## Metal Building Student Competition

# *QuickStart* Guide

MBMA
METAL BUILDING MANUFACTURERS ASSOCIATION®
Research | Leadership | Education

# Content

# Preface

This resource has been assembled to provide architecture students and faculty with a concise summary that describes metal building systems and their use, to assist with the creative process needed to develop an entry for the MBMA Architecture Student Design Competition.

We think that after reviewing this resource document and the other referenced materials, you will begin to learn more about metal buildings and the important role they play in low rise non-residential construction. You may have a perception that metal buildings are only useful for warehouses and industrial buildings, but we hope you will learn that metal building systems have gone from "back street" to "main street" over the last 50 years and why architectural input and creativity are needed to design metal building systems that are functional, aesthetically appealing, sustainable, and economic.

MBMA is pleased to assist any faculty, students, and design teams with additional information or to answer any questions that arise. Please email any request for assistance or to receive any of the printed resource materials to: mbma@mbma.com.

Thank you for taking the time to learn more about metal buildings and good luck in the competition!

# 1

# Introduction to MBMA

The Metal Building Manufacturers Association (MBMA) serves as the voice of the metal building systems industry, providing leadership, research, and education to increase the prominence and usage of metal building systems. MBMA plays a lead role in research and engineering, and helps to improve codes and standards.

For over 60 years, the MBMA and its members have worked together as partners to further their mission: to conduct research, to help advance building codes and standards, and to educate the construction community. Our passion is to support a strong, sustainable metal building systems industry that meets the needs of owners and communities. Metal building systems are far more sophisticated today than they were decades ago; and due to MBMA's research programs, additional evolution is not far down the road. MBMA has invested heavily in engineering technology, fabrication concepts, structural improvements, and building quality. As a result,buildings today are far better in terms of cost, strength, function, aesthetics, and sustainability.

# MBMA

MBMA has two membership categories: **Building Systems members** and **Associate members**.

Building Systems members provide the engineering design, and fabrication of structural steel framing systems, metal roofing, wall systems, and accessory equipment for low-rise, non-residential construction projects. MBMA Building Systems member firms employ more than 12,000 people in 65 worldwide manufacturing plants. These firms engage in the design, manufacture and sale of metal building systems. A current list of Building Systems members can be found on the MBMA website (www.mbma.com).

The MBMA Associate membership program was developed to serve the industry's ancillary manufacturers and suppliers. Associate members help shape MBMA's direction and activities through such affiliations as the Associate Member Advisory Council. This council is composed of a broad cross-section of members, each from a major product category. A current list of Associate members can be found on the MBMA website (www.mbma.com).

All members of the Metal Building Manufacturers Association are committed to sustainable development, to continuous improvement in safety and health, and to achieving an injury-free workplace.

# 2

# Introduction to Metal Buildings

The modern metal building system is normally framed with some variation of the rigid frame. The rigid frame is the primary framing system; these are the members that carry the imposed loads to the foundation. Secondary framing members, typically purlins and girts, collect the imposed loads and transfer them to the primary framing system.

There are many applications for metal building systems as listed in the next section. The advantages of using a metal building system are the design versatility, economy, speed of construction, and sustainability. Unlike other construction systems, metal buildings are the result of a manufacturing process. All parts can be custom manufactured and therefore can greatly reduce the amount of scrap and waste during the construction process.

The MBMA website (www.mbma.com) features examples of metal building applications. Under the Building Solutions tab, there are examples of various applications by use category. Also, on the competition website, there are several case studies provided, with a focus on educational facilities. In addition, there are videos and narrated PowerPoint presentations that can be found at **https://www.youtube.com/mbmamedia** that provide further introduction to metal building systems.

For example:

1. Introduction to Metal Building Systems: https://www.youtube.com/watch?v=TEKSDLEVDD8
2. Metal Buildings 101: https://www.youtube.com/watch?v=bYDIGZb5GAw
3. Award Winning Metal Building Projects: https://www.youtube.com/watch?v=T9Vy0ZIT4PY

## Metal Building Applications

Metal buildings are used for virtually all types of low rise, non-residential construction - from churches to warehouses - and almost everything in between. It is estimated that 35% of the one- and two-story non-residential buildings in the United States use metal building systems.

1. Office Buildings
2. Mercantile/Malls/Retail
3. Religious Facilities
4. Auto Show Rooms
5. Auto Repair Shops
6. Factories
7. Warehouses
8. Distribution Centers
9. Education
10. Sports Facilities
11. Agricultural/Greenhouse
12. Aircraft Hangars
13. Military
14. Food Preparation
15. Health Care

## Definitions

**Metal Building System**: An integrated set of components or assemblies, including but not limited to frames that are built-up structural steel members, secondary members that are cold-formed steel or steel joists, and cladding components, specifically designed to support and transfer loads and provide a complete or partial building shell. These components and assemblies are manufactured in a manner that permits plant and/or field inspection prior to assembly or erection.

**Building Envelope:** The elements of a building that enclose conditioned spaces through which thermal energy is capable of being transferred.

**Fabrication**: The manufacturing process performed in a plant to convert raw material into finished metal building system components. The main operations are cold forming, cutting, punching, welding, cleaning, and painting.

## Primer to Metal Building Systems

Metal building systems are unique in many ways. It is important to review these differences, especially with regard to the roles and responsibilities of architects, energy professionals, owners, contractors, and the metal building manufacturer. The Appendix contains Common Industry Practices which provides more information on industry practices.

Metal building systems are no longer “pre-engineered” or selected from a catalog of standard designs, based on the required size of the building. Metal building system manufacturers custom design a building after the order is placed based on the applicable building code, loading conditions, and serviceability requirements. Metal building systems are governed by the same building codes and material standards as other forms of construction. Advanced computer methods are used to help facilitate this design customization and optimization.

Metal building systems are assemblages of structural elements that work together as a very efficient structural system. The basic elements of the metal building system are: primary rigid frames, secondary members composed of wall girts and roof purlins, cladding, and bracing.

## Energy Efficiency for Metal Building Applications

Metal buildings have the ability to meet and exceed the requirements prescribed in various energy codes. The MBMA Energy Design Guide for Metal Building Systems is a resource that provides the culmination of all of the pertinent information on how to design, construct, and maintain metal buildings to be energy efficient. Note that a complimentary copy will be provided to faculty upon email request to mbma@mbma.com.

The table below, from the MBMA Energy Design Guide summarizes the primary factors that come into play for energy code compliance by end use. The entries in the table represent the relative influence or applicability of the various factors that have a role in energy design and efficiency for the typical metal building designed for the end uses listed.

| End Use | Finished Perimeter Cavity Walls | Window to Wall Ratio | Percentage of Vehicular Access Doors | Semi-Heated | Fully Conditioned | Plug Loads | Lighting |
|---|---|---|---|---|---|---|---|
| Warehouse/ Hangar/ Manufacturing/ Distribution | No | Low | High | Yes | No | Low | Low |
| Sports Facilities | No | Med | Low | Yes | No | Low | High |
| Food Preparation | Yes | Low | Low | No | Yes | High | High |
| Health Care | Yes | Med | Low | No | Yes | High | High |
| Religious Facilities | Yes | Med | Low | No | Yes | Med | High |
| Office Buildings | Yes | High | Low | No | Yes | High | High |
| Education | Yes | High | Low | No | Yes | High | High |
| Mercantile/ Malls/Retail | Yes | High | Low | No | Yes | High | High |

## Metal Building System Advantages

1. Design: quick, efficient, and design drawings provided by manufacturer
2. Weight: as much as 30% lighter due to more efficient use of steel
3. Foundation: simple design is lightweight and easy to construct
4. Accessories: designed to fit the system, including flashing and trim
5. Erection: easy, fast and step by step
6. Changes: future expansion is simple and cost efficient
7. Responsibility: single source manufacturing results in total responsibility from one supplier
8. Performance: all buildings are designed to meet national and local building codes

## Design Versatility

1. All buildings are custom engineered, detailed and manufactured
2. Wide range of framing, roof and wall product options
3. Systems can be combined with traditional materials such as concrete, brick, glass or wood
4. Metal building systems offer excellent solutions for most low-rise applications, such as manufacturing and distribution centers, retail and commercial, office and schools, and recreation centers

## Energy Efficient “Cool” Coatings

1. Technology originally developed for the Stealth Aircraft by the U.S. Military
2. Metal building manufacturers offer paint/coating finishes that are “Cool”
3. To be “Cool” products must have a solar reflectance of at least 25%
4. Can reduce energy design load (cooling) by more than 40%
5. Generate lower environmental temperatures reducing smog and the urban heat island effect
6. Cooler roof panels extend paint/coating life

## Sustainability

MBMA has done a great deal to extract peer reviewed data from member companies measuring the sustainability of metal buildings and to make this information available in a national data base. These Environmental Product Declarations (EPDs) are available for the Primary Framing, Secondary Framing, and Roof/Wall Cladding. EPDs disclose the environmental impacts of a product based on the results of a Life Cycle Assessment (LCA), in addition to other useful information. These EPDs can be used by the design community when specifying the use of MBMA member structural steel and metal panel products. They can be obtained from the MBMA website using the following links:

https://www.mbma.com/media/101.1_EPD_MBMA_PrimaryFrame_20160120.pdf
https://www.mbma.com/media/102.1_EPD_MBMA_SecondaryFrame_20160120.pdf
https://www.mbma.com/media/103.1_MBMA_EPD_RollFormedMetalWallandRoofPanels_20160120.pdf

MBMA has further retained the nationally recognized consulting firm, Walter P. Moore, to compare metal building construction with other forms of construction. In almost all cases, metal buildings compare quite favorably to other forms of construction not only because of the economical use of recycled steel but also because of the lesser need for concrete in the foundations. This case study report can be downloaded from the MBMA website using the following link:

http://mbma.com/media/WalterPMooreAthenaImpactorCaseStudies-MBMA_Aug2015.pdf

Other sustainability considerations and features of metal buildings are summarized below:

1. Recycled steel uses significantly less energy than conventional steel production
2. Typical metal buildings are manufactured from 50 to 55% recycled steel
3. 100% of the metal on a metal building can be recycled in the future
4. Metal building systems can qualify for up to 5 LEED points and increased envelope insulation can add up to another 19 points
5. Buildings are as much as 30% lighter than conventional construction due to custom design and more efficient use of steel, and often reduces foundation requirements and costs
6. Metal buildings provide a lighter, more favorable environmental footprint than most forms of construction

7. Due to engineering and detail layouts, manufacturing metal buildings can result in scrap as low as 3%, with the industry average less than 6% scrap. All scraps are either reused in parts or recycled
8. Job site waste is minimal
9. Building erection is faster than conventional construction
10. Metal roofing keeps roofing materials out of landfills

# 3

# Metal Building Systems

This chapter covers the components of metal building structural systems. Known simply as metal building systems, these systems are interdependent assemblages of structural elements that work together to create a very efficient structural system. The basic elements of the metal building system are primary frames (structural steel members), secondary purlin and girt members (cold-formed steel and steel joists), and metal roof and wall cladding systems. These building elements are described on the next page.

There are multiple types of primary framing, including steep-slope roof, multi-span, single slope, lean-to, and clear span. Each framing type offers unique layout and spatial experience. Different types can also be combined as long as the transition occurs at a frame line. The secondary framing system refers to the purlins and girts. Purlins are used to support the roof panels and girts support the wall panels.

## Metal Building Structural Components

1. Primary Framing
    a. Interior rigid frames
    b. End walls
2. Secondary Framing
    a. Purlins
    b. Girts
3. Bracing
    a. Lateral bracing for rafters and columns
    b. Longitudinal X-bracing
4. Cladding
    a. Metal roof sheeting
    b. Metal wall sheeting or other finish material
5. Connections
    a. Bolted
    b. Fastened, e.g. screws

## Definitions

**Girt**: A horizontal structural member that is attached to sidewall or end wall columns to which panels are attached. Girts may be (1) “outset” or mounted on the outside of the columns, sometimes referred to as bypass girts, or (2) “inset” or mounted flush or nearly flush with the face of the columns.

