

# Roof Systems

## References:

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**Jefferis, A. & Madsen, D. A. (2005). Architectural drafting and design (5<sup>th</sup> ed.). Clifton Park, NY:Thomson.**

**McGowan, M & Kruse, K. (2003). Interior graphic standards. New York: Wiley & Sons.**

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# Roof Systems

**What do Roofs do?**

**Protection from water**

Area

Slope

Overhangs

Gutters

Drainage

**Light and Shade from sun**

Overhangs

Thickness And Insulation

Skylights And Openings

**Provides Shelter**

Temperature and Humidity

Wind

**Define Aesthetic**

# Roof Systems

## Roof Construction

Roof Framing includes:

Conventional (Rafter Framing)  
Plank And Beam  
Truss Framing Methods

Each has its own special terminology

There are many terms that apply to all systems.

# Roof Systems

## Roof Construction

### Roof parts

#### Ridge

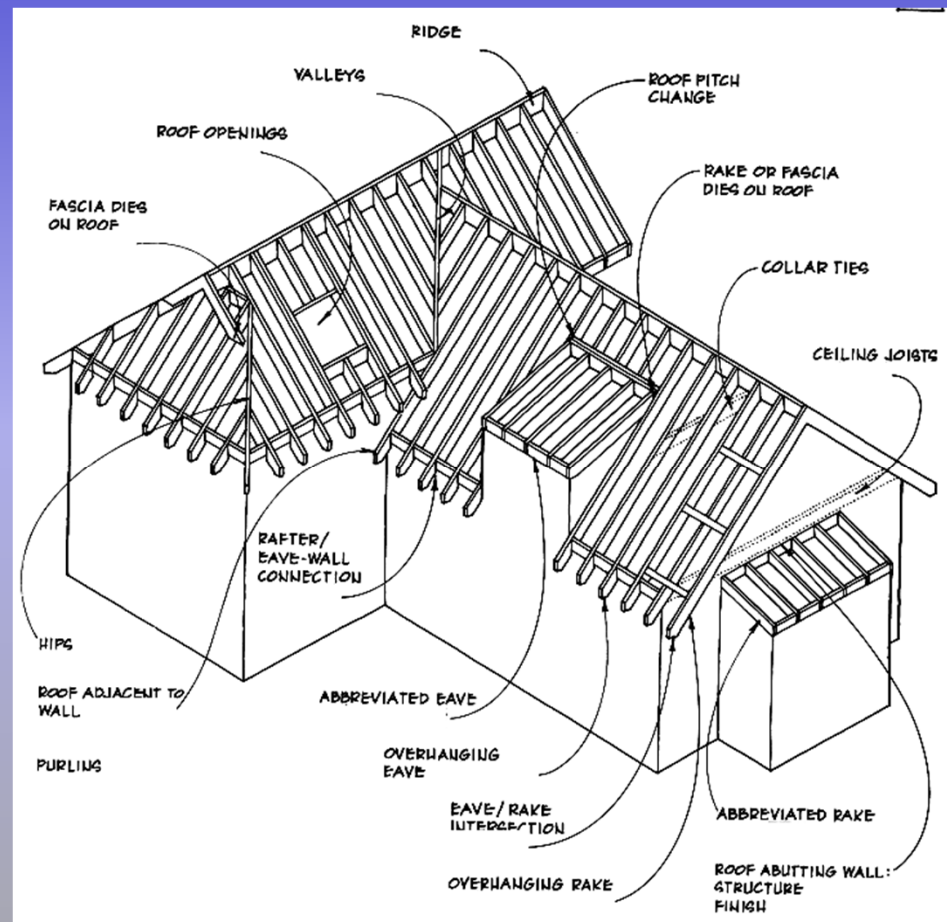
The highest point of a roof  
Formed by the **intersection** of the rafters or the top chords of the truss

#### Eaves

The eave is the portion of the roof that extends **beyond the walls**

#### Cornice

The **covering** that is applied to the eaves



# Roof Systems

## Roof Construction

### Roof parts

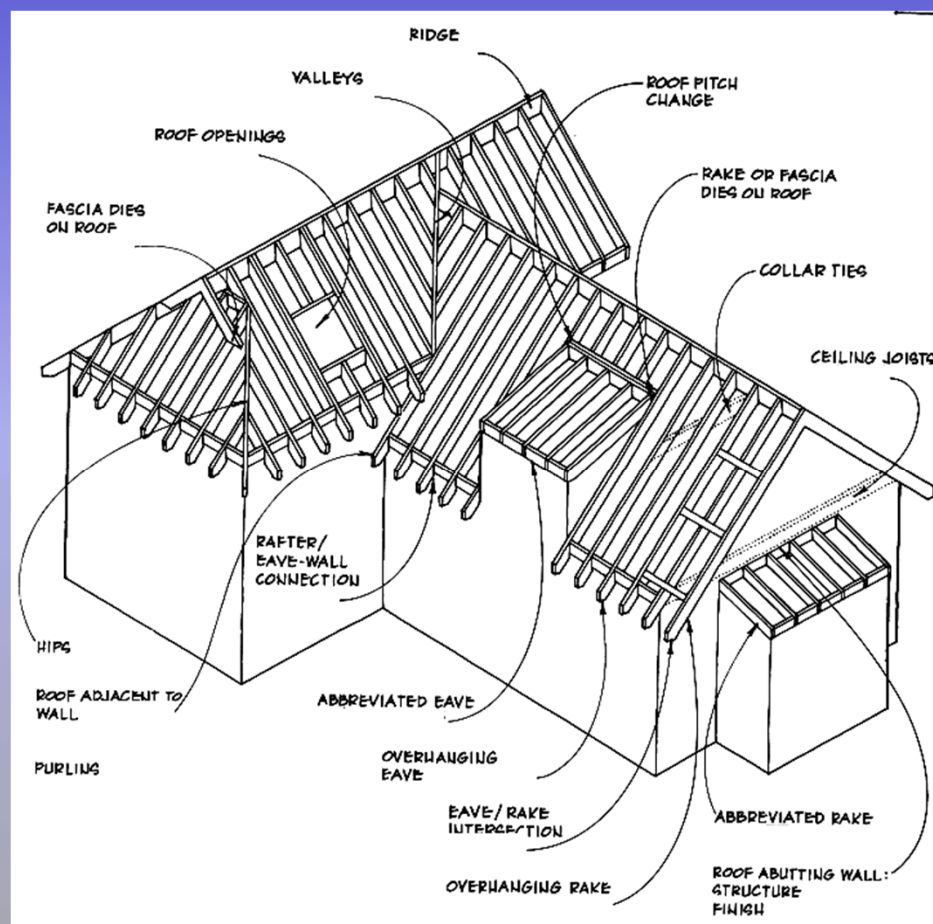
#### Eave blocking

A **spacer block** placed between the rafters or truss tails at the Eave

Keeps the spacing of the rafters or trusses uniform

Keeps small animals from entering the attic

Provides a cap for the exterior siding.



