUR flat roof – Photo courtesy of Triangle Fastener Corp.

Example: Pullout testing has established that the average pull-out value of a 1/4”-14 x #3-drill point self-drilling screw penetrating through a 1/8” thick steel bar joist chord is 2100 pounds per fastener. To determine the quantity of fasteners at each base shoe or zee member, this value is divided by the maximum negative uplift load determined in the engineer of record retrofit system design calculations. (Make sure that the total pullout resistance value includes the required safety factor, typically specified in the local code or the contract documents. If a safety factor has not been specified or included in the calculations, the contractor should consult with the design professional of record.

For this example, the design professional determines the maximum negative uplift load (upward) is 1100 pounds which must be multiplied by the safety factor of 2.5. The example calculation is 1100 x 2.5 = 2750 pounds of uplift force. This is the total pullout value that must be satisfied by the anchorage method. To determine the number of fasteners required, the 2750 pounds of uplift is divided by 2100 pullout resistance/fastener = 1.31. This number is always rounded up to the next highest value and, in this case a minimum of two fasteners required. (Note: It is recommended that a minimum of two fasteners be installed at any location where the framing base member is subject to twist or pivoting at the attachment point to the existing structure. This is not necessarily true with continuous base zee members which are not subject to twist.)

The table on the following page provides pullout values of common anchors used for various types of roof construction.

Common Anchors used in Retrofit Applications[1]				
Existing Support	**Manufacturer Designation**	**Diameter - Threads per inch**	**Available Lengths**	**Pullout Value[2] (LBs)**
Attachment to Wood				
2" x Pine[3]	Concealor® Pancake Head Screw	#14-13	1½" to 9"	991
2" x Fir[3]	Triangle Fastener Corp Tapper Type A	¼"	up to 6"	991
	Common Lag Screw	5/16"	up to 6"	172-1169
		3/8"	up to 12"	186-1330
		½"	up to 24"	191-1609
Attachment to Concrete				
Concrete[4]	Sentry Plus Five® Roofing Screw	#14-13	1¼" to 12"	740
		#15-13	1¼" to 24"	1002
	Zamac Drive Pin	3/16"	7/8"	500
		¼"	¾" to 2"	580-1150
	Spike® Nail-in	¼" (1¼" Embed)	2" to 14"	820-5460
	Tapcon® Threaded Screw	¼" (1¼" Embed)	1¼" to 6"	1050
		¼" (1½" Embed)		1380
		¼" (1¾" Embed)		2020
Attachment to Steel				
14 Gauge	Concealor® Pancake Head Screw	#1/4-14 DP3	1 3/8" to 6"	1077
12 Gauge				2170
1/8"				2030
¼"				4493
3/16"	Blazer® Drill Screw Hex Washer Head	¼-14 DP3	¾" to 8"	3863
¼"				4493
3/8"		¼-20 DP5	3" to 8"	4283
½"				4680

[1] Values are as provided by Triangle Fastener Corporation (TFC) manufacturer's literature and testing. Note that most MCA member retrofit manufacturers do not furnish framing base member anchors. They are typically obtained locally by the contractor, but it is important to make sure the fasteners selected will meet the ultimate pull-out calculated value, determined by the on-the-roof testing.

[2] Average ultimate value in pounds with no safety factors applied. Where a range is provided, the ultimate pullout value is totally dependent on the actual condition of the material being attached to.

[3] Fastener with full penetration (greater than 1") into wood member. Consult with Fastener manufacturer or distributor for minimum requirements.

[4] Concrete based on 3,000-PSI minimum with manufacturer specified embedment. Tapcon anchors based on 3,145-PSI concrete.

Satisfying Compression Resistance

As mentioned in Chapter 3, satisfying compression resistance of the existing roof substrate and membrane is another calculation that must be performed. If the compression resistance is not satisfactory for the retrofit imposed loads, a load-distributing component will be required between the base shoe or zee member and the existing roof at each deficient anchor location. This load distribution component can be any high compressive strength material where the size is calculated by dividing the maximum positive load (provided by the retrofit framing system manufacturer) by the compression resistance value obtained from field-testing. This value is determined during the pullout testing described above or by extracting actual core specimens of the existing roof substrate and membrane and then having them tested by a laboratory.

Photo 5-3: Pull-Out Tester

Standard Retrofit Framing Components

Standard retrofit framing components vary by manufacturer. Shape, size, and gauge thickness will vary based on the production and manufacturing processes and how well these framing components fit in with the other products included in the system provided by the manufacturer. The typical details in this chapter illustrate accepted components, design and materials used throughout the light-gauge structural framing retrofit market. Components are readily available from a multitude of MCA Member Manufacturers referenced in Chapter 9.

Each retrofit project is unique in required design and member composition as illustrated in this manual. For purlins and posts, project design requirements may require that more than one component size is selected. Most MCA manufacturer Technical Services and Engineering departments are equipped to fully engineer the retrofit system and produce erection drawings and other installation documents required for a complete installation.

It is important to note that purlins are normally spaced from eave to ridge based on the span capacity of the selected new metal roof system. Metal roof systems are tested for wind uplift in accordance with ASTM E-1592 (Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference).

This testing identifies the ultimate negative pressure that the metal roof system will withstand. The resulting test values are used in the design of all metal roof systems for new and retrofit construction projects. An industry standard is to install structural standing seam metal roof systems (SSSMRS) over support framing (purlins or joists) having a maximum span of 5’-0” without the benefit of solid roof decking (metal or wood). Refer to Chapter 9 for more information on accepted structural metal roof systems.

Vertical Posts

Vertical posts are typically 4”x2” or 2-1/2” nominal cee-shaped members. The typical member thickness is 16-gauge, but sizing is subject to height of the member and the amount of directly imposed design bearing load applied. In most cases, horizontal struts are necessary, and the use of these struts allow post height limitation to extend to approximately 20’ above the existing roof. In cases where the height is greater than 20’or the design loading is excessive, cee-shaped post members up to 8” deep have been used. In some cases, these larger members have been secured back-to-back to satisfy the required design loading.

Intermittent and Continuous Base Members

When not permitted to use a standard base shoe channel-shaped member (parallel conditions), a continuous base zee-shaped member will be required as illustrated in Chapter 4. Some retrofit manufacturers also use other shapes including a laid down channel to receive vertical posts. This type of member typically lacks the ability to span from one point of attachment to the next, where a zee-shaped member has this ability. For continuous members, it is always recommended to use a rainwater-shim beneath every point of attachment to the existing roof structure to allow the member to span and transfer load only at each point of attachment. These shims do not allow continuous bearing on the existing roof. In addition, shimmed base zees permit rainwater to flow to the existing drainage during installation to prevent damming, which could overload the existing roof. Again, a qualified structural design professional should review these types of details to ensure they are not overloading the existing roof deck. Both types of base members are normally a nominal 4” x 2½” component with a thickness of 16-gauge.

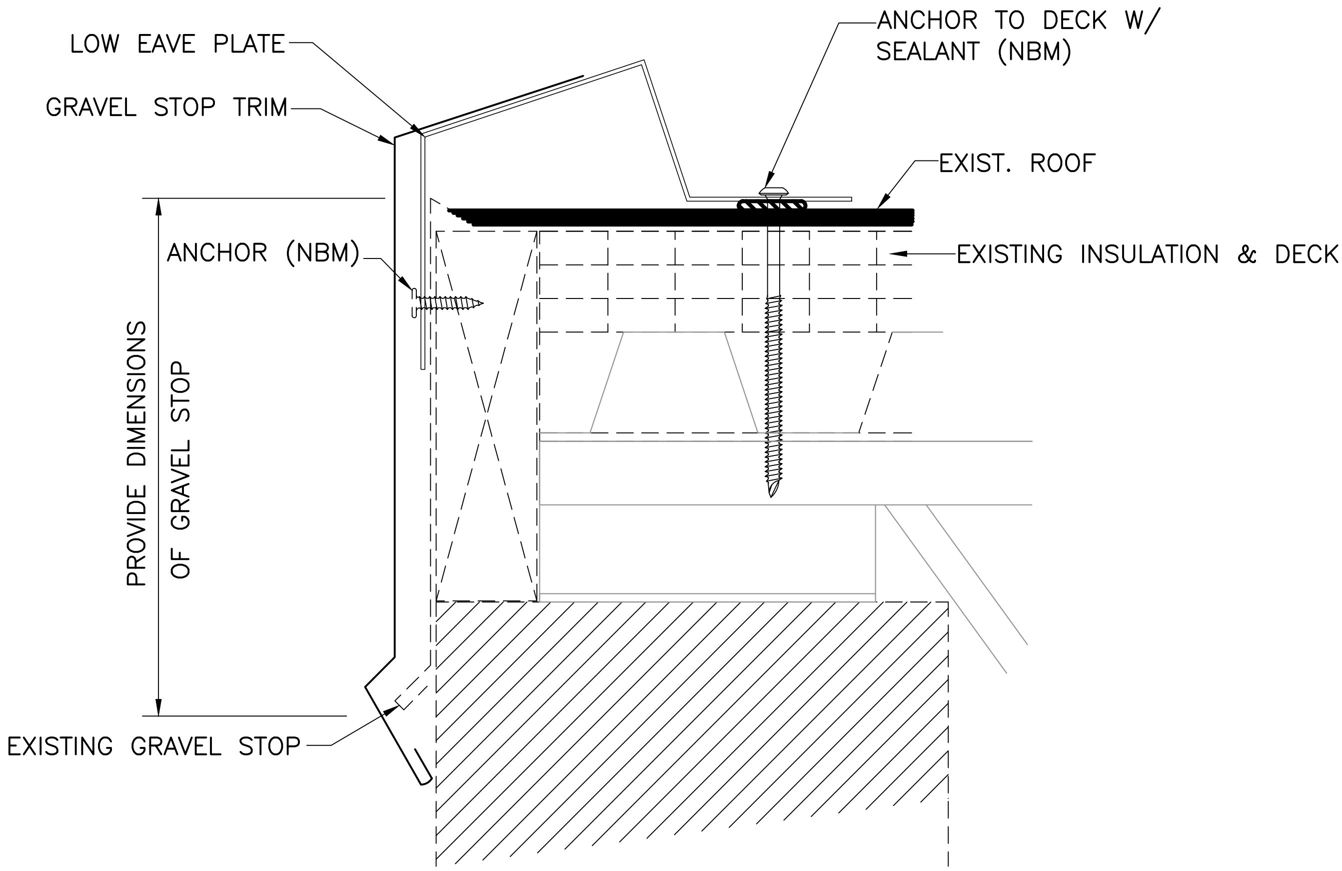
Photo 5-4: Existing flat roof flooded after a rainfall due to continuous base members not being shimmed at their point of attachment. (Photo courtesy of retrospect, LLC)

Chapter Summary

It is evident by the procedures and post-construction changes to a building roof that a design professional must be employed to conduct analysis of the existing roof and its structural load capacities. Furthermore, the design professional will engineer the new retrofit framing and metal roof assembly to comply with the specified building code and criteria required. These elements are necessary for a retrofit project to provide safe shelter for the building owner and to be completed successfully and without incident of failure.

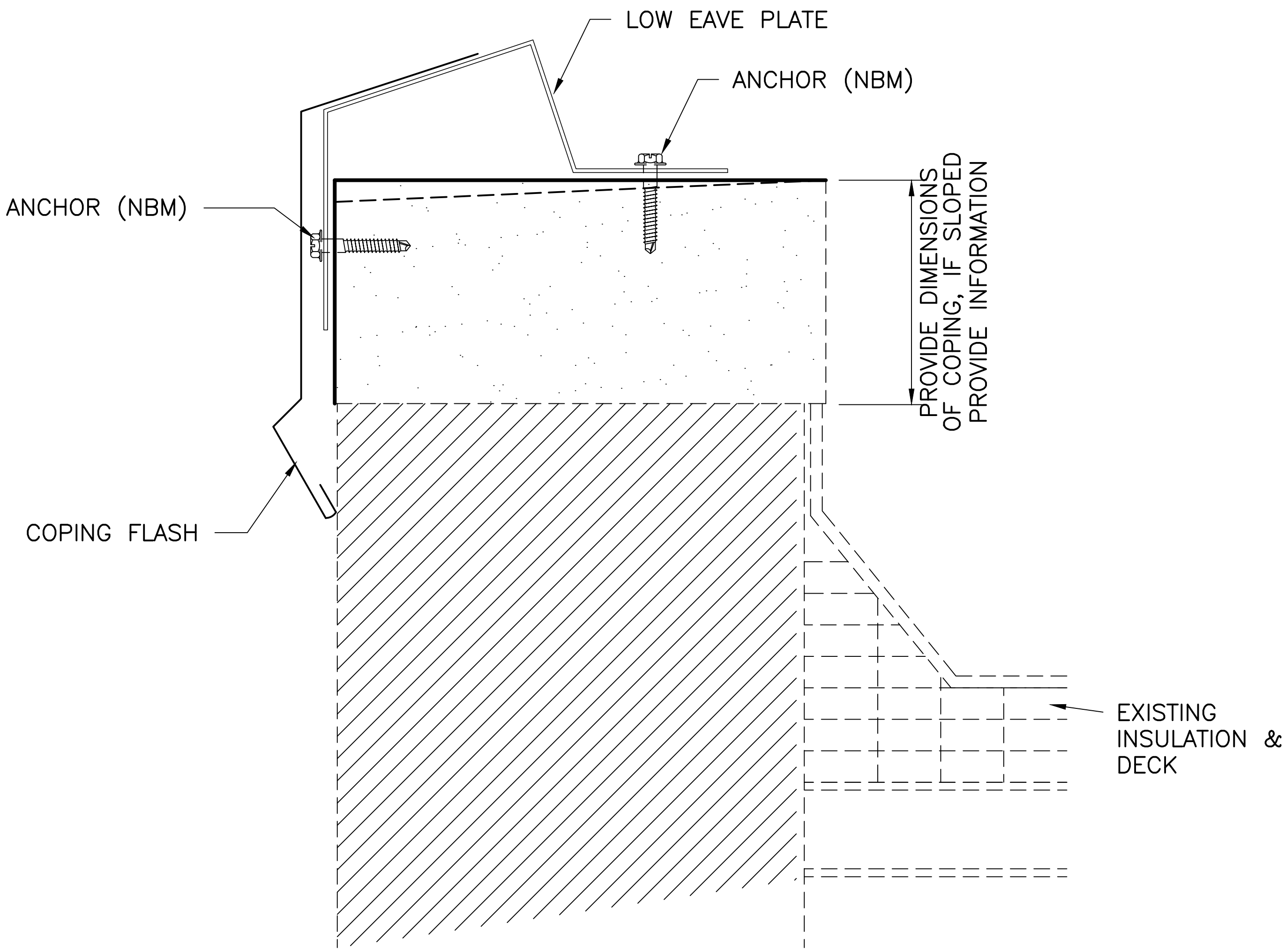
Typical construction details have been provided below for illustrative purposes only. The details are generic and will differ from one retrofit manufacturer to the other. Refer to Chapter 9 for a listing of MCA Members that furnish complete metal-over-flat roof retrofit framing systems.

Typical Construction Details



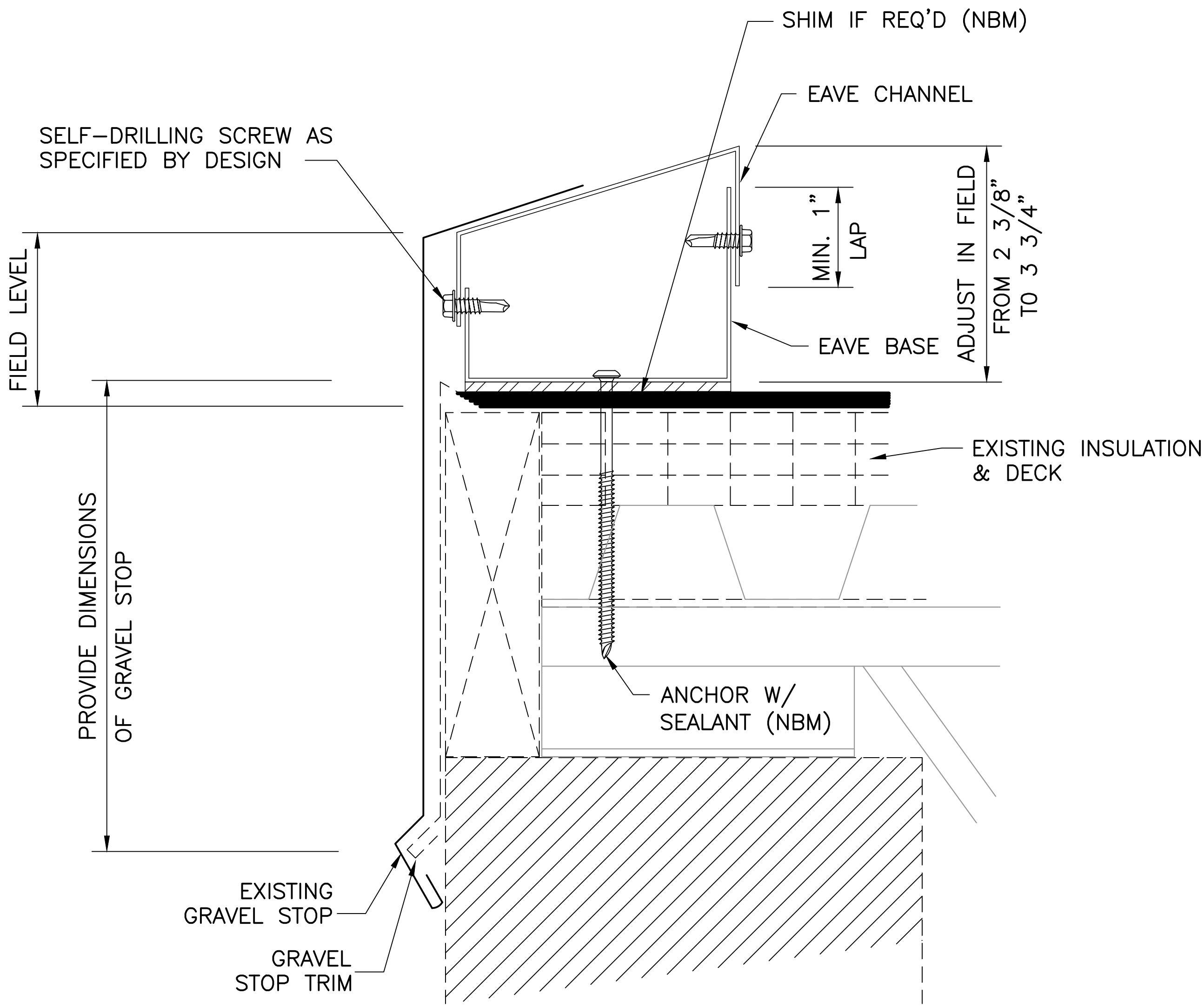
LOW EAVE

@ GRAVEL STOP



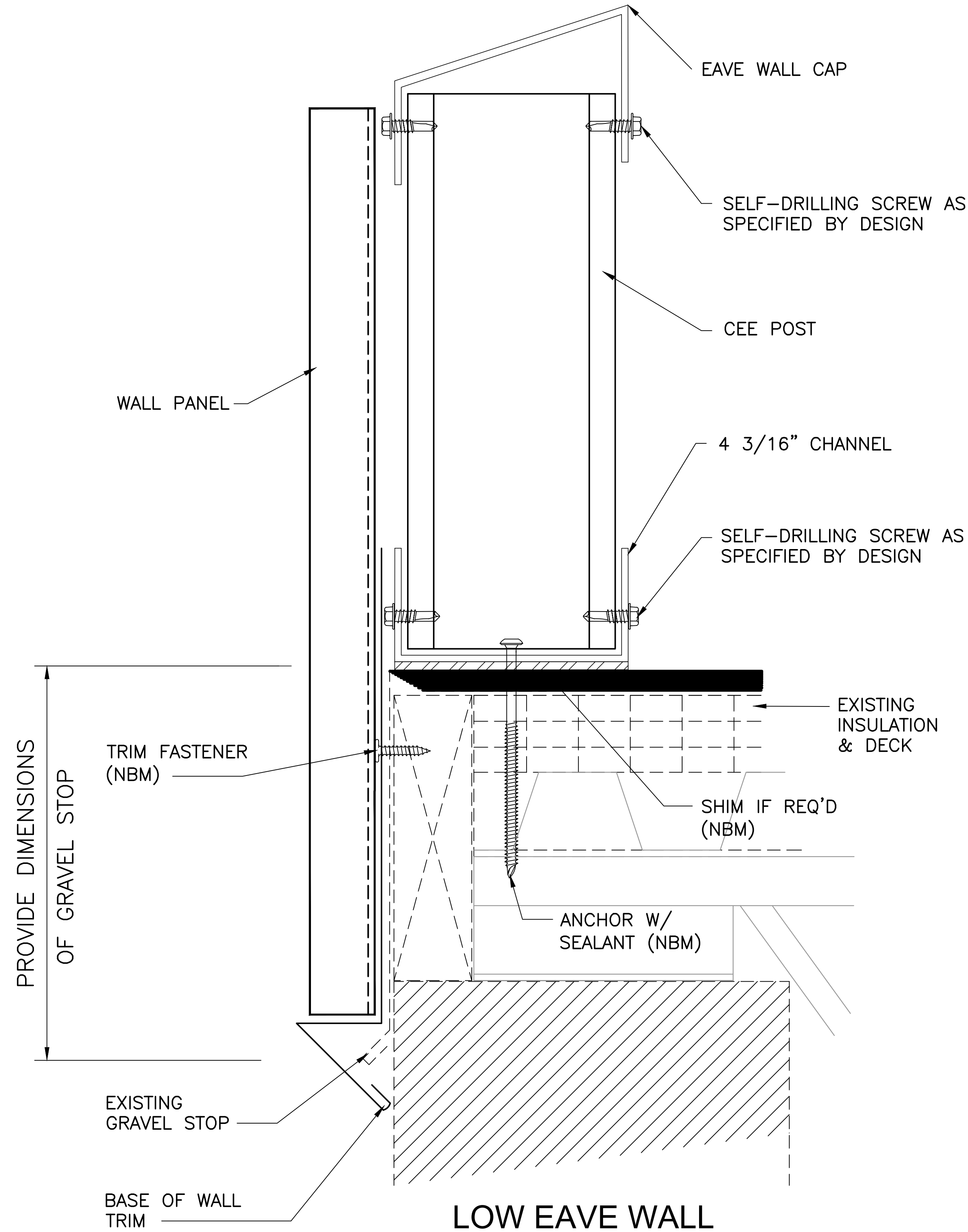
LOW EAVE

@ LOAD-BEARING PARAPET



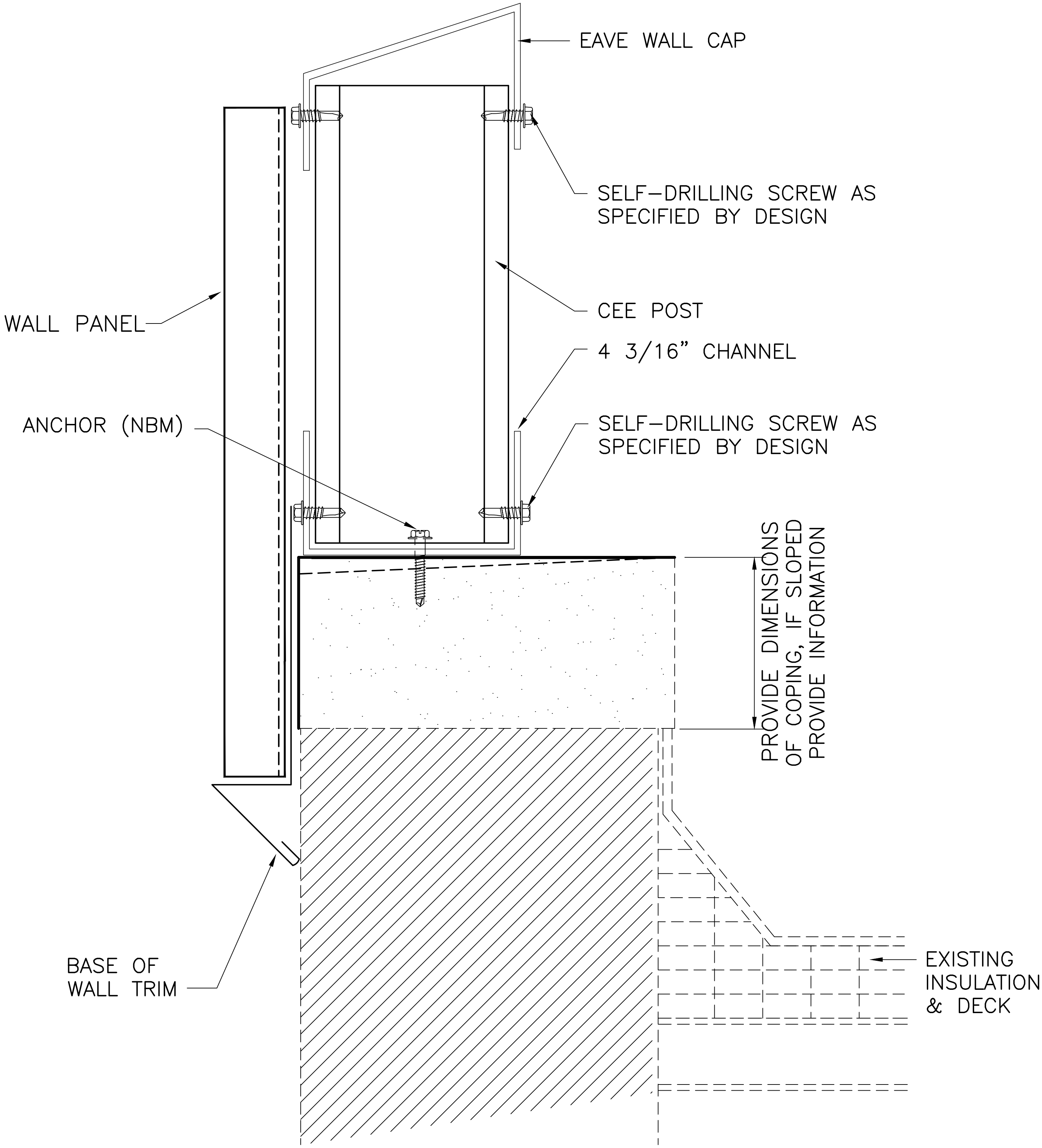
FLOATING LOW EAVE

@ GRAVEL STOP



LOW EAVE WALL

@ GRAVEL STOP



LOW EAVE WALL

@ LOAD-BEARING PARAPET

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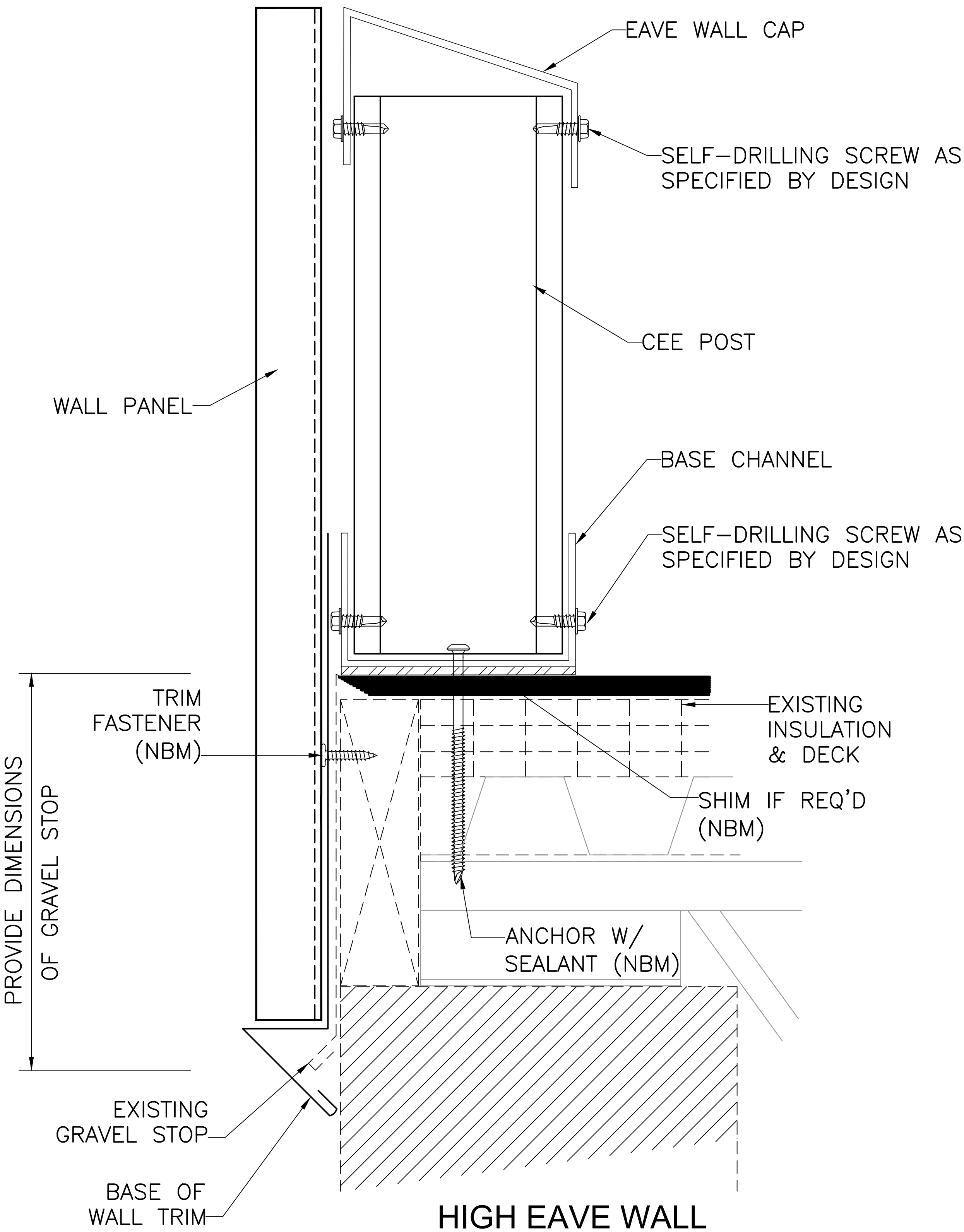
PERIMETER FRAMING

EAVE CONDITONS

date



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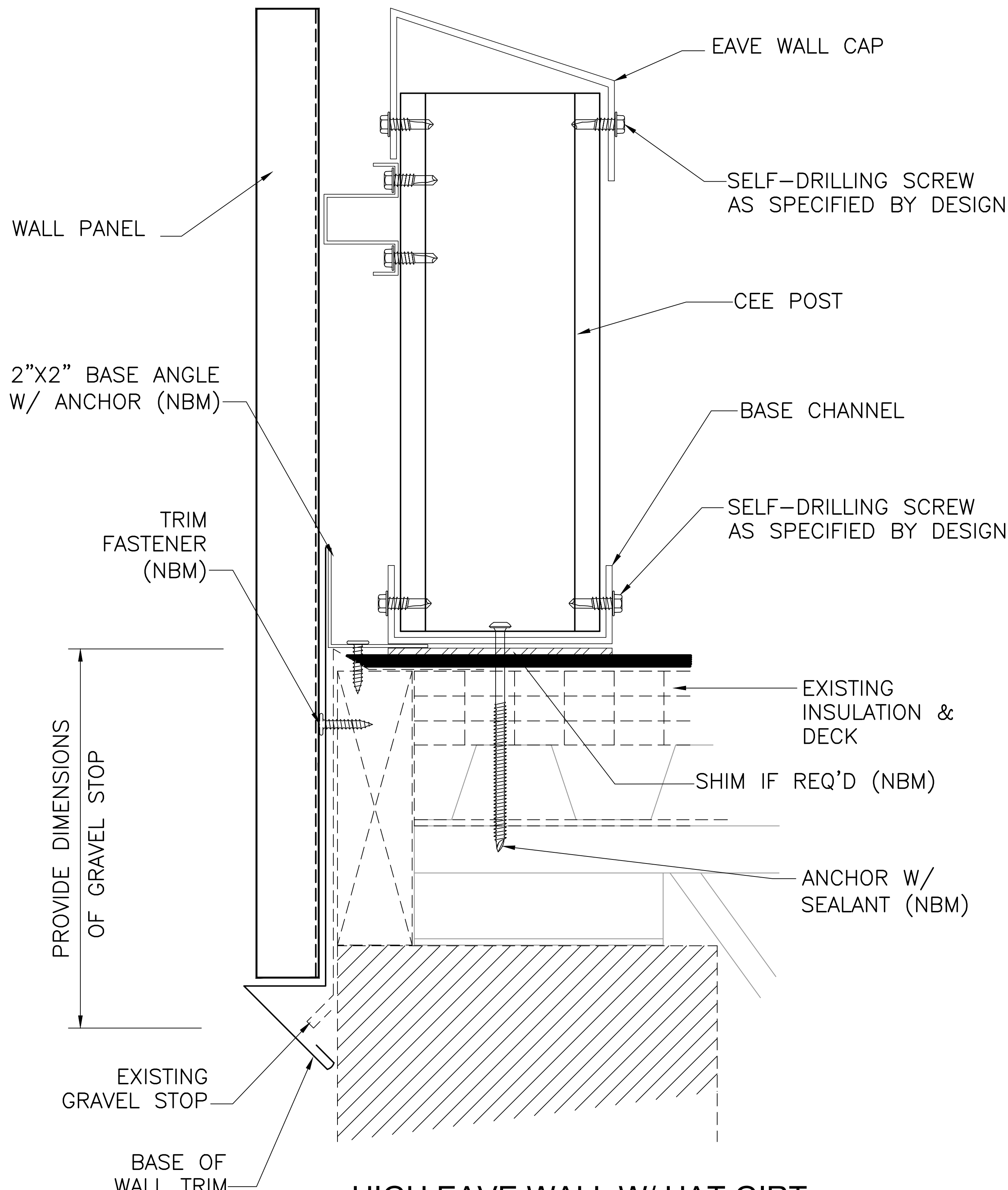