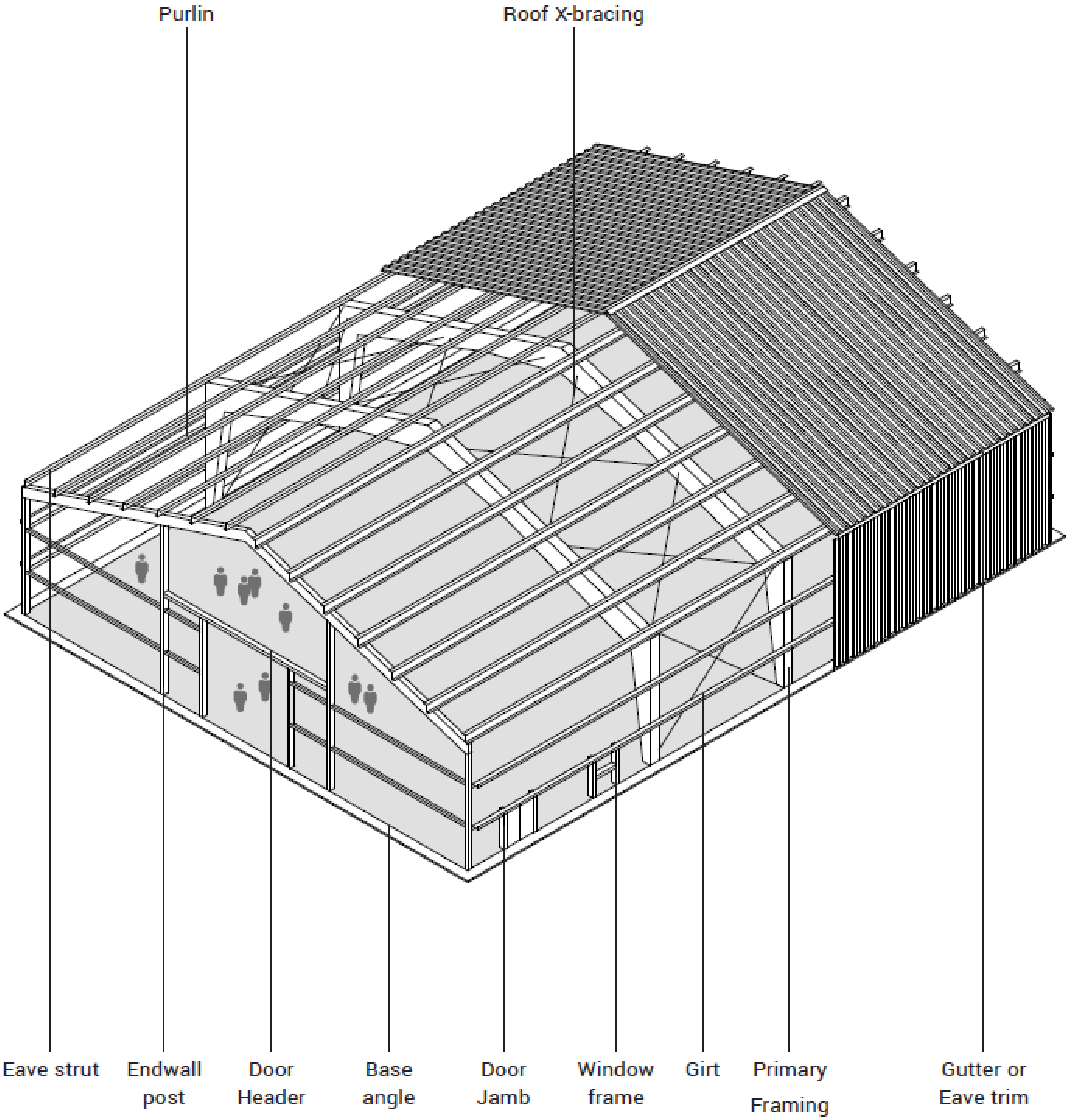
**Primary Frame**: An assemblage of rafters and columns that support the secondary framing members and transfer loads directly to the foundation. Sometimes referred to as a moment frame because the rigid connections transmit moments, similar to arch behavior.

**Metal Building Wall**: A wall whose structure consists of metal panels that span between girts.

**Purlin**: A structural member attached on top of and perpendicular to frames that supports roof covering.

**Roof**: The upper portion of the building envelope, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60 degrees from horizontal.

**Canopy:** Cantilevered roof system projecting from sidewalls or end walls.


Purlin
Roof X-bracing
Eave strut
Endwall post
Door Header
Base angle
Door Jamb
Window frame
Girt
Primary Framing
Gutter or Eave trim

## Primary Framing: Single Slope

1. Single slope single span frames are currently popular for small commercial buildings and strip shopping center applications where one-way roof drainage is desirable.
2. While this frame can be supplied with a clear span up to 120 feet, this type of framing is most economical in clear spans less than 60 feet, or with interior supporting columns.
3. With the high side of the building to the front, the high side wall can be used for sign display requirements.

## Primary Framing: Multi-Span (Modular)

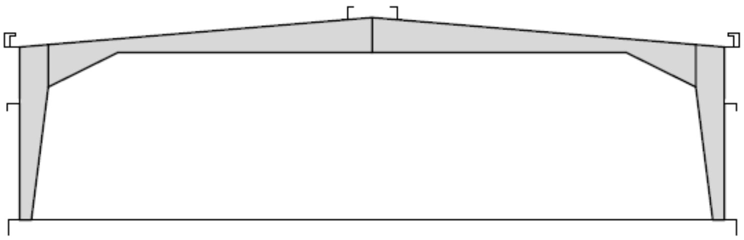
1. Where very large areas are required and interior columns are not a problem, the multi-span rigid frame is an ideal solution.
2. With a roof slope of 1/4-in-12, a 1000-foot wide building can be designed without excessive height buildup at the ridge or high side location.
3. The interior column spacing can vary from 20 to 100 feet and does not need to be uniform.

## Primary Framing: Steep Slope Roof and Lean-To

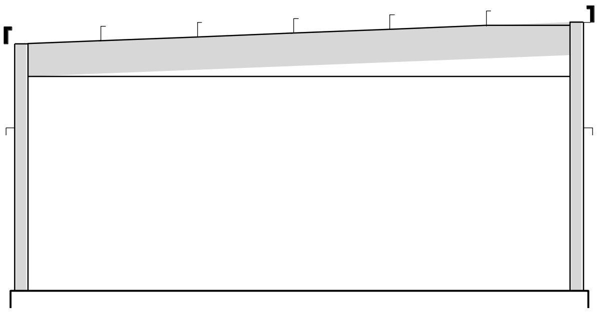
1. The high slope clear span rigid frame was the dominant product in the early days of the rigid frame.
2. In today's market, the high roof slope is still important in sports facilities and other community type applications and for other architectural purposes.
3. Tennis, basketball, football, workout gyms, etc. can take advantage of the extra headroom that a 2-in-12 roof slope and above offers the end user.
4. Spans of 120 feet are popular for many applications, particularly tennis courts, but wider spans are readily available for football practice facilities or for multipurpose buildings.

## Primary Frame Types

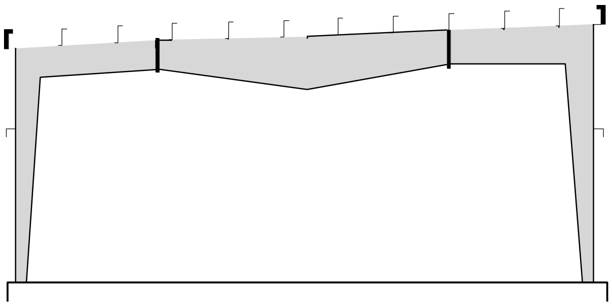
Example representative frame types are shown below with the most common, the clear span low slope roof with tapered members shown at the top. But any frame configuration can be designed as a single slope or gable frame, with straight or tapered columns, clear spans or with interior columns, and at any roof slope. Some limitations may apply for certain configurations and there can be an economic consideration as far as the optimal steel used in a particular frame.



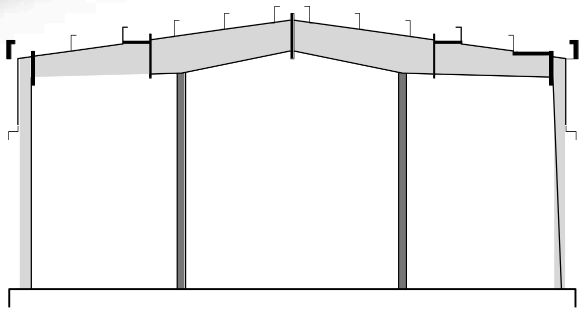
**Low Slope Clear Span with Tapered Columns (Up to120' Wide)**



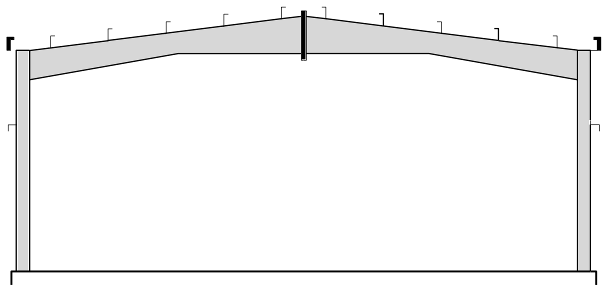
**Single Slope Clear Span with Straight Columns (Up to 80' Wide)**



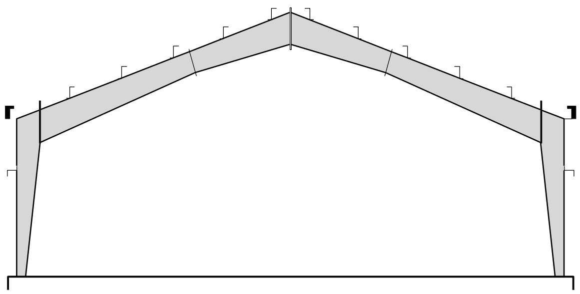
**Single Slope Clear Span with Tapered Columns (Up to 120' Wide)**



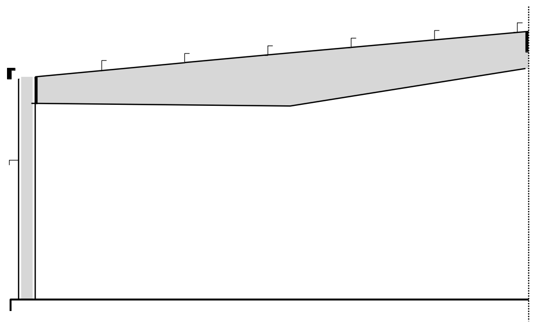
**Modular Frame with 2 Interior Columns (3 Modules)**