# Roof Systems

## Roof Construction

### Roof parts

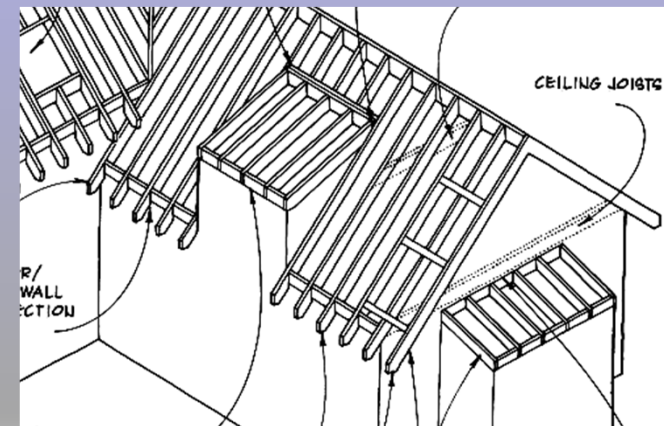
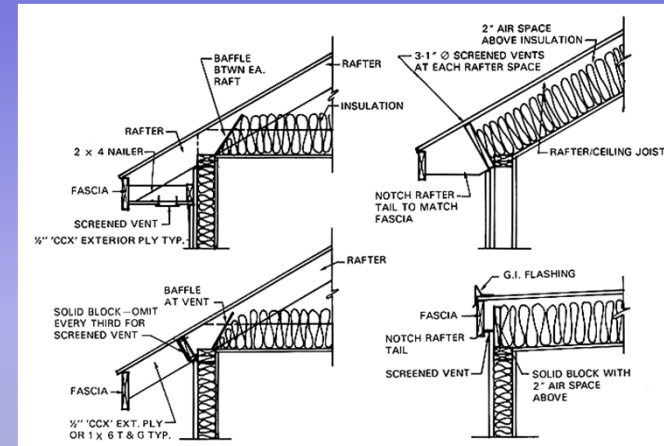
#### Four types of eaves

**Soffited eaves:** The underside of the eave is sealed with ccx plywood to make a soffit. Vents are placed in soffit to provide air circulation under roof

**Exposed eave:** The Underside of the plywood sheathing is exposed

**Boxed in eave:** The Underside of the rafters are sealed with plywood. This maintains the rake, but seals the system

**Abbreviated eave:** Short overhang. Very easy and cheap to build



# Roof Systems

## Roof Construction

### Roof parts

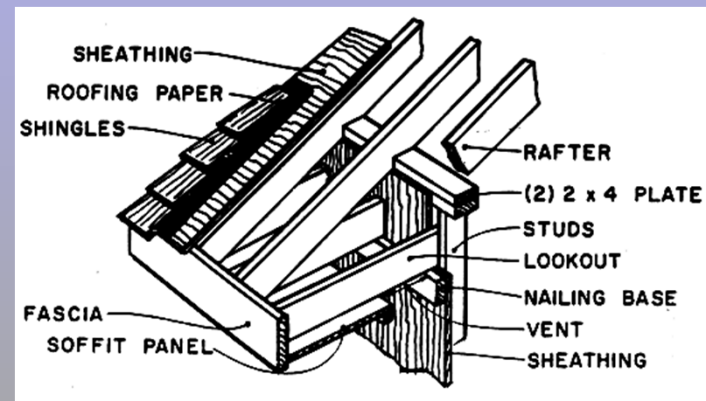
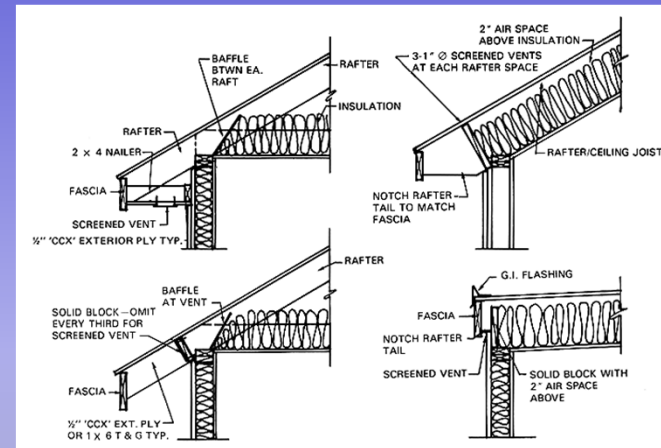
#### Fascia

A fascia is a trim board placed at the end of the rafters or truss tails and perpendicular to the building wall

Hides the truss or rafter tails from sight

Provides a surface where the gutters may be mounted

Typically 2 in. deeper than the rafters or truss tails.



# Roof Systems

## Roof Construction

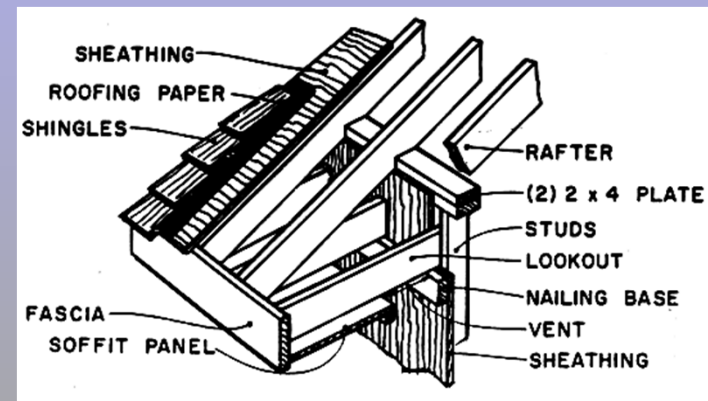
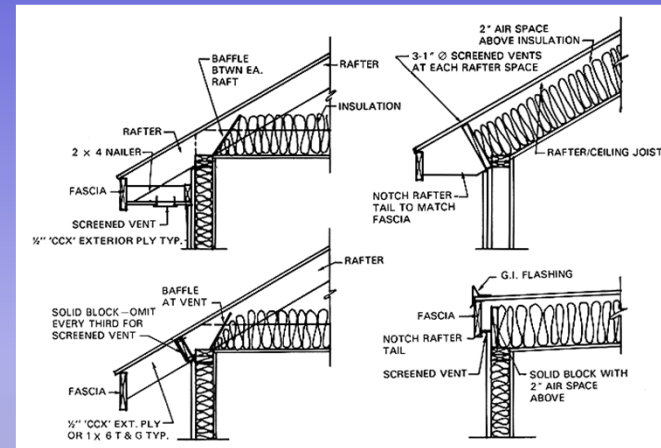
### Roof parts