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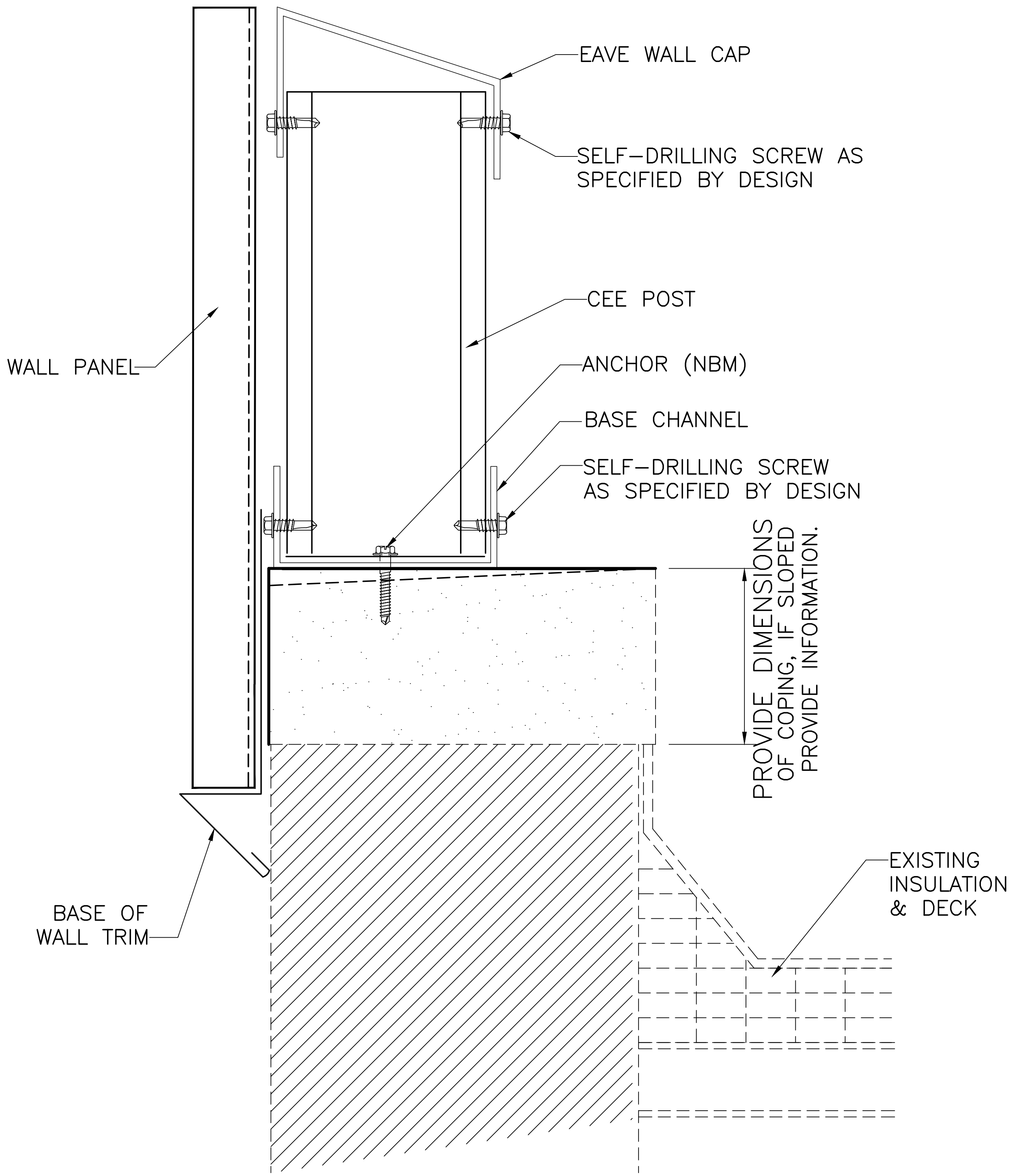

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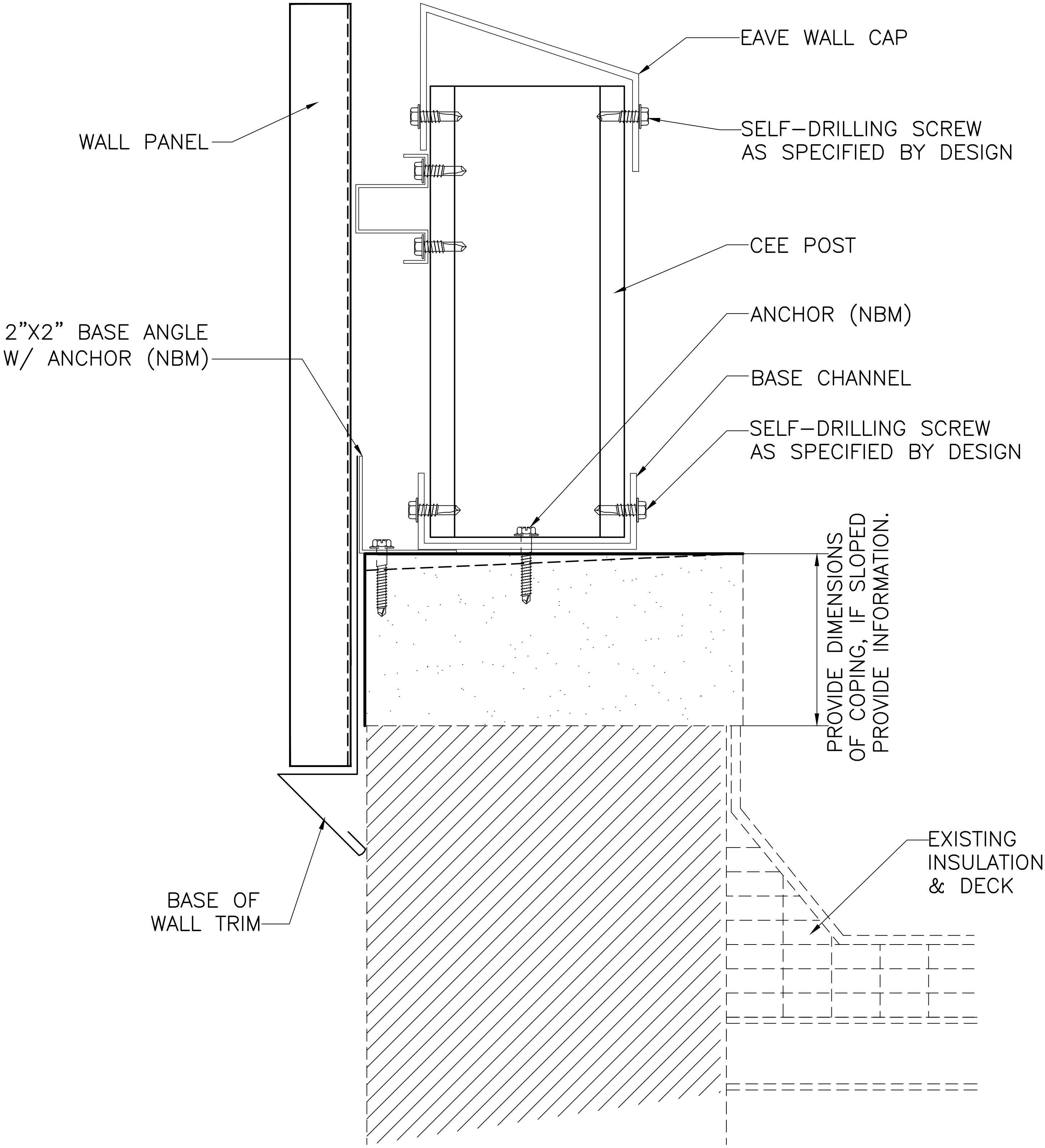

HIGH EAVE WALL W/ HAT GIRT

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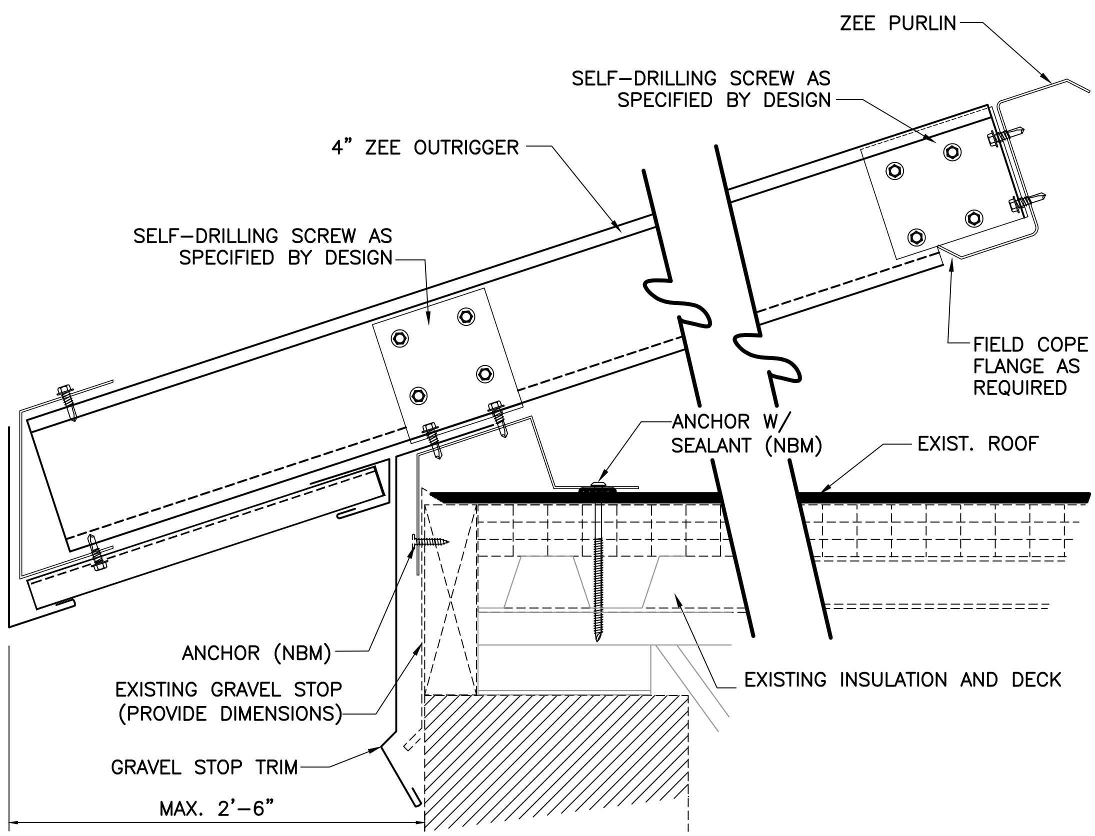

LOW EAVE CANOPY

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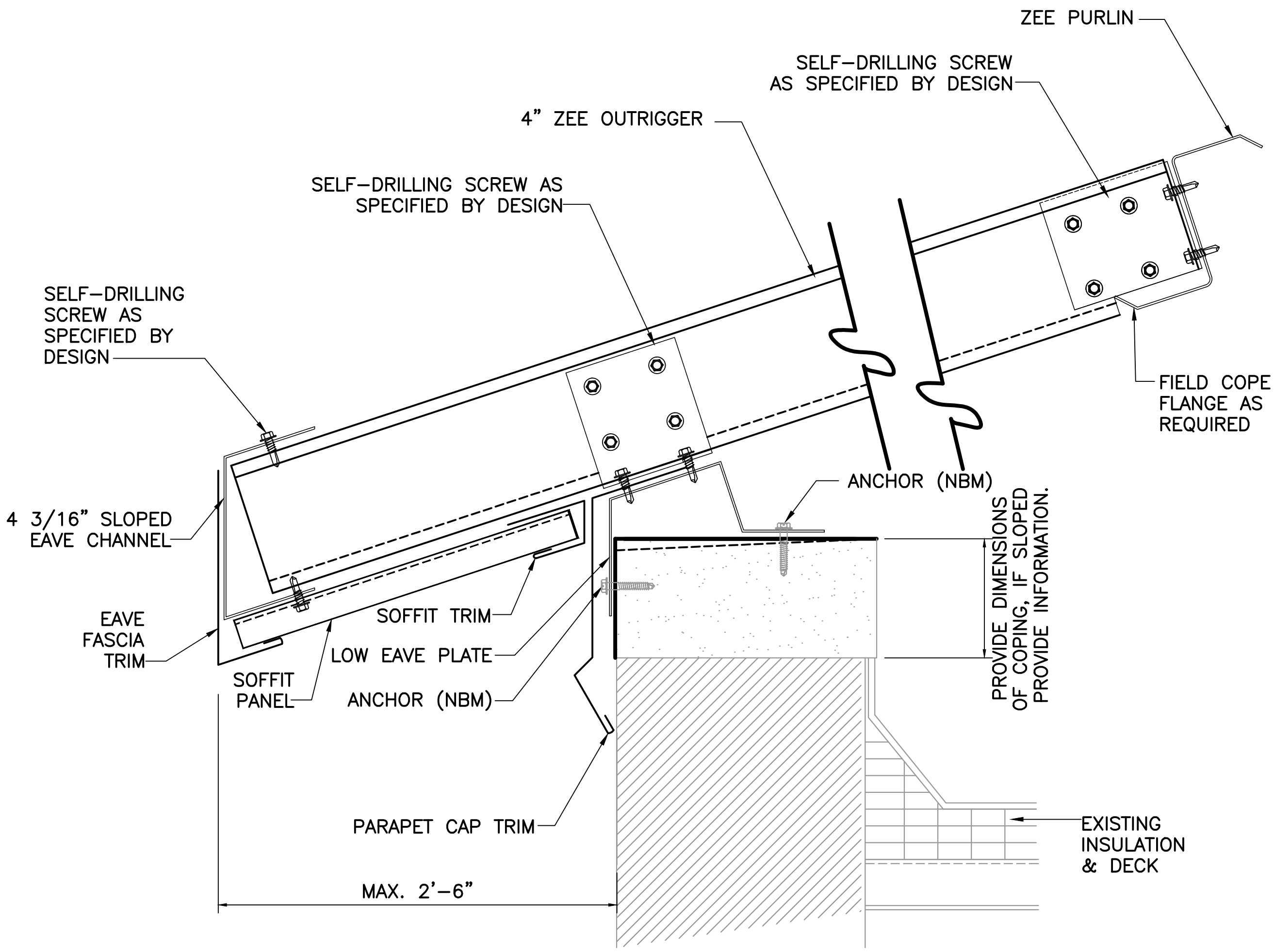

LOW EAVE CANOPY

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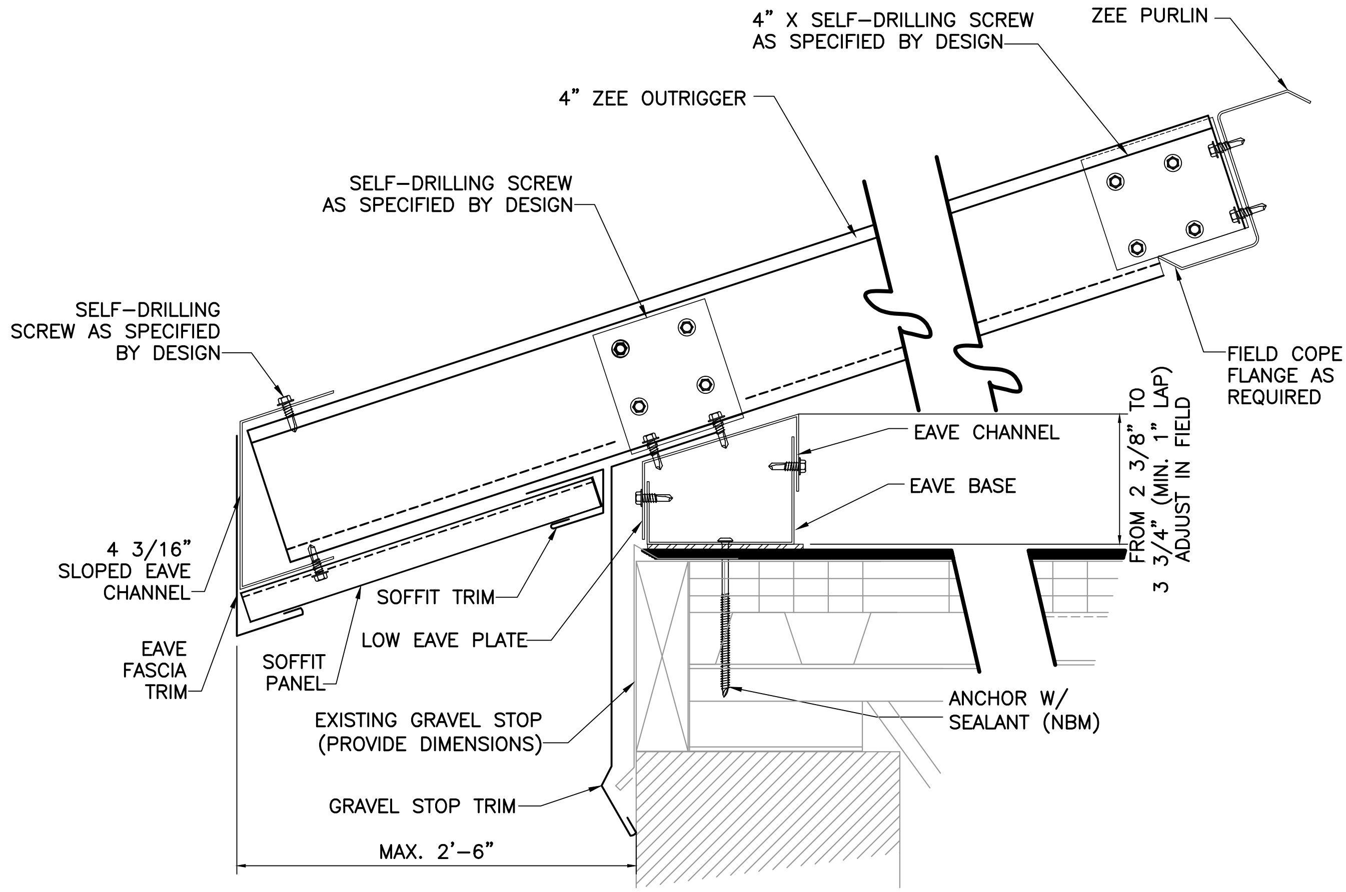
PERIMETER FRAMING

CANOPY CONDITONS

date



LOW EAVE CANOPY FLOATING

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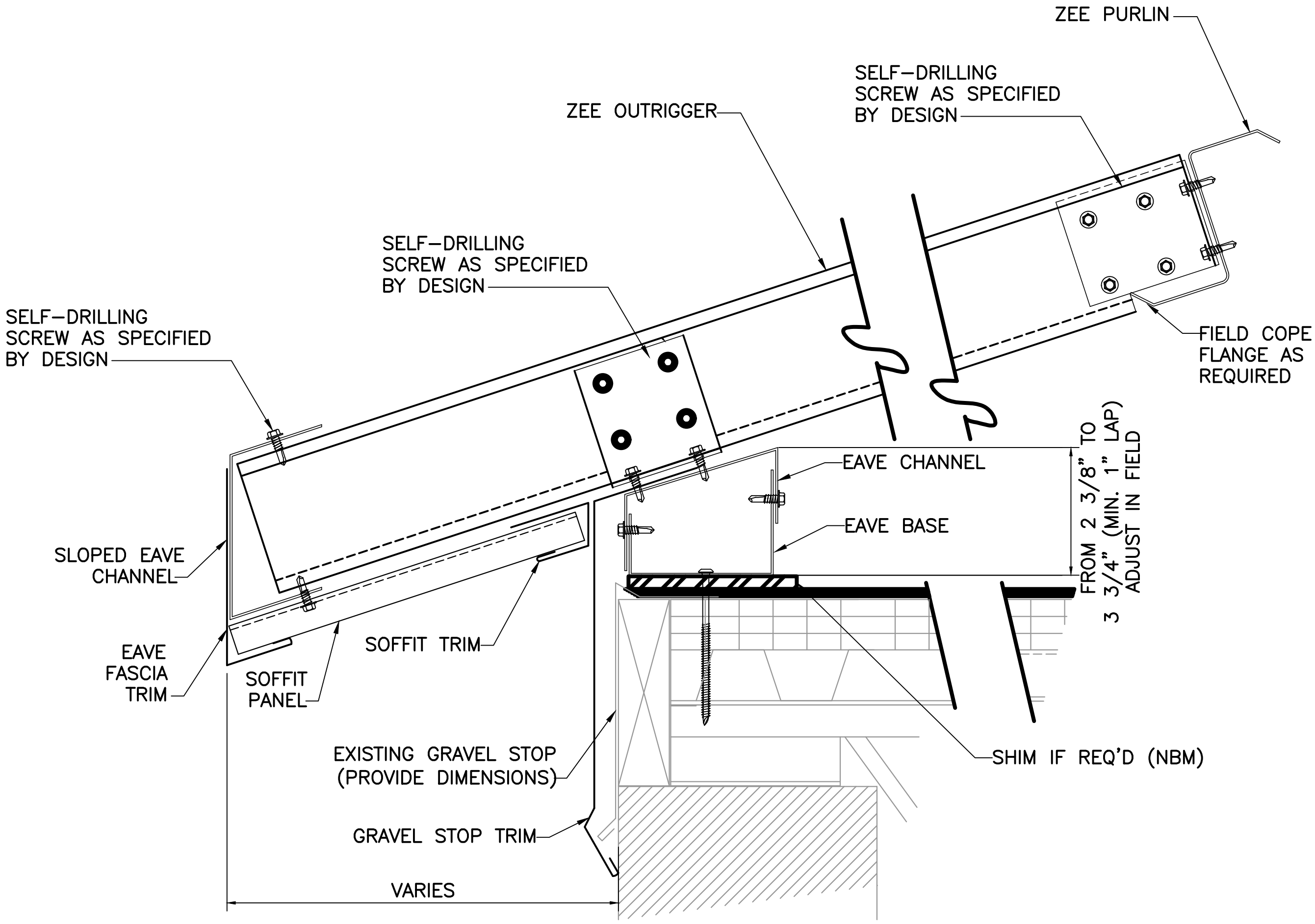

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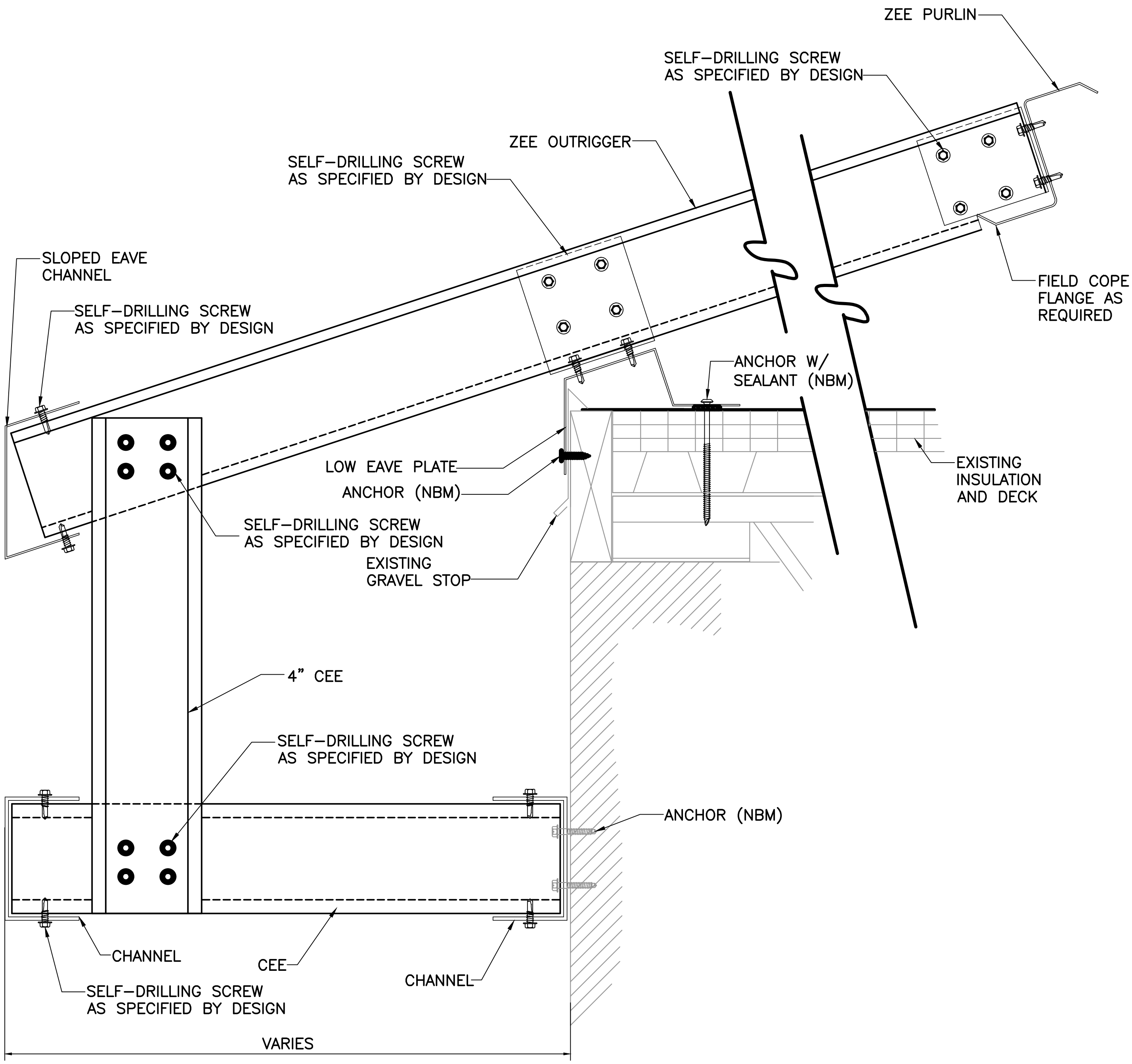

CANOPY FASCIA W/ LOW EAVE

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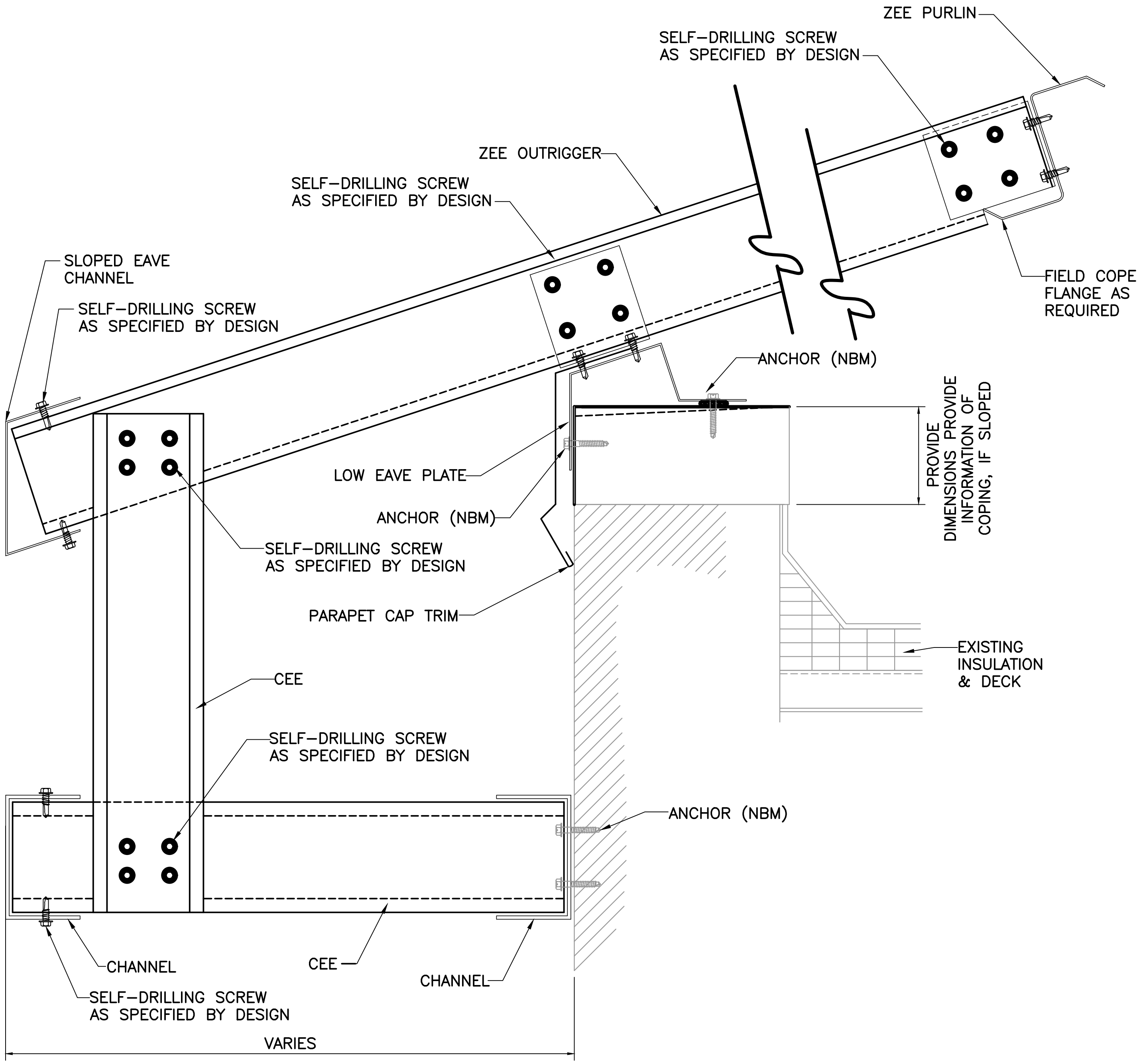

CANOPY FASCIA W/ LOW EAVE

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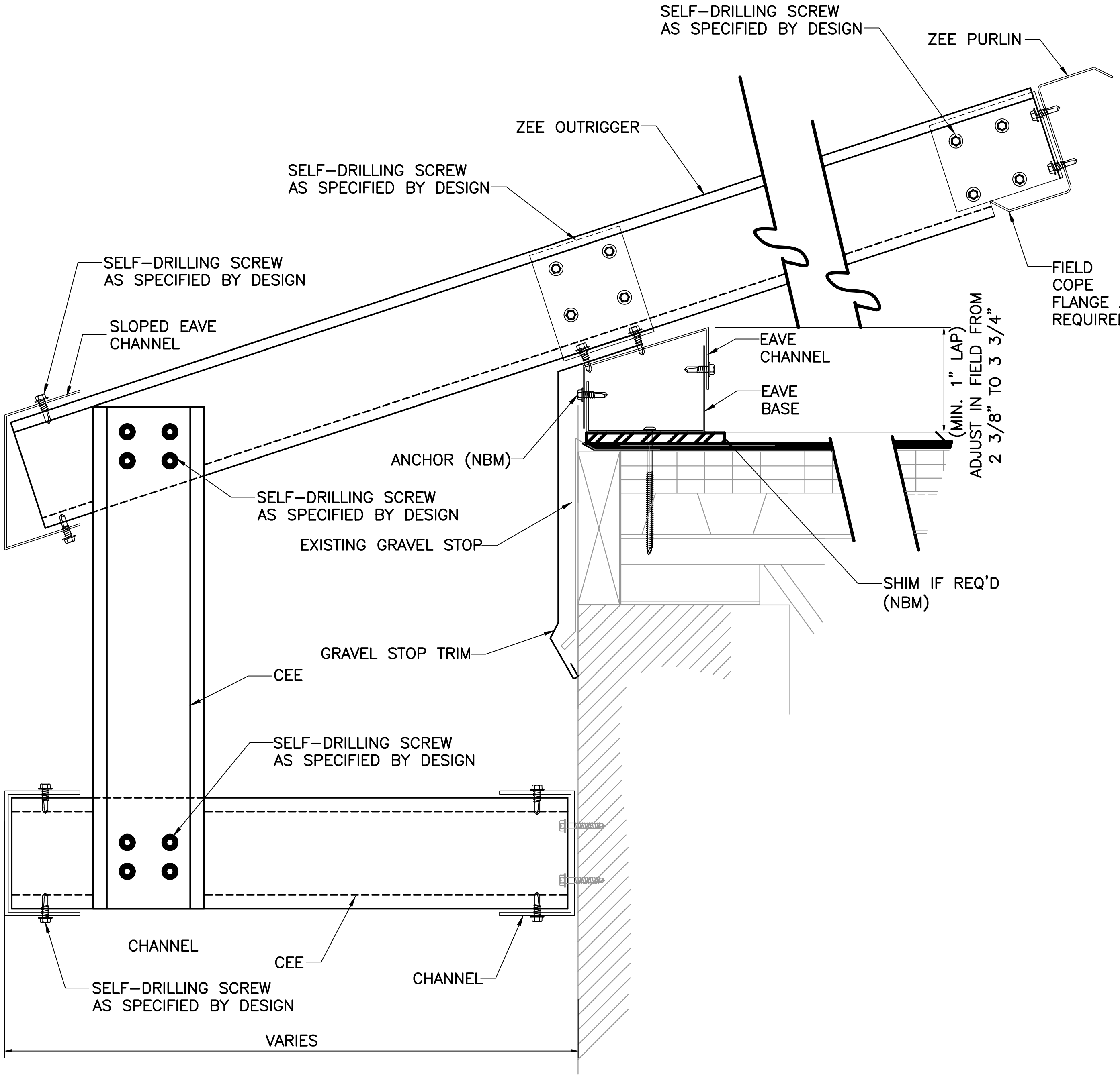

CANOPY FASCIA (FLOATING)

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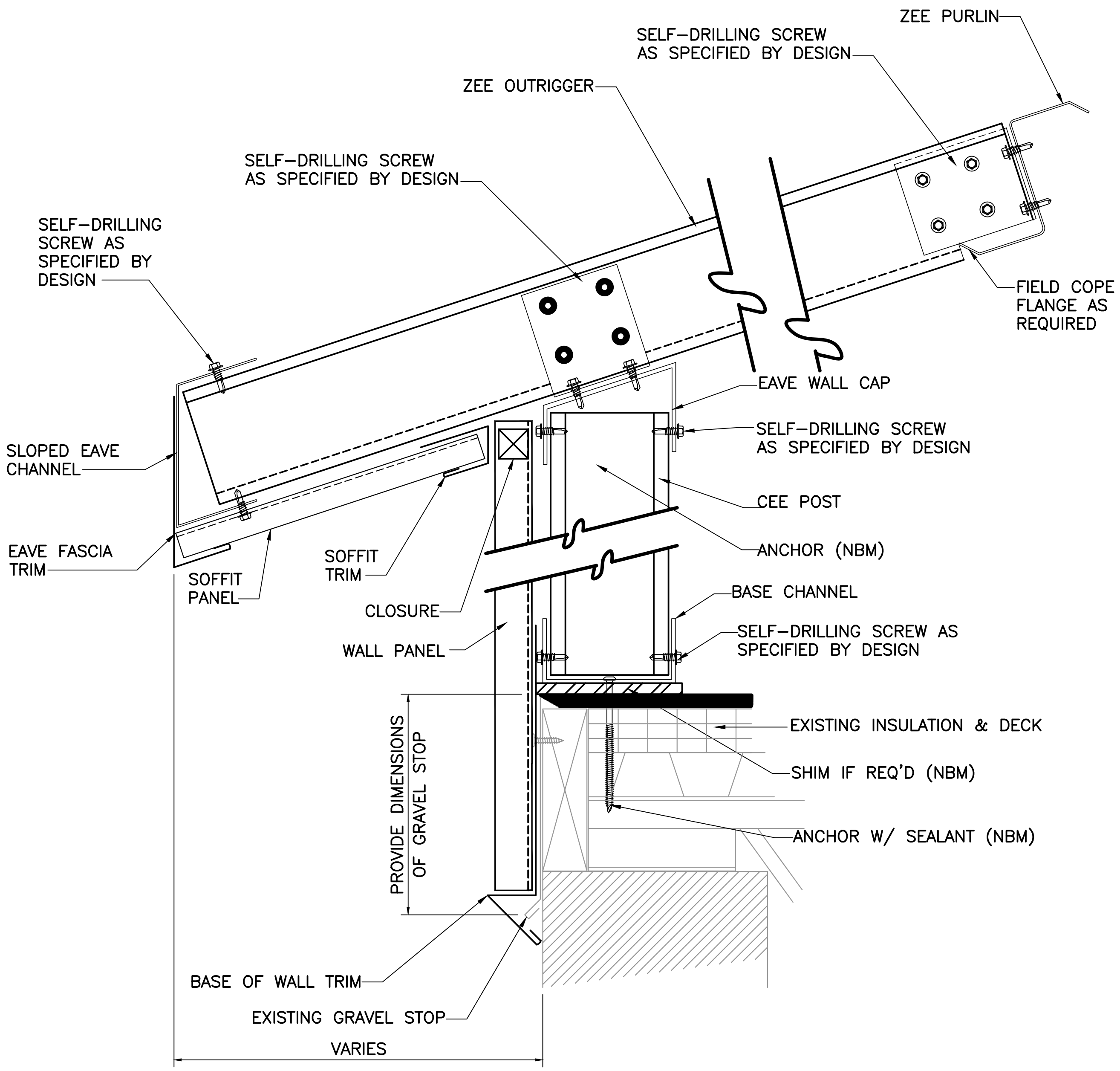