**Clear Span with Straight Columns (Up to 80' Wide)**

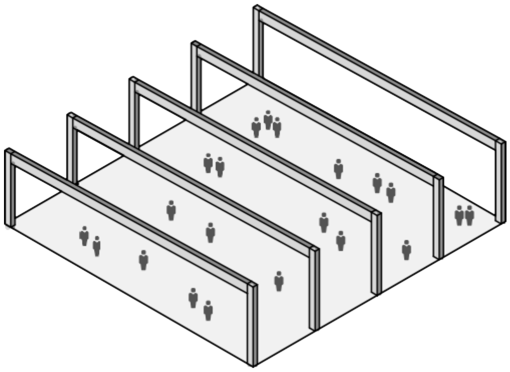


**Steep Slope with Tapered Columns (Up to 150' Wide)**

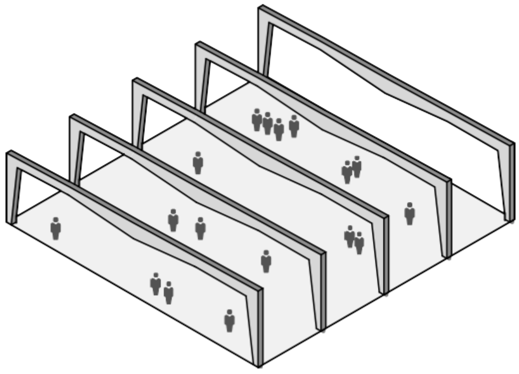


**Lean-to with Straight Columns (Up to 60' Wide)**

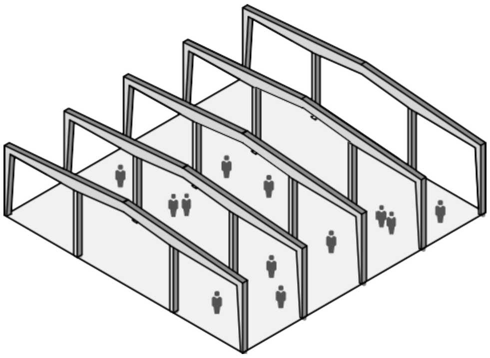
# Primary Framing Layouts



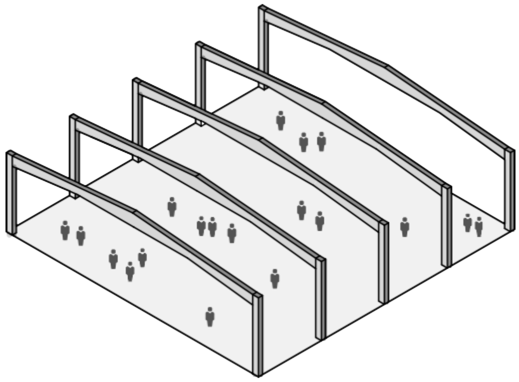
Single Slope Clear Span with Straight Columns
(Up to 80' Wide)



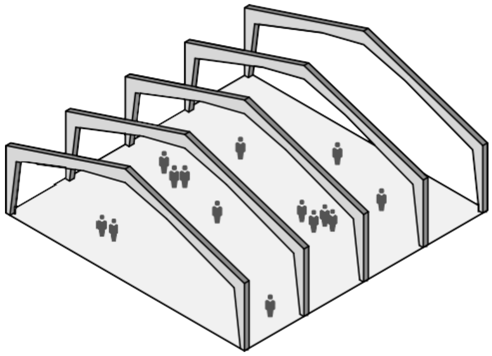
Single Slope Clear Span with Tapered Columns
(Up to 150' Wide)



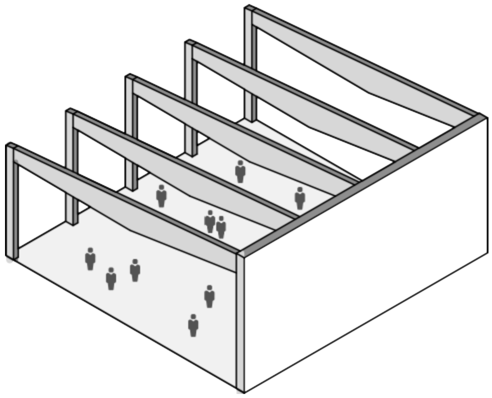
Modular Frame with 2 Interior Columns
(3 Modules)



Clear Span with Straight Columns (Up to 80' Wide)



Steep Slope with Tapered Columns (Up to 150' Wide)



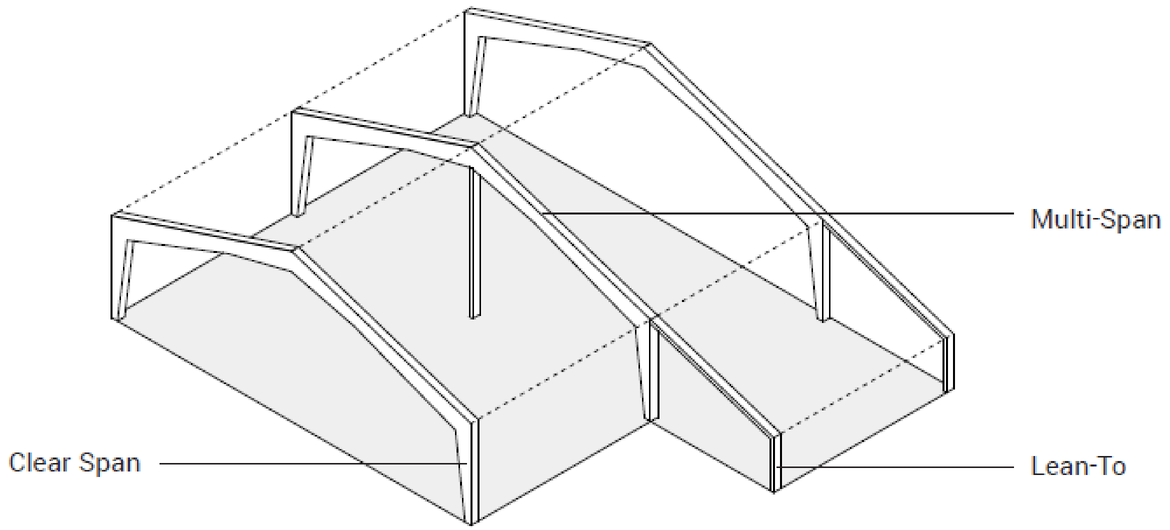
Lean-to with Straight Columns (Up to 60' Wide)

## System Selection

1. The decision on selecting whether to use a clear span or a multi-span frame depends upon the interior building use and cost.
2. The clear span frame provides a more flexible solution as it gives you total control over the enclosed space. A clear span, for an office, will give the designer complete flexibility in laying out the interior partitions and they can be moved without the worry of interference with a column. However, the consequences will be higher cost and much larger exterior columns and roof beams intruding into the office area, possibly requiring increased width and/or height of the building.
3. As an example, a 200-foot clear span will not be cost effective for a warehouse with isles on 20-foot centers.
4. A clear span may be essential for a plant manufacturing aircraft with a 150-foot wing span.

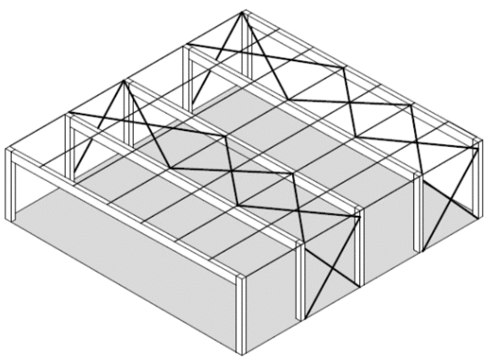
## Combining Framing Types

1. Framing systems can be combined, clear spans frames can transition to framing with multiple interior columns.
2. Heights and widths can be varied along the building length as long as the transition occurs at a frame line.

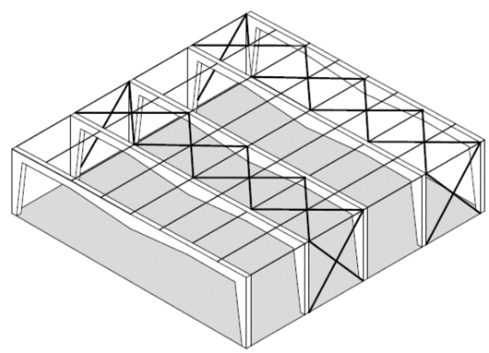


## Longitudinal Bracing

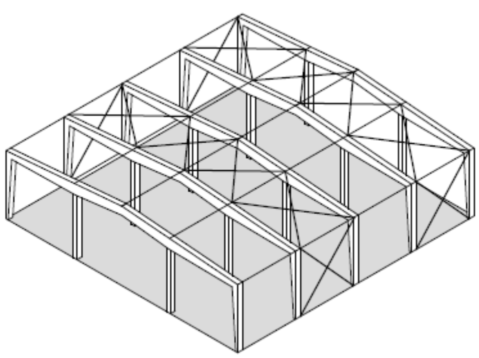
While the primary framing system carries the lateral loads in the transverse direction, a separate system carries the lateral loads in the longitudinal direction. This utilizes longitudinal bracing in the form of X-bracing (rods, cables, or angles) in some of the bays (sidewalls and roof) or portal frames in the sidewall. The figures below show typical X-bracing in a metal building. Longitudinal lateral loads on the end wall would be transmitted through strut-purlins that align with the X-bracing attachment locations. Strut-purlins may be heavier than the other purlins, multiple adjacent purlins or even a different cross-sectional member. Longitudinal wall bracing must be considered in the design of building elevations. If X-bracing interferes with the wall or fenestration layout, a portal frame can be used in the sidewall. Note that in the following diagrams, the only roof purlins that are shown are the strut purlins, since they are part of the longitudinal bracing.



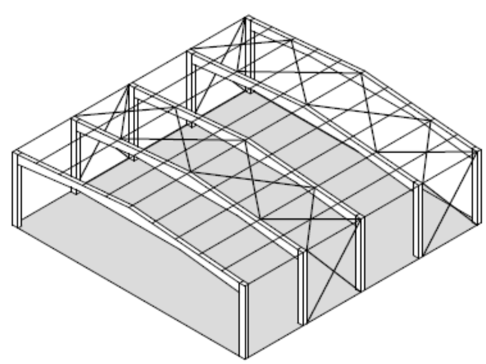
**Single Slope Clear Span with Straight Columns**
**(Up to 80' Wide)**



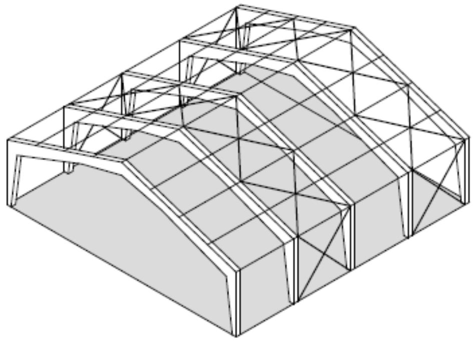
**Single Slope Clear Span with Tapered Columns**
**(Up to 150' Wide)**



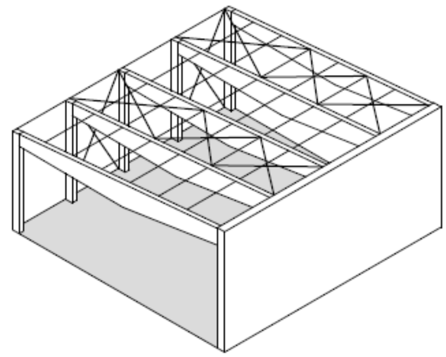
**Modular Frame with 2 Interior Columns**
**(3 Modules)**