### Sheathing

Sheathing is used to cover the structural members and stability to the system

Roof sheathing may be either

**solid**  
**skip.**





# Roof Systems

## Roof Construction

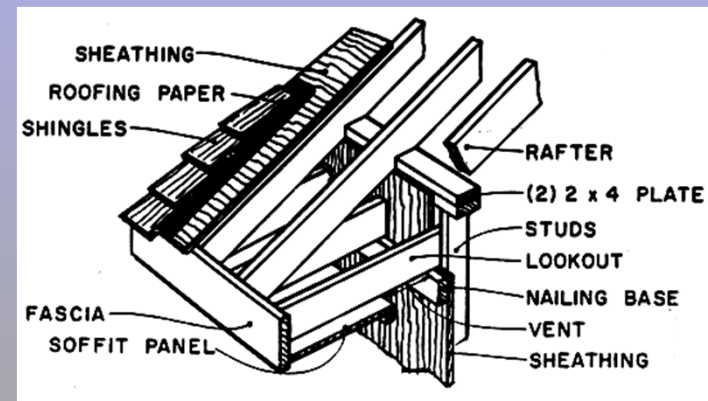
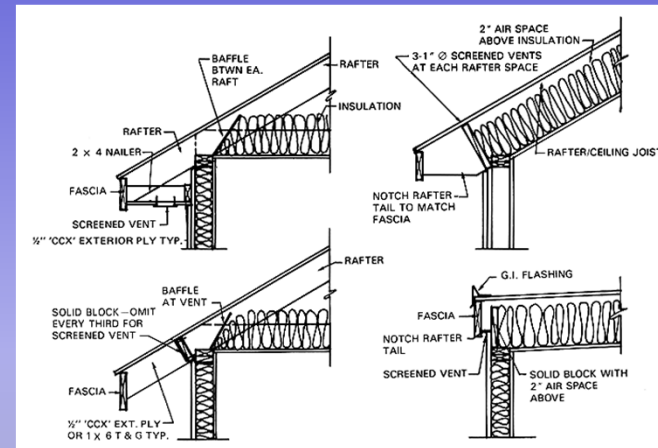
### Roof parts

#### Solid sheathing

5/8 " CDX plywood is generally used  
CDX plywood is the specification  
given by the American  
Plywood Association (APA)  
Designates standard grade  
plywood.

Standard grade Plywood provides an  
economical, strong covering for the  
framing as well as an even base for  
installing the finish roofing.

CCX plywood is exterior grade  
plywood ...water resistant.  
Should be used at the eaves  
because they are exposed to  
the weather.



# Roof Systems

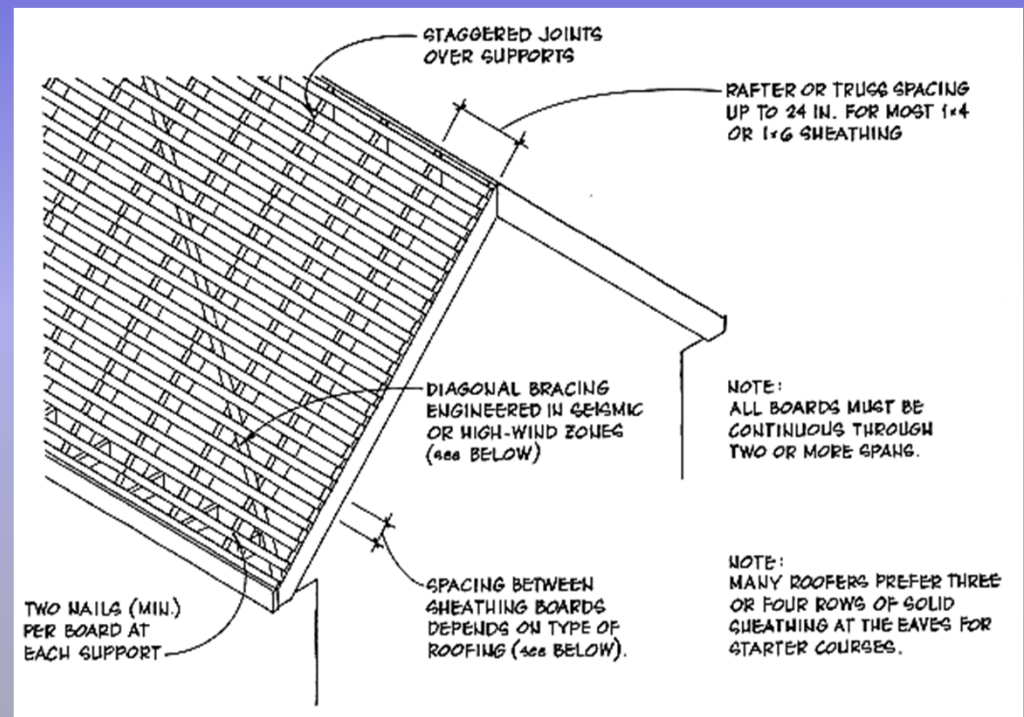
## Roof Construction

### Roof parts

#### Skip Sheathing

Used with either tile, metal or shake roofing

Typically 1x4 purlins are laid perpendicular to the rafters with a 4 in. space between each member



# Roofing Construction Systems

## Types

**Rafter:** Commonly known as stick framing, this method uses wood members placed in a repetitive fashion

**Truss:** A truss is a component used to span large distances without intermediate supports  
A truss system uses trusses to transfer the loads of the roof to exterior walls

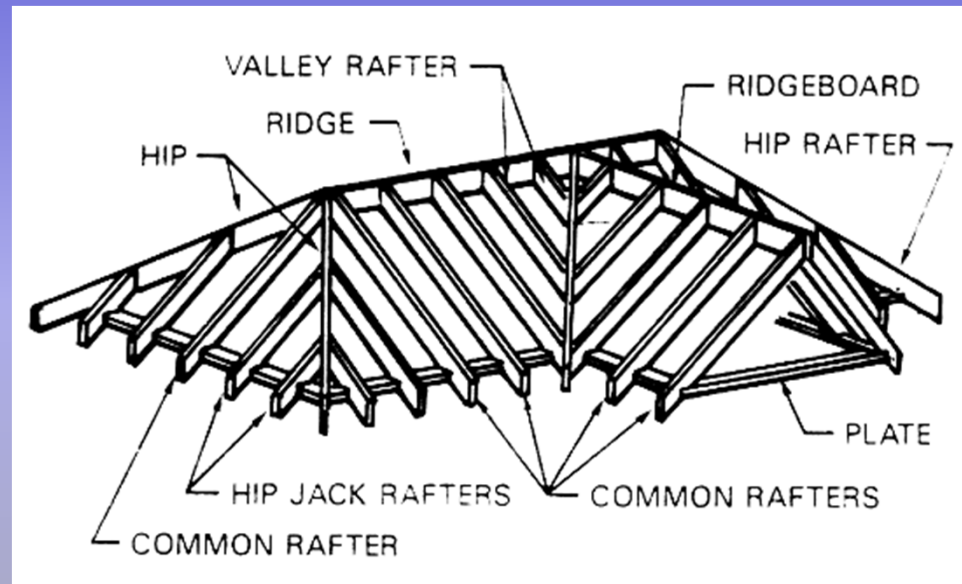
**Plank And Beam:** In this system Beams transfer the loads of the roof to the exterior walls.