LOW EAVE CANOPY WALL

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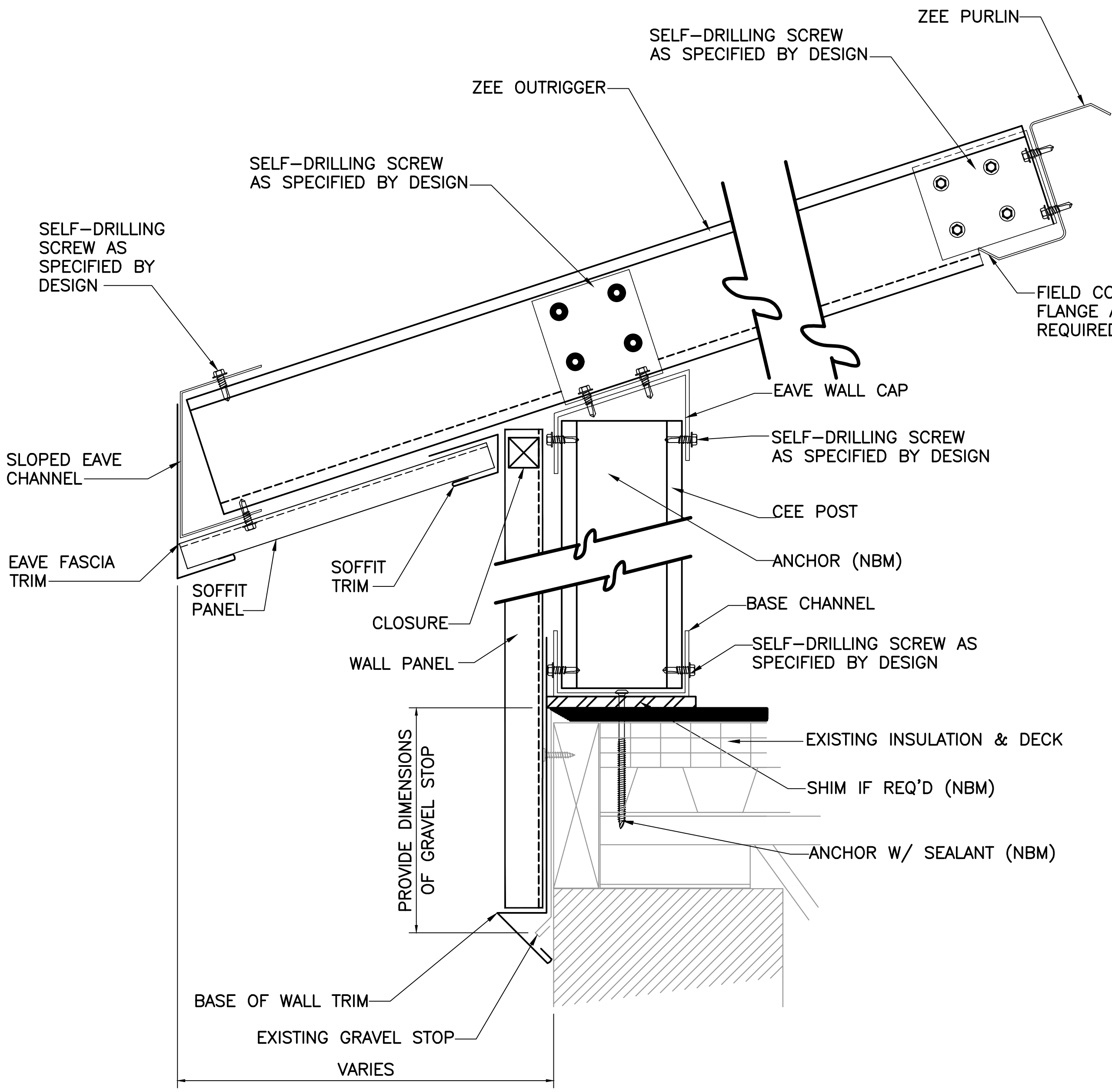

LOW EAVE CANOPY WALL W/ VENT STRIP

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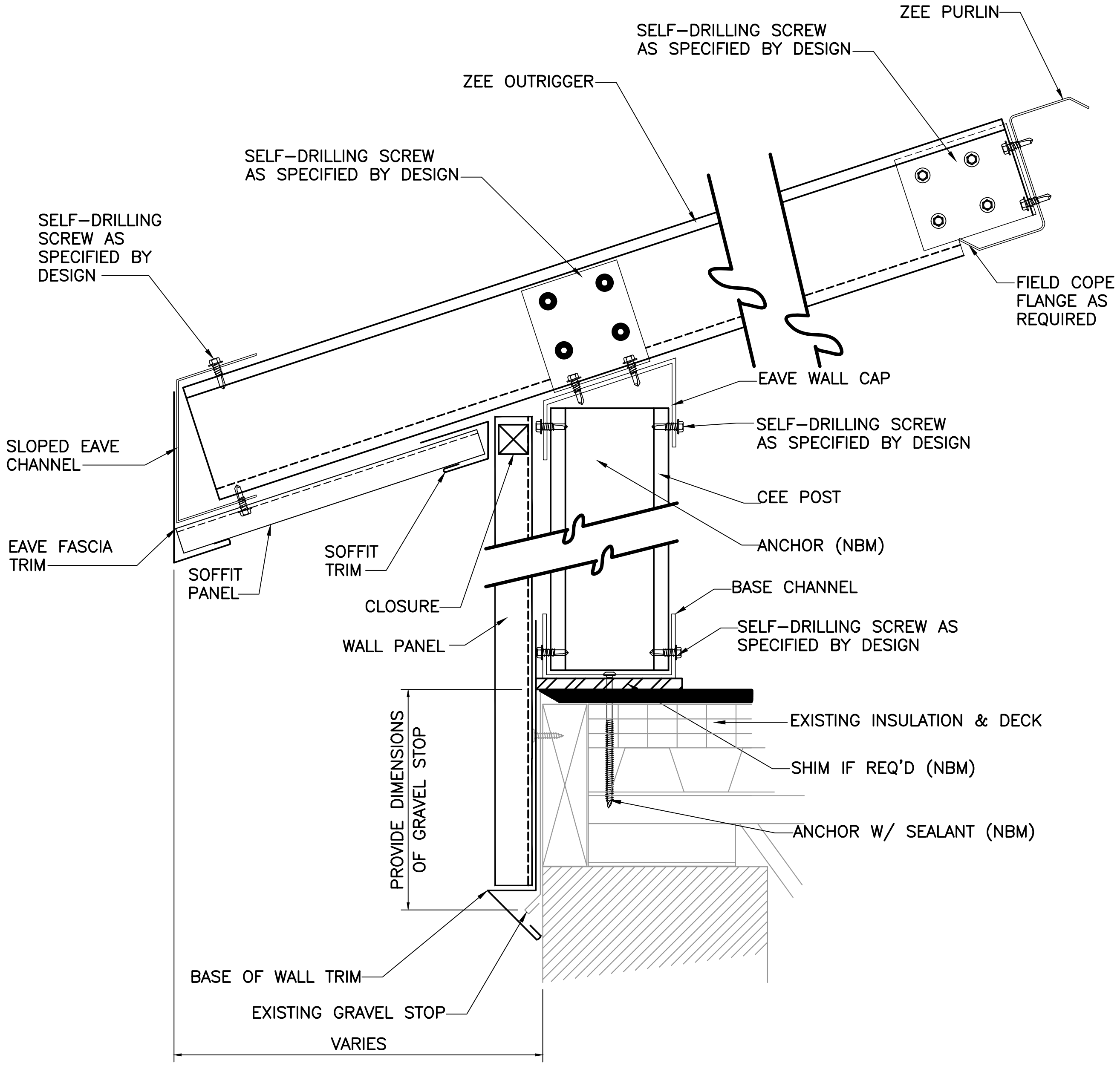

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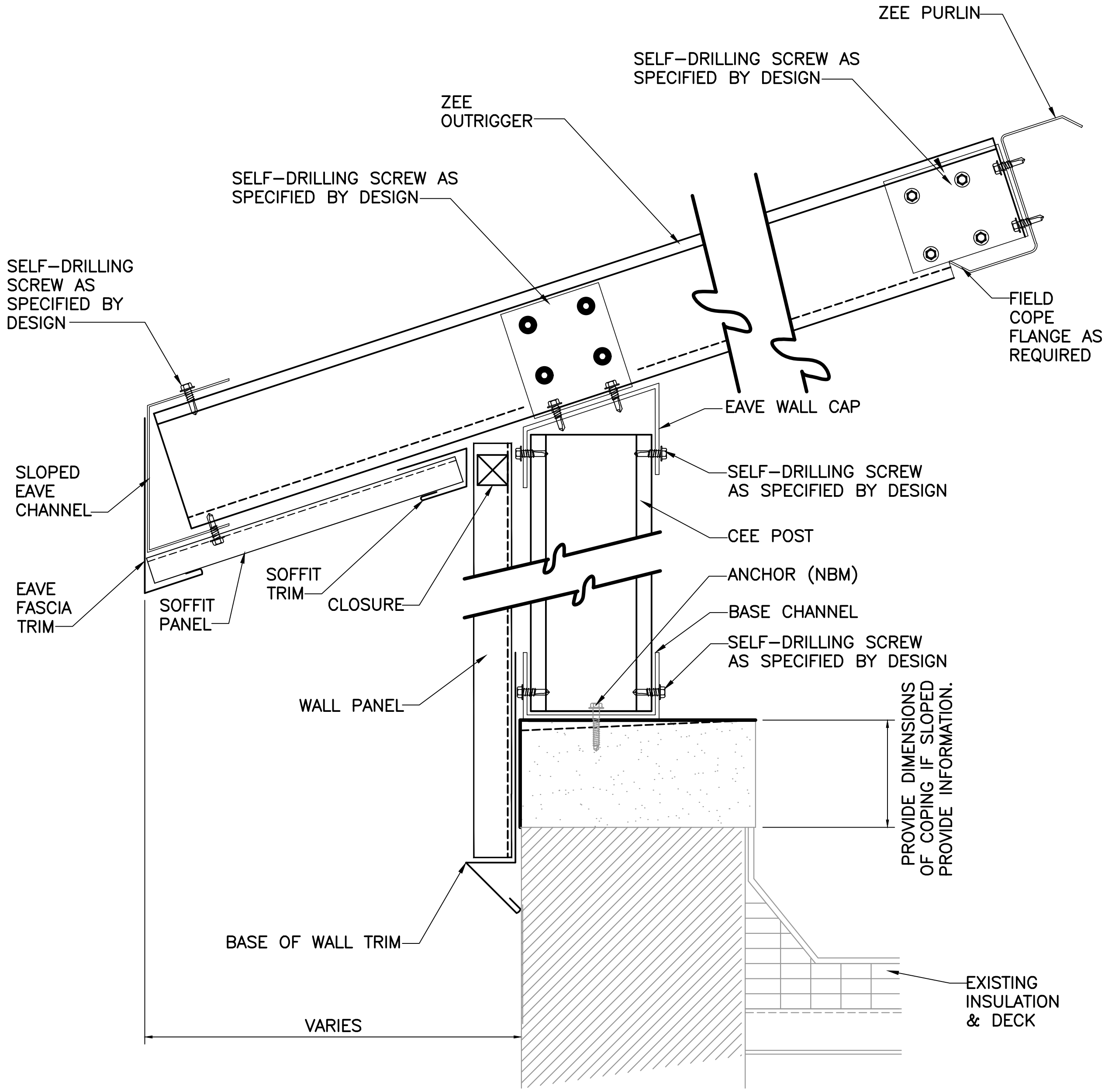

LOW EAVE CANOPY WALL W/ VENT STRIP

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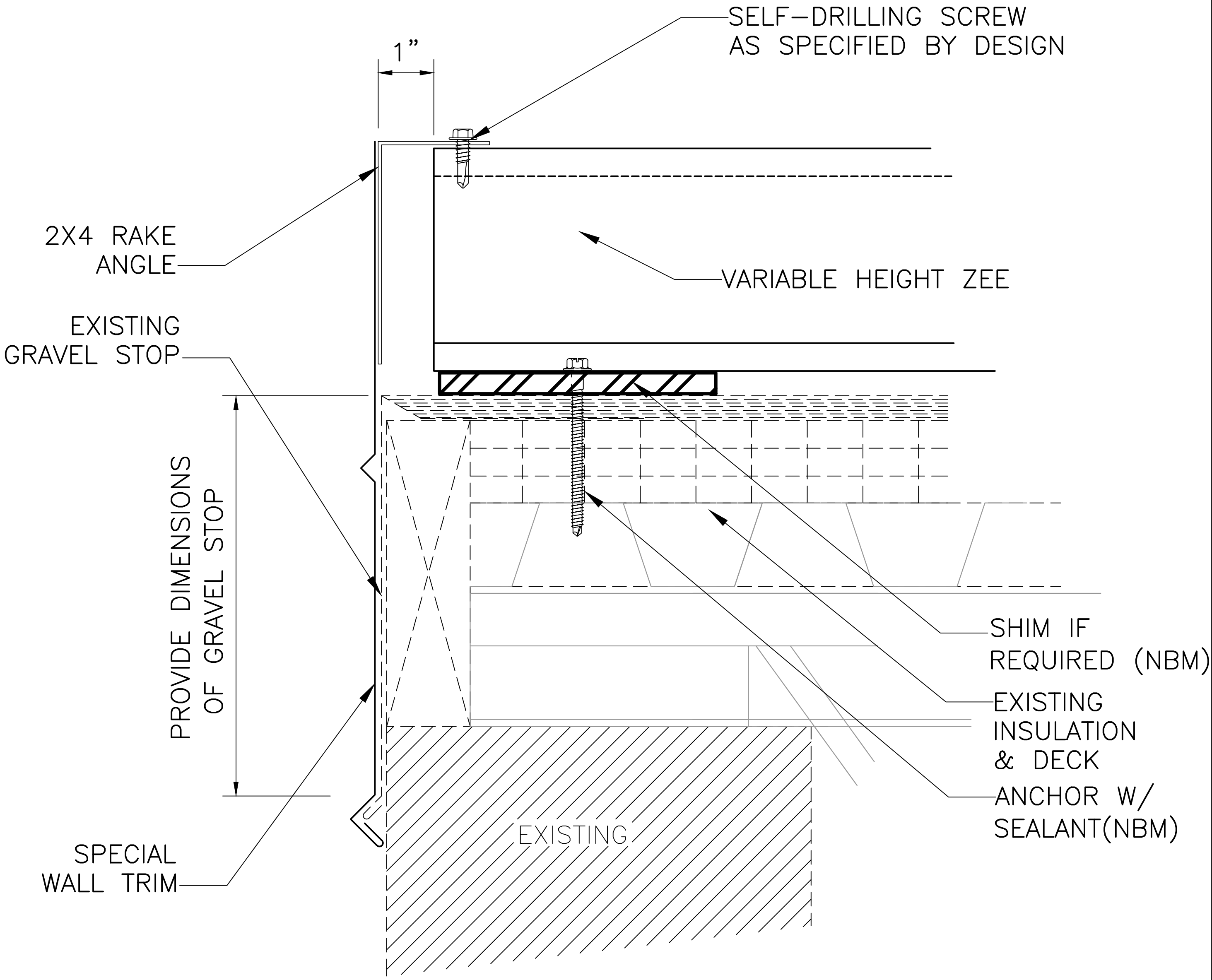

LOW SLOPED GABLE
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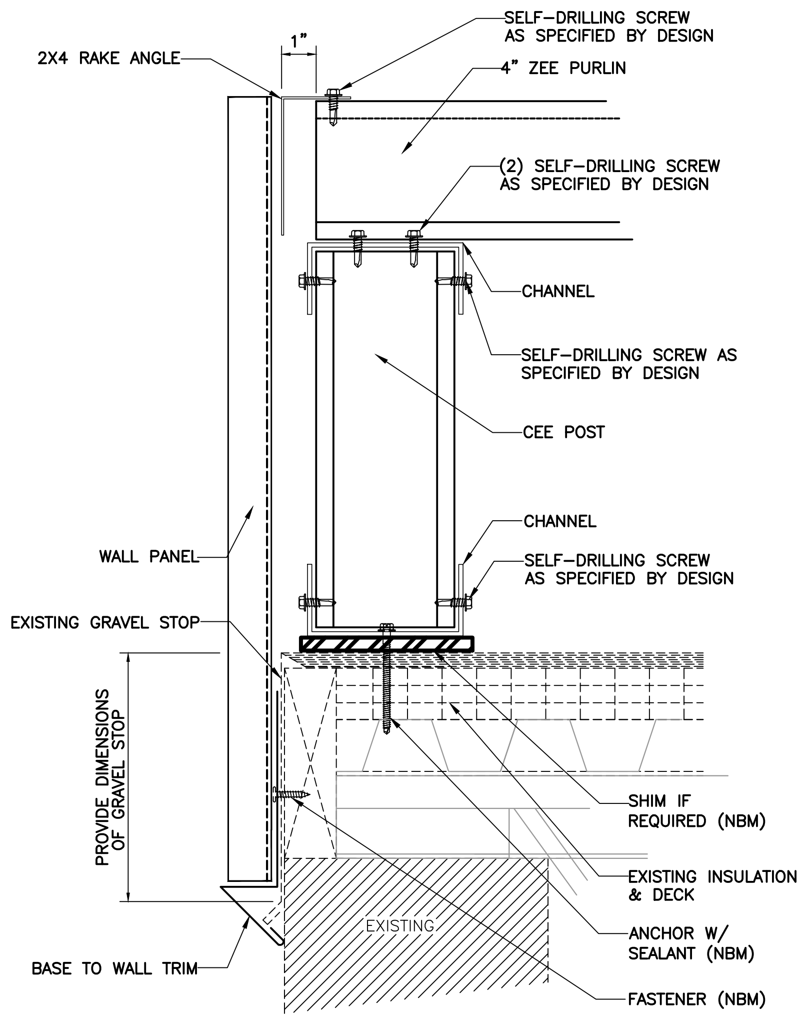

GABLE WALL

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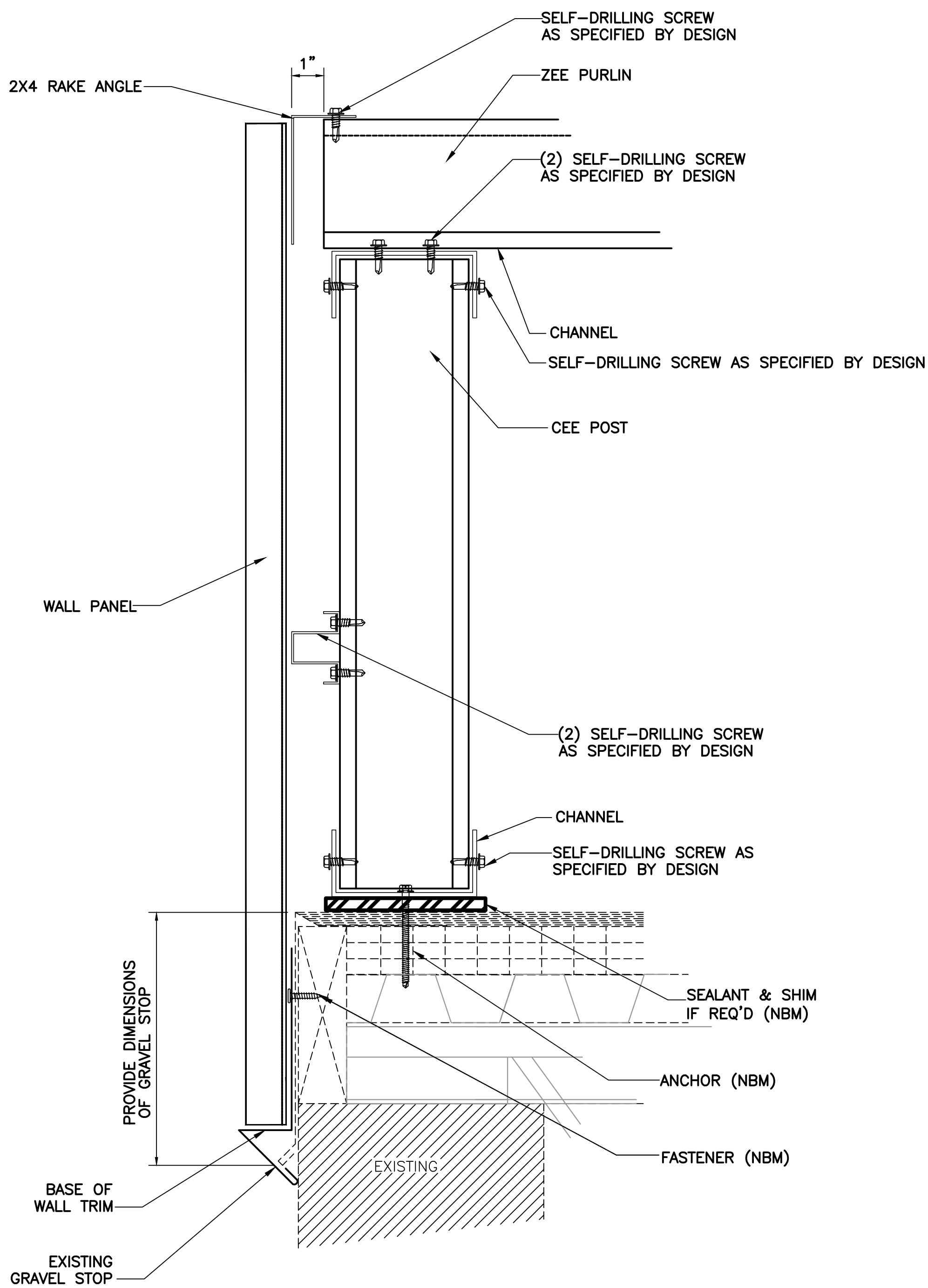

GABLE WALL W/ HAT GIRT

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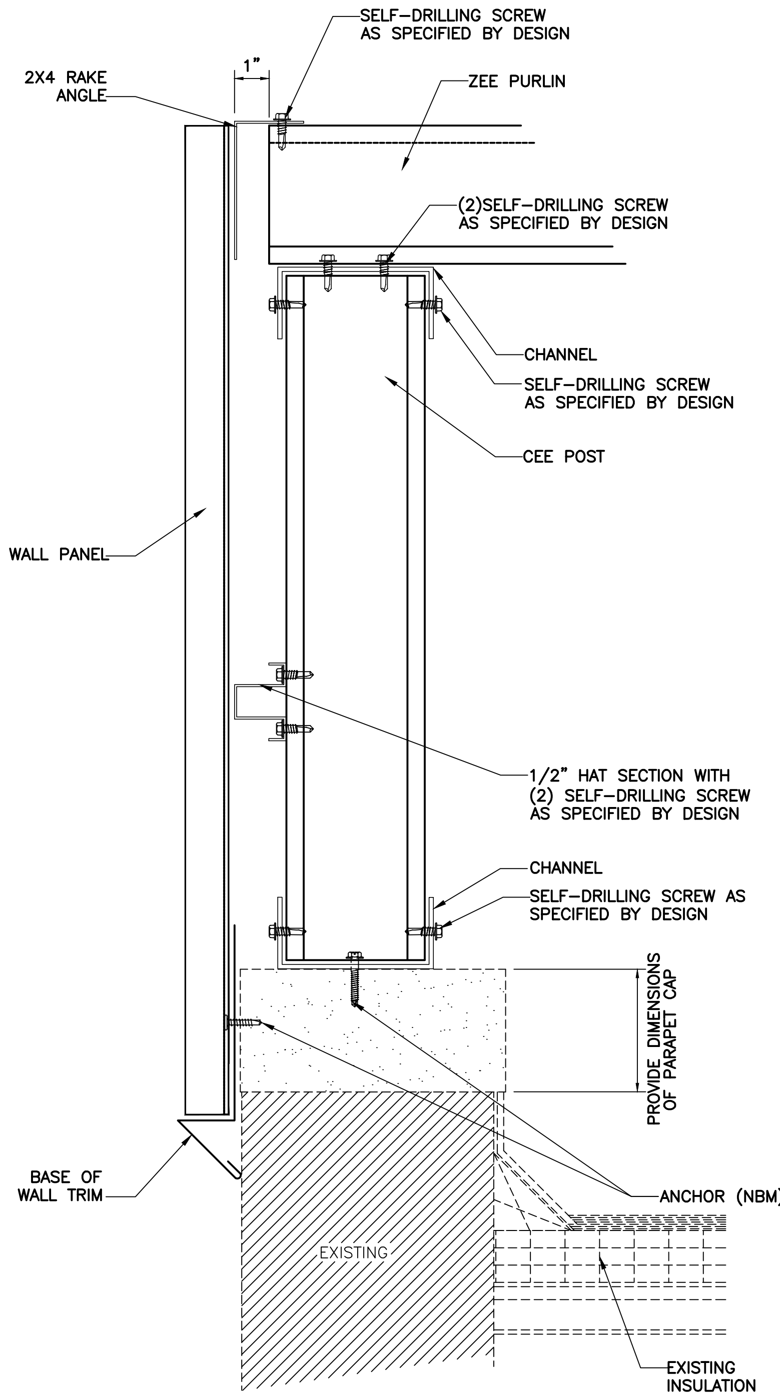

GABLE WALL W/ HAT GIRT

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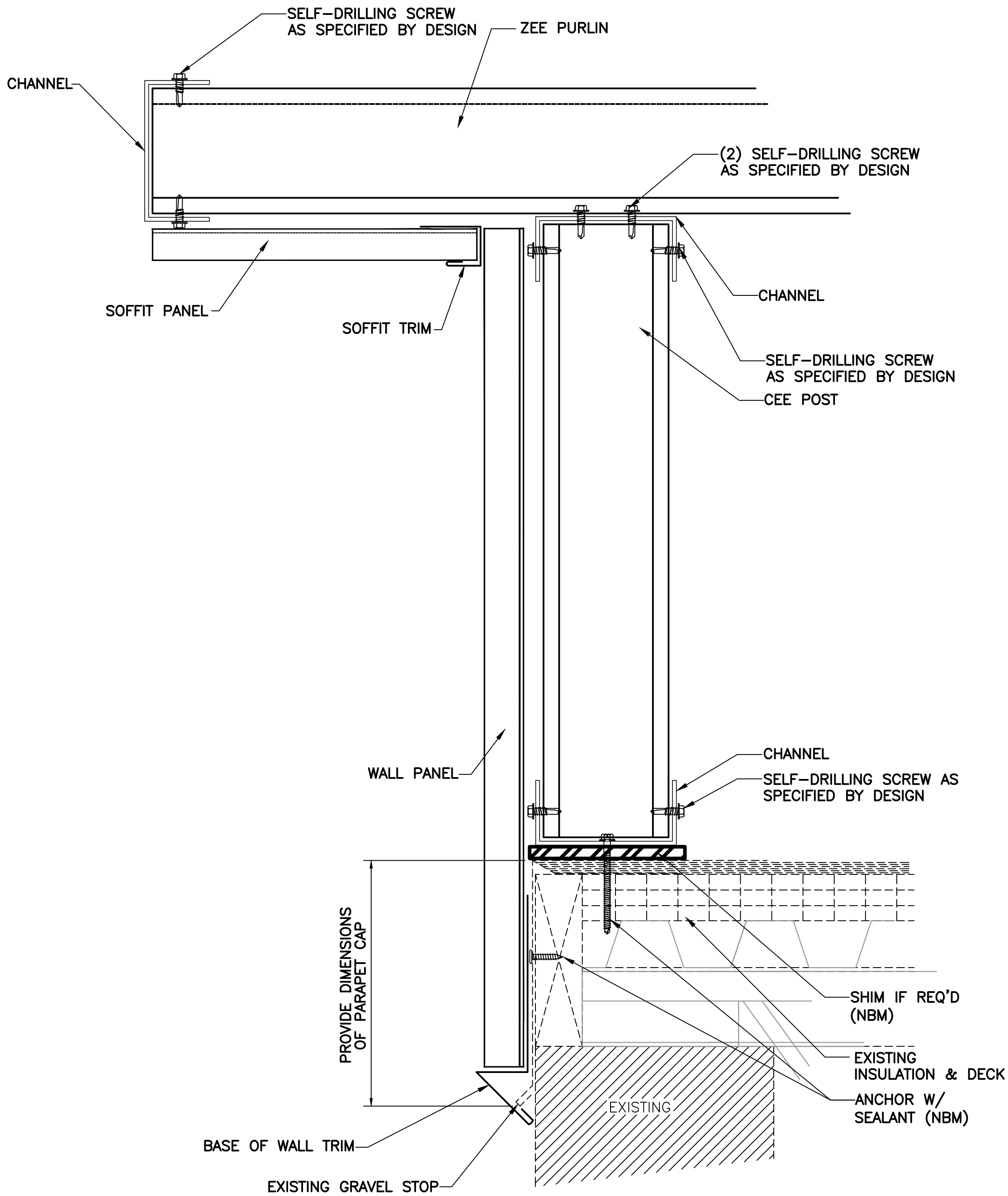

GABLE WALL W/ PURLIN EXTENSION

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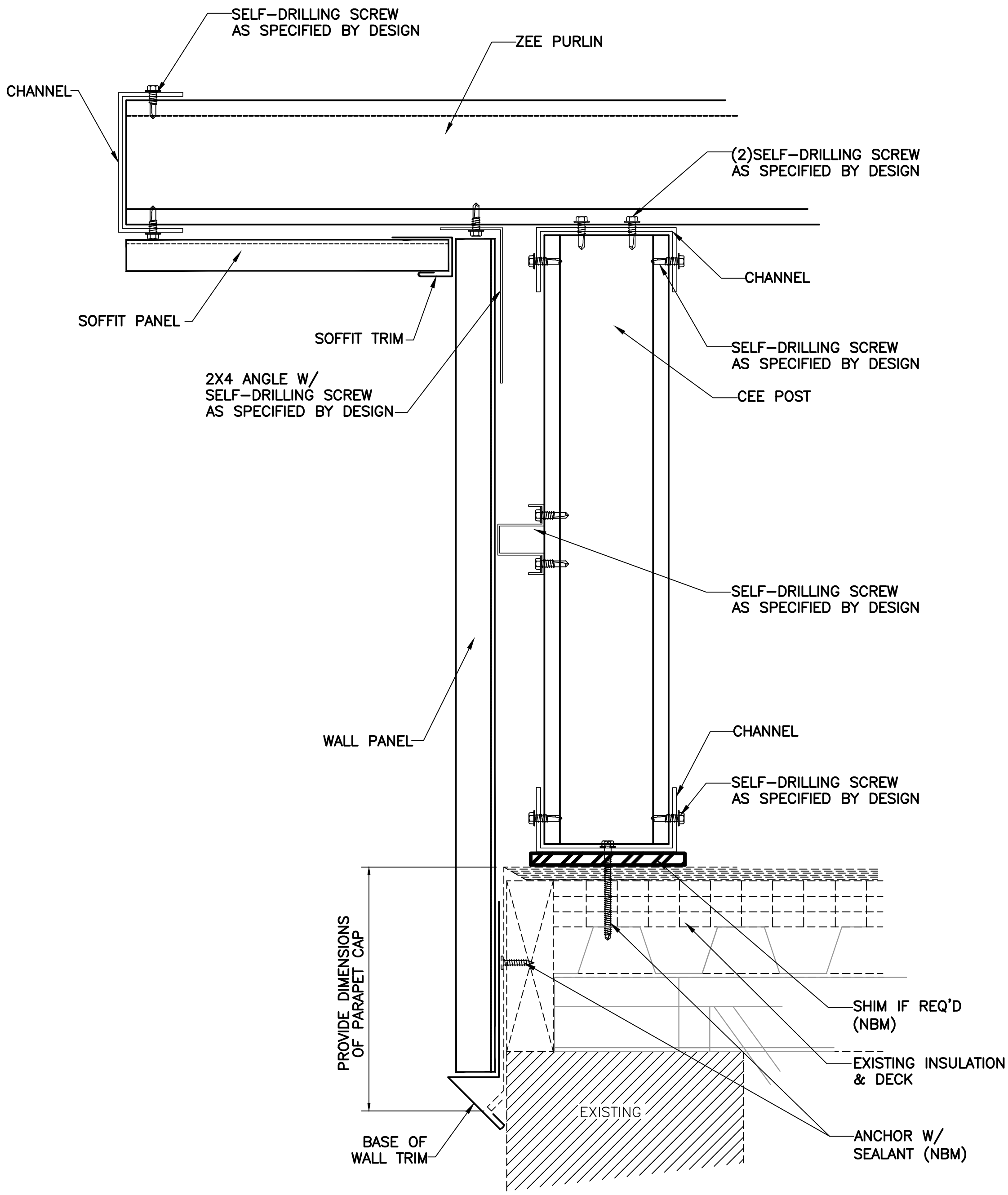