**Clear Span with Straight Columns**
**(Up to 80' Wide)**

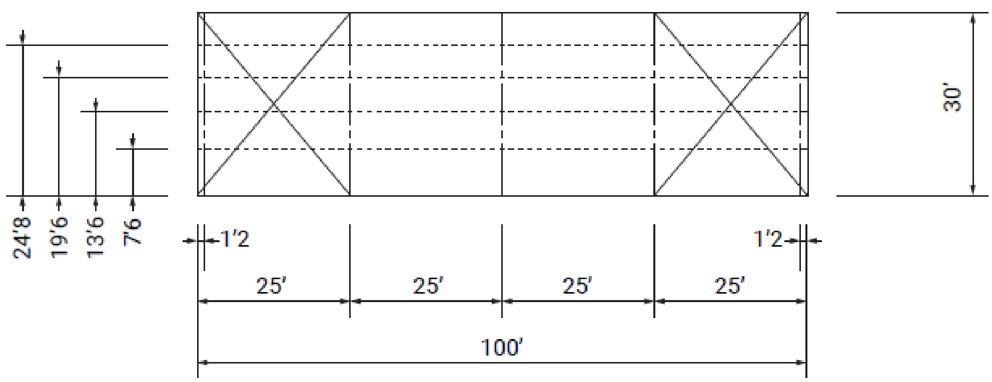


**Steep Slope with Tapered Columns**
**(Up to 150’ Wide)**

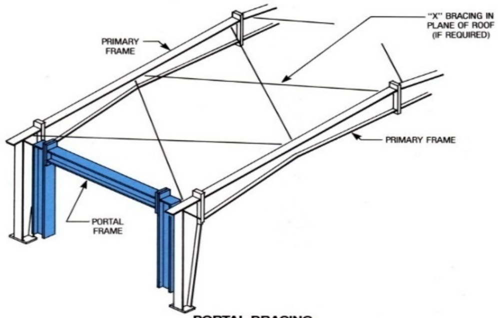


**Lean-to with Straight Columns**
**(Up to 60’ Wide)**

Elevation showing typical wall X-bracing

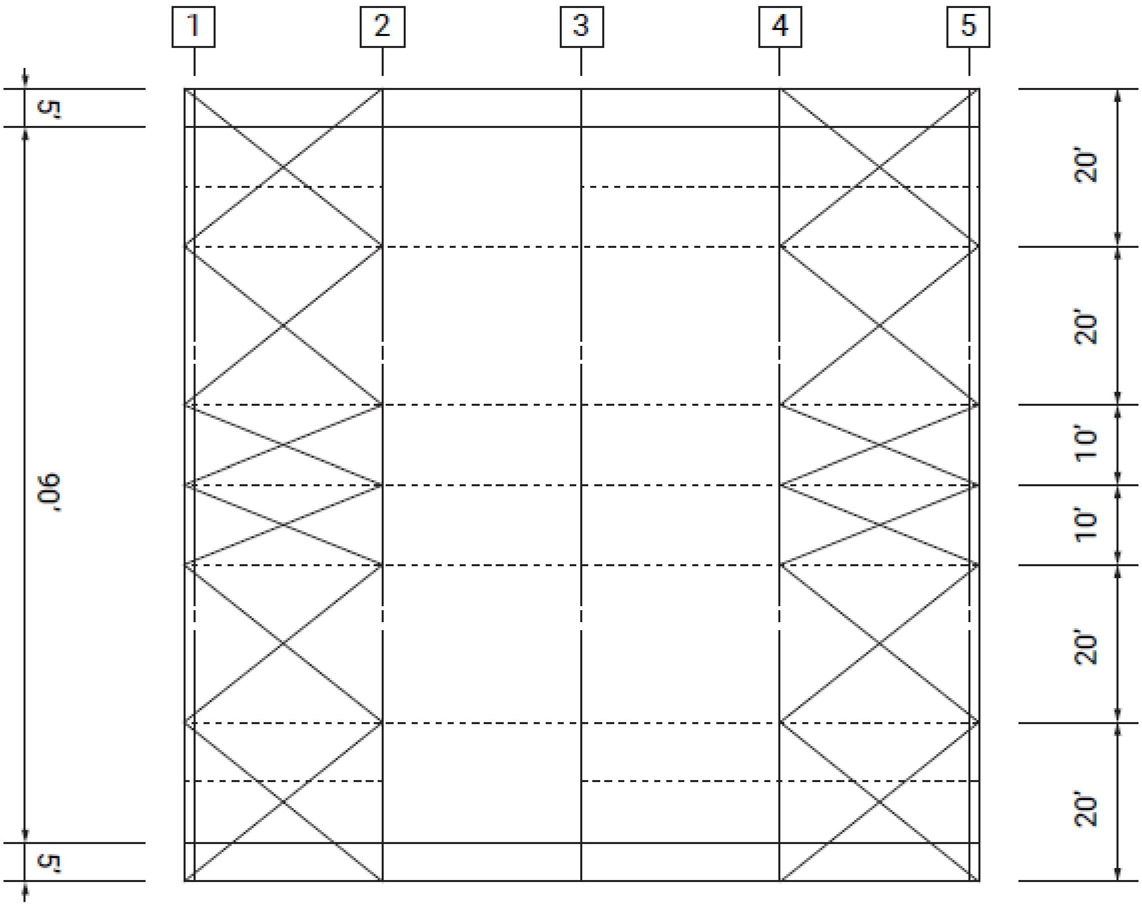



Alternate portal frame that can replace sidewall X-bracing




PORTAL BRACING

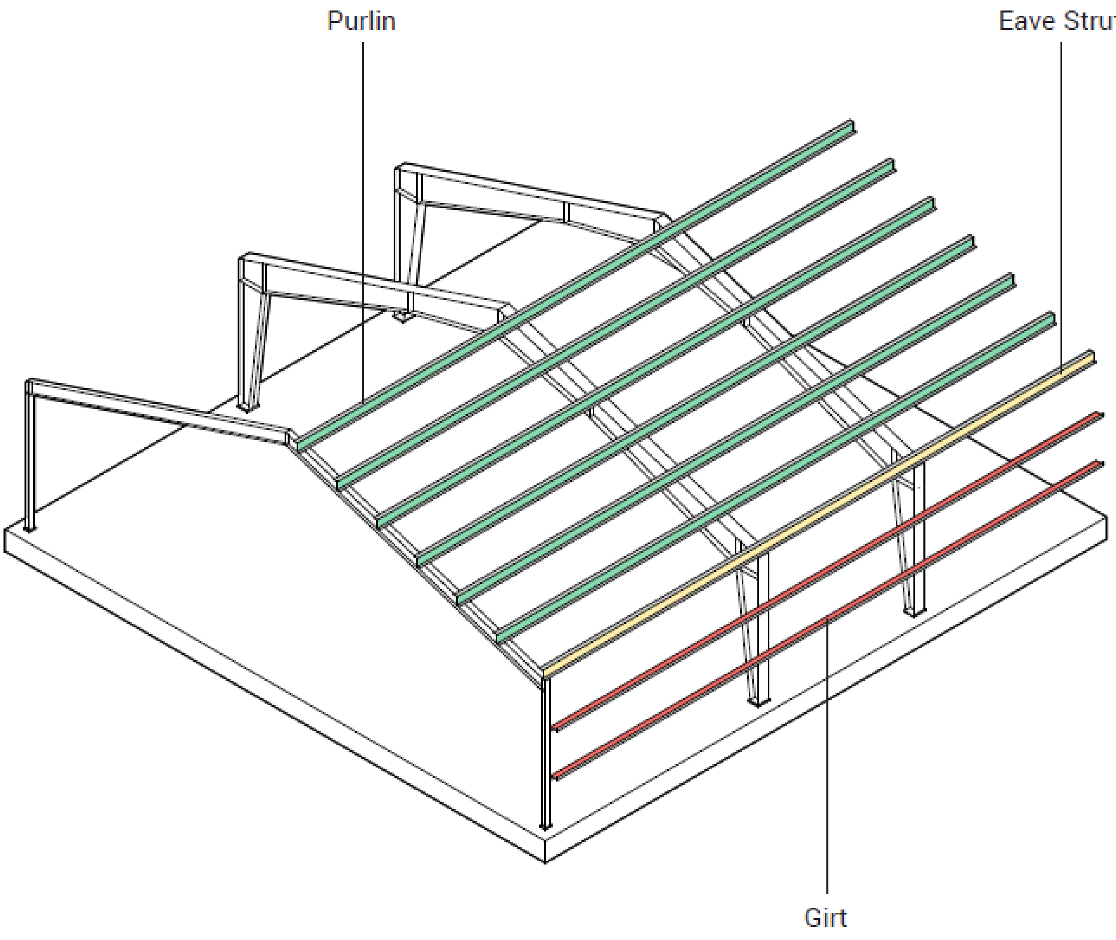
Plan view showing typical X-bracing in roof




Plan

## Secondary Framing

1. The function of secondary framing is to support the roof and wall covering and transfer the loads to the primary framing.
2. A major breakthrough in the metal building systems business occurred with the practical application of roll forming technology to the mass production of economical cold-formed members for use as purlins (roof) and girts (wall).

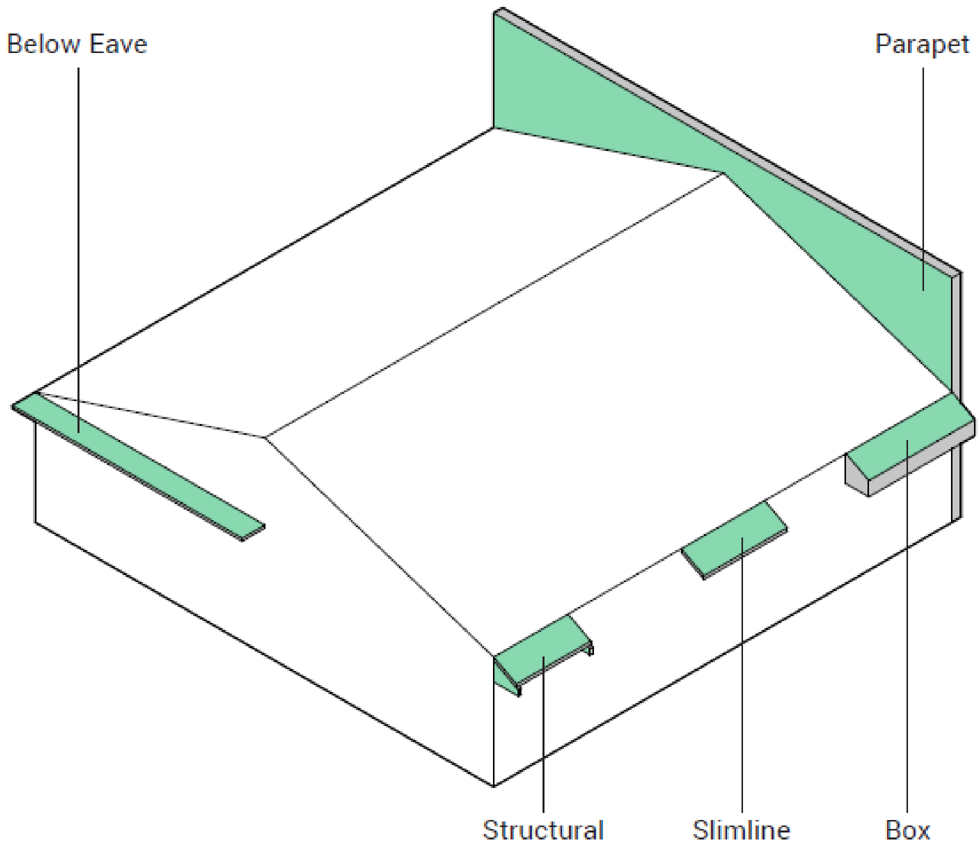


## Secondary Members

1. Purlins are secondary roof structural members which transfer gravity and wind loads from the roof panel to the rafter.
2. Cold-formed steel purlins are generally either C or Z-sections.
3. For longer spans, when a C- or Z-section is not economical, steel joists are used.
4. Steel joists may be fabricated using hot-rolled or cold-formed steel chord and web members.

## Canopies and Parapet

1. Structural canopy can extend up to 15’ from the building
2. “Slimline” canopy can extend 5’



4

# Wall Systems

This chapter addresses the basics of metal wall systems. With metal building systems there are a surprising variety of different combinations of wall materials. Since the structural steel frame bears the load, there are options for architectural or industrial metal walls, brick, glass, wood, masonry, tilt-up, insulated steel wall panels or other materials. Six example section drawings are provided in this chapter to show different combination of metal wall systems.