# Roofing Construction Systems

## Rafter

**Rafters are the sloping members used to support the roof sheathing and finished roofing**

**Typically spaced at 12, 16, or 24 inches on center (O.C.).**



# Roofing Construction Systems

## Rafter

### Kinds Of Rafters

#### Hip Rafter:

forms the ridge at the Hip of Hip roof

#### Valley Rafter

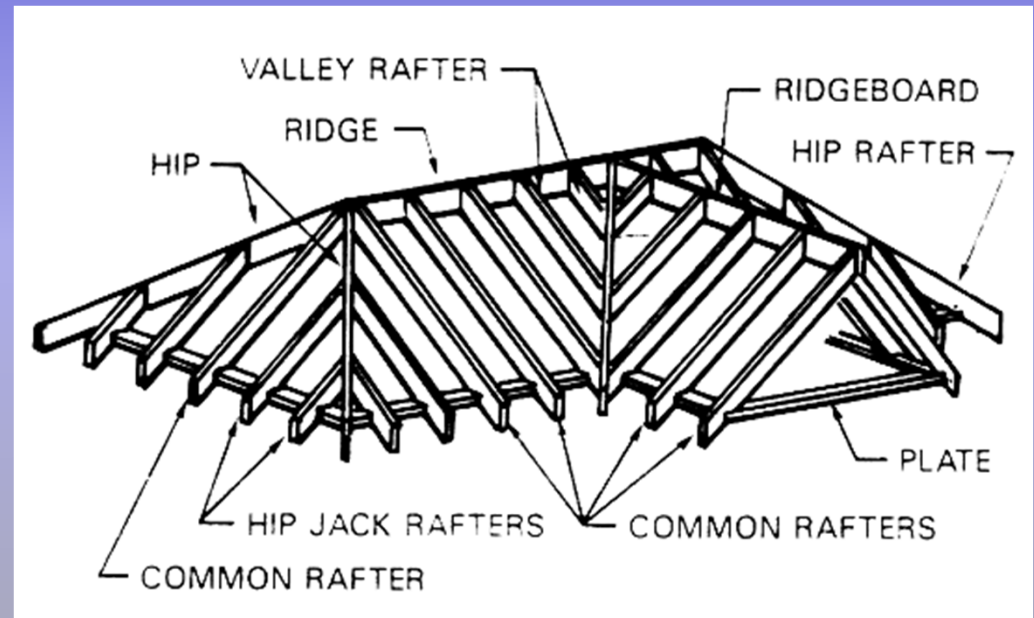
Is the support at the lowest part of the valley

#### Common Rafter

Extends from the ridge board to the top plate.

#### Jack Rafters:

Extend from either the Hip rafter to the top plate or the ridge to the valley rafter.



# Roofing Construction Systems

## Rafter

### Rake and Barge Boards

## Barge Board

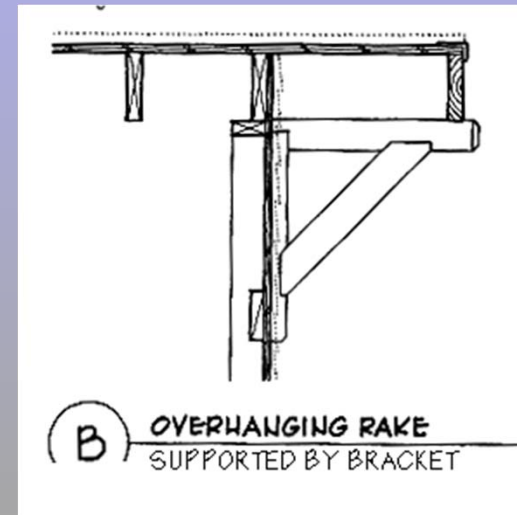
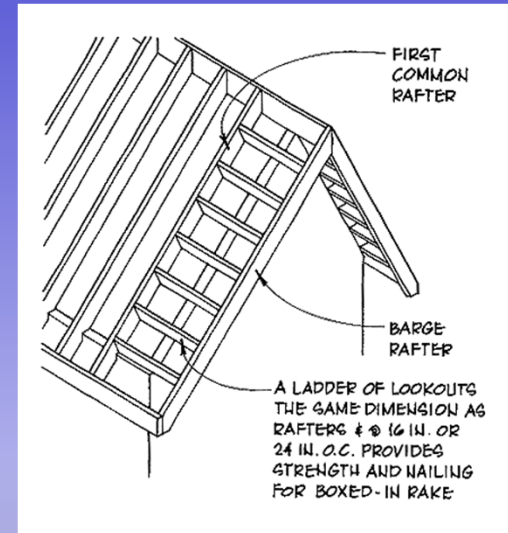
The board that extends beyond the wall at the rake or gable end of the roof. It is supported by a ladder of boards running perpendicular to the rafters called *Lookouts*, or by a bracket

## Bracket:

The bracket attaches to the wall and supports the barge through triangular bracing

## Lookouts:

The lookouts tie back to the structure and support the extended rake through cantilever

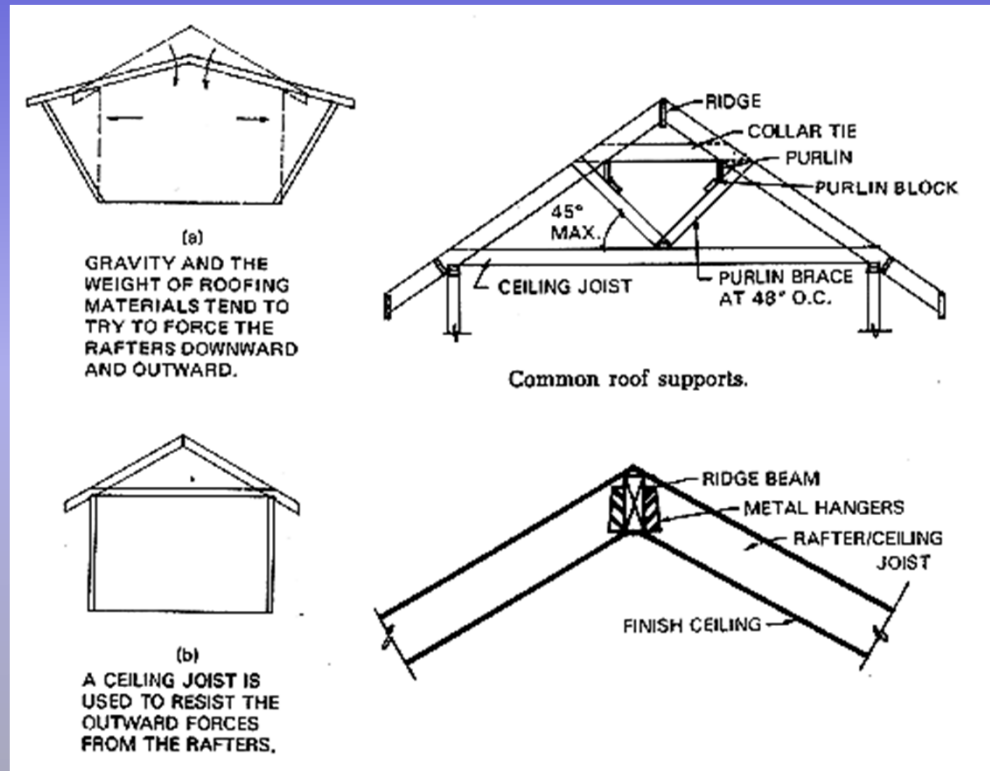


# Roofing Construction Systems

## Rafter

### Loads On Rafters

Push supporting walls downward and outward. Special members to resist these forces.