GABLE WALL W/ GIRT PURLIN EXTENSION

@ GRAVEL STOP

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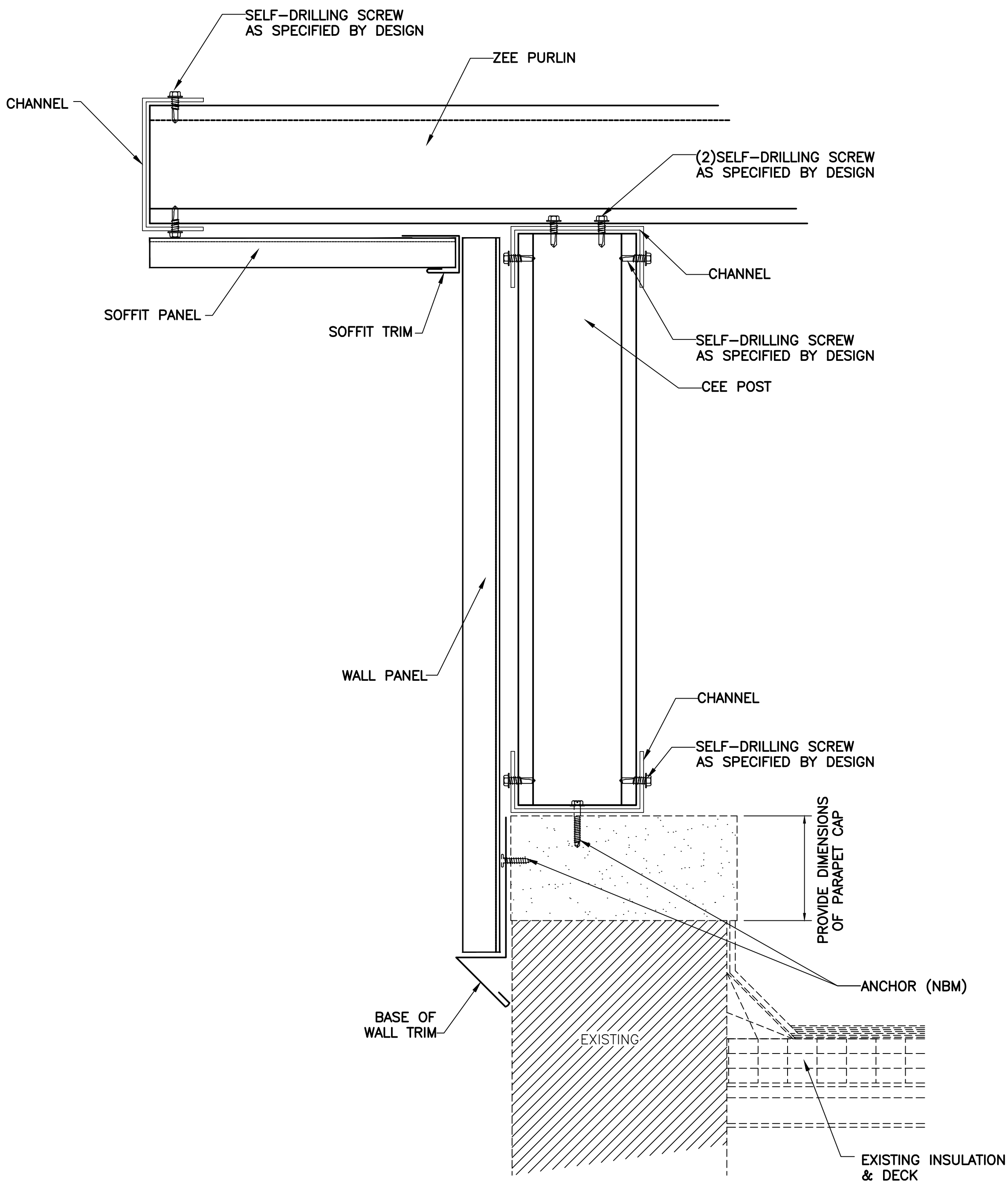
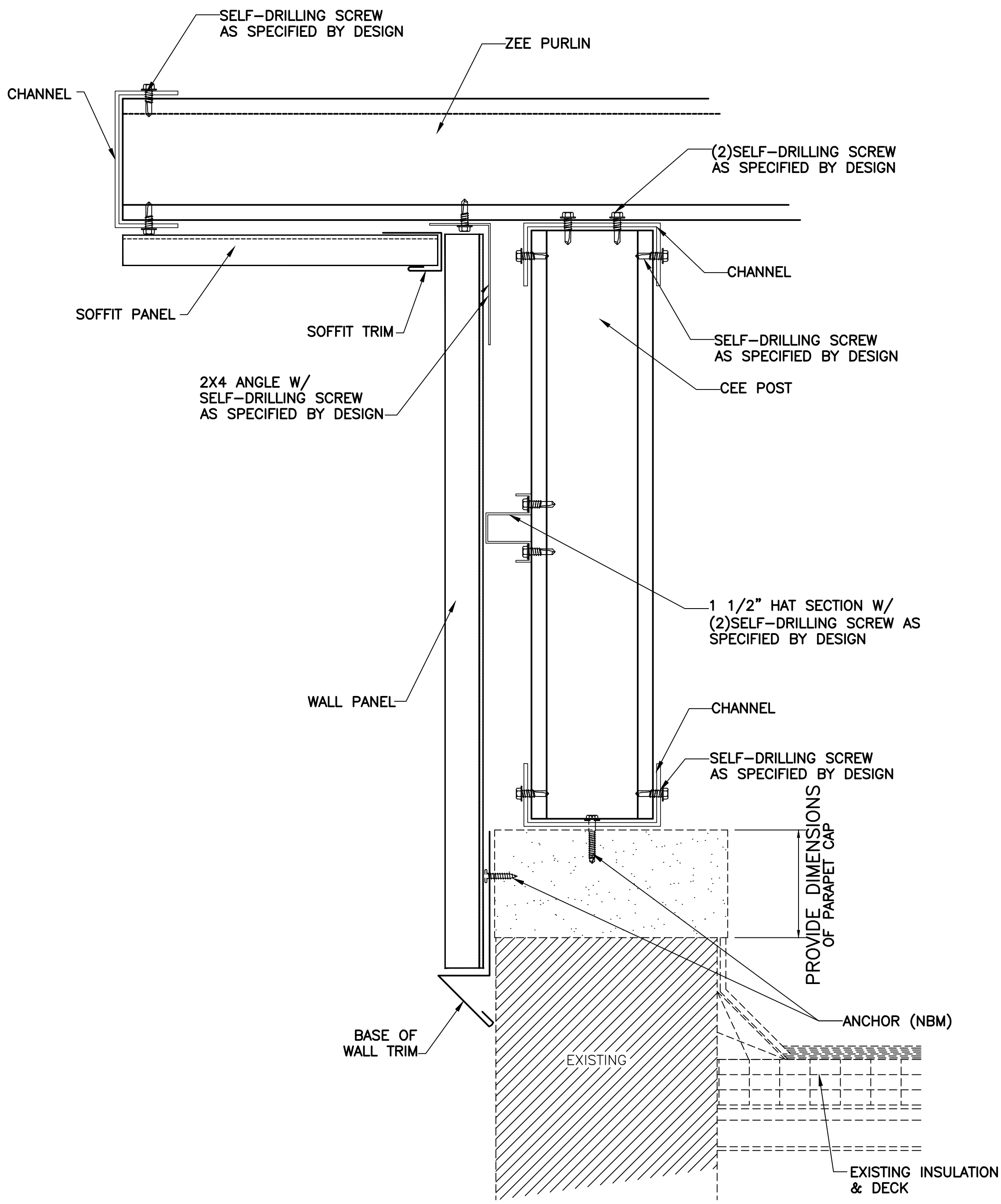
PERIMETER FRAMING

GABLE CONDITONS



GABLE WALL W/ PURLIN EXTENSION

@ LOAD-BEARING PARAPET



GABLE WALL W/ GIRT & PURLIN EXTENSION

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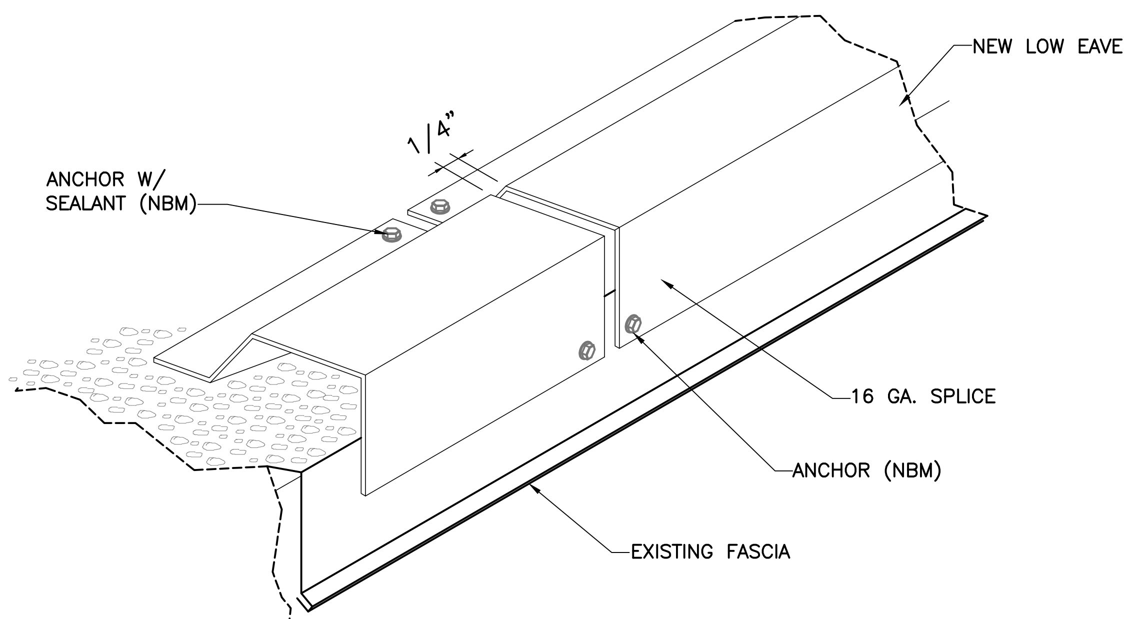

LOW EAVE PLATE SPLICE

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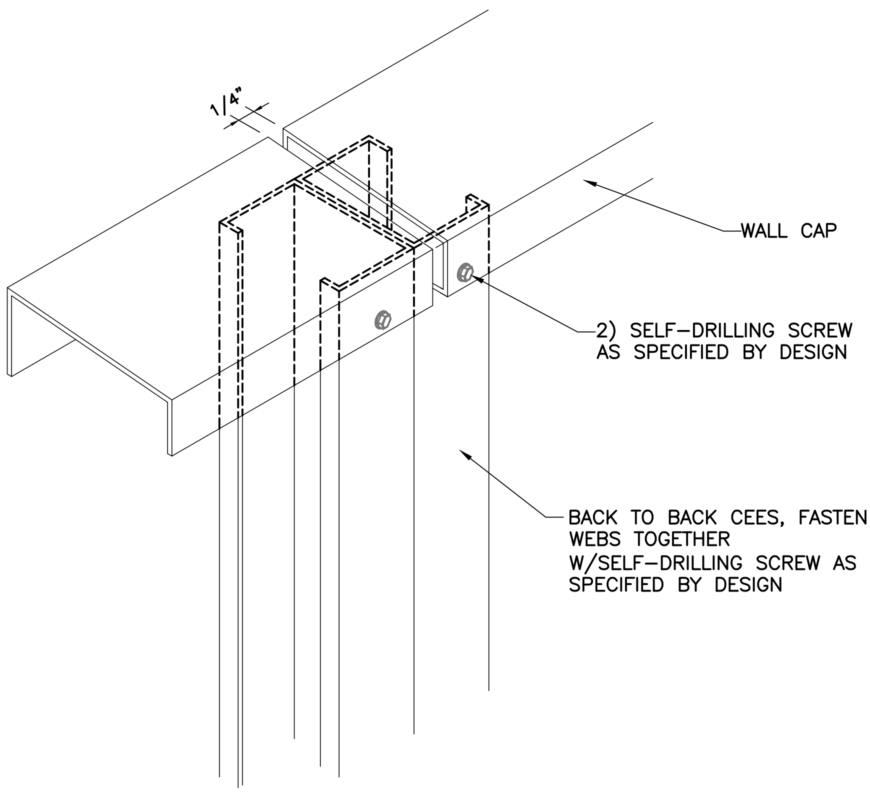
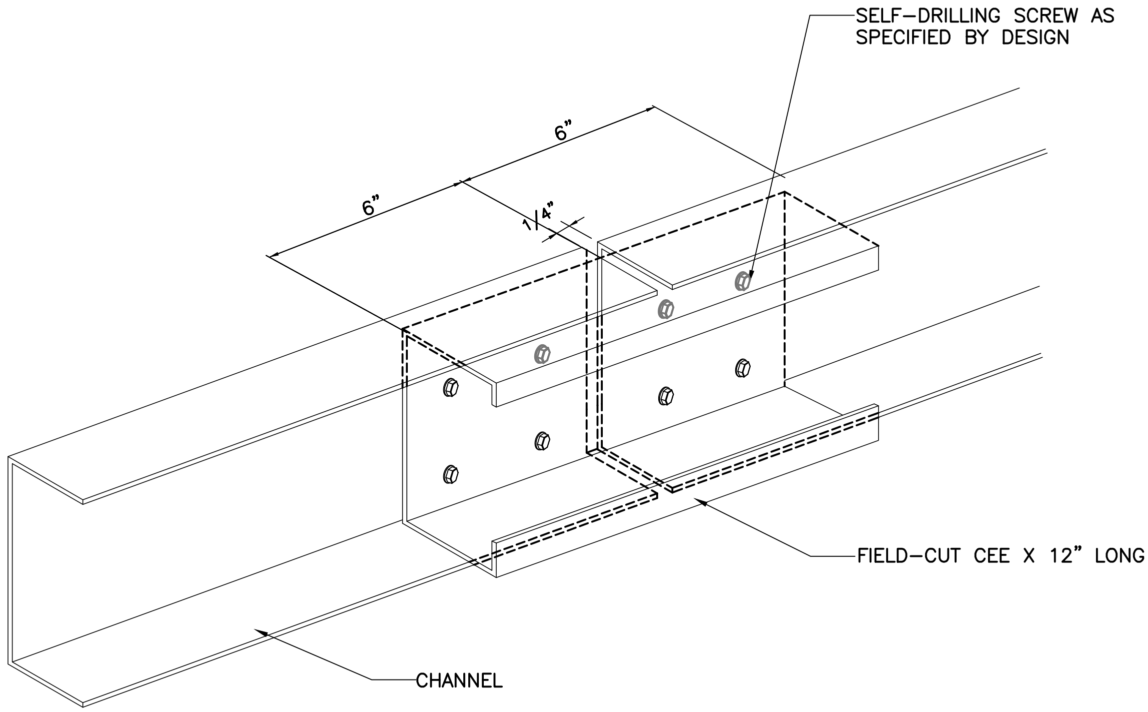
PERIMETER FRAMING

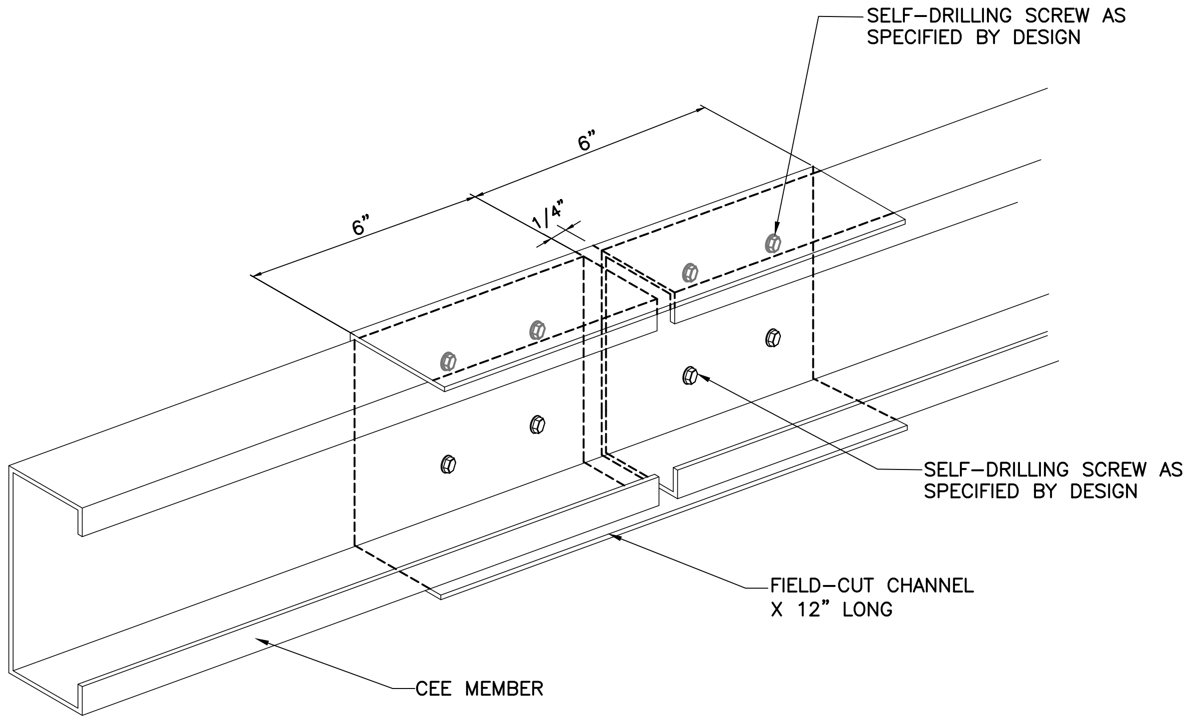
SPLICE DETAILS



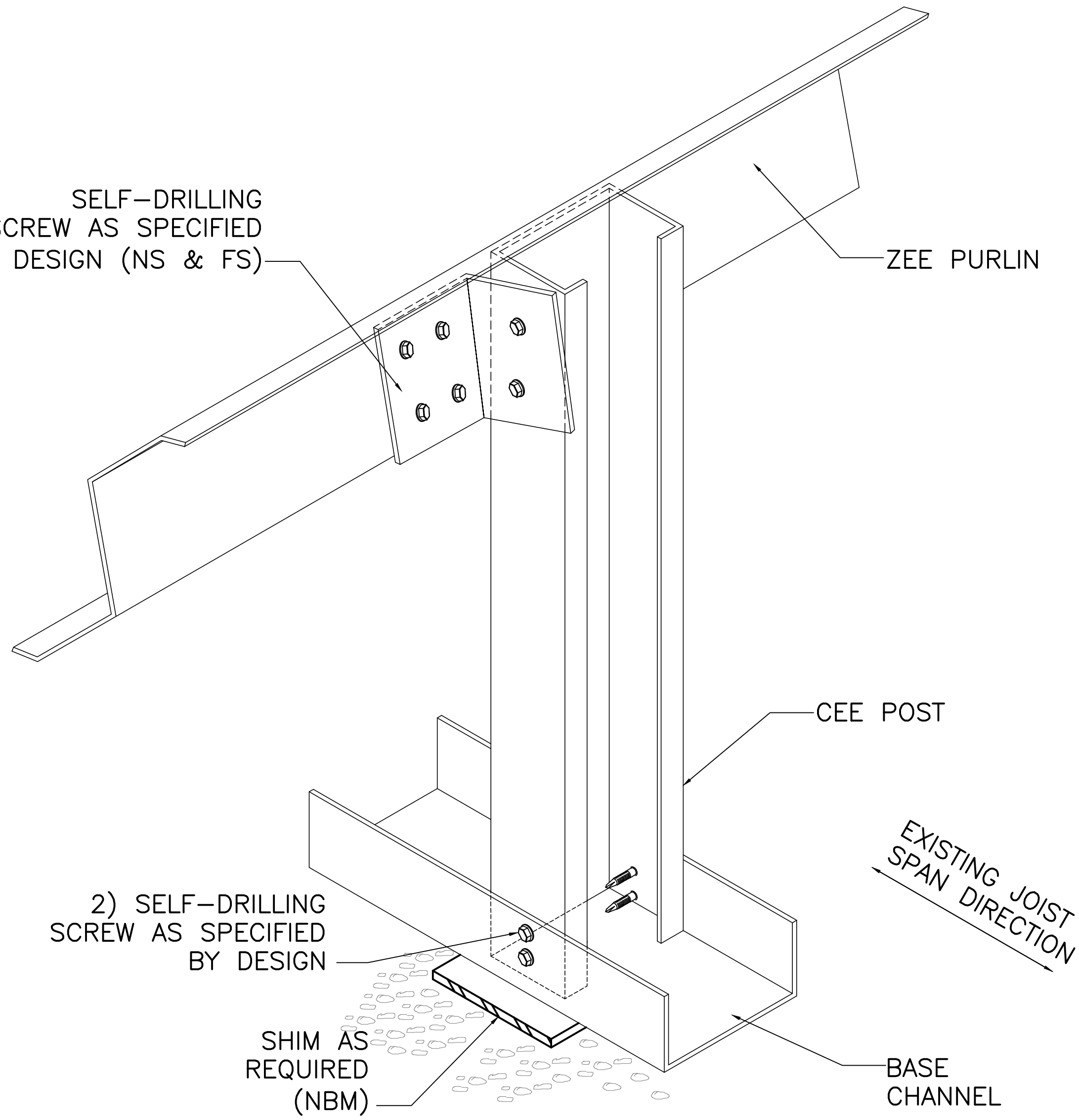
LOW & HIGH EAVE WALL CAP SPLICE



CHANNEL SPLICE

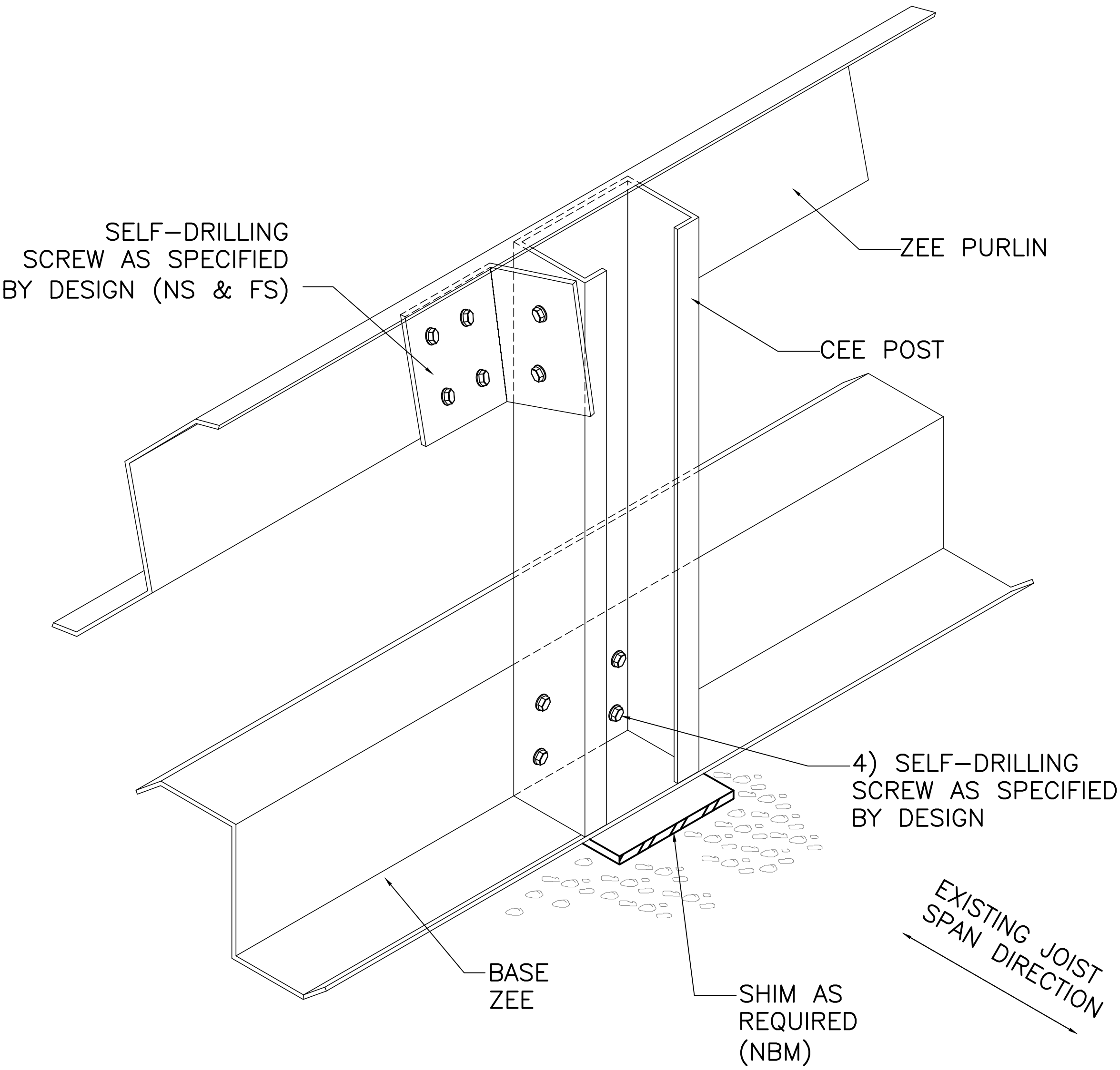


CEE MEMBER SPLICE



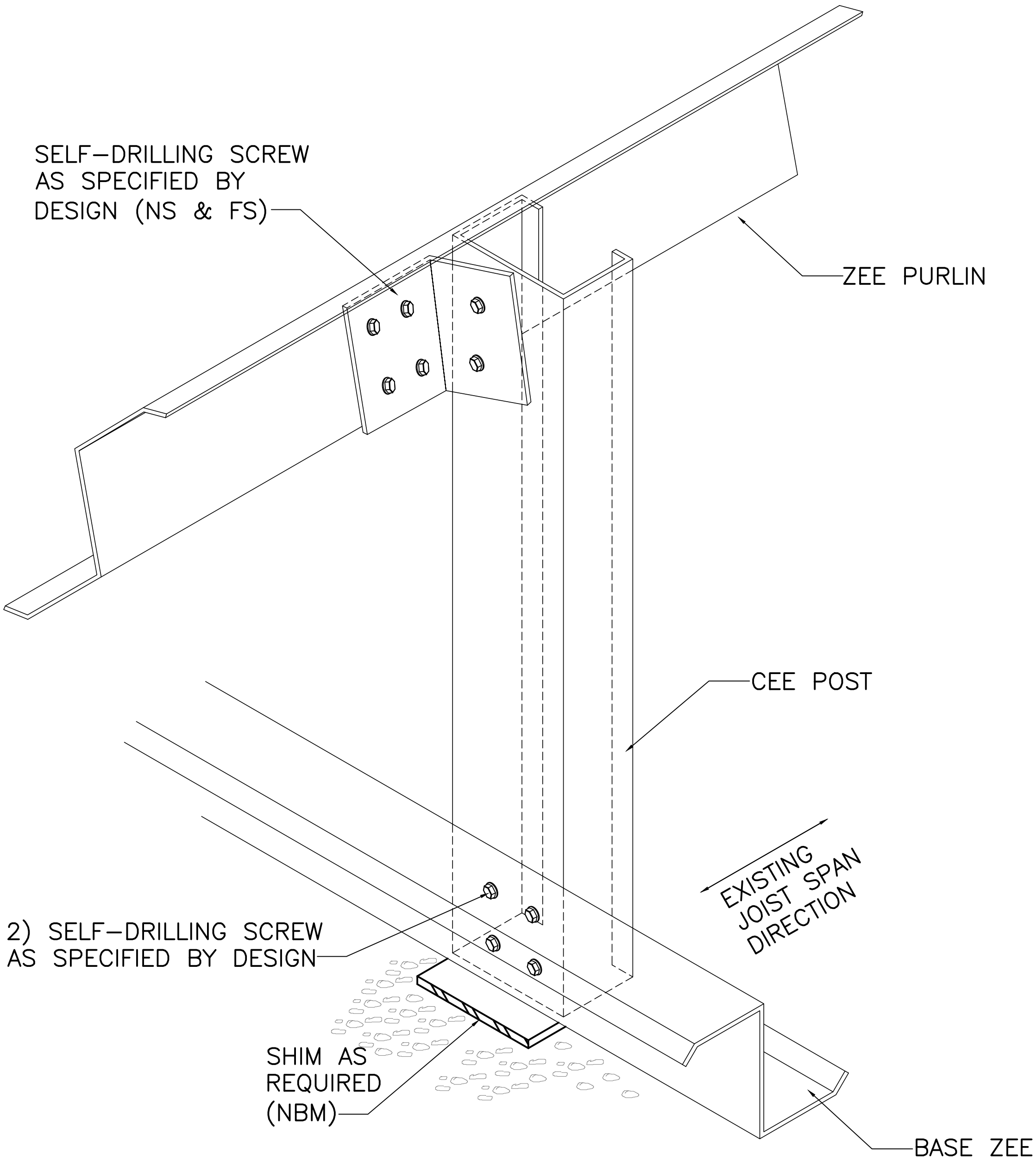
POST WITH BASE SHOE

(PARALLEL CONDITION)



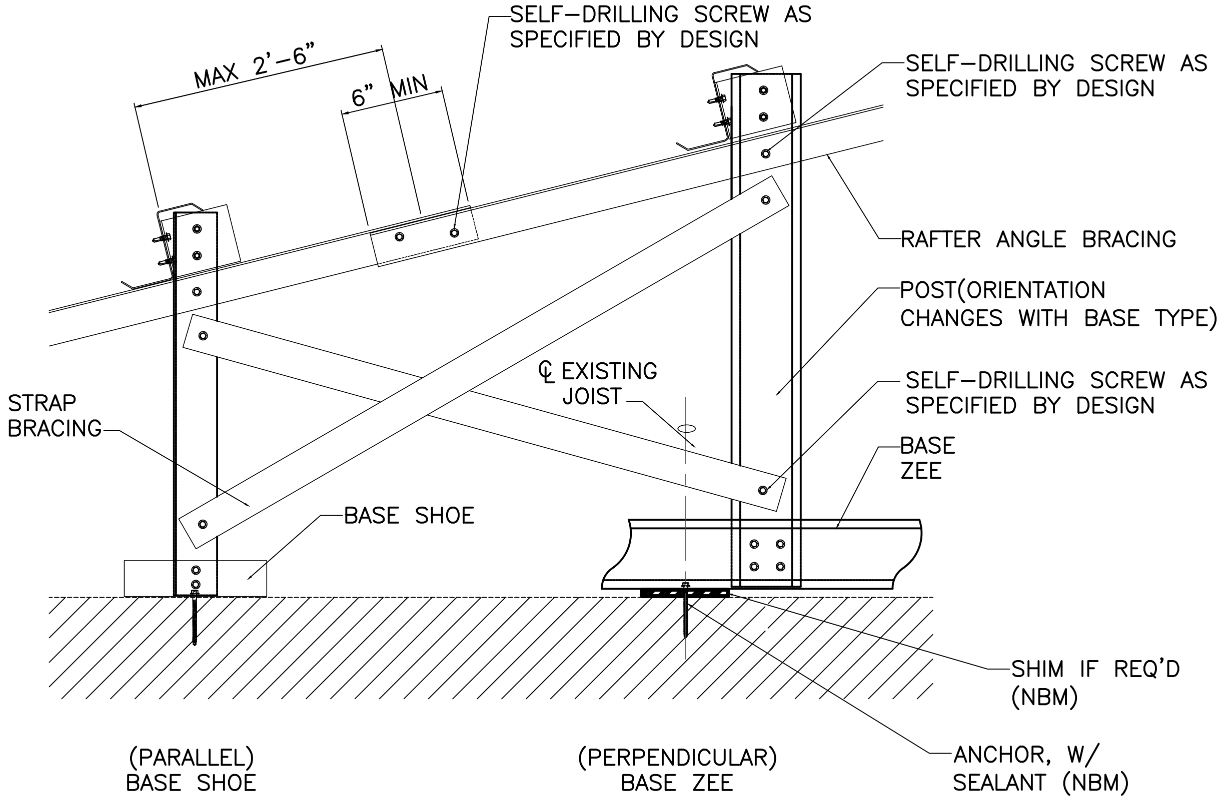
POST WITH BASE ZEE

(PARALLEL CONDITION)

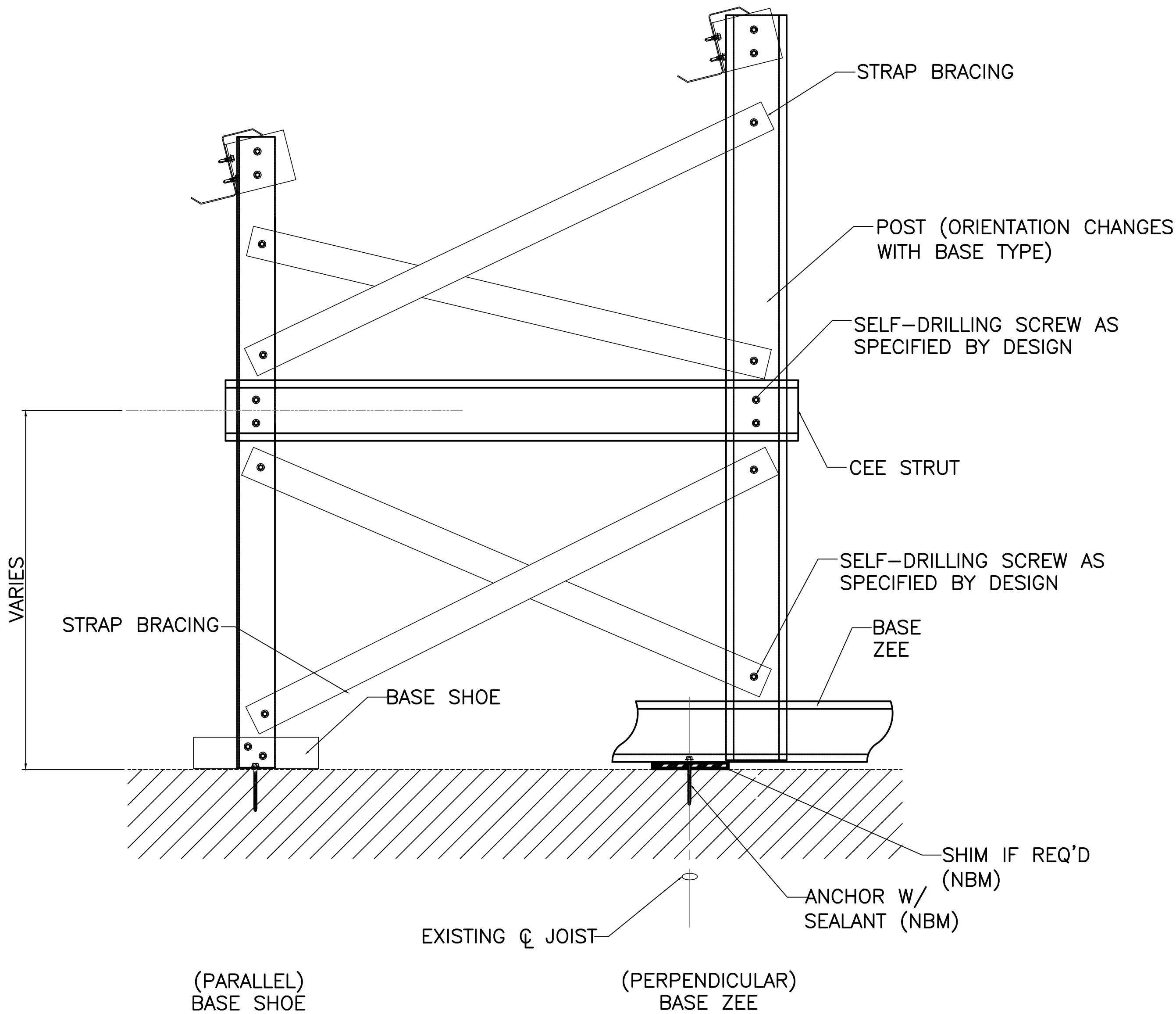


POST WITH BASE ZEE

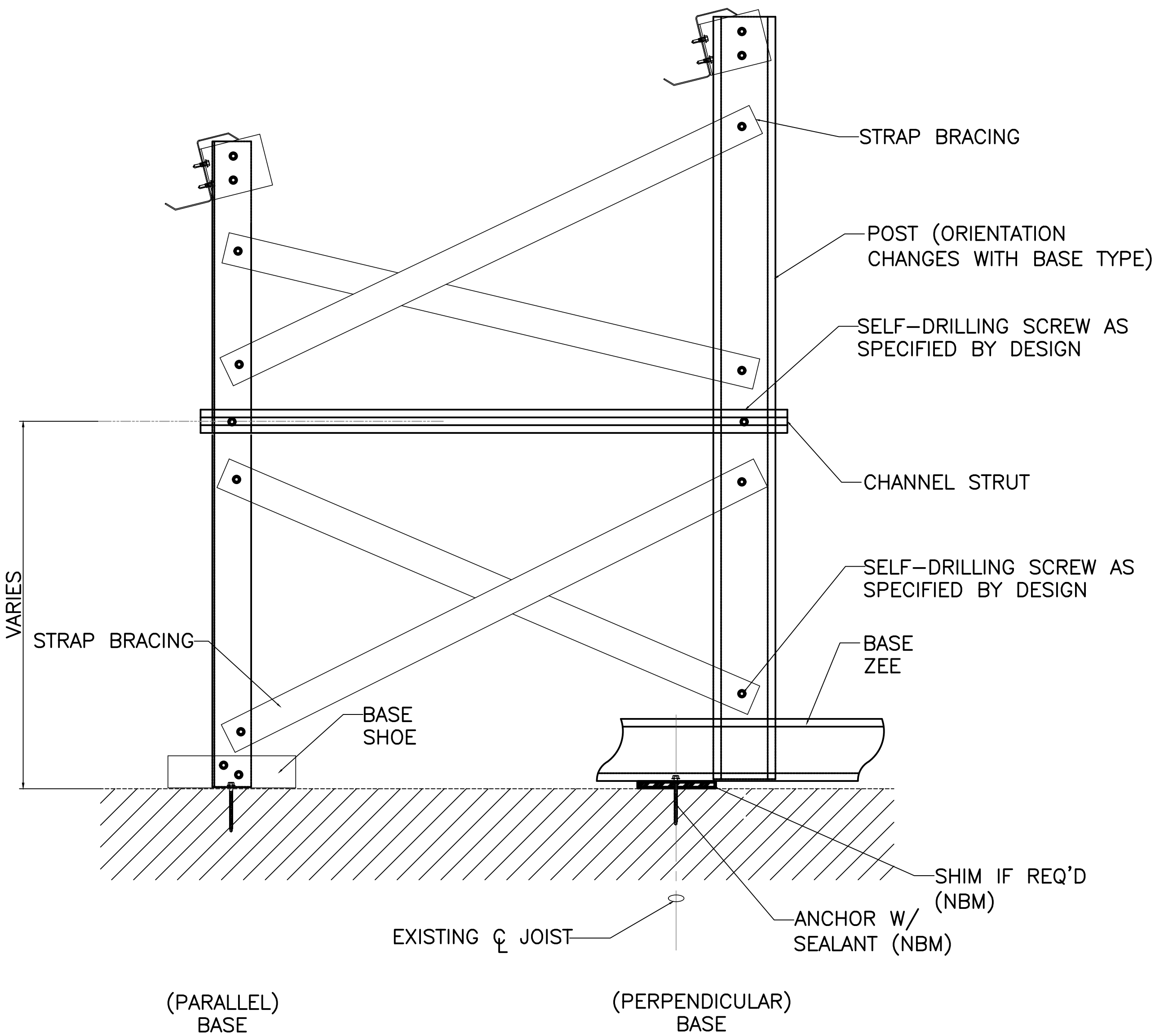
(PERPENDICULAR CONDITION)