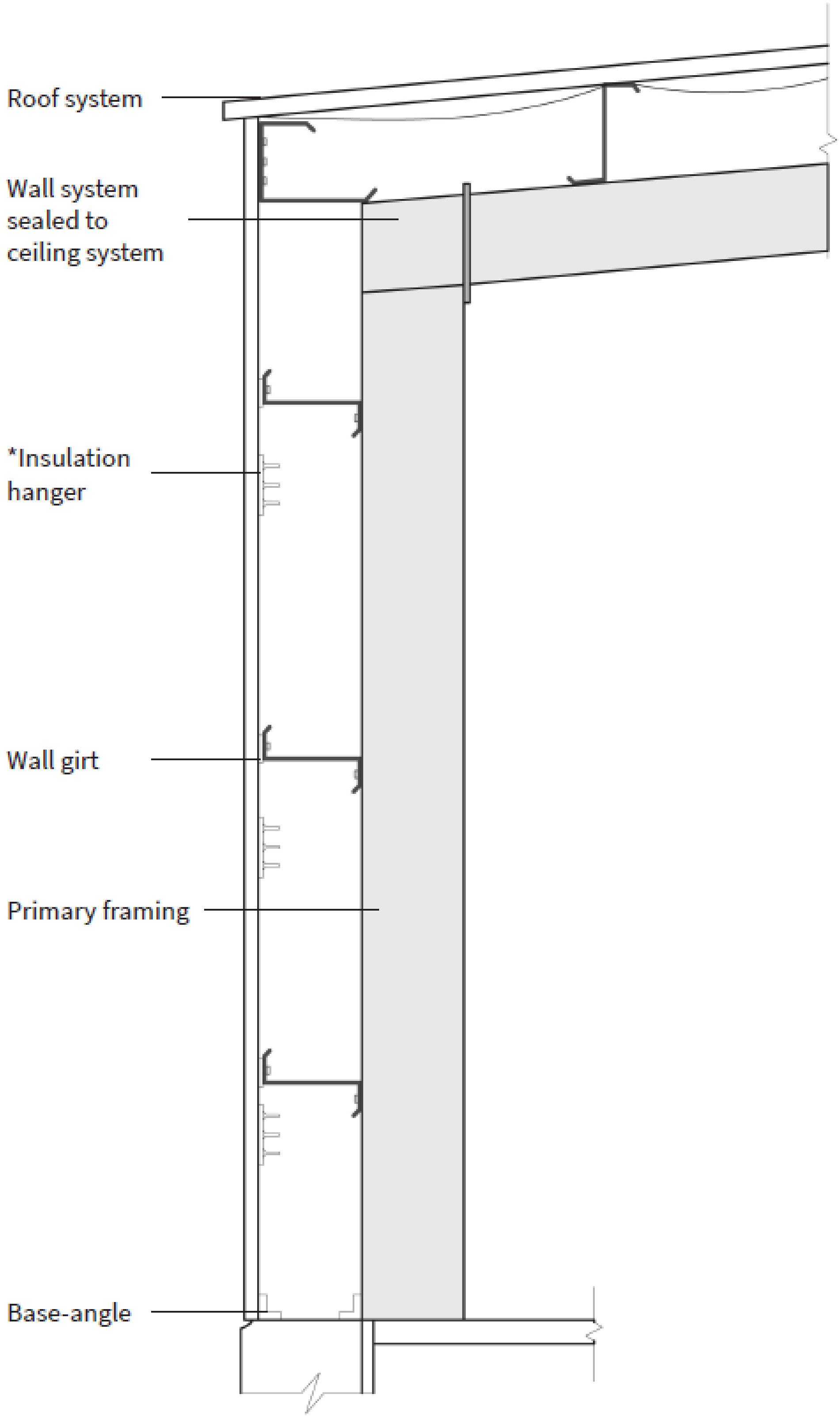
## Metal Wall Panels

1. In the 1940s and 1950s the metal building system wall selection was the same metal panel that was used on the roof. The single skin, simple box rib panel came in one color – galvanized.
2. The first major improvement came with the addition of painted panels. This proved to be very popular with owners. This was followed by panels that were specifically designed as wall panels.
3. The single skin metal wall panel continues to be offered as the basic low cost wall. These panels are available in a variety of long life finishes and colors.
4. Breaks in the panel can give a more pleasing shadow line and certain wall panels allow the fasteners to be semi concealed in the trough of the main corrugation.
5. Panels with fully concealed fasteners in a variety of flat and fluted styles are available from a number of metal building systems suppliers.
6. Metal wall systems can be effectively insulated by using field installed blanket insulation or by the use of factory insulated metal panels.

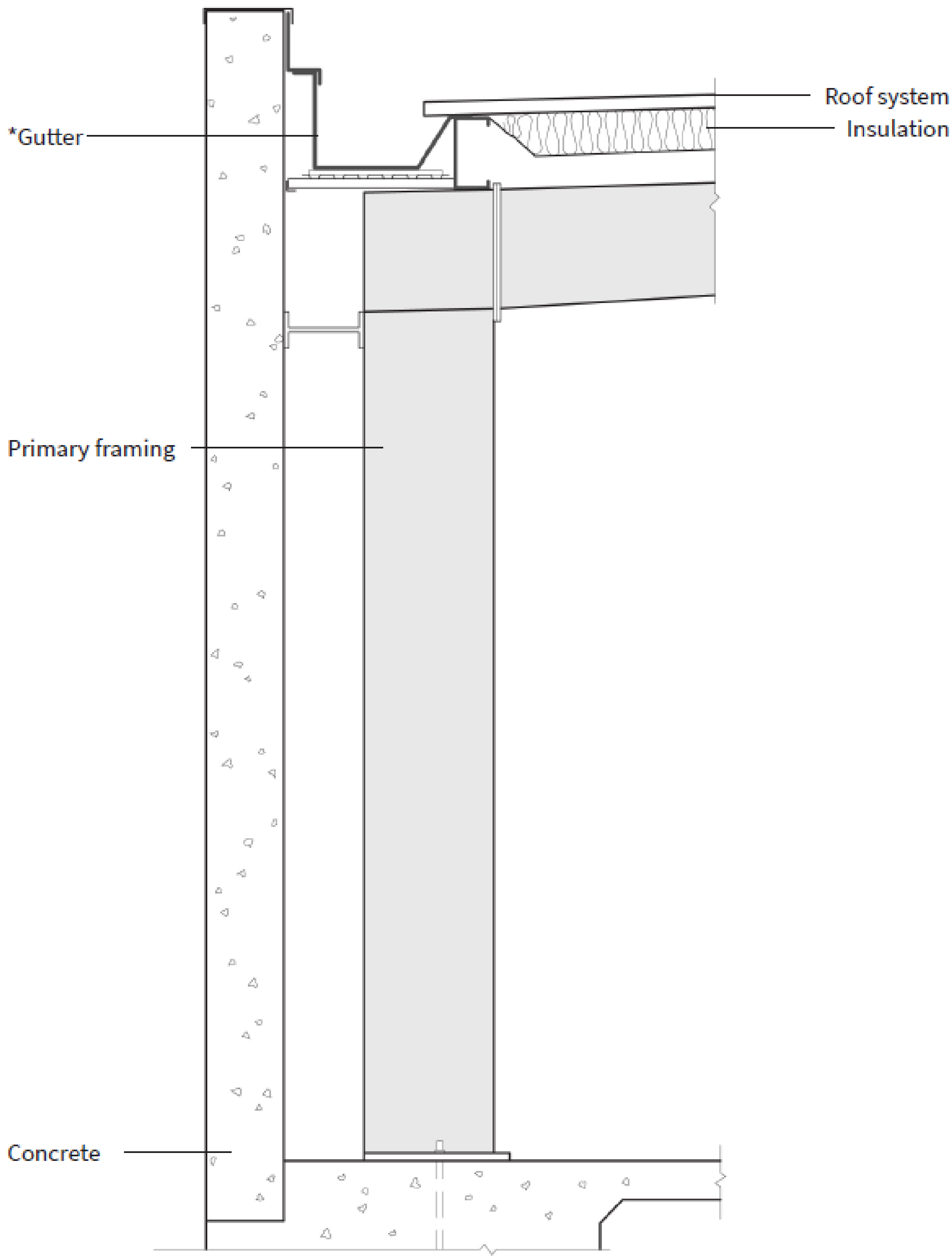
## Insulated Wall Panels

1. Insulated wall panels have reliable thermal performance and insulation continuity: no cavities, no gaps, no crushed insulation or cold bridges
2. Insulated wall panels can meet aesthetic requirements of local communities
3. Textured coatings provide design opportunities
4. Panels meet or exceed current or anticipated wall insulation requirements by ASHRAE or other energy codes. Increasing thickness adds “R” values
5. Insulated panels minimize or eliminate air infiltration