# Roofing Construction Systems

## Rafter

### Loads On Rafters

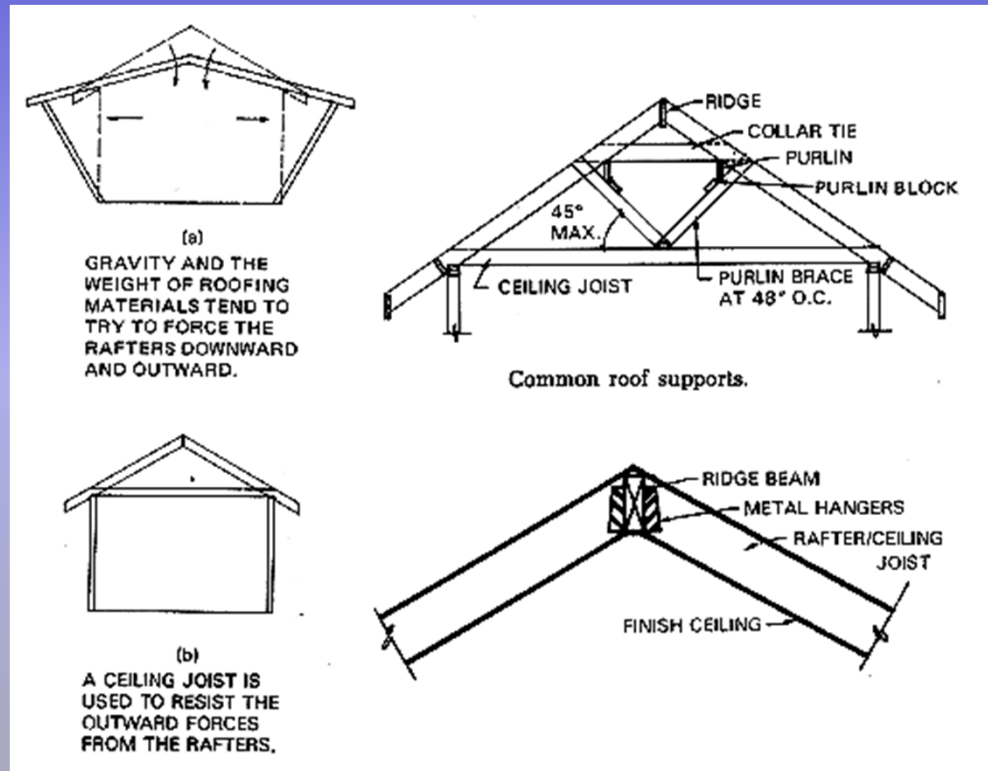
### Members

## Ridge Board

The horizontal member at the ridge which runs perpendicular to the rafters

The ridge board is centered between the exterior walls when the pitch is equal on both sides. Doesn't support the rafters - used to align the rafters

Resists the downward thrust of gravity and forces the rafters in a V shape





# Roofing Construction Systems

## Rafter

### Loads On Rafters

### Members

### Ceiling Joists

Span between the top plates of the bearing walls

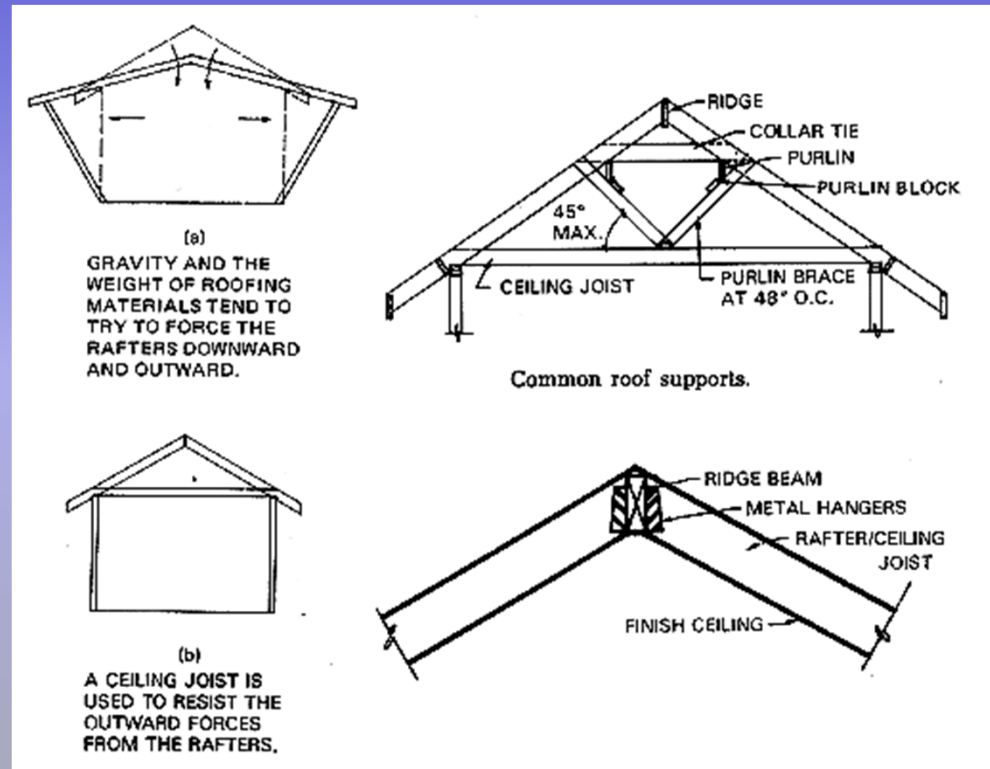
Resist the downward and outward force on walls

The ceiling joists also support the finished ceiling

### Collar Ties:

Resist the downward and outward force on walls

Used if ceiling joists don't span from top plate to top plate



# Roofing Construction Systems

## Rafter

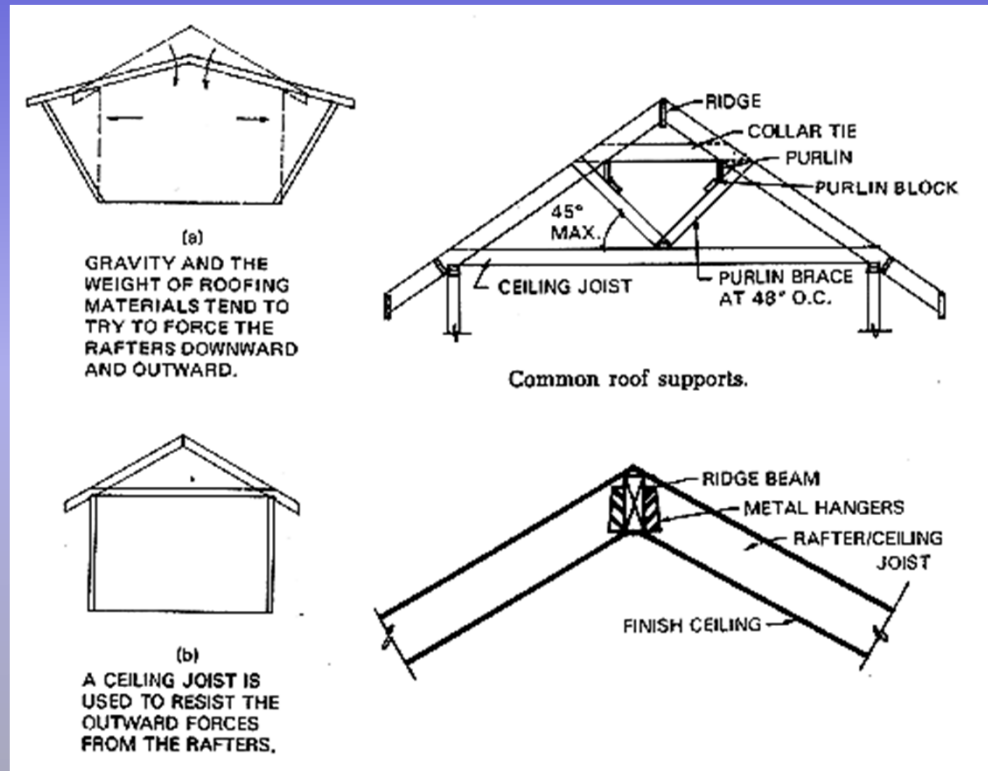
### Loads On Rafters

### Members

### Purlins & Purlin Braces

Purlins run perpendicular to the rafters, usually about mid span, and provides them with added support.