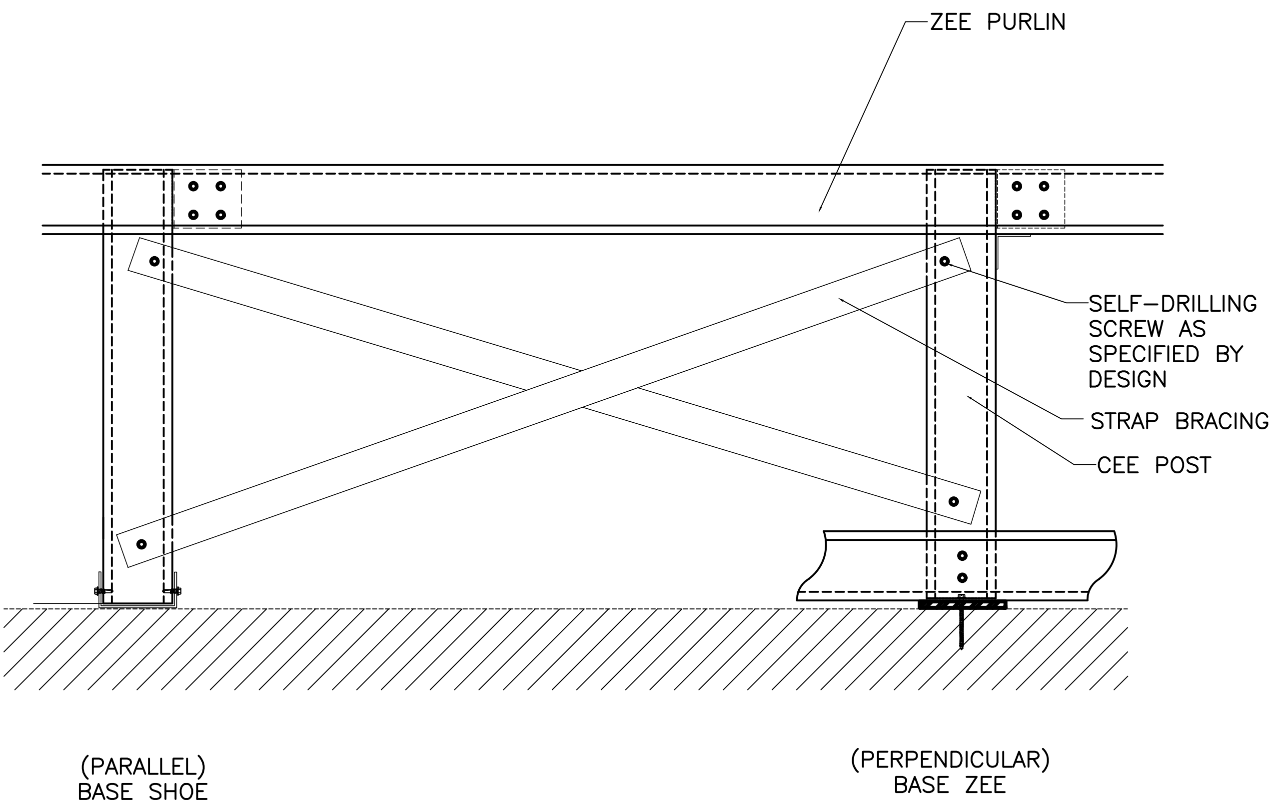
TRANSVERSE ANGLE & STRAP BRACING



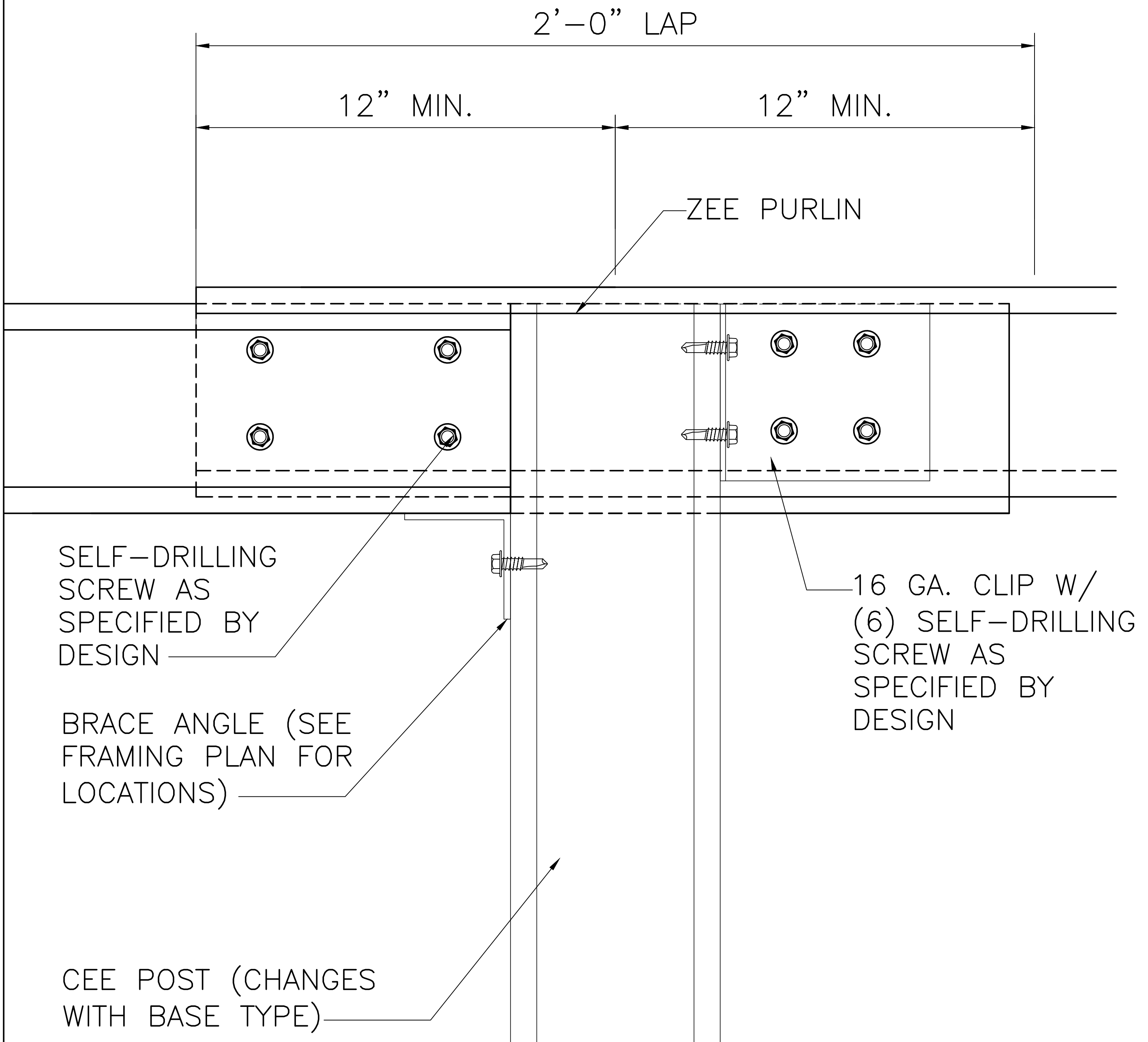
TRANSVERSE CEE STRUT BRACING



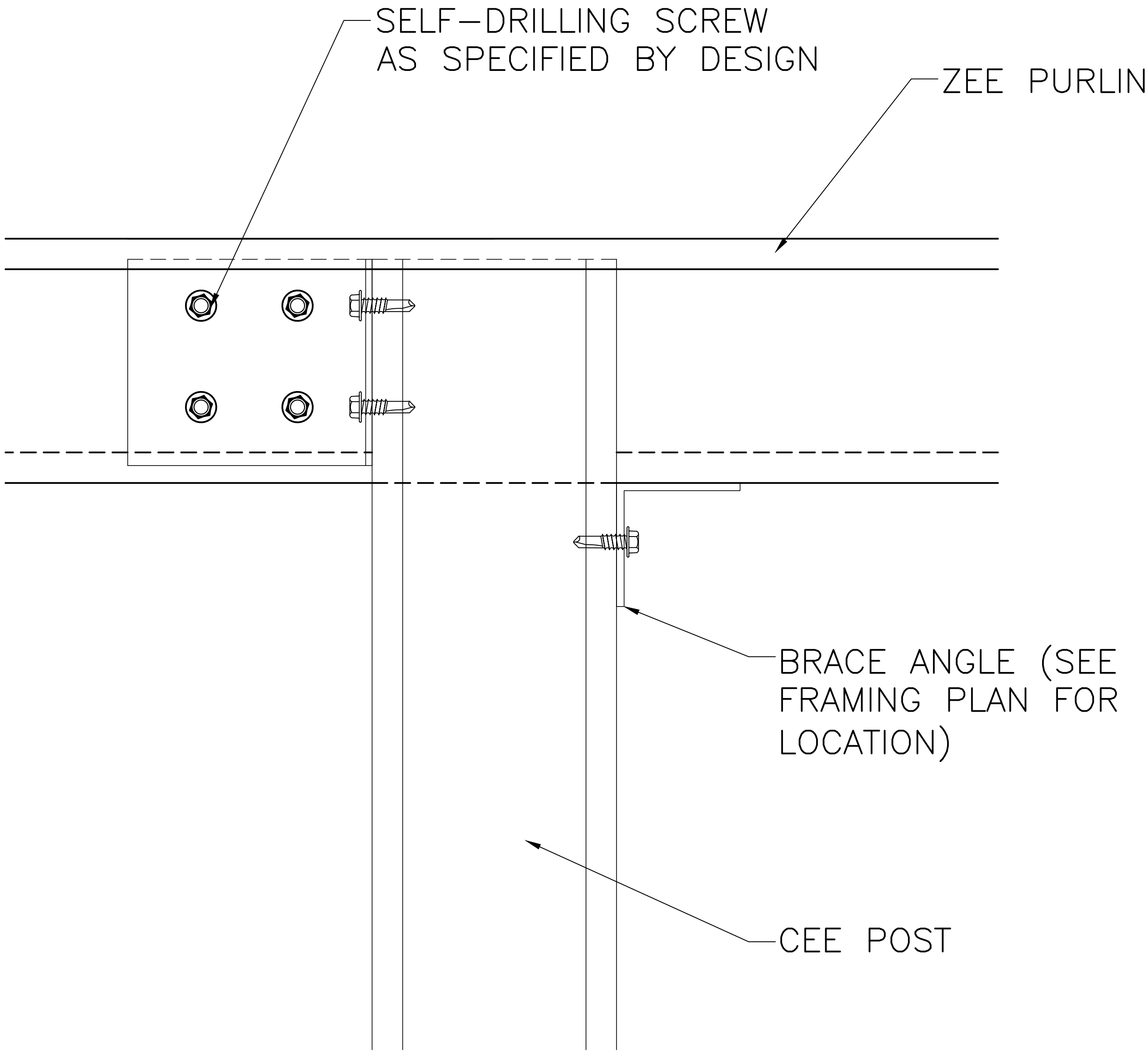
TRANSVERSE CHANNEL STRUT BRACING



LONGITUDINAL BRACING

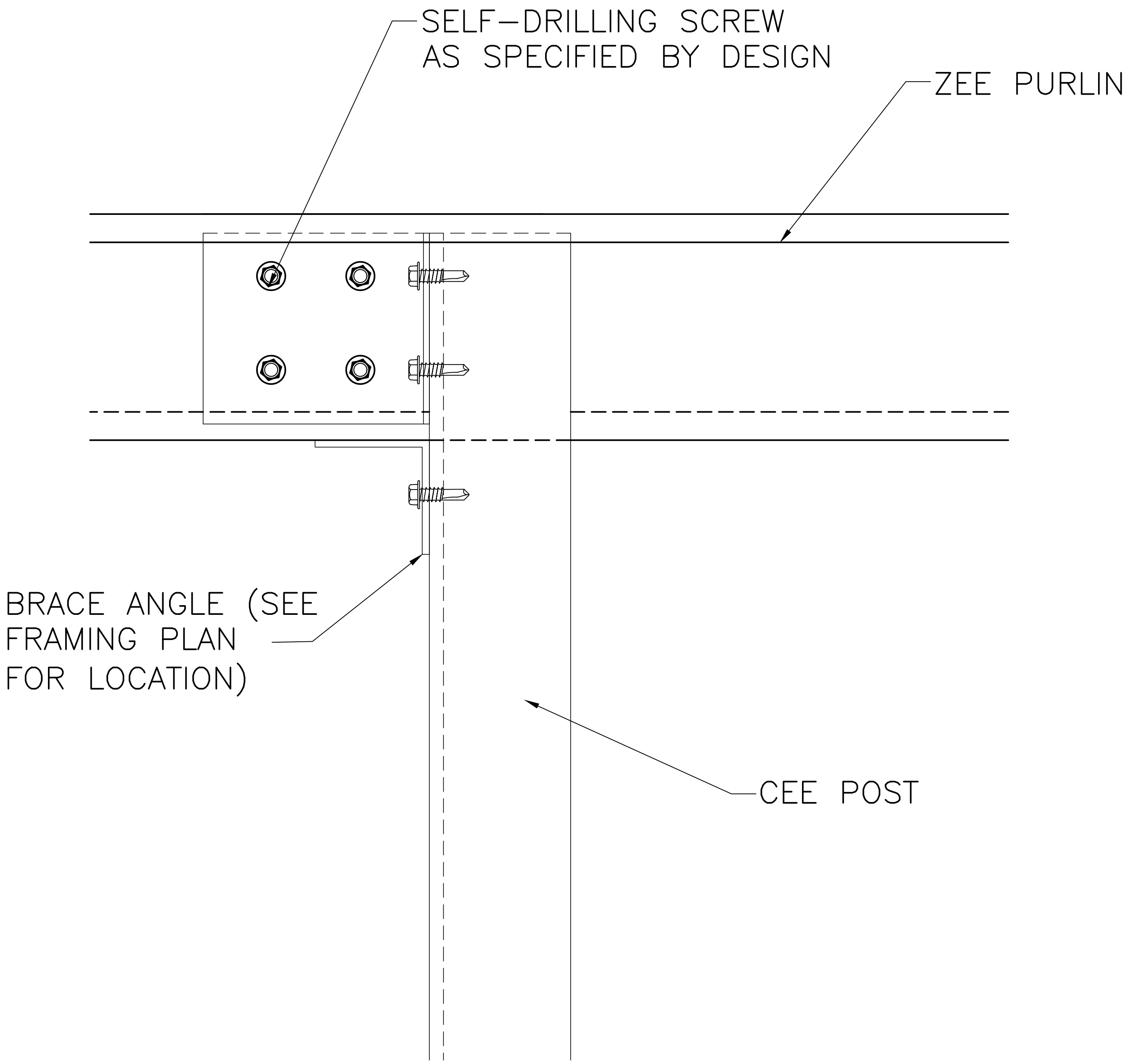


PURLIN LAP LOCATED @ POST



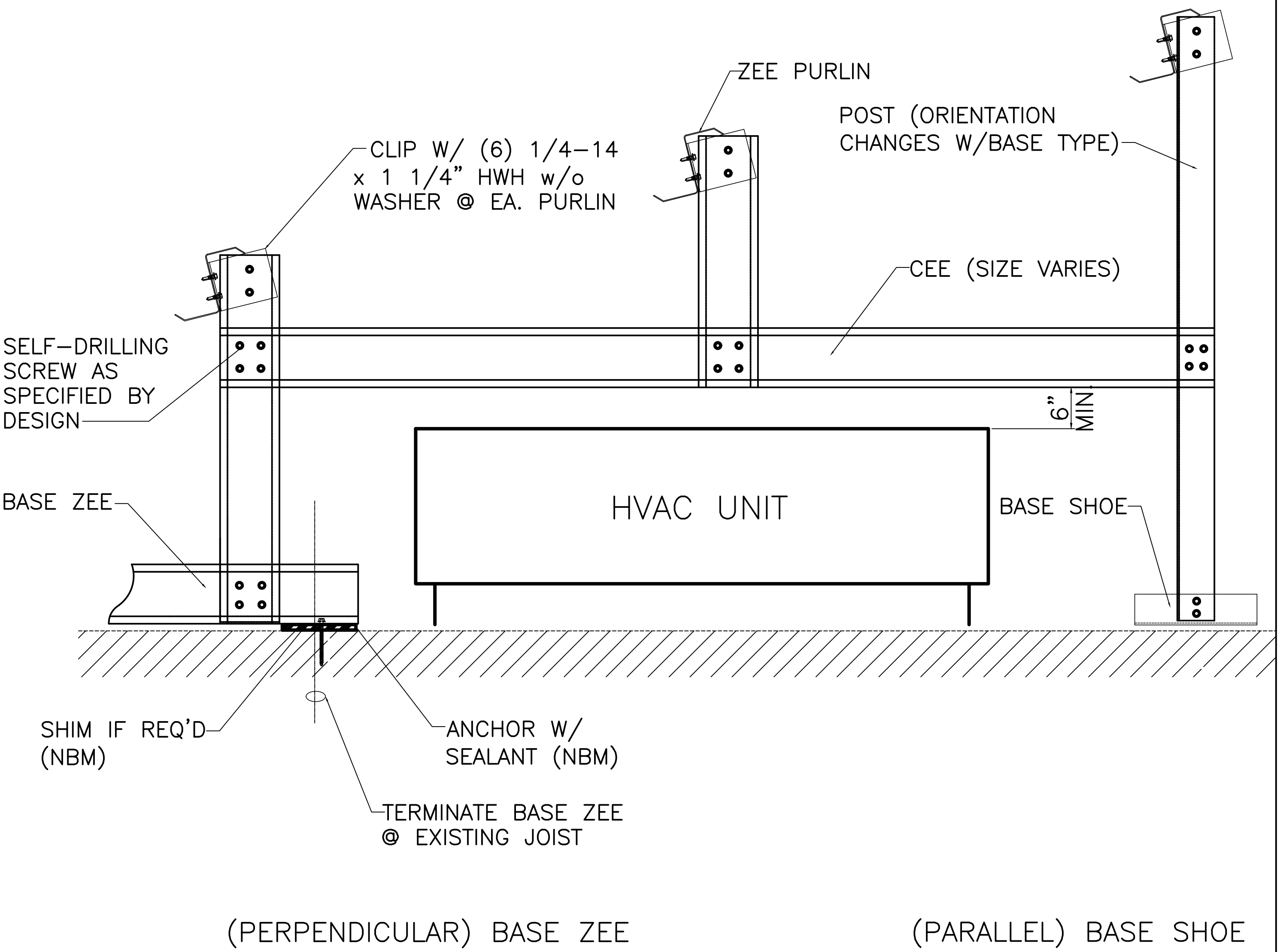
POST TO PURLIN CONNECTION

OCCURS W/ STD. BASE SHOE $
W/ BASE ZEE @ PARALLEL CONDITION

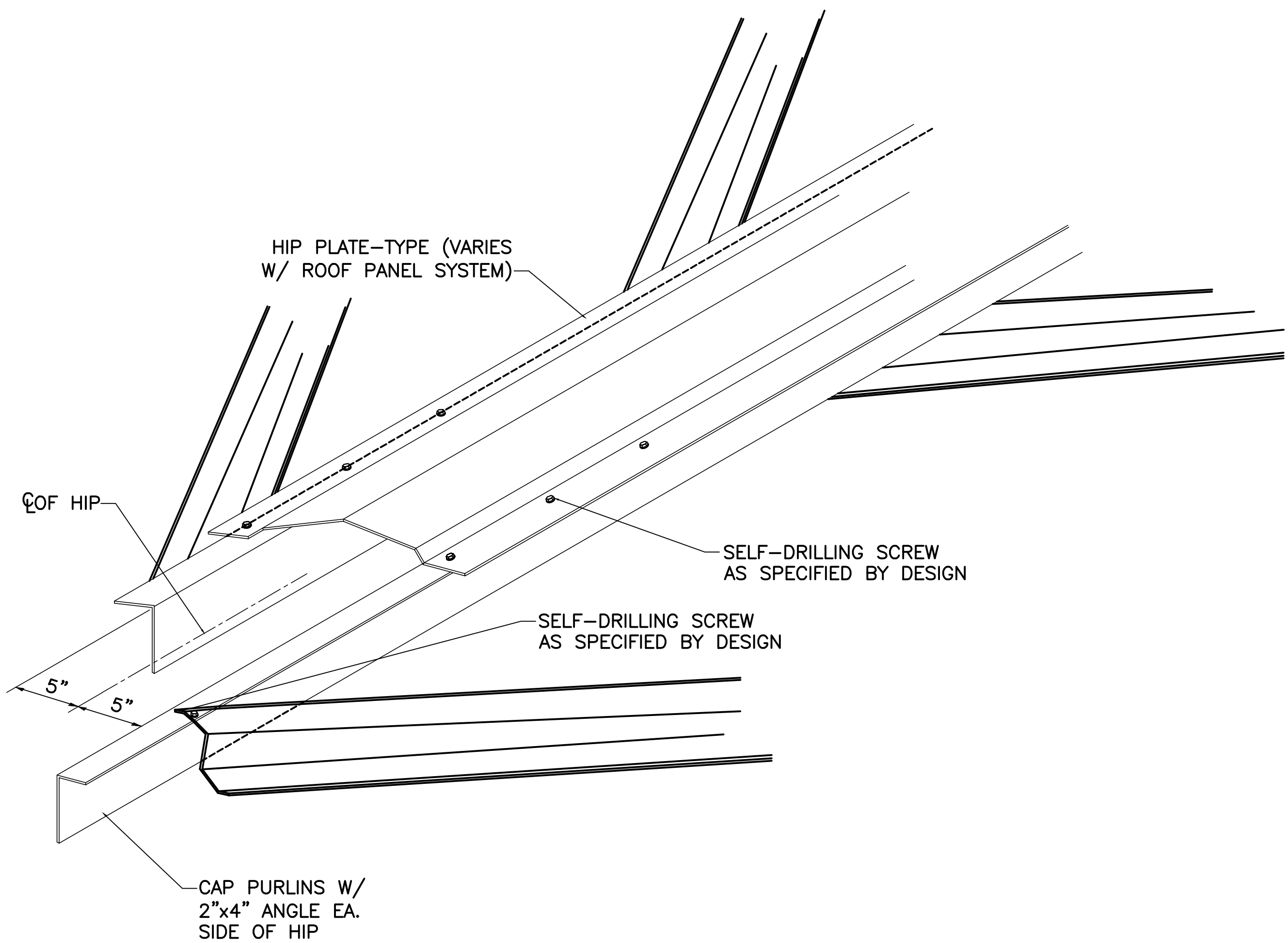


POST TO PURLIN CONNECTION

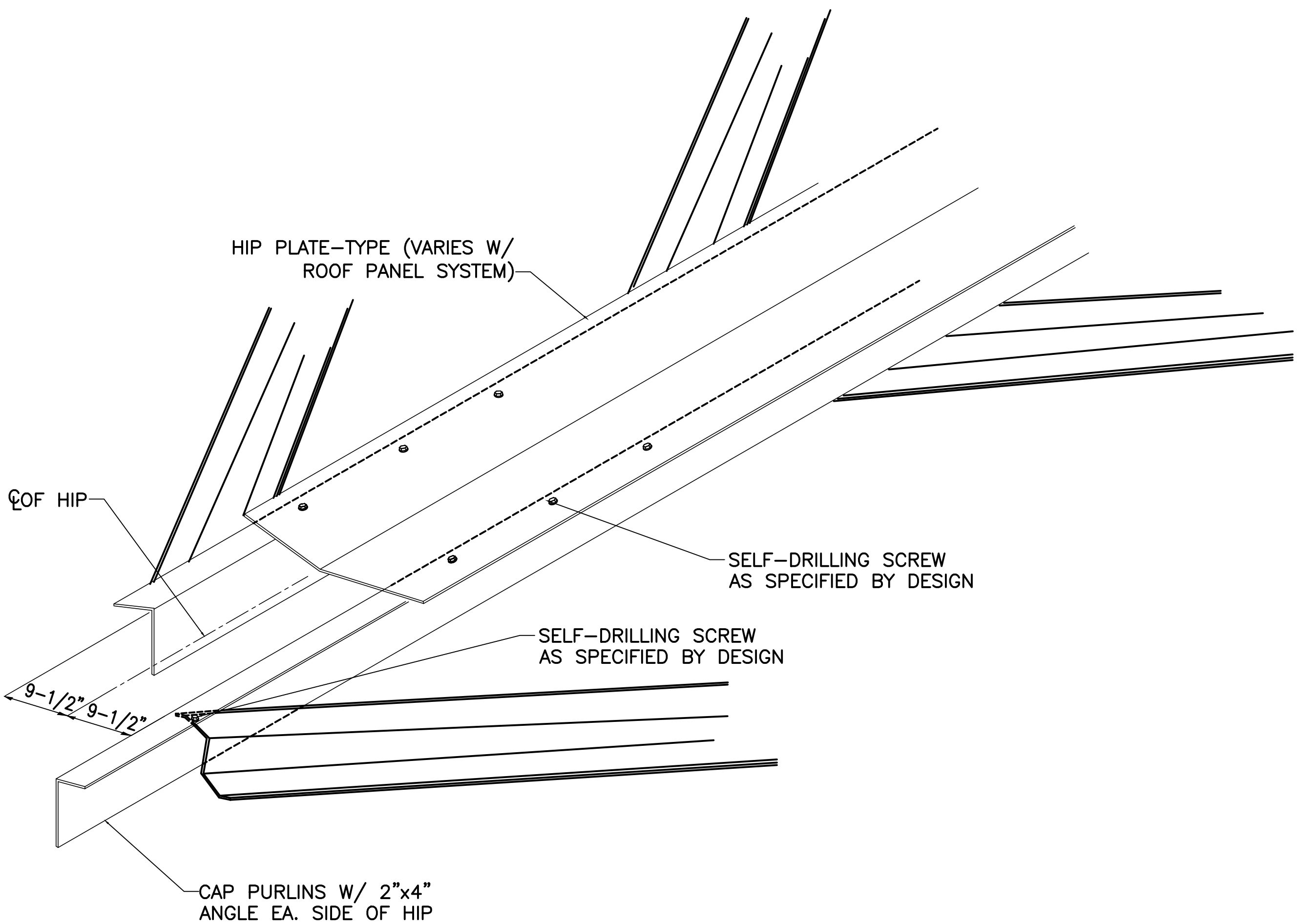
OCCURS W/ BASE ZEE @
PERPENDICULAR CONDITION



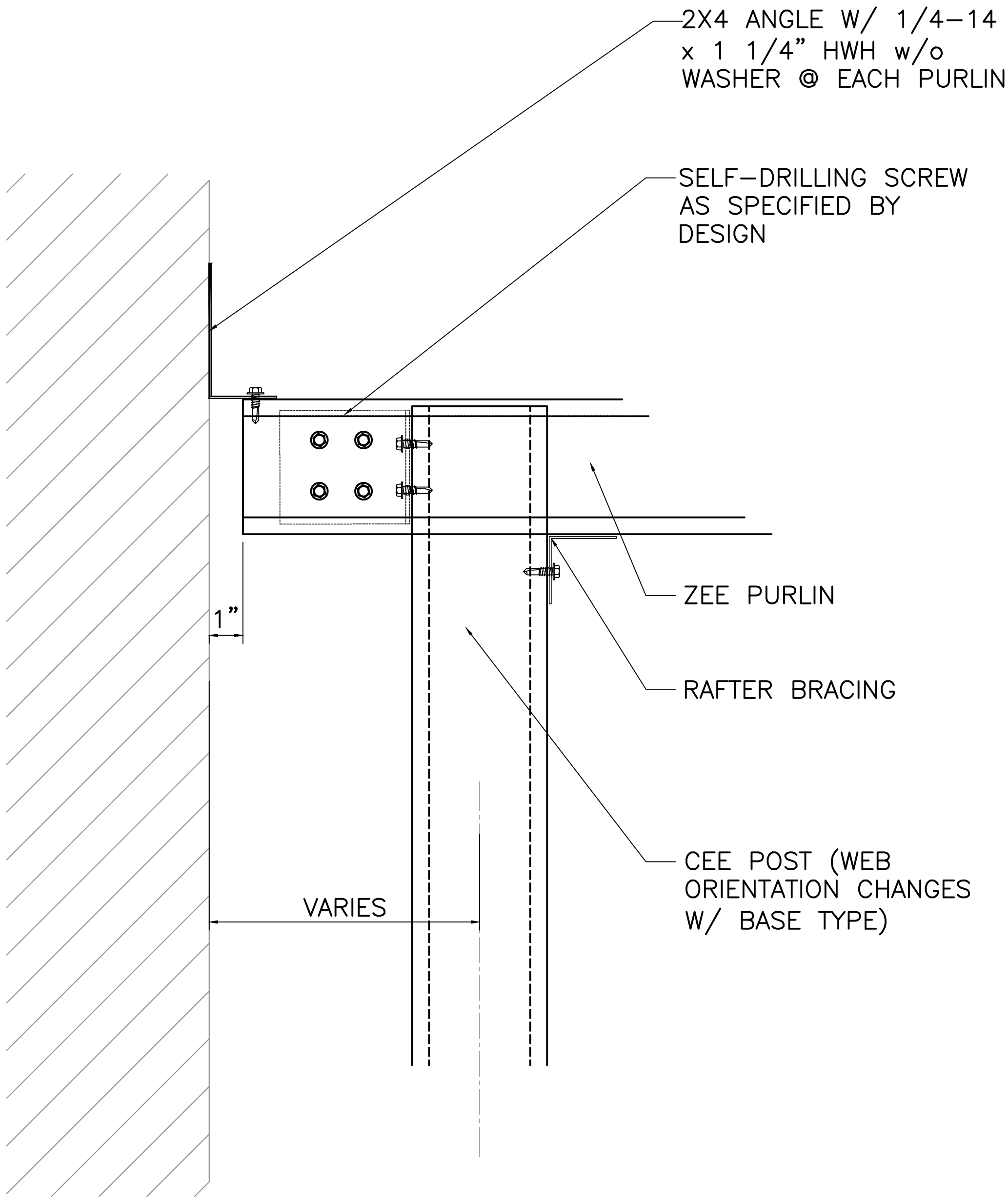
HVAC EQUIPMENT FRAME-OVER


HIP PLATE–TYPE (VARIES
W/ ROOF PANEL SYSTEM)
℄ OF HIP
SELF–DRILLING SCREW
AS SPECIFIED BY DESIGN
SELF–DRILLING SCREW
AS SPECIFIED BY DESIGN
5"
5"
CAP PURLINS W/
2"x4" ANGLE EA.
SIDE OF HIP