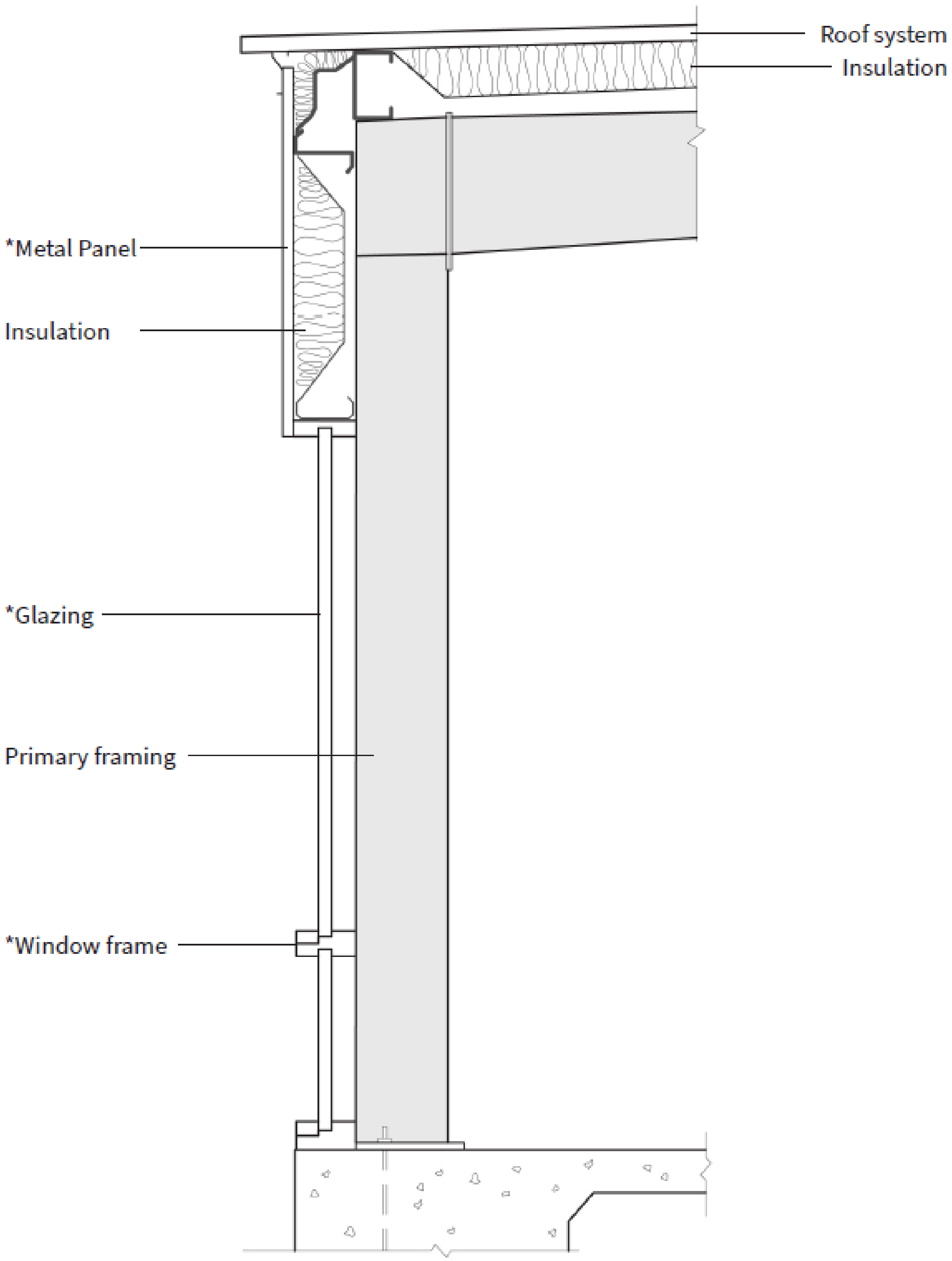
# Metal Wall System



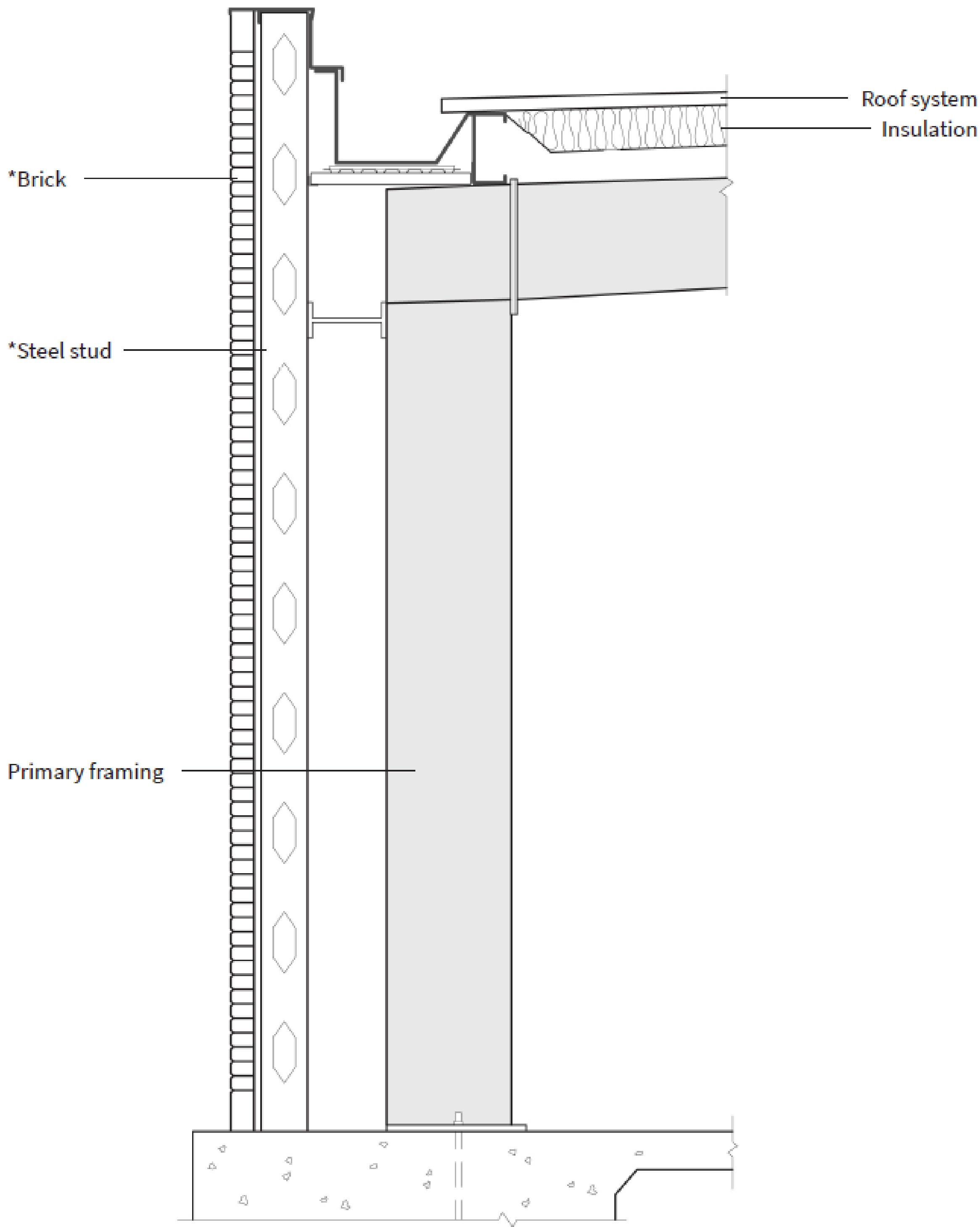
# Tilt-Up Wall with Parapet Gutter



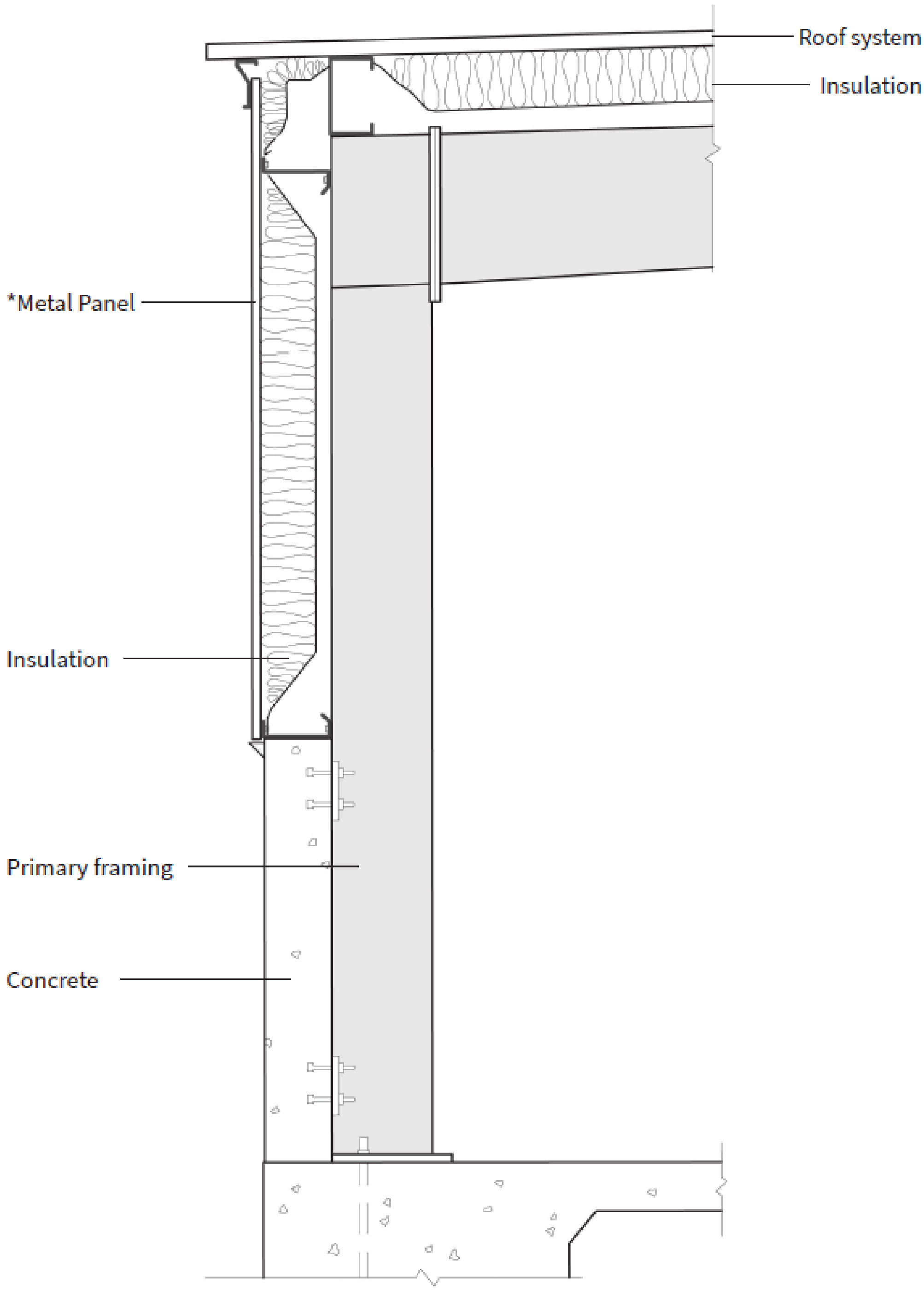
# Store Front Frame with Wall Panel Above



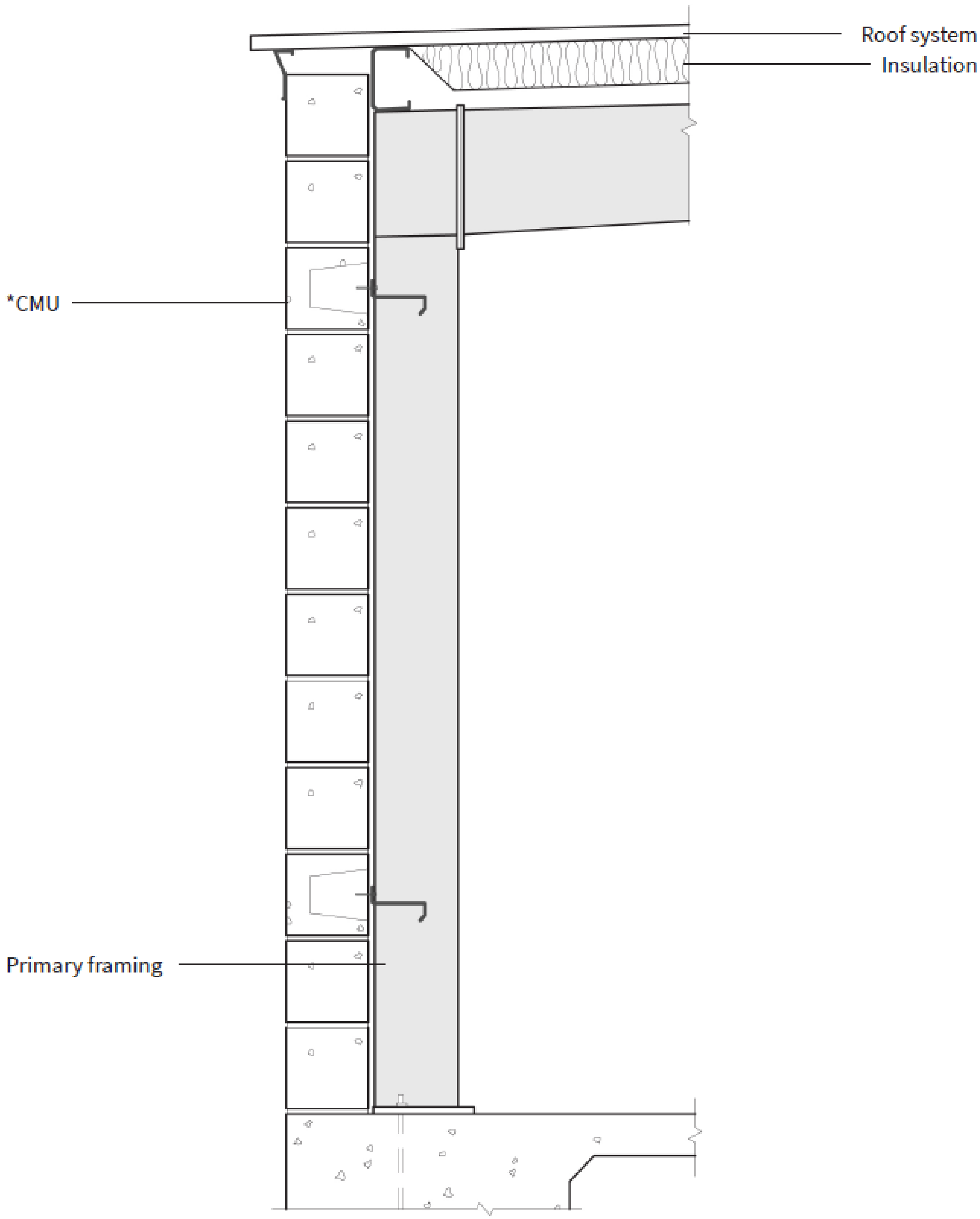
# Steel Stud and Brick Wall with Parapet Gutter



# Concrete Wall with Wall Panel Above



# Concrete Masonry Unit (CMU) Wall



5

# Roof Systems

This chapter addresses the basics of metal roof systems. There are many different types of metal roof systems designed to meet the performance and aesthetics needs.