Reduces the span of the rafters by carrying the loads down to interior load bearing partitions



# Roofing Construction Systems

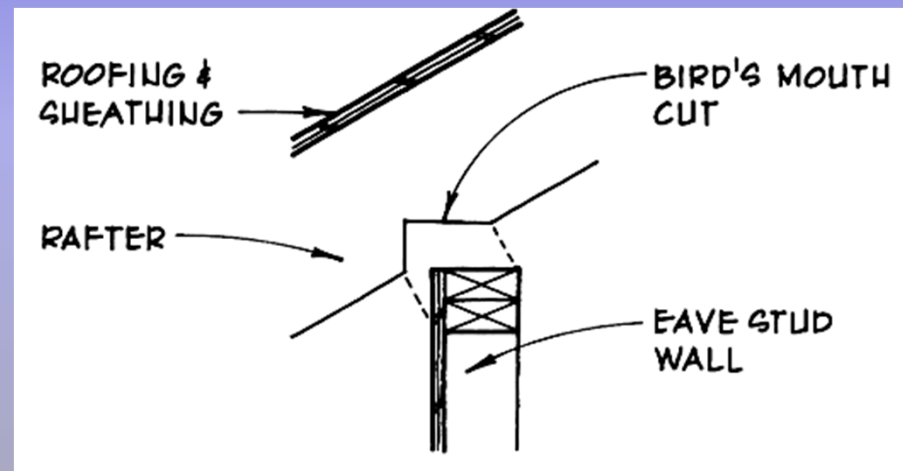
## Rafter

### Rafter wall connection

Generally illustrated in the Wall Section drawing

This drawing, along with the building section, framing plan and details explains the roof system

At supporting walls the rafters are notched at the point of support with a notch called a *Bird's Mouth*.



# Roofing Construction Systems

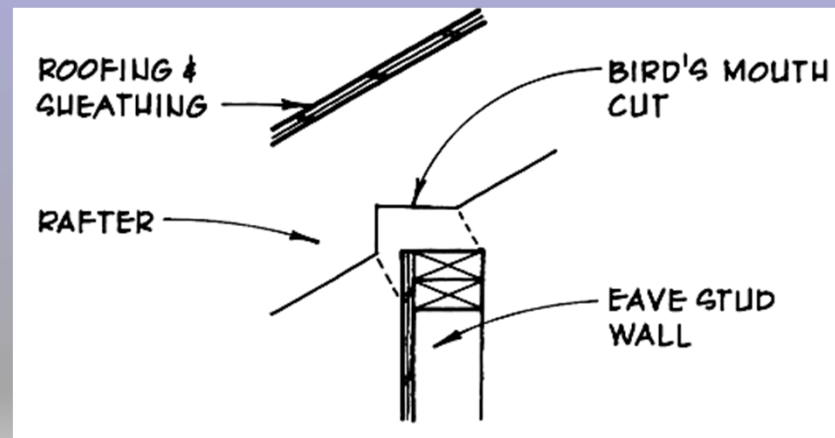
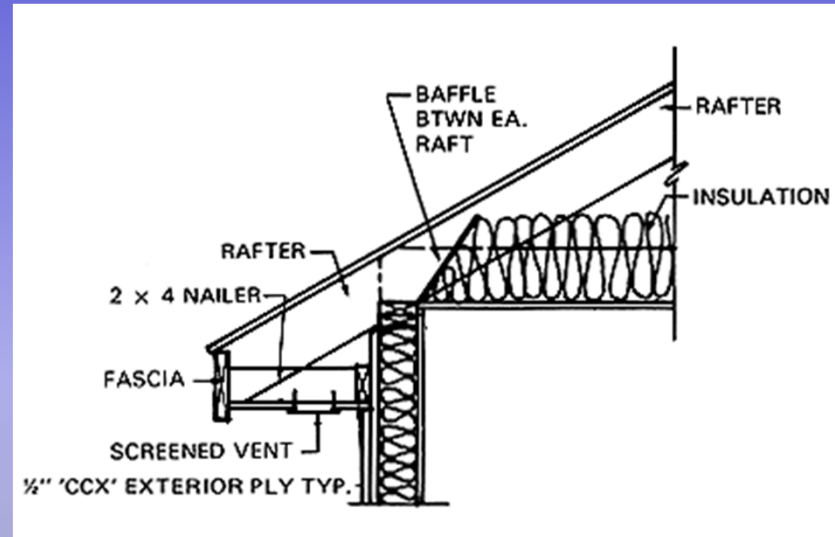
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# Roofing Construction Systems

## Rafter Span

Rafters span the distance from the center of the ridge board to the interior edge of the exterior walls

This Dimension would be given on the building section drawing

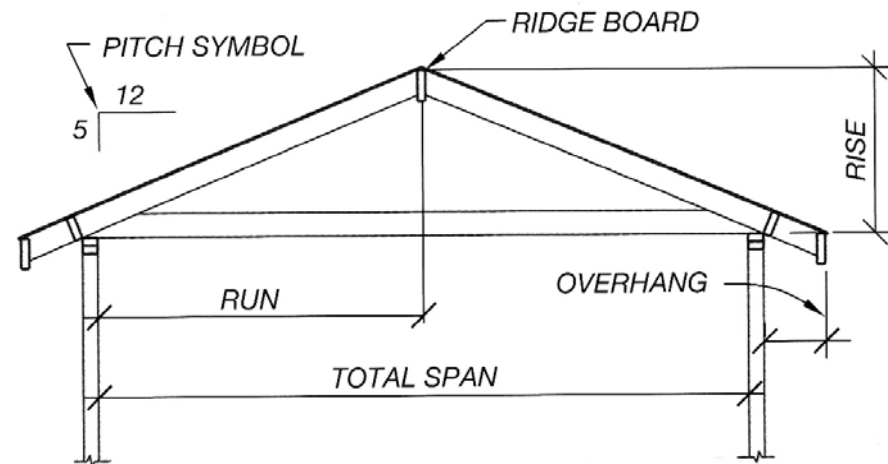


FIGURE 26.32 ■ Roof dimensions needed for construction.