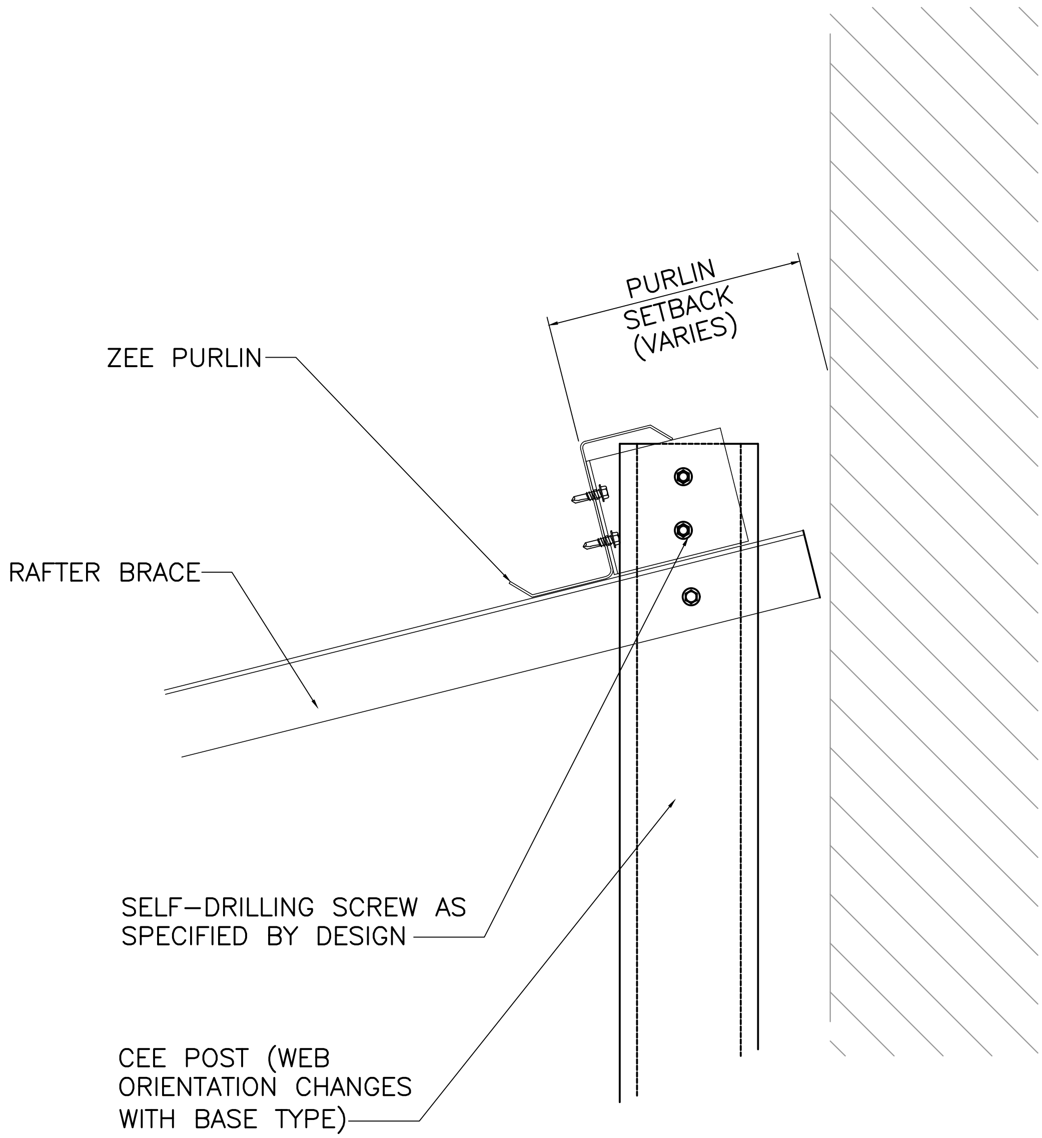
HIP FRAMING



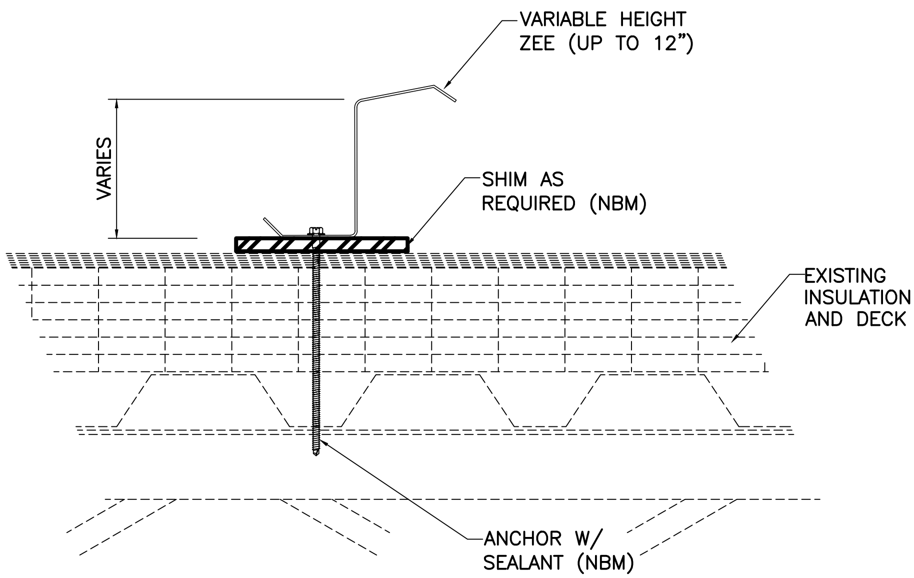
VALLEY FRAMING



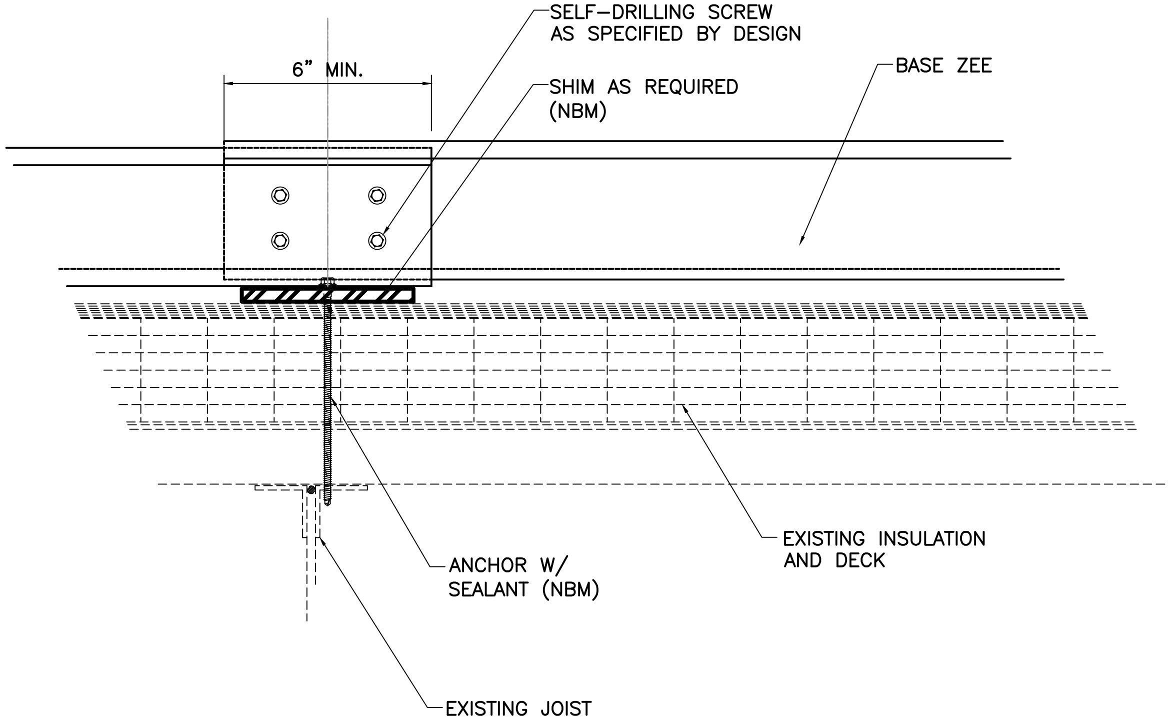
RAKE-TO-WALL TRANSITION



ROOF-TO-WALL TRANSITION



VARIABLE HEIGHT PURLIN



BASE ZEE / VARIABLE HEIGHT ZEE LAP

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CHAPTER 6

Metal-over-Metal retrofit Roofing

Overview

This Chapter provides a general explanation of the benefits of Metal-over-Metal (MOM) retrofit roofing and explains some of the pitfalls of the various methods that have been used. As discussed in Chapters 1, 2 and 4, these systems address aging metal roofs that that have reached their end-of-service life or have failed for other reasons, including improperly installed metal roof on new construction.

To understand the overall opportunity in this market, MOM retrofit is principally found on existing metal buildings constructed over the last several decades. It is important to note that the term "metal building" also refers to steel building, pre-engineered building and other types of metal construction. The opportunity in the MOM market is tremendous.

Factory-notched structura sub-purlins being installed over old aging roof and receiving a new traoazoidal standing seam roof (Photo courtesy of Roof Hugger,LLC)

An independent study conducted in in the late 1990's found that approximately 18-billion square feet of metal buildings were shipped in the U.S. between 1970 and 1990. This study was conducted under permission of the Metal Building Manufacturers Association (MBMA), which tabulated MBMA associate manufacturer member shipment reports over the 20-year time frame. The data did not include metal roofs installed over conventional roof systems. Many contractors have entered the retrofit market selling MOM projects. However, due to changing building codes, increased wind load requirements, and a renewed interest in energy efficient buildings, MOM projects have become more complicated. Nevertheless, MOM construction projects are still abundant and offer great growth for small metal construction contractors.

Benefits

Proven Longevity and Performance

Metal roof systems have always been known to have a long-life expectancy, but exactly how long they last have been a subject of debate. According to a 2014 study conducted by the Metal Construction Association and the Zinc Aluminum Coaters Association, the projected service life for GALVALUME® standing-seam roof systems is a minimum of 60 years. This is the longest service life of any commonly used roof system in the marketplace. Interestingly, the service life appears to be governed by a conservative estimate of the expected life of the butyl sealant used in laps, flashings, and penetrations. This study can be downloaded at: MCA Report.

In a 2015 study, the National Coil Coating Association (NCCA) reviewed data for pre-painted PVDF fluoropolymer metal panels subjected to exposure testing in South Florida. NCCA concluded it was reasonable to project a minimum service life for pre-painted PVDF panel of 40 years. Like any other construction material; proper design, detailing, installation and maintenance are critical to achieve the best performance and expected service life. However, all roof systems, including metal, eventually need to be replaced or re-covered. What happens when these roofs need to be replaced? Building owners will turn to the roofing professional and/or contractor for advice on whether to replace or re-cover their existing. A video on coil coating is available at: NCCA Video.

Energy Efficiency

MOM applications can provide additional benefits in energy efficiency with the addition of insulation and/or dynamic ventilation to the space between the old roof and underside of the new metal roof. Many MOM projects also include the addition of renewable energy systems. These can include photovoltaic solar power, solar thermal and hot water systems, and rainwater harvesting applications. For more detailed descriptions of numerous energy efficient systems, see Chapter 10 in this manual.

MOM assembly being installed with unfaced fiberglass insulation (Photo courtesy of Roof Hugger, LLC)

Increased Strength and Building Code Compliance

Reinforced corner zone framing (Photo courtesy of Roof Hugger, LLC)

When planning a MOM project, the new retrofit assembly will be required to be engineered to current mandated local building codes. These loading requirements can be substantially greater than the design load requirements from the time the building was initially erected. MOM retrofit systems can be designed to resist the increased wind uplift loads and the higher mandated uniform snow and drift loads. Some systems also have the ability to compensate for the new retrofit assembly weight being added to the existing roof system. Later in this chapter, there are some typical construction details that illustrate how this can be accomplished. To properly accommodate these increased wind and snow loads, it is highly recommended to attain the services of a design professional either directly or as a service from the retrofit system manufacturer.

It is important to understand that there are some MCA member manufacturers that furnish only the sub-framing systems, but do not furnish the new metal roof. Other MCA member manufacturers provide the metal roofing only or can provide the entire package including any required engineering.

Regardless, the sub-framing and the new metal roof system must be designed as an assembly. In nearly all cases, the capability of the new metal roof system to satisfy the required wind load will control the design of the sub-framing system.

Replacement/Recover Options and Pitfalls

When considering the re-cover option, there are several elements required to achieve proper longevity of the new metal roof system. Numerous methods have been employed for replacing the metal roofs including any of the following:

- Full tear-off of the existing metal roof and installation of a new metal roof directly over the existing roof support structure.
- Installation of various metal sub-framing components over the existing roof and then installation of a new metal roof over the new sub-framing system. Some shapes used in this subframe development include hat sections, zee-shaped members, and a very popular factory-notched sub-purlin member that is zee-shaped and nests over the major ribs of the existing roof panels. These zee-shaped members then attach through the pan of the panel, directly into the existing roof support structure.
- Installation of a conventional membrane roofing material directly over rigid insulation installed on top of the existing metal roof. This method has a very low initial cost and is normally referred to as an Overlay. Multiple pitfalls of utilizing the Overlay method have been identified in a white paper named "Comparison of Retrofit Systems Over Existing Metal Roofs", authored by Brian Gardiner FRCI, RRC, CCS. (White Paper). The pitfalls include existing purlin deflection, water flow, snow loading and service life. Most conventional membranes used have a service life, if properly maintained, of 20 – 23 years. For detail on overall cost savings, Table 3-6 illustrates the benefits of metal roofing compared to other conventional reroofing systems.

The MOM retrofit option is far superior to other options for the following reasons:

- Removal and replacement of the existing metal roof exposes the interior of the building to rain, snow and countless other issues where MOM retrofit can be performed even while building operations and processing continues.
- Removal and replacement of the existing roof may require extensive upgrading of the existing roof purlin system to meet current load requirements. It is important to understand that an existing screw-down/thru-fastened roof system should not simply be removed and followed with the installation of a new standing seam roof without major structural modifications. Screw-down roofs provide diaphragm resistance by bracing the roof structure of the building. Without the screw-down roof in place, the building structure becomes unbraced. Standing seam roof systems alone do not brace the roof structure. This type of roofing requires additional bridging and other added frame elements to stabilize the existing roof purlins. If the new roof replacement system has to satisfy updated wind and snow loading, it is highly probably that additional roof purlins will have to be required prior to installation of the new metal roof.
- New insulation can be installed during a removal and replacement but can be very labor intensive because of existing mechanical and electrical equipment and plumbing.
- In a removal and replacement, the old metal roof has to be disposed of adding cost to the project and

the added environmental landfill or recycling concerns.

- Certain MOM systems are Factory Mutual (FM) approved and certified, which is advantageous to building owners that require FM design criteria for insurance purposes. Most MOM systems can be engineered to meet FM design criteria, but a certificate cannot be provided.
- Many projects in Florida require minimal design criteria where Florida Product Approved products are mandatory.
- Additional worker safety is provided by working on an existing roof deck versus open-framed purlins.

Summary

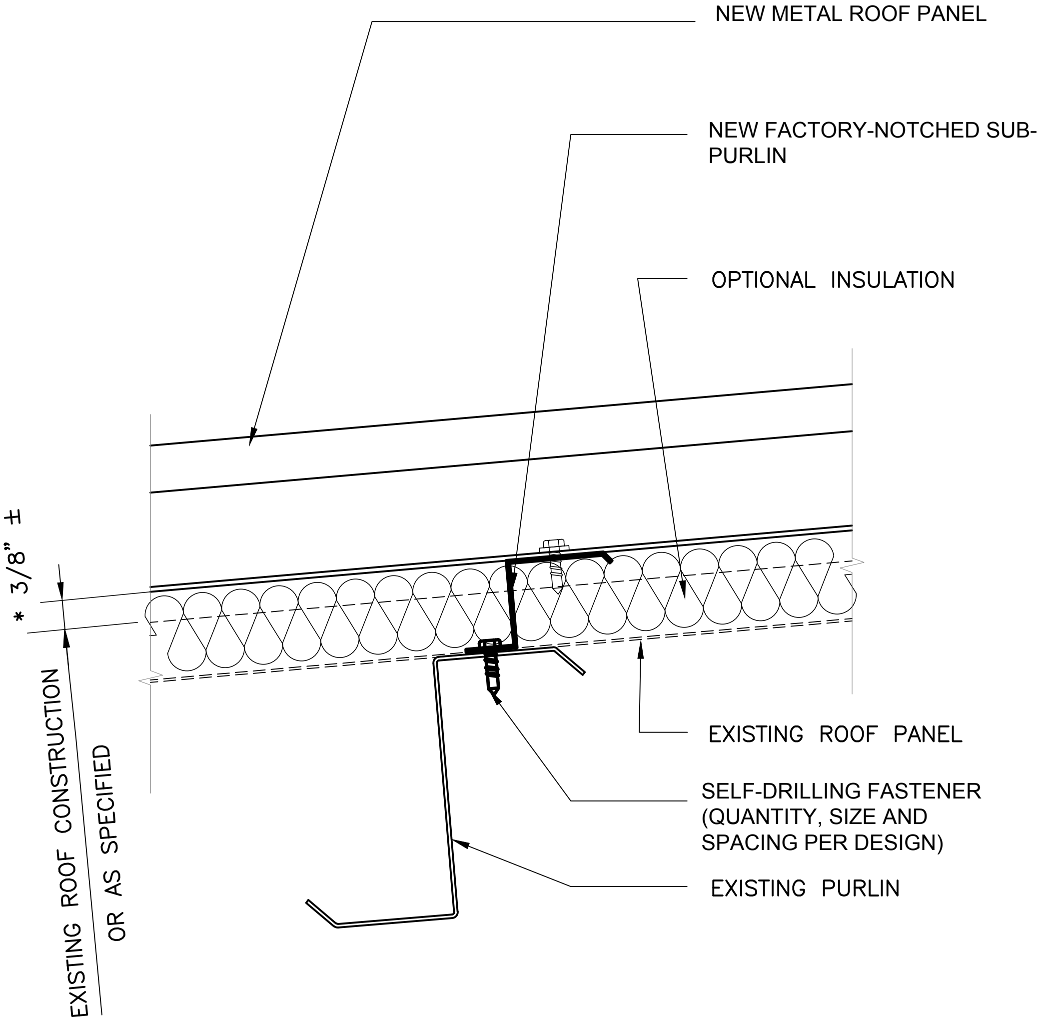
A Metal-over-Metal retrofit application is far better for the metal building owner that is looking for a solution to never-ending roofing problems including leaky roofs; aging rusted roofs; lack of thermal efficiency; and the economic costs associated with ceasing operations during the time required to replace the roof system. Design professionals can utilize the MOM retrofit option for those looking to repurpose an old building or wanting to update a building for new aesthetic appeal or increased appraised property value.

Following are several typical construction details illustrating the simplicity of one type of Metal-over-Metal retrofit roof system. The example system utilizes factory-notched low-profile structural sub-framing products that have been wind uplift tested and installed on a multitude of existing metal roofs. Other systems including hat-over-hat, hat-over-zee, zee-over-zee and tall stand-off clip attachments are available by several MCA member manufacturers referenced in Chapter 9.

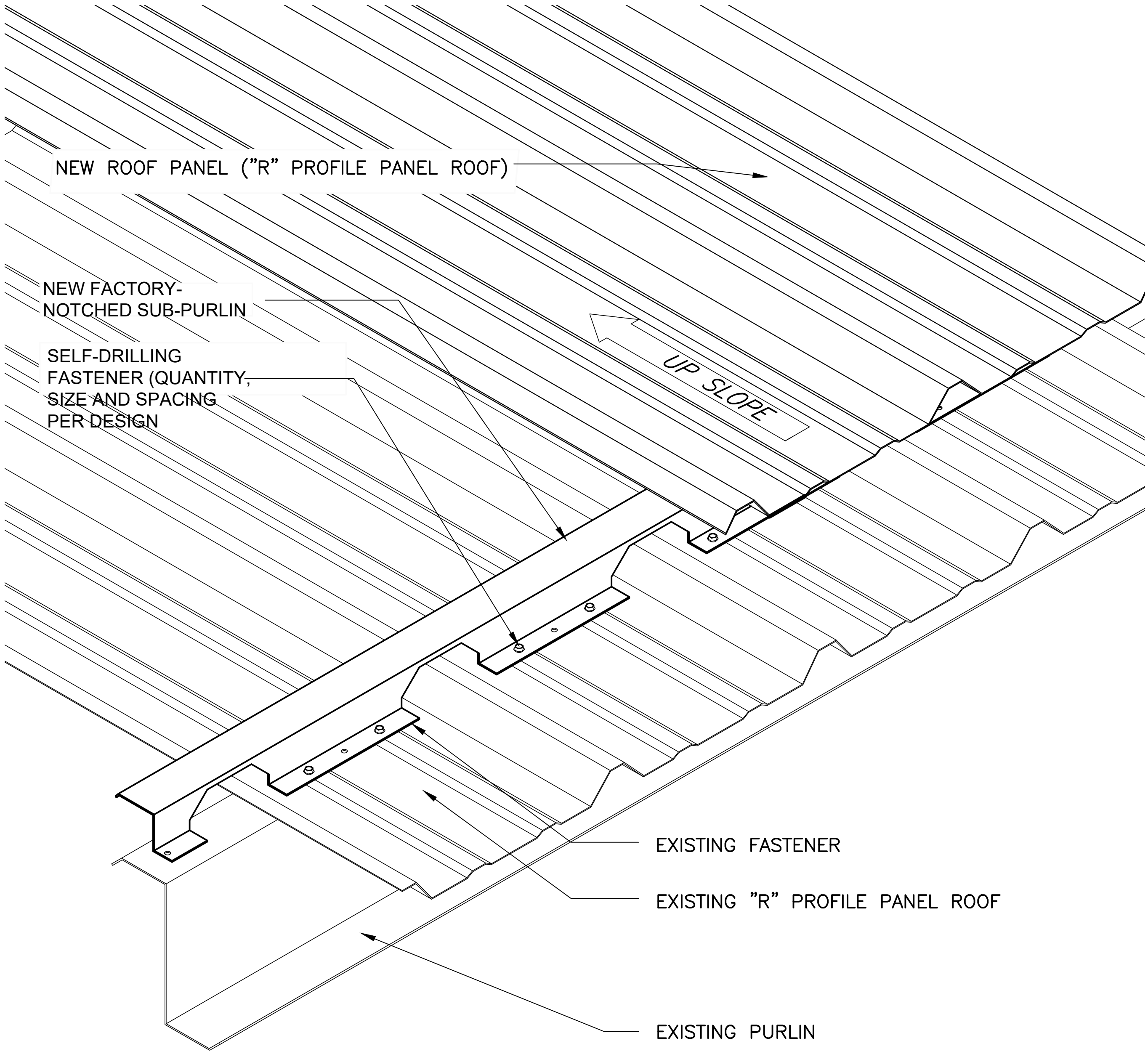
Zee-over-Zee MOM system (Courtesy of MBCI)

Hat-over-Hat MOM system (Courtesy of Roof Hugger, LLC)

Stand-off clip MOM system (Courtesy of Roof Hugger, LLC)

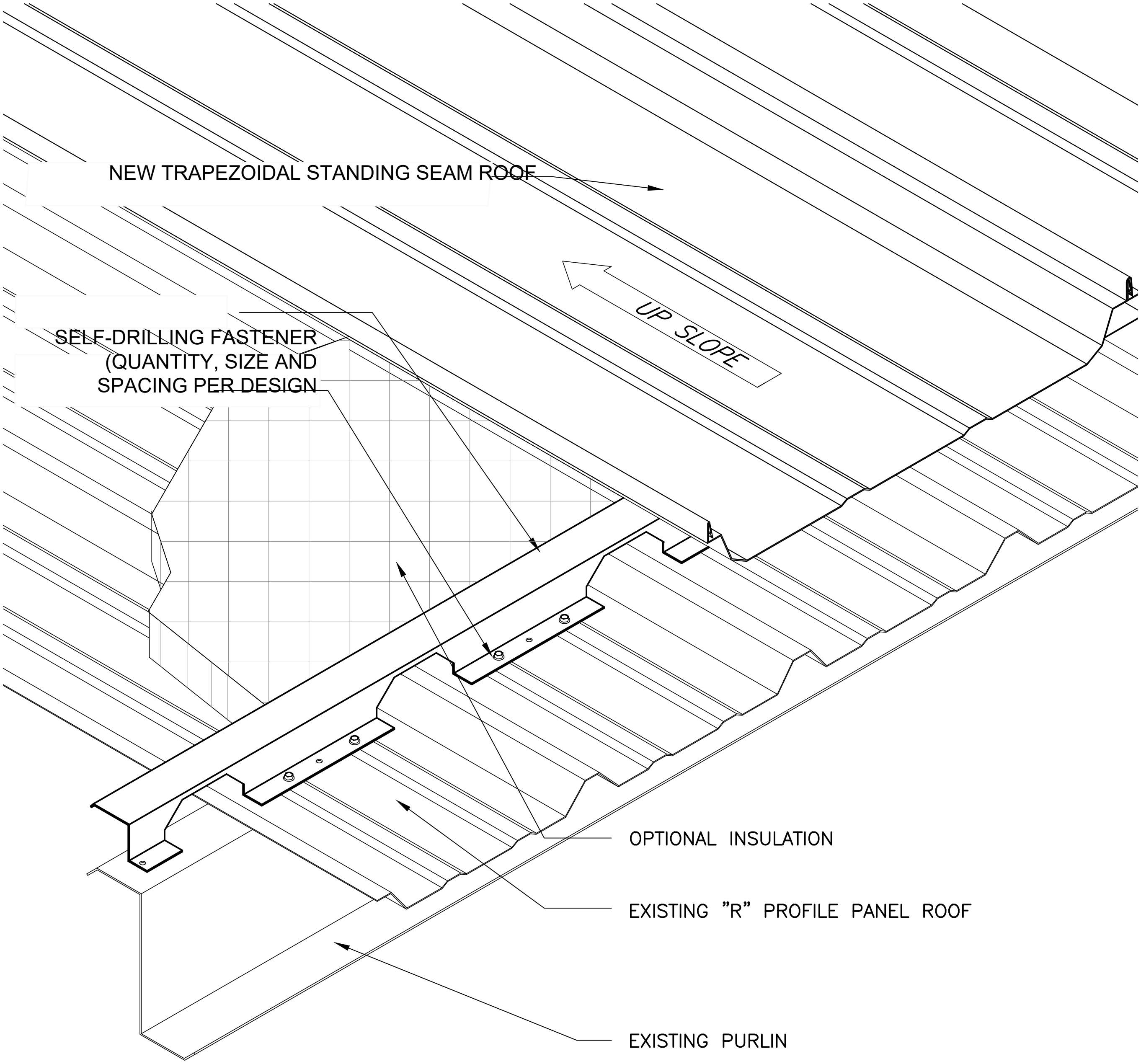


CROSS SECTION OF NEW SUB-PURLIN TO EXISTING ROOF PURLIN



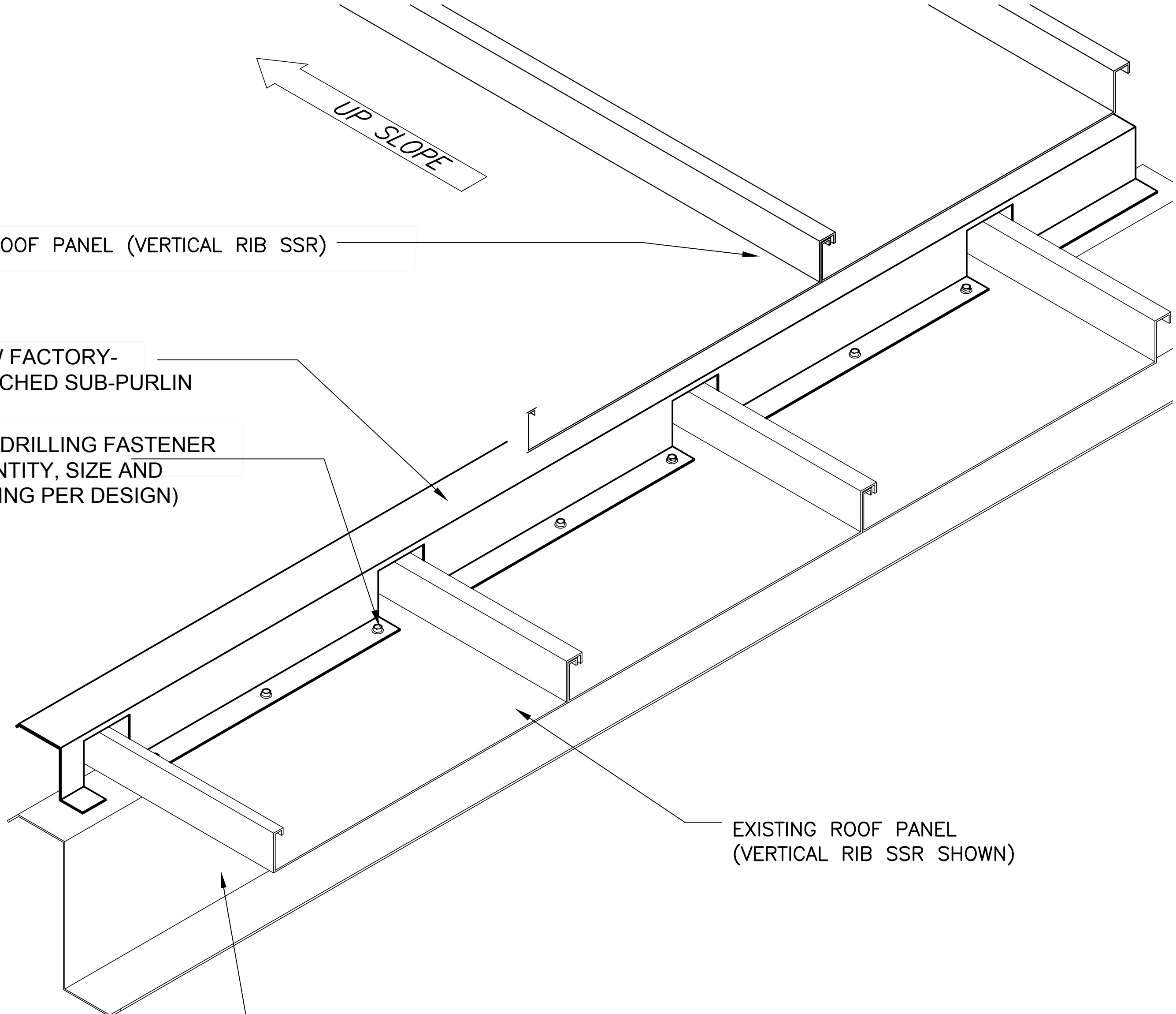
IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGURATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

NEW "R" PANEL OVER EXISTING "R" PANEL



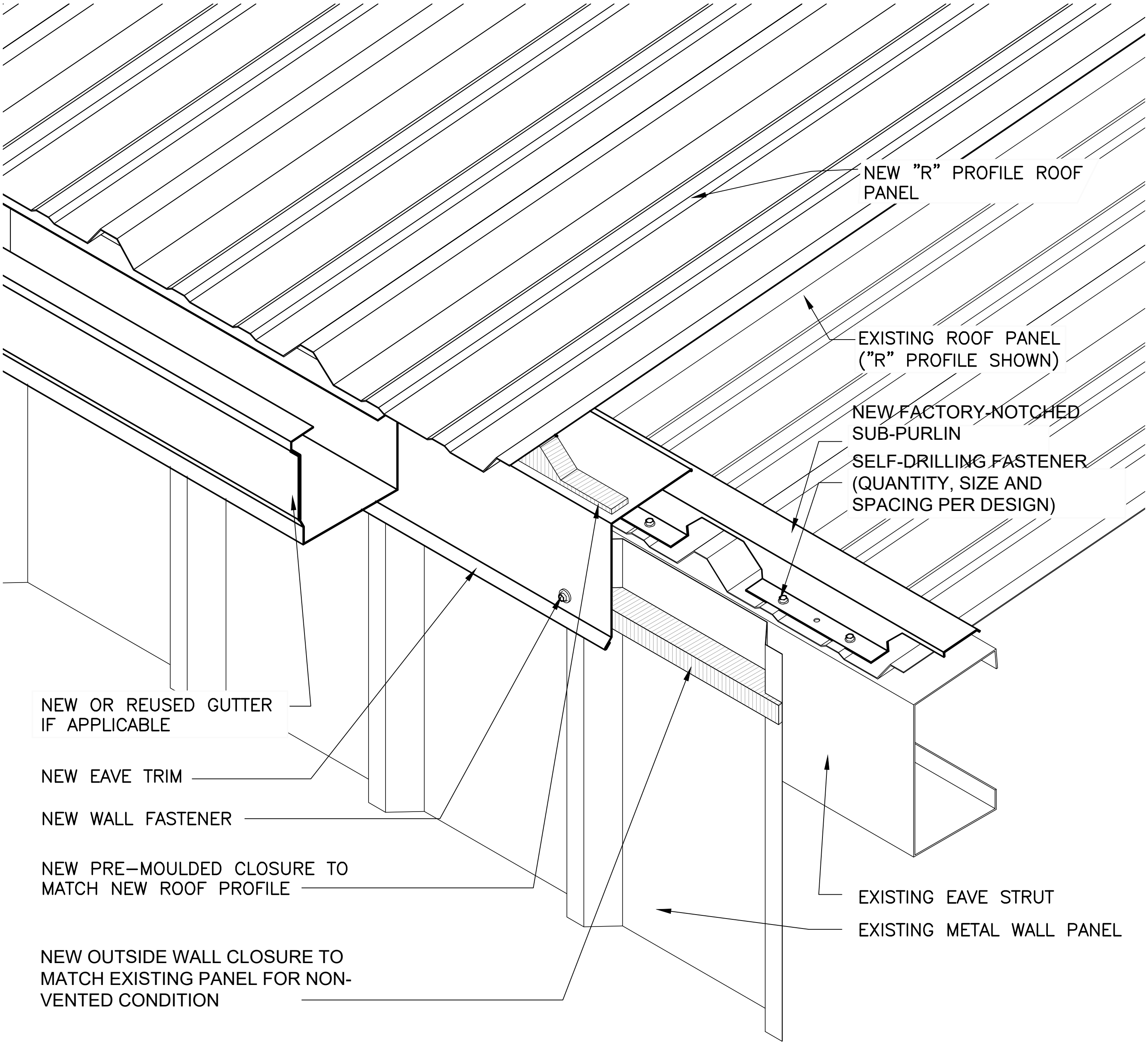
IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGURATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

NEW TRAPEZOIDAL SSR OVER EXISTING "R" PANEL



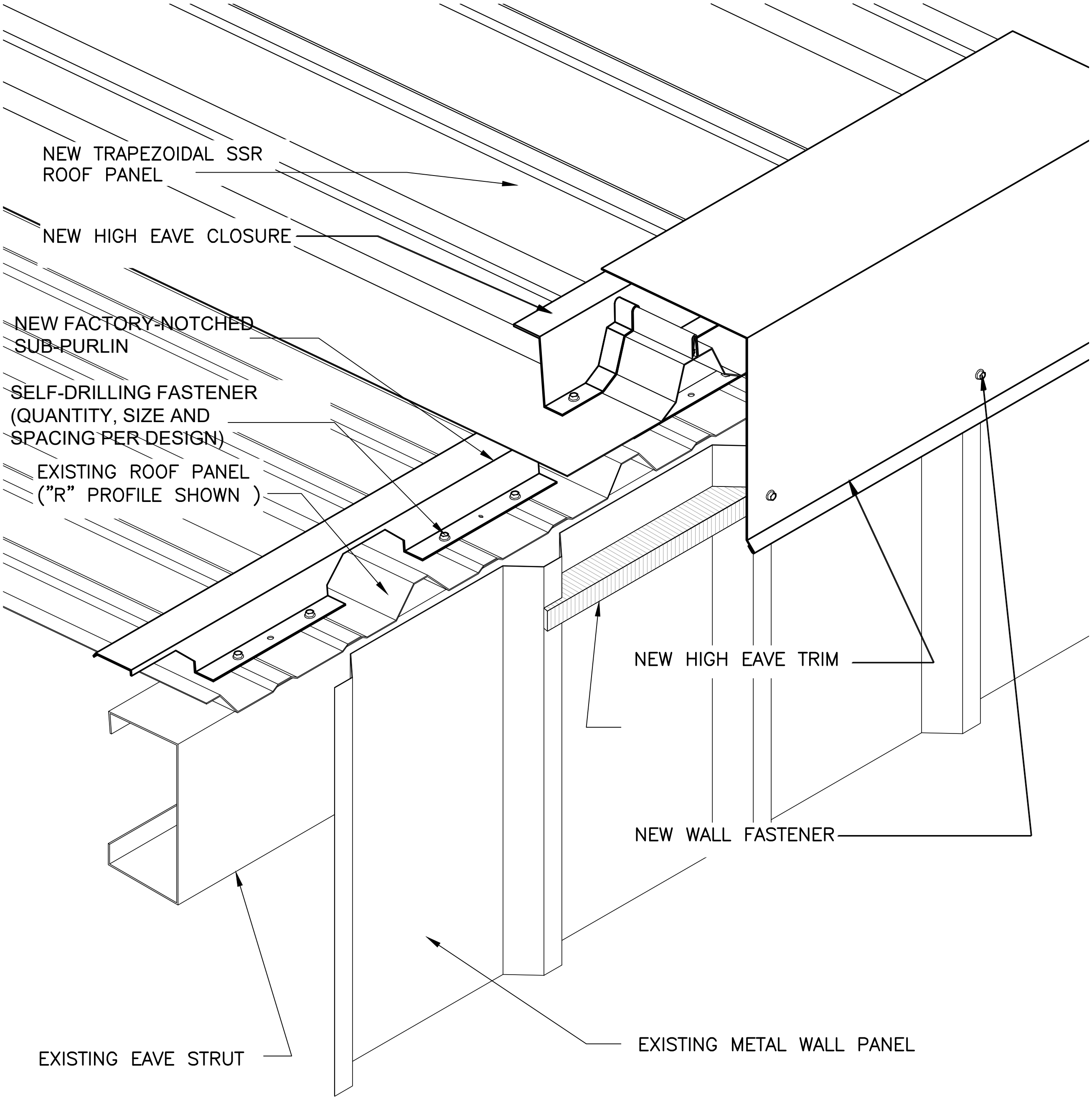
IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGRATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