There are two common types of metal roof systems: through fastened roof and standing seam roof. Metal roof systems are easy-to-install, low maintenance, and have notable thermal performance.

## Metal Roofing System Advantages

1. Offer maximum protection in extreme weather conditions
2. Aesthetic options for architects and designers
3. Lightweight
4. Recyclable
5. Used regularly for schools and military
6. Significantly outlast conventional flat roof systems with an expected life of 40 years+
7. Cool coatings reduce air conditioning energy cost
8. Provide convenient platform for mounting solar panels that can be directly attach to vertical ribs

## Metal Roof Panels

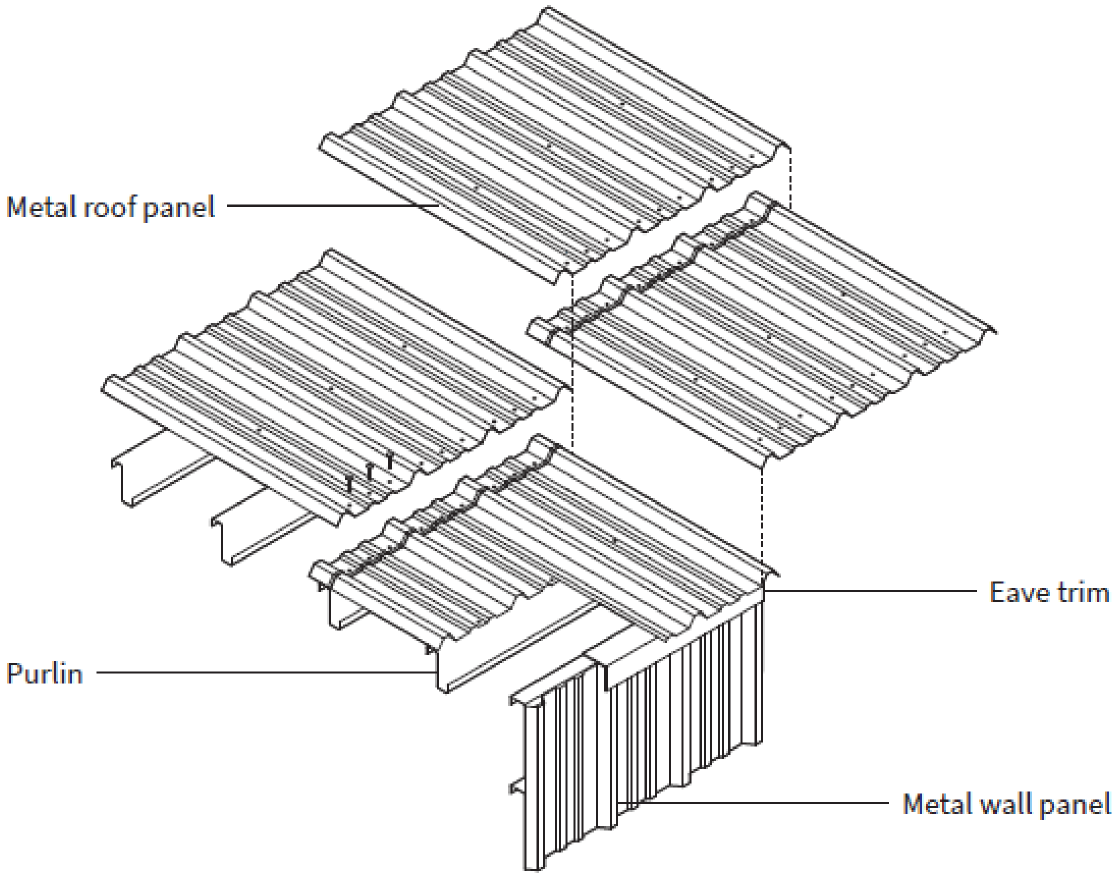
1. Function as an environmental barrier
2. Provide structural integrity to purlins
3. The two basic types of panels are standing seam and through-fastened
4. The structural integrity of the purlins for both gravity and uplift wind loads is highly dependent upon the roof panel.

## Through Fastened Roofs and Standing Seam Roofs

**Through Fastened Roofs (TFR):** A through-fastened roof system is one in which the roof panels are attached directly to the roof substructure with fasteners that penetrate through the roof sheets and into the purlins. TFRs are generally limited to shorter (100’ to 200’) panel runs in order to control the panel expansion and contraction which can lead to the slotting of panel fasteners holes. TFRs are not generally recommended on bar joists due to their stiffness compared to cold formed purlins which can lead to more slotting at the fastener holes.

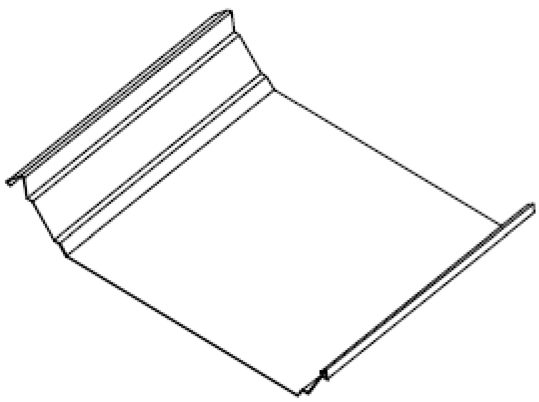
**Standing Seam Roofs (SSR):** A standing seam roof system is one in which the side laps between the roof panels are arranged in a vertical position above the roof line and secured to purlins by special clips which better allow for panel expansion and contraction.

## Through-Fastened Construction

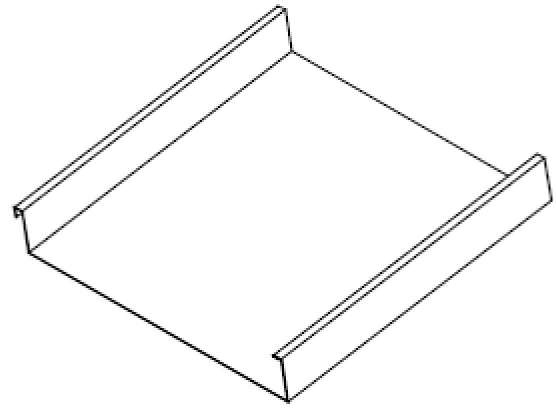


## Standing Seam Metal Roof

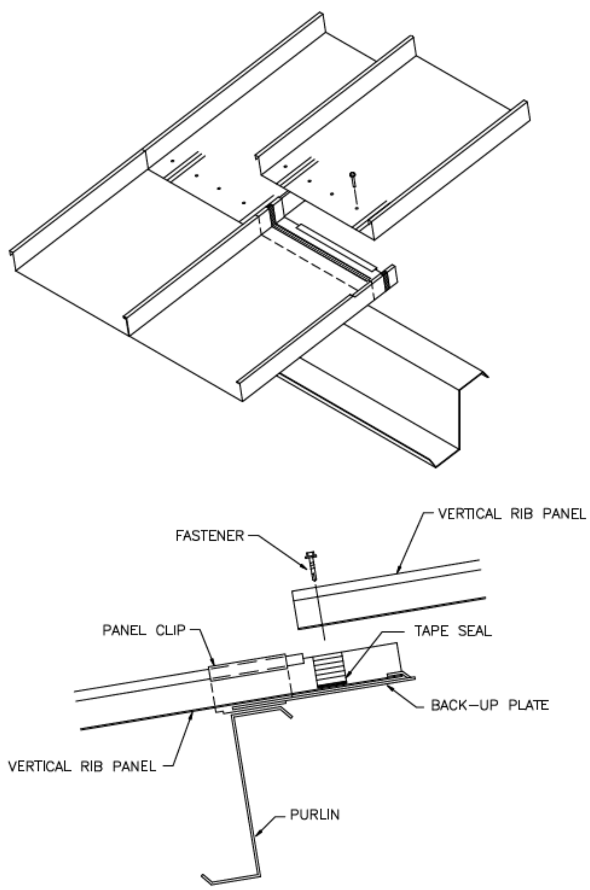
Standing seam metal roofs are differentiated by their geometric rib profiles as either trapezoidal rib panels or vertical rib panels.



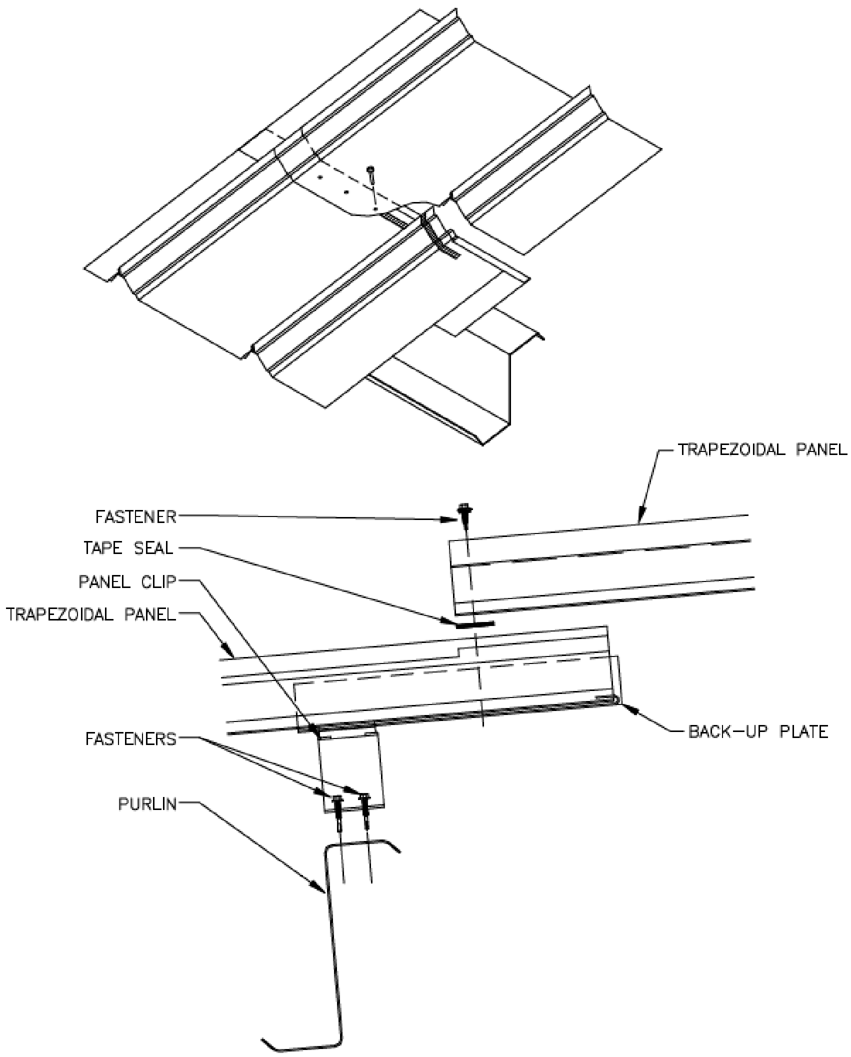
**Trapezoidal Rib Panel**



**Vertical Rib Panel**




**Vertical Rib Standing Seam Roof with Typical Panel End Lap Detail**




**Trapezoidal Rib Standing Seam Roof with Typical Panel End Lap Detail**

## Structural and Non-Structural

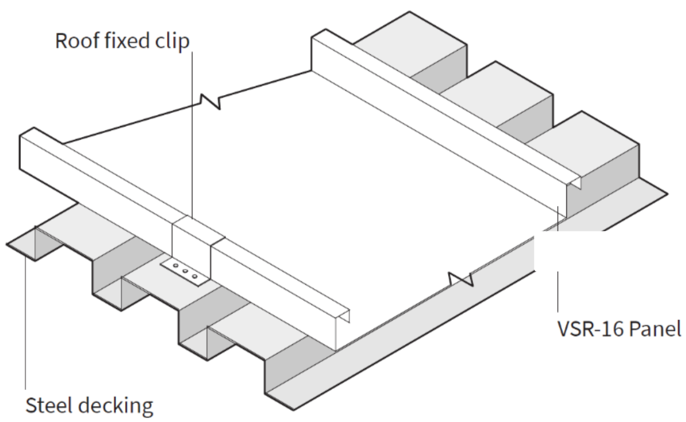
Most metal building roofs utilize structural metal roofs, which means that the roof panels carry any loads directly to the supporting secondary members (purlins/joists). Another option is to use a non-structural metal roof, where the roof panels are applied to a substrate that carries the loads to the secondary members. The non-structural metal roof would be at more expense, but there may be other advantages such as the ability to add insulation above the substrate or the choice of a metal roof style that only comes in a non-structural option.