# Roofing Construction Systems

## Rafter

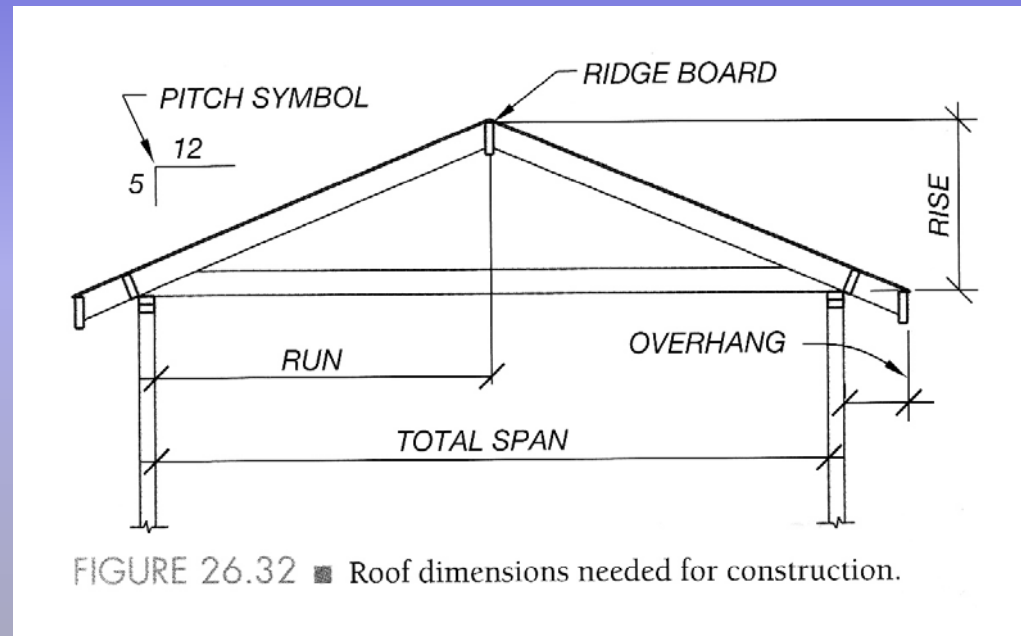
### Dimensioning the Roof

Pitch, span, and overhang dimensions that are needed to define the angle, of the roof. These are given in the building section drawing

**Pitch** is the ratio between the horizontal run and the vertical rise of the roof

**Run** is the horizontal measurement from the outside edge of the wall to the centerline of the ridge.

**Rise** is the vertical distance from the top of the wall to the highest point of the rafter being measured.



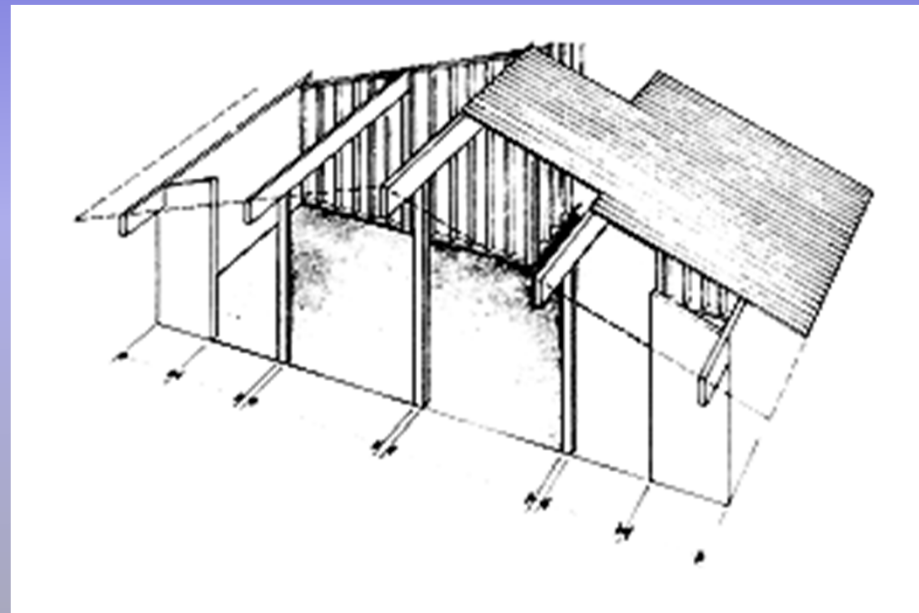
# Roofing Construction Systems

## Rafter

### Plank And Beam Construction

Essentially a skeleton frame work  
the planks span between beams

This system allows for gabled or  
cathedral ceiling and an  
expression of structure



# Roofing Construction Systems

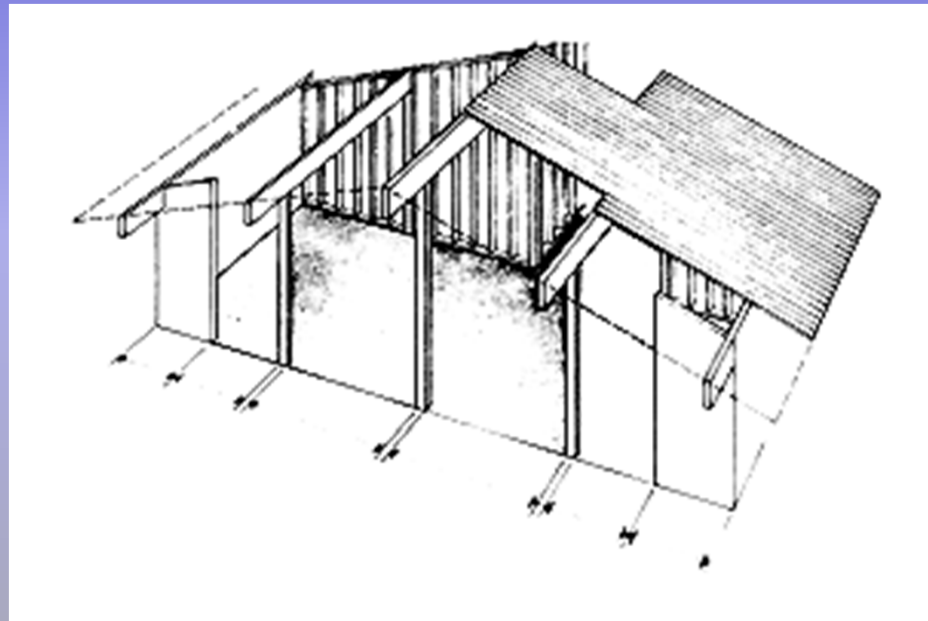
## Rafter

### Plank And Beam Construction

## Beams

The beams can be either  
Longitudinal - spanning the length  
of the building

Transverse- spanning across half  
the building along the slope.