CROSS SECTION OF NEW SUB-PURLIN TO EXISTING ROOF PURLIN



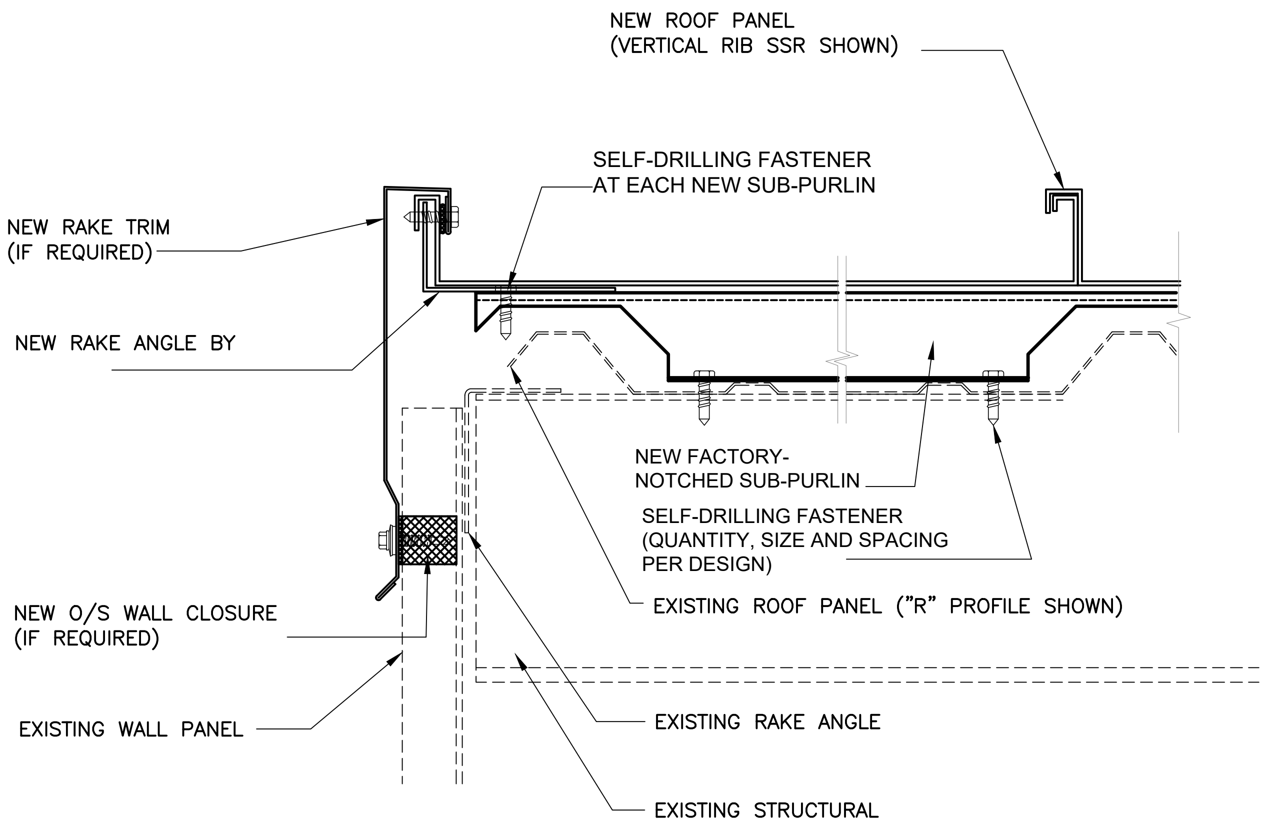
IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGURATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

NEW SUB-PURLIN AND FLASHING AT LOW EAVE



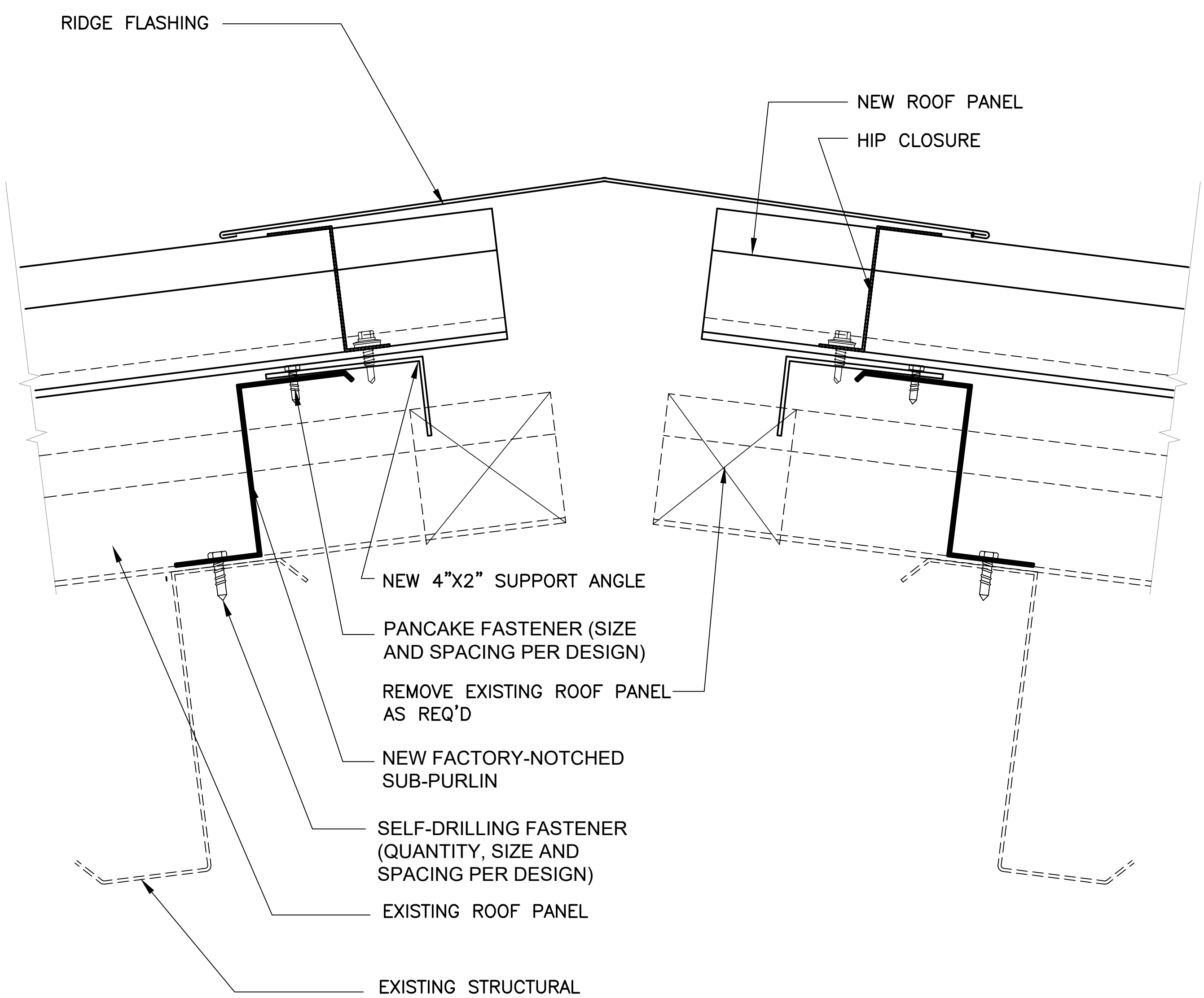
IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGURATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

TRAPEZOIDAL SSR OVER "R" PANEL WITH NEW SUB-PURLIN AND FLASHING AT HIGH EAVE



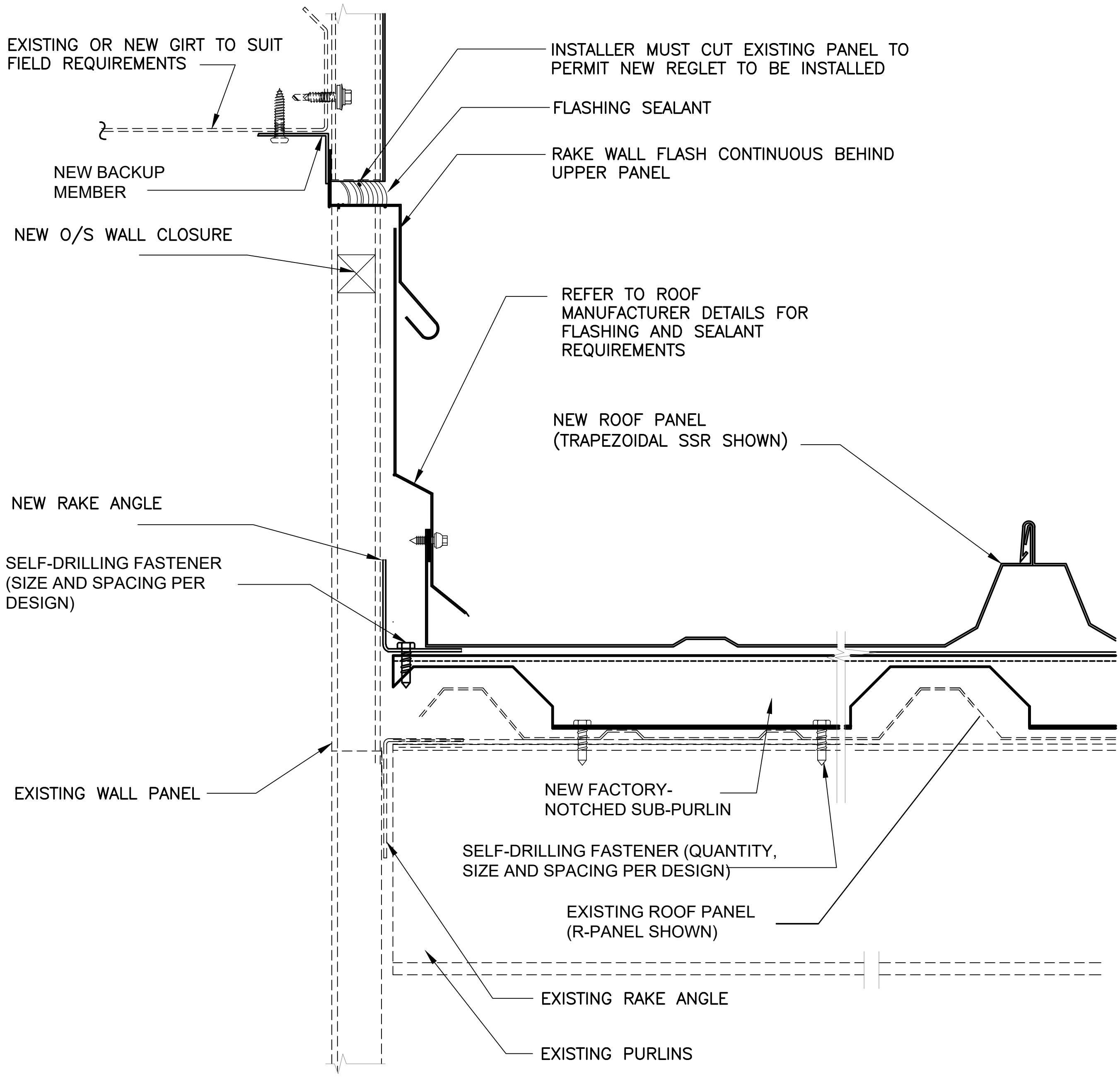
IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGURATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

CROSS SECTION OF NEW VERTICAL RIB SSR OVER "R" PANEL AT RAKE/GABLE TERMINATION



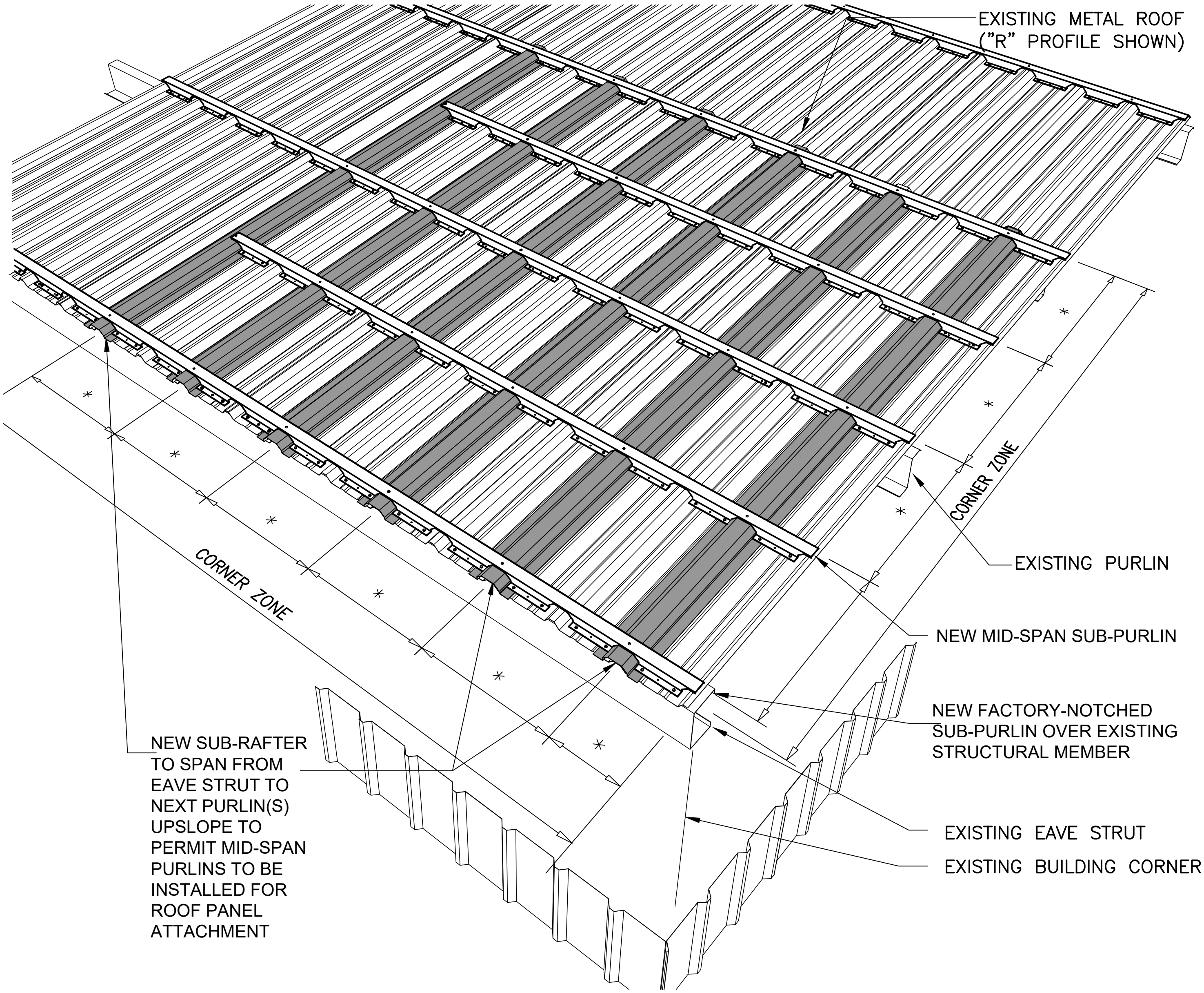
IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGURATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

NEW SUB-PURLIN AT NON-VENTED RIDGE



IT IS IMPORTANT TO NOTE THAT FACTORY-NOTCHED SUB-PURLINS CAN BE MANUFACTURED TO BE INSTALLED OVER VARIOUS EXISTING METAL ROOF PROFILES/CONFIGURATIONS AND THE NEW METAL ROOF CAN VARY AS WELL

CROSS SECTION OF NEW SUB-PURLIN AT RAKE-TO-WALL TERMINATION



NOTES:

1. THIS DETAIL ILLUSTRATES HOW ONE MCA MEMBER MANUFACTURER ACCOMMODATES ROOF EDGE AND/OR CORNER ZONE FRAMING IF REQUIRED BY DESIGN. OTHER MCA MEMBER SYSTEMS WILL VARY.
2. THIS CONDITION MUST BE ENGINEERED BASED ON THE NEW METAL ROOF SYSTEM'S WIND UPLIFT TESTING. DEPENDENT ON TEST VALUES AND THE SPECIFIED WIND LOAD REQUIREMENTS, THIS TYPE OF SPECIAL FRAMING MAY OR MAY NOT BE REQUIRED.
3. ALL REQUIRED FASTENER QUANITY, SIZE AND SPACING WILL BE PER DESIGN.
4. * = SPACING VARIES PER DESIGN

CROSS SECTION OF NEW SUB-PURLIN TO EXISTING ROOF PURLIN

Metal Construction Association
Chicago, IL
Retrofit Systems Design Guide
www.metalconstruction.org

METAL-OVER-METAL

CORNER/EDGE ZONE FRAMING

CHAPTER 7

Metal Roof, Wall and Soffit Systems

Overview

This chapter describes a variety of "single skin" metal roof, wall and soffit panel systems. Systems that are intended to be a focal point of the building design by shape, color, texture, etc. are generally called "Architectural" and these systems can be further divided into either "Structural or Non-Structural" systems. Structural systems have the ability to span over "open framing". Non-Structural systems are not able to span the framing and require the benefit of a solid backing substrate such as metal or wood. When used as a roofing material, both structural and non-structural systems tend to be color-coated and installed on higher slopes. Single skin wall and soffit systems are often uniquely designed panels that add shadowing or architectural relief to the appearance of the building.

Functional type systems are not determined based on physical appearance. These functional systems are more utilitarian in nature and commonly used in low slope roofing applications where aesthetics is not an important factor in the overall building design. The systems can be structural or non-structural depending on the project design. In areas where functional systems are installed, wall and soffit systems tend to be more conventional panel profiles.

Discussion

Architectural roof systems offer vertical leg interlocking side joints providing coverage (the dimension measured between side joints) from 12 – 24". The side joint height (rib height) range from 1½" – 3" and are joined by machine seaming the connection from 90 – 360°. Panels are also available with "snap" together side laps however, with some exceptions, these panels are commonly considered to be non-structural systems and require a substrate. Panels with the ability to span open framing without support from a substrate are referred to as "Structural Standing Seam Metal Roofs" (SSSMR). Panels requiring a substrate are referred to as "Architectural Standing Seam Metal Roofs" (ASSMR). The National Roofing Contractors Association (NRCA), Construction Specifications Institute (CSI), and most building authorities have adopted these two acronyms for use in specification and construction documents.

Functional roof systems are normally more economical than architectural systems, however they are also more limited in application to various metal roofing conditions such as hip and valley conditions. These systems are provided in both exposed-fastener (also referred to as "thru-fastened") and standing seam profiles with interlocking side joints. Exposed-fastened systems have overlapping side joints providing up to 36" of coverage with intermittent ribs formed into the panel spaced 9 – 12" on center. Once interlocked, the side joint is secured with exposed fasteners and sealed with rolled butyl mastic. SSSMR functional profiles form a trapezoidal rib at the side joint once installed, providing coverage from 16 – 24". These systems come in a variety of seam joints from snapped together to machine seaming during installation with 90 – 360° joints. In roof applications, panel finishes are frequently non-painted zinc-aluminum finishes.

The selection between architectural or functional systems depends on the scope and intended application of the project. All attachment fasteners and clips secured to the roof framing for standing seam roofs are "concealed", even though the roof may or may not have exposed fasteners at the exterior surface of low eaves, ridges, and other conditions. If aesthetic value is important, the design professional should choose one of the architectural systems especially in higher roof slope applications.

Since metal roof, wall, and soffit panel systems are discussed thoroughly in the MCA Roofing Installation Manual, this Chapter only describes these single layer panels in general. The MCA Roof Installation Manual is available for download at:

http://www.metalconstruction.org/Tech-Resources.

Table 7-1 illustrates various metal roofing profiles and distinguishes between Architectural and Functional Systems. As previously stated, all of these panels are structural in nature and are able to span open-framing, which is necessary for retrofit roof framing systems.

Table 7-1 Architectural and Functional Roof Systems

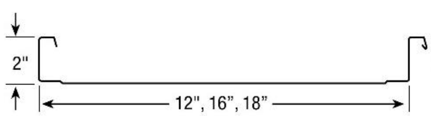
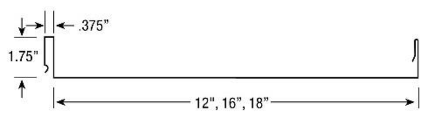
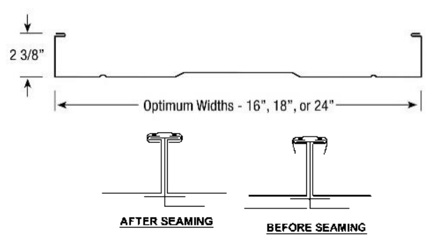
Profile/Generic Name	Common Seam Heights	Rib-to-Rib Coverage	Common Material
 Vertical Rib SSR – Mechanical Seam "Architectural"	1.5", 2" and 3"	12" to 18"	24 and 22-Gauge Steel
 Vertical Rib SSR – Snapped Seam "Architectural"	1.5", 1.75" and 2"	12", 15", 16" and 18"	24 and 22-Gauge Steel
 T-Rib SSR – Mechanical Seam "Architectural"	2-inch plus	16", 18" and 24"	24 and 22-Gauge Steel
 Trapezoidal SSR – Snapped Seam "Functional"	2.75" and 3"	12", 18" and 24"	24 and 22-Gauge Steel

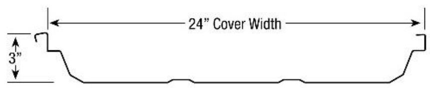
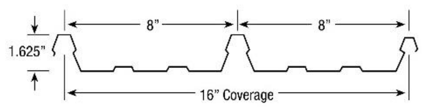
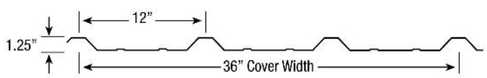
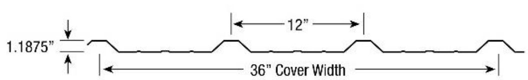
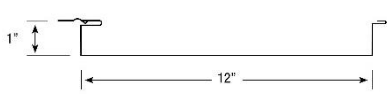
Table 7-1 Continued			
Profile/Generic Name	**Common Seam Heights**	**Rib-to-Rib Coverage**	**Common Material**
 Trapezoidal SSR – Mechanical Seam “Functional”	2.75” and 3”	12”, 18” and 24”	24 and 22-Gauge Steel
 Integral Lock SSR – Snapped Seam “Functional”	1.625-inch plus	16” and 18”	24 and 22-Gauge Steel
 Ribbed Panel - Thru-fastened “Functional”	1.25, 1.5 and 1.625-inches	36”	26, 24 and 22-Gauge Steel

Table 7-2 Vertical Applications- Walls and Soffit Panel Systems			
Profile/Generic Name	**Common Depth**	**Width Coverage**	**Common Material**
 Ribbed Panel – Thru-fastened “Functional” Wall and Soffit	1.1875 and 1.25-inches	36”	26 and 24-Gauge Steel
 Concealed Fastener “Architectural” Wall and Soffit	1 and 1.5-inches	12”	24-Gauge Steel and 0.32” Aluminum

It is important to note that there are a multitude of panel profiles available. This Chapter has included the most common types that are used in retrofit applications. In addition, all metal roof, wall, and soffit panel systems have specific profile flashings to prevent rainwater infiltration through the building envelope. Each manufacturer designs systems for weather-tightness and wind induced forces as well as aesthetic appeal and fit-for-use functionality. The tables illustrate the various, and commonly used, applications for each. Each project should have panel profiles selected that best suit the design intent, the project budget, and the geometry of the new metal roof being installed over a retrofit framing system.

Summary

In the Chapter 9, the MCA member manufacturers that furnish retrofit systems, including Metal-over-Flat and/or Metal-over-Metal applications are listed. Since the MCA is forever expanding its membership, this list is dynamic. Check with the MCA to confirm that this manual is the most current edition. Visit www.metalconstruction.org for MCA Member Manufacturers and any additional profile information.

CHAPTER 8

Energy Savings

Overview

Green or sustainable design is becoming a common practice in both new construction and renovation projects. Building owners now have the opportunity to achieve significant energy savings when tackling a roof replacement project. If the building owner is interested in pursuing LEED(R) certification, a retrofit system can help pave the way to compliance. The United States Green Building Council (USGBC) rating system for Existing Buildings: Operations & Maintenance provides criteria to address issues such as water and energy use, environmentally preferred materials, and exterior building site maintenance programs. A retrofit roofing system has the potential of contributing several points towards a Retrofit LEED V4 Project dependent on what the design team incorporates into the overall project.

High performance retrofit roofing systems introduces an opportunity to use proven and commercially available technologies to help achieve a sustainable building. A retrofit roofing project can utilize the surface of the new metal roof as well as the space between the top side old roof and bottom side of the new roof to install the following energy saving technologies.

Increasing Thermal Resistance with Insulation

As simple as it sounds, adding insulation between the old and new roof to increase thermal resistance can reduce energy use. Whether the decision is to upgrade to locally adopted energy code requirements or to install insulation with thermal resistance values up to R-50, the addition of insulation is a cost-effective option that provides a return on investment in the form of reduced energy consumption. While particularly applicable to buildings that are temperature controlled, added insulation in buildings will lead to a more comfortable and temperature stable work environment for the occupants.

Photo 8-1: Cellulose Insulation (Courtesy of RetroSpec, LLC)

A very important point to remember when adding insulation to a retrofit project is the benefit of the existing insulation R-value counting towards the total value required by the local energy code. Table 3-2 provides the insulating R-Values of both common older roof construction products and products used in retrofit today. This table can be used to determine what insulation type best suits a project to achieve necessary results.

Photo 8-2: Unfaced Fiberglass Installed Over Exisitng Roof (Courtesy of MBCI)

For retrofit over a flat roof, rolled fiberglass batt insulation or blown loose fill cellulose is best suited. For retrofit over sloped roofs, fiberglass or rigid board insulation such as polyisocyanurate works best. Using a laminated vapor barrier in either application does not suit the installation well. In the retrofit application over flat roof installation, the vapor barrier can actually trap moisture in the existing roof creating a deteriorating environment. For metal-over-sloped installations, the vapor barrier may also trap moisture and is not needed since the existing roof acts as the barrier itself. For metal-over-metal applications, Photos 8-3 and 8-4 illustrate the installation of either fiberglass or rigid insulation over the existing metal roof to achieve greater thermal resistance. Each of these projects utilized a factory-notched structural sub-purlin that "nests" over the existing roof panel ribs providing a low-profile system. Photo 8-4 from a U.S. Air Force project where the total thermal resistance, R-Value, was increased to R-50 including the existing R-19 insulation installed during the initial construction. This project also received a thin-film surface mounted laminated photovoltaic explained in the next section.

Photo 8-3: Metal-over-Metal Application with Fiberglass insulation (Courtesy of Roof Hugger, LLC)

Photo 8-4: Metal-over-Metal Application with Insulation (polyisocyanurate) (Courtesy of Roof Hugger, LLC)

Renewable Solar Technologies

Buildings of the future will be routinely clad with renewable energy systems that play an active role in building energy management. Progressive designers can create both new and re-roofing applications using building envelope systems that heat and cool both air and water and produce electricity in one common area. Some of the technologies that relate to a retrofit assembly include:

Solar Electricity

Photovoltaics are available in two different product application styles. A thin-film laminated PV (Photo 8-5) which comes prepared with a peel and stick butyl mastic adhesive on the non-exposed side. The laminated PV is known to be more productive in low sunlight. These can typically be installed at the jobsite depending on weather conditions or indoors in a controlled environment prior to shipment to the jobsite.

Photo 8-5: Thin-film Surface Mounted Laminate PV (Courtesy of Metal Sales MFG.)

The second type of PV is modular framed glazed systems. (Photo 8-6). These higher efficiency systems are manufactured in various assembly types. The protective glazing over the photovoltaic cells is in the form of a crystalline panel. This type of PV system can be installed individually or as a multi-panel array. These systems are more productive in bright sunlight and offer a much greater output relative to space needed.

Photo 8-6: Modular Surface Mounted Crystalline PV (Courtesy of S-5!)

Solar Thermal Air and Water

Another renewable solar technology is solar thermal energy. (Photo 8-7) Solar thermal systems produce heated air or water using radiation from the sun on the new metal roof creating domestic hot water, space heat or process heating applications. Solar thermal systems are suitable for both new and retrofit installations and are highly cost effective. Designers that choose building integrated solar thermal (BIST) systems as part of their overall design, have a vast array of building cladding materials, finishes, and colors available from the design pallet. When the roof and wall materials of a building became a solar absorber, building owners were delighted by the additional financial incentives included under the Federal Investment Tax Credit (ITC) program of IRS, Section 179d. While the original Federal tax credits have expired, new incentives could be reinstated by Congress in the future. Regardless, several state and energy supply companies have funds, grants and assistance available for a building owner installing efficient renewable energy systems.

Photo 8-7: Closed Loop Solar Thermal Hot Water System (Courtesy of Roof Hugger, LLC)

Solar thermal and thin-film PV systems can be synergistically engineered into one integrated PV-Thermal envelope assembly. Called BIPV-T, these systems are capable of producing 2 – 4 times the energy available from a thin-film PV system. The solar thermal system cools the PV increasing efficiency, while cooling the building envelope and putting otherwise waste heat to work in the building. The entire BIPV-T system is eligible for the Federal ITC and related state and local rebates and incentives (as available).

Ventilation of Space Below a New Roof

For retrofit over an existing flat roof, ventilation may be subject to code compliance as specified in the 2018 International Building Code (IBC), Section 1202.2. Enforcement of this section is dependent on whether the code review establishes the space between the old and new roofs as an "attic space". In many projects, ventilation has not fallen under the guidance of a code authority, but a recommended best practice for retrofit is this space should be ventilated. Check with your local code officials to determine what is required.

In a retrofit application, ventilation will assist in controlling condensation due to temperature changes throughout the day at the underside of the new metal roof. Ventilation also allows possible trapped moisture within the existing roof to dissipate. The IBC requires the net ventilated free area (NVFA) shall not be less than $^{1}/_{150}$ [1] of attic space volume to be ventilated, with 50% of the required ventilating area located in the upper portion of the attic space to be exhausted and the balance of the area to provide fresh ambient temperature intake air from the eaves. The 1/150 NVFA will, in most cases, require installing power ventilators in lieu of gravity ventilation (1/300 NVFA) which is a more typically specified factor for retrofit applications. In addition, some design professionals have required 3 – 4 air changes per hour, which simply means exhausting the volume of the space at a specified number of times and replacing it with new intake air each hour.

Retrofits over sloped roofing, a very well tested ventilated roof assembly, has experienced a great increase in demand in recent years because of its cost effectiveness. Figure 8-A, shows an assembly called Above Sheathing Ventilation (ASV). This type of ventilation is actually not a new technology as it has been used on tiled roofs for decades. The venting process is based on convection. Case studies and real-world laboratory tests confirm that ASV can reduce energy consumption by 20 – 40% and can be installed over existing sloped roofs through use of a sub-framing system that permits airflow beneath the new metal roof. In the case of a metal over existing metal roof, a factory-notched sub-purlin system provides for ASV very well by also providing for both types of new roofing systems, direct fastened and standing seam metal roofs, however the standing seam roof must be installed with a minimum 1" stand-off clip. The ASV assembly can accommodate the addition of fiberglass or rigid insulation but must still provide a minimum of 1" airflow above the insulation which a standing seam achieves with a stand-off clip. Figure 8-A illustrates an ASV assembly that includes a structural factory-notched sub-purlin, insulation (fiberglass or rigid board), radiant barrier, and a popular purlin vent strip that is available from a metal roofing accessories manufacturer.

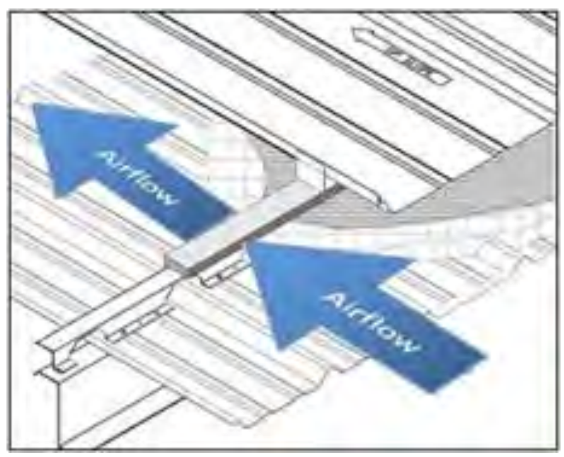


Figure 8-A: Metal-over-Metal application with ASV incorporated into the new roof assembly (Courtesy of Roof Hugger, LLC)

[1] One square foot of intake and exhaust airflow area per every 150 cubic foot of attic volume

ASV Application over Existing Metal Roofs

How does ASV work? Fresh air is introduced to the cavity between the old and new roof through natural ventilation at the low eave of the roof. When the sun radiates heat on the new metal roof, the air in the cavity becomes less dense and becomes more buoyant. This buoyant air travels up the slope along the immediate underside of the new metal roof. The buoyant air is then exhausted at the high point of the roof (ridge, etc.). This is known as convection. The end result is the system creates an insulating barrier of air between the two roofs. The steeper the roof slope, the more efficient the convection process becomes.

A multitude of ASV assemblies have been tested at Oak Ridge National Laboratory's (ORNL) Building Envelope Technologies Group since 2006. The results indicate that the system can reduce the heat radiation through the roof assembly from a minimum of 30% to a maximum of 45% when the new roof has a "Cool-Rated" coating/paint system. Effectively, an ASV system creates an air barrier, which reduces heat gain in the summer and heat loss in the winter. A very similar result to the addition of insulation.

Rainwater Harvesting

Another centuries old technology is gaining popularity in building construction. Rainwater collection, or harvesting, is a simple and cost-effective method of capturing rainwater for non-potable water uses where permissible by law. Harvesting can be incorporated into a potable water supply if a purification system is installed as well. Storage for collected rainwater can be above ground or below ground. One of the most effective uses for this technology is to supply water for irrigation. There are many equipment manufacturers and suppliers for these systems and this technology also contributes to LEED® points for building certification. From an 11,000 square foot retrofitted roof (Photo 8-8) shows a warm-dry climate installation in west Texas that produces 130,000 gallons of landscape irrigation water under normal annual rainfall. This system provides ample service to the approximate 1.5-acre grounds with above ground water storage.

Photo 8-8 – Rainwater above ground storage tank (Courtesy of Roof Hugger, LLC)

Other Technologies for Future Energy Savings

Innovative product components called Phase Change Materials (PCM) are now being specified in mainstream products such as drywall. ORNL has worked on the integration of PCM into optimized envelope systems, increasing the ability to store thermal energy and transfer it to the building when needed, when used in conjunction with cool roofing, thin-film PV and ASV applications. PV paints for roll to roll/continuous coating and PV inks with related printing processes are on the horizon.

Metal roofing is the ideal platform for renewable solar, the energy saving and renewable solar technologies state of the art in sustainable design. With the typical warranted life of roof mounted renewable solar technologies established from 25 – 30 years, conventional roof replacement is not a solution because conventional roof membranes have an average service life that is less than the solar elements. Because of this expected lifespan, the building owner may have to remove the solar equipment, replace the conventional roof at the end of its service life and then re-install the solar elements. Metal roofing with a superior service life of over 40 years is the only proper and cost-effective platform on which to install surface mounted solar.