Structural

1. Metal roof panels are designed to carry loads
2. Purlins or joist depending on span may require bracing

Non-Structural

1. Architectural metal roof panels are not designed to carry loads
2. Substrate that carries the load is necessary: plywood, metal deck, etc.




**Non-structural Vertical Rib Standing Seam Roof over Steel Deck Substrate**

## Metal Roofing System's Life Cycle Cost

The selection of a roof system can include an economic analysis of the life cycle costs over a period of time, such as 40-50 years. This might especially come into play for a school or other publicly owned building where the total cost needs to be evaluated. Metal roofs come out very well in comparisons with other roof materials using a life cycle cost evaluation. In particular, metal roofing has the following features that factor into the analysis:

1. Competitive Initial Cost
2. Low Maintenance Costs
3. Good Thermal Efficiency
4. Cool Roof Availability
5. Long Life Expectancy

Below is an example of a Life Cycle Cost Analysis. The biggest factor is the life of the roof material and the need for replacements over the life of the building.

| **100,000 Sq. Ft. Roof** | | |
|---|---|---|
| | **Conventional Flat Roof** | **Metal Standing Seam** |
| **Assumptions** | | |
| Average Life | 8-15 Years | 40-50 years |
| Initial Cost | $4-6/SF | $6-8/SF |
| Maintenance | $.05-.25/SF/Year | $0/SF/Year |
| Average Warranty | 10 Years | 20 Years |
| Paint Finish Warranty | NA | 25-35 Years |
| **Initial Cost** | | |
| Initial Cost | $500,000 | $700,000 |
| Metal Deck @ $1.15/SF 22ga "B" | $115,000 | $0 |
| Total Initial Cost | **$615,000** | **$700,000** |
| **Maintenance & Replacement** | | |
| Maintenance - 12 Years | $20,000 | $0 |
| Replacement at year 12 | $500,000 | $0 |
| Maintenance - 12 Years | $20,000 | $4,000 |
| Replacement at year 24 | $500,000 | $0 |
| Maintenance - 12 Years | $20,000 | $6,000 |
| Replacement at year 36 | $500,000 | $0 |
| Sub Total | **$1,560,000** | **$10,000** |
| **Total Investment - 36 Years** | **$2,175,000** | **$710,000** |
| **36 Year Savings** | | **$1,465,000** |

## Metal Roof Fire Ratings

MBMA has undertaken an engineering analysis and fire tests on metal building roof systems, utilizing either a gypsum wallboard ceiling system (UL Design No. P516) or an acoustical tile ceiling system (UL Design No. P265 by MBMA and UL Design No. P268 by others), and obtained 1 hour and 1-1/2 hour fire resistance ratings. In addition to the roof ratings, the beams supporting the roofs have a 1 hour or 1-1/2 hour fire resistance rating. In the case of the gypsum wallboard ceiling system, it is recognized as providing 1-hour protection to the steel framing above.

The MBMA Fire Resistance Design Guide for Metal Building Systems is a resource that provides current practices and the results of research undertaken by MBMA, its member companies, and other industry groups. Note that a complimentary copy will be provided to faculty upon email request to mbma@mbma.com.

## Drainage Requirements

Along the gutters, it is essential that there be positive drainage after the roof is deflected under design load. Because the perimeter framing may be stiffer than the first interior purlin, a deflection check should be made to prevent standing water between the eave and first interior purlin. In the case of side edges, as in the case of membrane roofs, there could be separation in the flashing detail between wall and roof. This is a matter of limiting the vertical deflection to that which can be tolerated by the detail.

The concern for maintaining drainage on the overall roof is largely eliminated because the slope of the roof used in metal buildings is sufficient. The minimum slope is on the order of 1/2 in. per foot for TFR and on the order of 1/4 in. per foot for SSR. Model building codes require a slope of at least 1/4 in. per ft. However, it is essential that the deflection of purlins and rafters be checked to ensure positive drainage of the roof under load. This includes dead load and superimposed loads.

Because the drainage for metal roofs is universally at the eaves into interior or exterior gutters or onto the ground, a discussion of the location of drainage points is not required. However, the metal building manufacturer will typically evaluate the drainage and develop the plan for gutters and downspouts per the building code.

# Appendix

## Common Industry Practices

This appendix covers the six stages for a standard metal building manufacturing process. The first step is estimating, which involves networking and scope development. Once a building order is obtained from a client during phase two, the project coordinator(s) then review the order in phase three. Phase four is the design phase, in which the majority of the design decisions are made, including determining the primary, secondary, and bracing systems as well as producing drawings and BIM models. Phase five is the detailing process, and the production of construction documents and technical drawings that are then reviewed. The last phase is the production stage where all the components are manufactured in the fabrication plant.

## Definitions

**Manufacturer**: The party that designs and fabricates the materials included in the Metal Building System in accordance with the Order Documents as provided herein. If the Manufacturer sells the Metal Building System directly to the End Customer, the Manufacturer can also have the responsibility of the Builder as described below.

**Contractor**: The party that has the responsibility for providing the materials and erection of the Metal Building System as specified by the Contract Documents.

**General Contractor**: The party that has the overall responsibility for providing all materials and work for the Construction Project (including the Metal Building System) as specified by the Contract Documents.

**Erector**: The party that erects the Metal Building System. Either the Builder, Contractor, General Contractor or another party pursuant to an agreement with the Builder, Contractor, General Contractor or End Customer may act as the Erector.

**Builder**: The party that orders and purchases the Metal Building System from the Manufacturer for resale. The Builder is an independent contractor and is not an agent for the Manufacturer. For purposes of this definition, Builder means any Buyer of a Metal Building System other than the End Customer. In those situations, where the Builder also meets the definition of the End Customer, the relationship to the Manufacturer remains that of a Builder, not an End Customer.

**End Customer**: The party who will be the initial owner of the Construction Project for the purpose of occupying the building or leasing or reselling the completed structure for purposes of occupancy by others. As used herein, the term includes any agent of the End Customer including any Design Professional or General Contractor retained by the End Customer. In those situations, where the Builder also meets the definition of the End Customer, the relationship to the Manufacturer remains that of a Builder, not an End Customer.

**Design Professional**: An architect or engineer retained by the End Customer or General Contractor or the Builder to assist in the preparation of design specifications for the Construction Project including the Metal Building System and its erection, and where appropriate, to assist in supervising the construction process for compliance with the Contract Documents.

For a specific Construction Project, the responsibilities and rights of the Design Professional and the End Customer (or General Contractor or Builder) are defined in a separate agreement for professional services between the parties.

**Order Documents**: The documents normally required by the Manufacturer in the ordinary course of processing an order through which the Builder orders the Metal Building System from Manufacturer. The Order Documents consist of the Purchase Order; the Manufacturers' written acceptance, drawings, specifications and any other written communication required by the Manufacturer in the ordinary course of processing an order. Unless specifically agreed to in writing by the Manufacturer, specifications and drawings prepared by the Builder, End Customer or its Design Professional are not part of the Order Documents.

**Contract Documents**: The documents that define the material and work to be provided by the Contractor or the General Contractor (or the Builder, if acting in these capacities) for a Construction Project. The Contract Documents consist of a written agreement defining the scope of work, contract price, schedule and other relevant terms of the agreement. Typically, they include the Design Professionals drawings and specifications (if any), and may include the erection instructions and preliminary drawings of the Manufacturer, drawings of any other subcontractor and general or special terms and conditions referenced and bound with the Contract Documents.

**Construction Project**: Includes all material and work necessary for the construction of a finished structure for occupancy by the End Customer, such as site preparation, foundations, mechanical, electrical work, etc. The Metal Building System and the erection of the Metal Building System are both elements of the Construction Project.

## Metal Building System Engineering Process

Estimating

↓

Manufacturer Scope and Scheduling

↓

Production Detailing

## Contracting and Procurement of Metal Building Systems

A building owner has many options available in the design and construction of a metal building system. There are many participants involved in providing the metal building system. They may include the manufacturer, the building contractor, the erector, the general contractor, various subcontractors, the architect or designer, the engineer of record, and the owner or end customer. The end customer is defined as the party who will be the initial owner of the construction project for the purpose of occupying the building, leasing, or reselling the completed structure for purposes of occupancy by others. The building contractor may also act in a design build capacity by coordinating or providing local engineering and architectural services to the end customer.

The building contractor will specify and select products from the various framing, roofing, siding, and accessory options available from the manufacturer. All materials included in the metal building system are in accordance with manufacturer's standard product offerings unless otherwise specified in the order documents.

## Design Responsibilities: Building and Energy Codes

The end customer would benefit greatly by hiring an architect, engineer of record, or design building contractor who would be responsible for specifying the design criteria for the metal building system, including all applicable design loads. The architect or engineer is also typically responsible for the design of any components or materials not sold by the manufacturer and the interface and connection with the metal building system. This would include the foundation design, concrete or masonry wall, storefronts or large glazed openings, interior finishes and partitions. The architect or engineer of record can also provide valuable inspection services to the end customer to ensure that the project is constructed according to the manufacturer’s erection drawings.

The architect will identify all applicable building codes, energy codes, zoning codes, or other regulations suitable to the construction project, including the metal building system. The building contractor is responsible for conveying the requirements for and compliance to any pertinent local codes to the manufacturer on the order documents. This would include the required structural design codes and loads.

It is the responsibility of the end customer, architect, local engineer or mechanical contractor to design, specify and assure that adequate provisions are made for ventilation, heating, air-conditioning, condensation, insulation, and the lighting or daylighting necessary to meet any energy codes or energy conservation requirements. It is important for the end customer, architect, and mechanical contractor to consider all of these items that impact energy consumption in order to properly balance each item to achieve the best overall cost effective goal of reducing energy consumption. Focusing on only one or two design aspects without regard to the others can lead to an inefficient and costlier building solution.

## Building Erection

The manufacturer of a metal building system is not responsible for the erection of the metal building system, the supply of any tools or equipment, or any other field work unless it has specifically contracted for these responsibilities. The manufacturer does not provide any field supervision for the erection of the structure nor does the manufacturer perform any intermediate or final inspections of the metal building system during or after erection. The term 'erector' refers to whichever firm or corporation that has been contracted to erect the metal building system. The erector may be the building contractor, a subcontractor to the building contractor, or an independent subcontractor.

The building contractor is responsible for interpreting all aspects of the end customer's specifications and incorporating the appropriate specifications, design criteria, and design loads into the order documents submitted to the manufacturer. The building contractor is defined as the party that orders and purchases the metal building system from the manufacturer for resale. The building contractor is an independent contractor and is not an agent for the manufacturer.

Since many of the building components play a role in the energy efficiency and energy code compliance, they must be considered as part of the overall envelope design. The contractor would be the party to supply the insulation and prescriptive compliance path for the energy code.

The manufacturer may supply erection drawings and instructions suggesting the sequence of erection and appropriate connection of the metal building system components. The erection drawings are not intended to specify any particular method of erection to be followed by the erector. The erector remains solely responsible for the safety and appropriateness of all techniques and methods utilized by its crews in the erection of the metal building system. The erector is also responsible for supplying any safety devices, such as scaffolds, runways, nets, etc. which may be required to safely erect the metal building system.