ORNL continues to conduct research and testing on the next generation of sustainable energy envelope systems. Building on a deep knowledge base acquired over many years of research and development, with federal funding and industry sponsorship, ORNL is working with industry partners and trade associations such as the Metal Construction Association (MCA), Cool Roof Rating Council (CRRC) and others to develop, test, and commercialize the next generation of roofing and curtain wall products for both new and retrofit construction.

Federal Tax & Other Incentives

Since the Energy Policy Act of 2005, commercial buildings that improved their energy efficiency were eligible for tax deductions as allowed by the U.S. Tax Code 179D as mentioned earlier in this Chapter, it is important to understand that depending on the State your project is located in, a multitude of loan guarantees/funding, grants, renewable energy bonds and tax programs may be available. Consult your tax professional for specific investment tax reduction details and what can or cannot be included. You may also visit www.dsireusa.org to explore what incentives are currently available in your local area.

Summary

All of these technologies are applicable for not only new construction, but even more so for existing buildings. The DoE's Energy Information Administration reports that there are 5 million plus existing commercial and industrial facilities in the U.S. that consume 74.7% of our building energy demand or 29,189 Trillion BTU's per year for cooling and heating. Needless to say, the opportunity to reduce our building energy consumption is with upgrading existing buildings through retrofit roof systems.

CHAPTER 9

Glossary and References

Glossary of Metal Construction Terms

The following glossary provides definitions of common terminology associated with the metal construction industry. These are related to pre-engineered buildings, metal components, metal roof and wall systems, and retrofit framing systems.

A

Accessory

An extra building product that supplements a basic solid sheeted roof or wall such as louver, ventilation device, curb, or roof jack.

Adaptor trim

Trim designed to close off and trim the junction of a wall panel with masonry.

Aggregate

1. Crushed stone, crushed slag, or water-worn gravel used for surfacing a built-up roof.
2. Any granular mineral material.

AISC

American Institute of Steel Construction

AISI

American Iron and Steel Institute

Anchor

A fastener such as screw, bolt, drive pin, or expansion sleeve used to secure a structural member to a support system.

Anchor bolts

Bolts used to anchor structural members to a foundation or other support system. Usually refers to the bolts at the bottom of columns.

Anodic

(In regard to metal and galvanic response) When two metals are connected in an electrolyte, they will form a galvanic cell, with the higher metal in the galvanic series being the anode. The anodic metal, being more "active," oxidizes first, protecting the cathodic metal from corrosion.

Approval drawings

Approval drawings may include framing drawings, elevations, and sections through the building as furnished by the manufacturer for approval from the buyer. Approval by the buyer or the authorized approving authority affirms that the manufacturer has correctly interpreted the overall contract requirements for the system and its accessories, specifically for the products being provided by the manufacturer.

Architectural Panel

An intricately formed panel with special attention given to its appearance and its primary purpose to aesthetically enhance a building or structure.

Assembly

In relation to metal systems, a group of mutually dependent and compatible components or sub-assemblies of components.

Asphalt felt

An asphalt-saturated and/or an asphalt-coated felt.

ASTM

American Society for Testing and Materials

Attic

In relation to retrofitting a building, the area between the existing roof and the new metal roof system.

Auxiliary Loads

All specified dynamic live loads other than the basic design loads that the building must safely withstand such as cranes, material handling systems, machinery, elevators, vehicles, and impact loads.

Axial Force

A force tending to elongate or shorten a structural member.

B

Ballast

Material used in conventional roofing to hold down the roof membrane with its weight. Gravel and lightweight aggregate are common ballast types used with built-up and rubber membranes.

Bar joist

(Open web joist) Normally used as beams or horizontal structural members suitable for the support of floors or roof decks, with top and bottom chords of tees, pairs of angles, or round bars and round bar web members.

Barrel vault

A semicircular-shaped roof.

Base Angle

An angle secured to the perimeter at the existing roof edges to support wall panels.

Base flashing

The lower flashing component of a two-piece metal flashing detail. Two-piece flashing details are often used either for expedience or to allow differential thermal movement between building elements or accessories. The lower component is the "base" flashing and the upper component is the "counter-flashing."

Base Member

A structural member that attaches to the existing building roof support structure and accepts the vertical retrofit framing members. May be in the shape of a channel, angle, plate, zee, or cee.

Base plate

A steel plate of particular dimensions, normally square, used beneath a base member to distribute the imposed positive loads. Also known as a spreader plate.

Base Trim

A formed trim designed to close off the opening at the base of the wall and to flash to other construction components.

Batten

Raised rib, in a metal roof, or a separate part or formed portion in a metal roofing panel.

Bay

The space between frame center lines or primary supporting members, normally in the lengthwise direction of the building or roof.

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Bearing Plate

(See Base plate)

Bill of Materials

A list that enumerates, by part number or description, each piece of material or assembly being shipped to a job site. Also referred to as a tally, shipper, or shipping list.

Bird Screen

Wire mesh used to prevent birds, rodents, or other pests from entering the roof cavity area through ventilation devices such as louvers.

Blanket Insulation

Fiberglass insulation in roll form, often installed between metal roof panels and supporting purlins or directly over the existing roof in retrofit projects.

Blind rivet

A small-headed pin with an expandable shank for joining light-gauge metal, typically used to attach flashing components.

Blocking

Term used to describe various materials of varying thickness to support a framing member between it and the existing roof decking.

Boot

A rooftop device used to flash, and seal around circular penetrations caused by sanitary vents, flues and other mechanical or electrical construction. Commonly referred to as a roof jack or Dektite.

Box-sill

The trim at the outermost portion of a soffit and a vertical wall or other surface.

Bracing

Members used to resist lateral wind forces imposed on the framing system. May be angle or cee-shaped members, cable, or flat strapping.

Brake-formed

Metal sheet or strip that has been cold-formed into a desired cross section by press brake equipment. Lengths vary but are generally limited to 20'.

Bridging

Members used to brace two or more other members such as purlins, girts, etc. May be angle shaped or of steel-threaded rod.

Building code

Adopted regulations established by a recognized agency or authority describing design loads, procedures, fire safety and construction details for structures; usually applying to a designated political jurisdiction (city, county, state, etc.).

Built-up Member

Structural framing member comprising two or more steel plates cut to specific dimensions and joined by hand welding or continuous process.

Built-up Roofing/BUR

A roof covering made up of alternating layers of tar or asphaltic materials and layers (plies) of organic and synthetic fabric.

Button Punch

A process of indenting two or more thicknesses of metal that are pressed against each other to prevent slippage between the metal.

Butyl Tape

A common abbreviation for polyisobutylene-isoprene polymer sealant tape used between metal roof panels and flashing joints.

C

Camber

A predetermined curvature designed into a structural member to offset the anticipated deflection when loads are applied.

Cant

A diagonal strip normally found at the junction of a wall and roof. Used in conventional roofing to allow proper flashing methods.

Canopy

Any overhanging or projected roof structure with the extreme end usually unsupported.

Cantilever

A projecting beam that is supported and restrained at one end only.

Capillary Action

The action that causes movement of liquids when in contact with two adjacent surfaces such as panel side-lap.

Cathodic

With regard to metal and galvanic response, cathodic metals are lower (and more noble) in the galvanic series (see Anodic).

Caulk

A process to seal and makes weathertight the joints, seams, or voids by filling with a waterproofing compound or material.

"C" or Cee

A member cold-formed from steel sheet in the shape of a cee with returning stiffening lips.

Channel

A member cold-formed from steel sheet or hot rolled steel in the shape of a cee without return lips.

Cladding

Exterior metal coverings, including roof and wall panels and any related flashings.

Cleat

A sheet metal strip used in a concealed fashion to secure panels or flashing that permits thermal movement.

Clip

A piece of hardware used to fasten two or more members together.

Closure

A seal that is formed to match the configuration of panels or trim used at certain locations to seal off voids.

Closure Strip

A resilient strip formed to the contour of ribbed panels and used to close openings created by ribbed panels joining other components.

Coil Coating

The application of a finish to a coil of metal sheet using a continuous mechanical coating process.

Cold-formed

The process of forming sheet steel into desired shapes through a series of rollers in a rolling mill or by bending at ambient temperature. Shapes include angles, channels, "C" sections, and "Z" sections.

Collateral Load

All specified additional positive-acting (dead) loads other than metal roof framing and cladding (i.e., sprinklers, mechanical and electrical systems, ceilings, etc.).

Column Brace

A member such as a girt, an angle flange brace, or both. Used for lateral or longitudinal bracing.

Composition

Refers to the existing roof and all of the materials, which make up the system. This would include the substrate, insulation, membrane, and ballast

Compression Test

Refers to a series of tests at various locations on the existing roof where the membrane and insulation is evaluated for ultimate compression strength and resistance. Normally, a core is cut from the roof and then installed in a testing device. Other methods can be used in the case of retrofitting an existing building as referenced in this manual. The results are recorded and referred to in pounds per square inch.

Concealed Clip

A hold-down clip used with a wall or roof panel system to connect the panel to the supporting structure with the fasteners not exposed to the exterior surface.

Condensation

The conversion of water vapor or other gas to liquid as the temperature drops (see Dew point).

Conductor Head

A transition component between a through-wall scupper and downspout used to collect and direct rainwater.

Continuous Purlin

Purlin that overlaps at main primary framing assemblies and is based on the use of continuity in design.

Continuous Vent

A roof ventilator that is normally located at the ridgeline of a building and is made possible by connecting multiple vents or assemblies.

Coping

Term used to describe flashing at the top of a parapet wall. May be of various materials that are different than the wall material.

Corner Cap

A premanufactured custom trim piece used to trim the corner of a roof from the rake trim to the gutter or eave trim.

Cornice

A decorative finish or flashing that accents the top of a wall, or the juncture of a roof and wall.

Corrugated Panel

A metal or fiberglass panel with alternating sinewave-shaped ridges and valleys in parallel.

Cricket

A relatively small, elevated area of a roof constructed to divert water around a chimney, curb, or other projection.

Curb

A raised member used to support roof penetrations such as skylights, hatches, air-handling equipment, etc.

D

Dead Load

Nonmoving rooftop or suspended loads, such as mechanical equipment or ductwork, air conditioning units, fire sprinkler systems, and the roof deck itself.

Deck

A structural element that is fastened to the roof framing system, typically constructed of corrugated metal sheets or plywood. It acts as the substrate for nonstructural roof panels.

Deflection

The displacement of a structural member relative to its supports due to applied loads (can be horizontal or vertical).

Design Loads

The loads expressly specified in the contract documents, which the metal roofing system is designed to safely resist.

Design Professional

The architect or engineer responsible for the design of a construction project. May be a roof consultant if legally qualified.

Dew Point

The temperature at which water vapor starts to condense in cooling air at the existing atmospheric pressure and vapor content.

Diaphragm Action

The resistance to racking generally offered by the covering system, fasteners, and secondary framing except in most types of standing seam roof systems.

Downspout

Rectangular and/or round tube used to channel water from the gutter to a preselected location.

Draft Curtain

A vertical wall assembly used in the roof cavity/attic area to prevent fire and smoke from spreading. Normally constructed of noncombustible materials.

Drift Load

The positive-acting load that is created as the result of accumulation and drifting of snowfall. Typically located at valleys, roof-to-wall conditions, and other areas that allow snow to accumulate above its initial snowfall.

Drip Edge

A metal flashing, with an outward-projecting lower edge, intended to control the direction of dripping water and to protect underlying building components.

Dutch Gable

An architectural appearance; all eaves of the building are at one constant elevation and the sloping roof terminates at the hips to create a small gable condition. This appearance is commonly used to ventilate the roof cavity.

E

Eave

The line along the sidewall plane formed by the intersection of the roof and wall panels.

Eave Angle

An angular formed member with two legs that is attached to an eave purlin and receives the roof and wall panels.

Eave Fascia

Trim formed that may match the rake fascia that can be used to trim the low eave of the roof.

Eave Gutter

Preformed trim that receives rainwater and is formed with a face configuration that matches the rake fascia.

Eave Height

The vertical dimension from the finished ground level floor elevation to the intersection of the new roof and wall.

Eave Member

A steel assembly made of one or more members to receive the roof panel. May be designed for fixed (no vertical movement) or floating conditions.

Eave Plate

A one-piece structural member attached to the existing roof edge to receive the roof panels.

Eave Purlin

A zee-shaped member located at the roof eave to receive the eave angle.

Eave Trim

Trim designed to close off the top of wall panels or building materials, such as existing walls and gravel-stop fascia trim in retrofitted roofs.

Edge Strip/Zone

The surface area of a building at the edges of the roof and at the wall intersections, where the wind loads on components and cladding are greater than those at other areas of the building.

Edge Stripping

Application of felt strips cut to widths narrower than the normal felt roll width to cover a joint between flashing and built-up roofing.

Effective Wind Area

The area used to determine the wind coefficient. The effective wind area may be larger than or equal to the tributary area.

Endlap

A term that refers to the lapping of two components at their extreme ends such as roofs or wall panels, etc.

End Zone

The surface area of a building along the roof at the endwall and at the corners of the walls.

Engineer of Record

The engineer or architect who is responsible for the overall design of the building project. The manufacturer's engineer is not to be considered as the engineer of record.

Envelope

Term used to describe the entire roof system once completed inclusive of roof and wall panels with trim.

EPDM

Ethylene propylene diene monomer. A synthetic thermoset rubber that is popular for membrane roofing and flashings and as a gasketing material for the head of weather sealing screw fasteners or devices.

Erection

The on-site assembling of the prefabricated components to form a complete structure.

Expansion Cleat

A cleat designed to handle thermal movement of the metal roof panels.

Expansion Joint

A break or space in construction to allow for thermal expansion and contraction of the materials used in the structure. May be transverse or longitudinal.

Exposure

The terrain surrounding a building categorized by the amount of obstruction to wind or snow loading.

F

Fabrication

The manufacturing process performed in a plant to convert raw materials into finished roof system components. The main operations are cold forming, cutting, cleaning, and painting.

Factory Mutual Research Corp. (FMRC)

Factory Mutual Research Corp. is an organization devoted in general to property conservation. Its activities include writing internal standards; participating in the writing of consensus standards; third-party testing and approval of products; and certification of electrical apparatus for shock and fire safety. Their concern includes fire safety, electrical and construction related issues.

Fascia

A decorative trim or panel projecting from the face of a vertical wall.

Felt

A flexible sheet manufactured by the interlocking of fibers through a combination of mechanical work, moisture and heat. Roofing felts may be manufactured principally from wood pulp and vegetable fibers (organic felts), asbestos fibers (asbestos felts), glass fibers (fiberglass felts or plysheet), or polyester fibers.

Field

1. The job site building site, installation workers, or general market area.
2. The uninterrupted principal area of a roof, exclusive of edges, accessory, and other flashing areas.

Fishmouth

1. A half-cylindrical or half-conical opening formed by an edge wrinkle.
2. In shingles, a half-conical opening formed at a cut edge.

Fixed Clip

A standing seam roof system hold-down clip, which does not allow the roof panel to move independently of the roof substructure.

Fixed Eave

1. A condition in which the eave member(s) create a fixed vertical dimension and do not allow vertical latitude.
2. A condition in which the roof panels are fixed at the eave to promote thermal movement upward.

Flange

The projecting edges, or legs, of a structural member.

Flange Brace

Diagonal angle brace from the bottom of the purlin to the primary frame assembly.

Flashing

A sheet metal closure that functions primarily to provide weathertightness in a structure, and secondarily to enhance appearance.

Flashing Collar

A counterflashing used to cover and/or seal the top of a pipe flashing or other small base flashing at penetrations through the roof.

Floating Clip

(See Sliding clip)

Floating Eave

1. A condition in which the eave members create a variable dimension to satisfy irregularities at the existing roof edge.
2. A condition in which the roof panels can float as a result of thermal expansion and contraction movement. This condition must fix the roof panel at an upper point.

Foundation

As it relates to retrofit, the roof supports that exist at the time of the new framing system erection.

Frame

A primary framing assembly, which receives secondary members such as purlins. May be designed as a continuous section, trussed assembly, or other variation.

G

G-90

A typical coating weight for galvanized metal sheet. Equates to 0.90 ounces of zinc per square foot, measured on both front and back surfaces. Other coating weights are G-30 and G-60.

Gable

A triangular portion of the transverse end of a roof directly under the sloping roof and above the eave line.

Gable Sheets

Wall panels installed at the gable.

Gauge

Thickness of steel or distance between holes; also written as gage.

Galvalume®

A proprietary trade name for a coating that is used over sheet steel that is composed of an aluminum-zinc alloy for corrosion resistance.

Galvanic Action

An electrochemical reaction between dissimilar metals in the presence of an electrolyte. Also referred to as galvanic corrosion.

Galvanized

Steel coated with zinc for corrosion resistance.

Girder

A main/primary horizontal or near-horizontal structural member that supports vertical loads.

Girt

A secondary horizontal structural member attached to the vertical planes to receive the wall panels. May be hat, zee, or other shapes.

Grade

The term used when referring to the ground elevation around a building.

Gravel Stop

A trim piece used to retain the roof aggregate or ballast on the roof.

Grid

The term referred to in the layout of the retrofit framing in relation to the existing building's structural support system.

Grooves

(See Pencil ribs)

Ground Snow Load

The probable weight of snow on the ground for a specified recurrence interval exclusive of drifts or sliding snow.

Grout

A mixture of various compounds used to fill cracks and cavities. Often used under base plates or leveling plates to achieve a uniform bearing surface.

Gusset Plate

A steel plate used to distribute loads.

Gutter

A channel member installed at the low eave of the roof to carry water from the roof to the drains or downspouts.

Gutter End Closure

Metal insert provided with sealant and fasteners to close the end of the eave gutter.

H

Hardware

Miscellaneous roofing parts used to install roof panels and flashing such as clips, fasteners, joggles, cleats, etc.

Hat Section

A framing member used for various purposes that is hat shaped. Made of 22-, 20-, 18-, and 16-gauge material.

Header

A horizontal framing member over an opening used to support vertical and horizontal loads.

Header Flash or Trim

Trim piece used to hide the header framing.

Hem

The edge created by folding metal back onto itself. Can be open as in an open-hem or completely compressed as in a closed-hem.

Hip Roof

A roof that rises by inclined planes from all sides of the building at each outside corner.

Hot Rolled Shapes

Steel sections (angles, channels, I-beams, etc.) that are formed by rolling mills while the steel is in a semi-molten state.

Hydrokinetic

Metal panel systems that are designed to “shed water” are referred to as hydrokinetic. Hydrokinetic roof details are typically devoid of sealant and rely on water to freely shed over joints. These details are not be used on roof slopes less than 3:12.

Hydrostatic

Roof membrane systems, including metal roofing, that are designed to withstand submersion in water for periods of time are called hydrostatic systems. Hydrostatic roof details rely on sealant to keep water from infiltrating the joints and seams. These details can be used at almost any roof slope and a minimum of 1/4:12.

I

Ice Dam

A buildup of ice that forms a dam on the roof covering, usually along the low eave of the building.

Inset Girt

Girts that are installed with their outside face flush with their support structural member.

Inside Corner Trim

Trim designed to flash the inside corners of walls.

Insulation

Any material used in building construction to reduce heat transfer.

Intermediate Column

Also known as soldier column, a structural member located between two other main structural members normally used to support a roof structural member.

Internal Pressure

Pressure inside a building or roof cavity caused by wind entering the building or from air-producing equipment.

J

Jamb

Vertical members that frame openings in walls.

Jamb Trim

A trim used to conceal the opening’s jamb sub-framing.

Joist

Secondary structural member acting as a beam and supported by primary structural members or walls. Can be made of open or solid-web steel, wood, concrete, and other various structural materials.

K

Knee (Or Haunch)

The connecting area of a column and a rafter or structural frame assembly.

Knee Cap

A metal cover trim that fits over a panel rib or seam area after it has been cut and bent at a fascia break detail. Found at knuckle eaves or roof-to-wall turn down transition and commonly referred to as rib cover.

Knuckle Eave

An architectural appearance; the sloped roof transitions to a vertical plane at the eave line without the use of trim or other horizontal flashing. Rib covers are used to cover the rib transition openings.

L

LGSI

Light Gauge Steel Institute

Lap Joint

A joint at which one roof panel or flashing segment overlaps another.

Lean-To

A structure, such as a shed, having only one slope or pitch and depending upon another structure for partial support.

Liner Panel

Sheeting or covering on inside of building.

Live Load

Loads on floors and roofs that are produced

1. During maintenance by workers, equipment, and materials.
2. During the life of the structure by movable objects but not including wind, snow, seismic, or dead loads.

Longitudinal

A term, that refers to the direction that is perpendicular to the slope of the roof panels.

Louver

An opening provided with fixed or movable slanted fins to allow flow of air.

M

Main or Primary Framing

Structural assemblies spaced some distance apart to support secondary framing members such as joists, purlins, and girts.

Mansard

A steep sloped (almost vertical) real or mock roof element on the perimeter of a building. Originated by the French architect, François Mansart.

Manufacturer's Engineer

An engineer employed by a manufacturer who is in responsible charge of the structural design of a metal roofing system fabricated by the manufacturer. The manufacturer's engineer is not considered the engineer of record.

Mastic

Caulking or sealant furnished in rolls, normally used for sealing roof panel laps with other roof panels or flashing.

Material Safety Data Sheet (MSDS)

A written description of the chemical composition of a product and other information such as safe handling and emergency procedures.

Mean Roof Height

The average height of a roof measured at the mid-point between a roof's lowest and highest elevations above grade.

Model Energy Code

In 1989 the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) adopted a standard practice code to influence compliance with minimum levels of energy efficiency in nonresidential buildings. Titled ASHRAE 90.1, the code has been adopted by most states and federal agencies and sets forth design requirements for the efficient use of energy in new buildings intended for human occupancy, apart from single- and multifamily residential buildings of three or fewer stories above grade.

Module Strip

A tool used to maintain the roof panel module (rib spacing) during installation.

Monoslope

A roof area that slopes only one direction from one side of the building to the other side.

N

Non-structural Panel

Panels that are not designed to carry positive snow or live loads and are not normally capable of spanning between structural supports without benefit of solid substrate materials such as wood, metal, or concrete decks.

Notch

1. Factory-prepared condition on roof panels to allow the pan of the panel to bend under and form a finished edge.
2. Miter cut at the top of ribbed wall sheets to allow them to mate with a ribbed roof sheet.

O

Oil Canning

An inherent characteristic of metal panels manufactured with broad noninterrupted flat areas caused by the expansion and contraction of the metal during outdoor temperature changes. All panels manufactured from light-gauge metal may exhibit oil canning in the broad flat portion or pan of the panel. It is not considered to be a defect, nor does it affect the structural integrity of the metal panels. Oil canning is not cause for rejection.

Order Documents

The documents normally required by the manufacturer in the ordinary course of entering and processing an order. These can include specifications, drawings, sketches, estimates, contracts, and purchase orders.

OSB

Oriented strand board (OSB) is composed of rectangular-shaped wood strands that are cross-oriented, compressed, and glued together with waterproof adhesives. OSB is often used in both residential and nonresidential construction for floors, walls, and roof sheathing. Particle board is not considered OSB and should not be used in roofing applications.

Outset Girts

Secondary framing member that passes by the outside faces of the wall framing.

P

Pan

The lower-most part of a roof panel (between the ribs), which is typically the bearing surface area.

Panel Creep

The tendency of the transverse dimension of a roof panel to gain in modularity due to spring-out or storage distortion.

Panel Rib Cap

Ridge cap sheet die-formed from a short piece of ribbed panel.

Parallel

The term used to describe the framing system application in which the new roof slope is parallel to the span of the existing secondary structural roof supports (joist, purlins, etc.).

Parapet

The portion of the wall that extends above the roof.

Peak

The uppermost point of a gabled roof.

Peak Cap/Box

Prefabricated trim piece that conceals the rake trim fascia connection at the peak of the gable.

Pencil Ribs

A groove or grooves roll formed longitudinally into a panel profile to either minimize oil canning or to introduce a pattern in the profile to meet aesthetic or specified requirements.

Perforated

In relation to metal construction, refers to panels or sheet metal strips that have been mechanically and uniformly punched with holes in various manners to provide air circulation.

Perpendicular

The term used to describe the framing system application where the new roof slope is perpendicular to the span of the existing secondary structural roof supports (joist, purlins, etc.).

Pitch

(See Roof pitch or Slope)

Pitchbreak

Flashing used at the high-end juncture of the roof panels and a vertical surface.

Pittsburgh Lock Seam

A method of interlocking two pieces of metal. Contrary to popular belief that a Pittsburgh seam folds the metal 360º, only one piece is 360º while the other is 180º.

Ponding

1. Gathering of water at low or irregular areas on a flat roof.
2. Progressive accumulation of water from deflection due to rain/snow/ice loads.

Pop Rivet

A small-headed pin with an expandable shank for joining light-gauge metal. Typically used to attach flashing, gutter, etc. Note, pop rivets are not a structural connection.

Primer Paint

The initial coat of paint applied in the plant to the structural framing.

Pullout

The term used to describe the ultimate strength of a fastener or anchor when subjected to pulling forces.

Pullover

The term used to describe the ultimate strength of a fastener when subjected to pulling forces from a prying action.

Purlin

A secondary structural member located in the roof that directly supports the roof sheeting and is in turn supported by the primary structural framing.

R

Raggle

A groove or slot often cut in a masonry wall or other vertical surface adjoining a roof, for inserting an inset-flashing component such as a reglet.

Rake

The roofline along the roof panel located at the roof's edge at a gable wall.

Rake Fascia

A flashing designed to close the opening between the roof and endwall panels.

Rake Trim

(See Rake fascia)

Reglet

A sheet metal receiver trim piece for the attachment of counterflashing, when mounted to a wall.

Retrofit

The reconstruction and improvement of a building. In relation to this design manual it represents the improvement of an existing building roof by the addition of sloping built-up light-gauge framework supporting a new metal roof system.

Rib

The longitudinal raised profile of a panel that provides much of the panel's bending strength.

Ribbed Panel

A panel that has ribs running its length, with sloping sides forming a trapezoidal shaped void at the end and the panel juncture with other panels at its sides.

Ridge Cap

A transition of the roofing materials along the ridge of a roof. Also called ridge roll or ridge flashing.

Ridge Purlin

First purlin downhill from the peak or ridge.

Ridge/Ridgeline

The peak of the building or the uppermost portion of a gabled roof.

Roll Formed

Specific width metal sheet coil or strip that has been cold-formed into a desired cross section by being inserted and driven through a rolling mill, which has a series of roller dies that progressively form the panel's final cross-section as the material passes through each die.

Roof Extension

Cantilevered continuation of roof at the gabled end of the roof.

Roof-Over

Term used to describe the retrofitting of an existing slope roof with or without sub-framing members.

Roof Overhang

A roof extension beyond the endwall or sidewall of a building.

Roof Pitch or Slope

The tangent of the angle that a roof surface makes with the horizontal, usually expressed in units of vertical rise to 12 units of horizontal run (e.g., 3:12 = 3" rise per every 12" horizontal).

Roof Seamer

A machine that crimps or folds adjacent edges of standing seam metal roof panels together to form a weathertight seam.

Rope Seal

(See Butyl tape)

S

Sandwich Panel

A roof or wall panel assembly made of normally an outer and inner sheet with an insulated center core. Also known as insulated panel.

Scupper

An opening in a gutter or parapet wall to discharge rainwater.

Sealant

Any material that is used to close up cracks or joints to protect against water and air infiltration.

Seaming Machine

A machine that crimps or folds adjacent edges of standing seam metal roof panels together to form a weathertight seam. Typically, the completed seam is folded to 90º or 180º.

Secondary Framing

The framing that consists of minor load-carrying members of a structure, such as joist, purlins, girts, struts, etc.

Self-Drilling Screw

A fastener that combines the functions of drilling and tapping its own hole. Used for attachment of framing members as well as panels to framing or other panels and flashing.

Self-Tapping Screw

A fastener, which taps its own threads in a predrilled hole.

Shim

An object of minimal thickness, of various materials, used to level or square framing.

Side-Lap or Side-Joint

The side junction of two panels which upon installation forms a weathertight seal.

Sill

The bottom horizontal portion of an opening such as a window or door.

Single-Slope ("Shed" Roof)

(See Monoslope)

Skylight

A roof accessory to admit light, normally mounted on a curbed framed opening, or custom fitted and manufactured to a metal panel.

Sliding Clip

A standing seam roof system hold down clip, which allows the roof panel to move independently of the roof substructure.

SMACNA

Sheet Metal and Air Conditioning Contractors National Association

Snap-On Cap

A cap that snaps over the vertical legs of some single-standing or batten-seam metal roof systems.

Snow Load

A positive-acting load imposed on the roofs of buildings or other structures as the result of snowfall.

Soffit

The underside covering of an overhang.

Soffit Trim

Trim used at the junction of the soffit and wall or another vertical surface.

Soffit Vent

A premanufactured or custom-built air inlet located in the soffit of a roof assembly.

Span

The distance between supports of any two framing members.

Specifications

A written document that outlines the expectations of the building project's owner and/or design professional insofar as specific information pertaining to the performance and provision of products, components, materials, labor, and other work to be performed during the construction of a building or structure.

Splice

Connections at two like parts in a structural member or a trim component.

Spreader Plate ("Bearing Plate")

(*See* Base plate)

SSR

Refers to Standing Seam Roof, which normally relates to trapezoidal profile roofing.

SSMRS

Refers to Standing Seam Metal Roof System

SSSMRS

Refers to Structural Standing Seam Metal Roof System. A metal roof panel that is structural in nature that allows it to span from one roof support member to adjacent ones.

Standing Seam

Side joints of roof panels that are arranged in a vertical position above the drainage plane of the panels or flashings.

Standing Seam Roof System (SSRS)

A metal roof system comprising standing seam panels, which are generally secured to the roof substructure by means of concealed hold-down clips; together with related flashings and other weatherproofing materials and accessories.

Stiffener Lip

A short extension of material that is at an angle to the flange of cold-formed structural members, which adds strength to the member.

Stitch Screw

A fastener used to connect panels together at the side-lap.

Strapping

Material used to satisfy bracing design requirements. Normally, specific width steel of various gauge thickness.

Striations (Shadowline)

Lines that are parallel to the panel ribs, which have a low silhouette pattern that is formed into the panel profile, having a light-diffusing quality, which assists in masking over oil canning in the broad flat pan of the panel.

Structural Panel

A panel that is capable of spanning between structural supports otherwise known as open framing. The panel can resist snow, dead, live, concentrated, and wind loads without the benefit of any underlying solid substrate material.

Structural Steel Member

Load-carrying members may be hot rolled sections, cold-formed shapes, or built-up shapes.

Strut

A brace fitted into a framework to resist forces in the direction of its length.

Substrate

A term that in retrofit constructions is used to describe the existing roof composition. This would include the decking and insulation. As it relates to metal roofing, it represents the material immediately beneath the new metal roof panel to which it is being attached.

Swedge

A factory forming process that reshapes the end of the uphill (upper) roof panel to fit into the downhill (lower) roof panel when panel end lap conditions are required.

T

Thermal Block

Extruded spacer block installed between the purlin and the metal roof panel to compensate for insulation value loss attributable to insulation compression over the purlin.

Thermal Movement

The expansion and contraction that occurs in materials as the result of temperature changes.

Thermal Resistance (R-Value)

Under steady conditions, the mean temperature difference between two defined surfaces of material or construction that induces unit heat flow through unit area. Thermal resistance and thermal conductance are reciprocals.

Thermal Transmittance (U-Factor)

The time rate of heat flow per unit area under steady conditions from the fluid on the warm side of a barrier to the fluid on the cold side, per unit temperature difference between the two fluids. First evaluating the R-value and then computing its reciprocal equate it

Thru-Fastened Roof System

A roof system in which the roof panels are attached directly to the roof substructure with fasteners that penetrate through the panel itself and into the substructure; the fastener heads are often exposed.

Transverse

The direction of a roof or building system. Most commonly relates to the direction parallel to the roof slope or eave-to-eave.

Trapezoidal

Roof panel profiles when the ribs have a semi-trapezoidal shape.

Tributary Area

The amount of load being subjected to a structural member or assembly. For example, a purlin's tributary area is the distance it spans from end to end, and one-half the distance from one purlin to the adjacent purlins on each side.

Trim

The light-gauge sheet metal used in the finishing of a building or roof system, especially around openings and at intersections of surfaces. Often referred to as flashing.

Truss

A structural assembly made up of three or more members, with each member designed to carry a tension or compression force. The entire assembly in turn acts as a beam.

U

UL Label

An identification label or seal affixed to a product or package with the approval of Underwriters Laboratories, Inc. The presence of the label indicates that the product has met certain performance criteria.

Underlayment

A secondary waterproofing sheet material installed between the substrate and the roof panels, usually used in hydrokinetic roof construction. Some types may be self-adhering.

Unsupported

The condition that exists when a structural member such as a column does not have any lateral support. A column is unsupported when there are no braces attached to its compression flanges.

Underwriters Laboratories, Inc. (UL)

An organization that tests, rates and classifies roof assemblies in their resistance to fire, impact, leakage, corrosion of metal components, and wind uplift.

Uplift

Negative pressure represented in pounds per square foot (PSF) caused by wind passing over a roof, creating suction that in fact, tries to lift the roof panels upward from their substructure and attachments.

V

Valley

An architectural detail created where two roof panels intersect at the downhill slope, usually having ridgelines at right angles to each other located at the uppermost end of the valley.

Valley Gutter

A sheet metal flashing created to collect rainwater from both of its sides as a result of two roofs sloping toward each other. Found in multi-gabled buildings with parallel ridgelines.

Vapor Barrier

Material used to retard the flow of vapor or moisture to prevent condensation from forming on a surface.

Vent

An opening designed to exhaust air, heat, water, vapor, or other gas from a building or a building component to the atmosphere.

Vertical Girt

Girt attached to masonry wall vertically to receive horizontal girts.

W

Wainscot or Wainscote

Exterior wall sheeting that begins at the base level (floor, etc.) and terminates before reaching the top of the wall where it joins with a different material.

Wainscot Trim

Trim piece located at the top of wainscot sheeting, which flashes over the sheeting and under the upper sheeting or material.

Wall Covering

The exterior wall cladding consisting of panels and their attachments, trim fascia, and weathertight sealant.

Waterproof Membrane

A self-adhered or mechanically adhered underlayment that offers leak protection in trouble-prone roof detail areas and performs as a vapor barrier. Typically referred to as ice & water shield. The product adheres to the roof deck, at laps, and seals around deck fasteners.

Web

That portion of a structural member between its flanges.

Wind Load

The load caused by wind from any horizontal direction.

Wind Uplift

The differential negative pressure caused by the deflection of wind at roof edges, roof peaks, or obstructions, causing a drop-in air pressure immediately above the roof surface. Wind uplift may also occur because of the introduction of wind pressure under the membrane and roof edges, where it can cause the membrane to balloon and pull away from the deck.

Y

Yield Stress

The stress value at which the strain ceases to be directly proportional to the stress.

Z

"Z" or Zee

A member cold-formed from steel sheet in the shape of a zee or also referred to as zee-shape.

Contributor References

The following recognizes those MCA Members that have contributed to this manual and that also manufacture products that relate to retrofit metal roof systems over flat/nearly-flat and/or existing metal roofs. For a full MCA Member listing you can visit the MCA website at this link: http://www.metalconstruction.org/product-locator. We have also included an Industry Partners list of those related to metal construction and the roofing industries.

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