# Roofing Construction Systems

## Rafter

### Plank And Beam Construction

## Planks

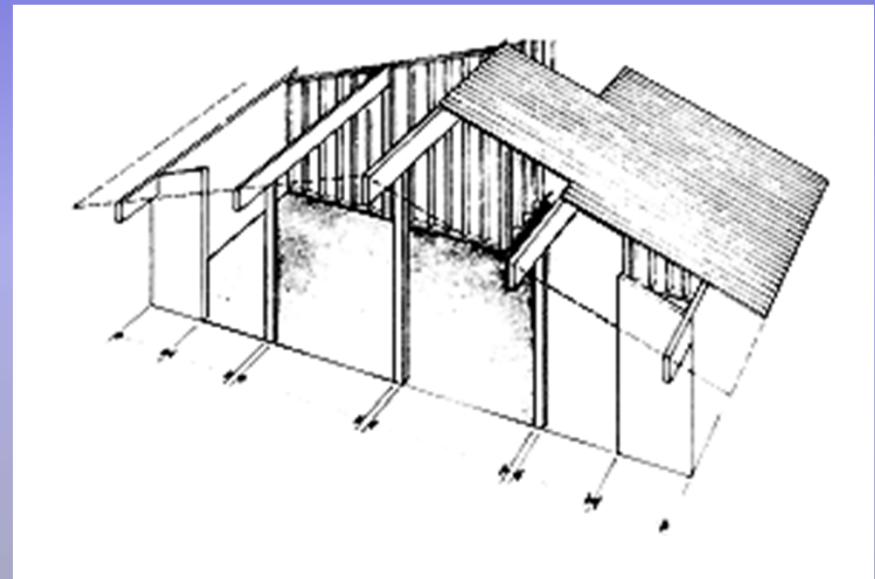
Planks are generally 2 X 6 tongue and groove lumber running perpendicular to beams

The connections of the planks to the beams give the structure rigidity

Planks can be replaced by 2 x rafters. They are placed on edge and spanning perpendicular to the beams and placed 16" to 24" on center

This allows for easier installation of openings in the roof

Gypsum wall board can then be installed on the underside of the rafters and between the beams



# Roofing Construction Systems

## Truss Roof Construction

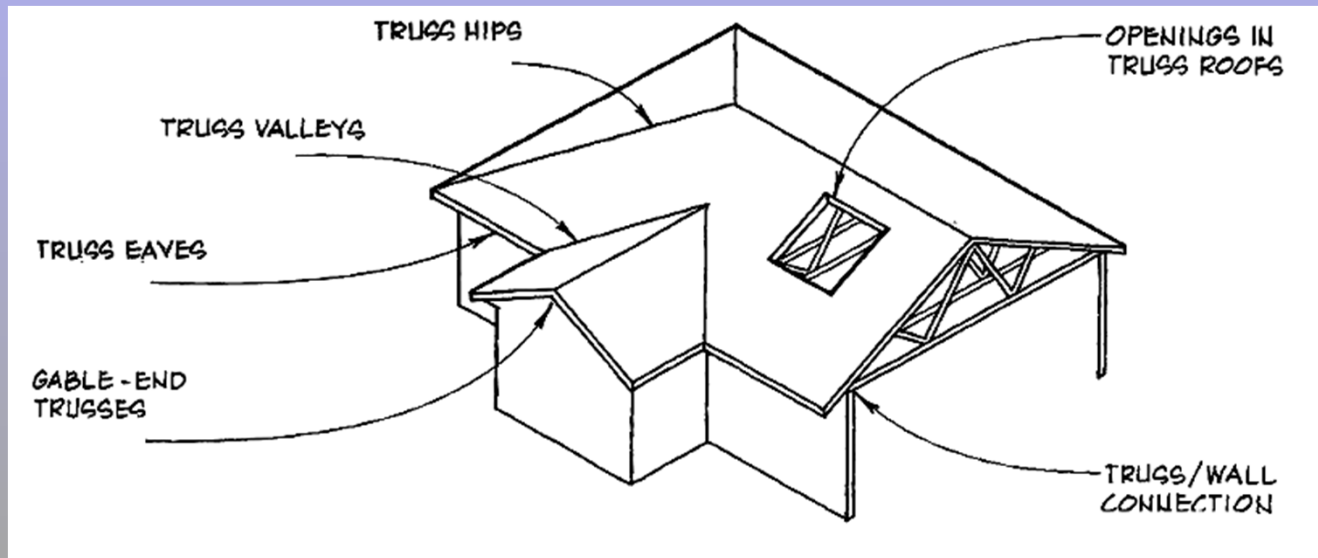
A truss is framework of small members that are connected together so that they act like a single member.

They are used to span large distances without intermediate supports.

Spaced 16" - 24" on center

Trusses are generally engineered by the manufacturer.

Truss roof systems are more quickly assembled and use smaller wood members that rafter systems do.



# Roofing Construction Systems

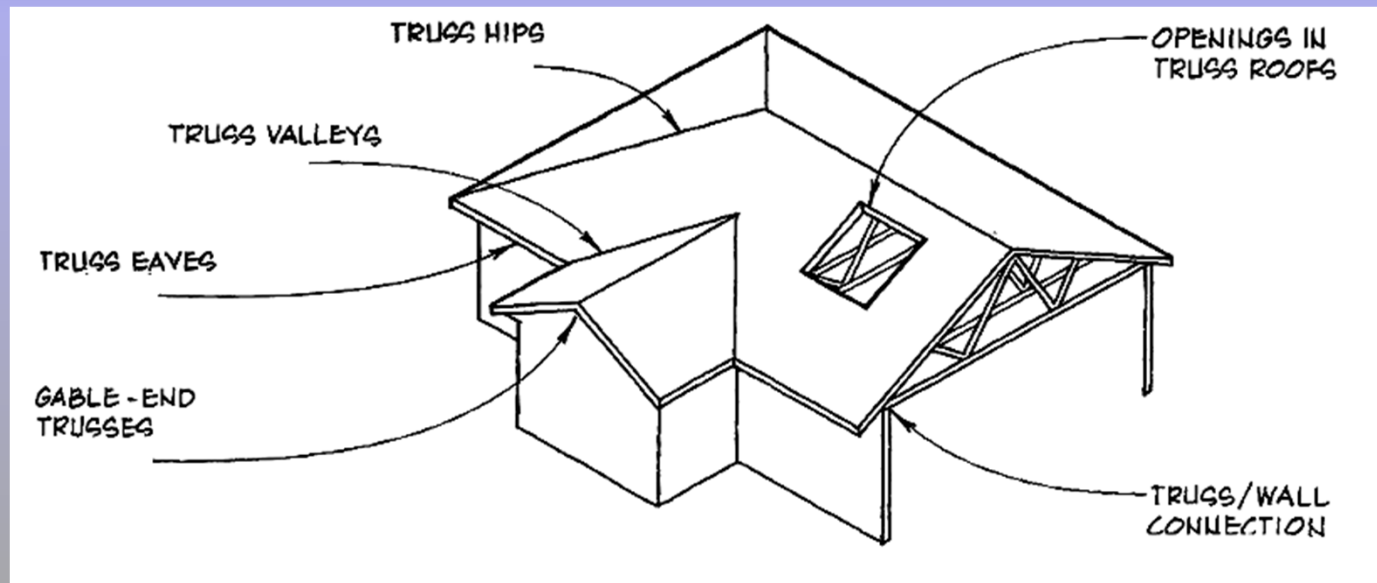
## Truss Roof Construction

### Disadvantages

Difficult to adapt to complex roof forms

Truss occupies space that could be used as storage or occupied

Trusses can't be cut or modified in reconstruction



# Roofing Construction Systems

## Truss Roof Construction

### Truss terms

#### Top Chord

The inclined member used to support the sheathing and finished roof material

#### Bottom Chord

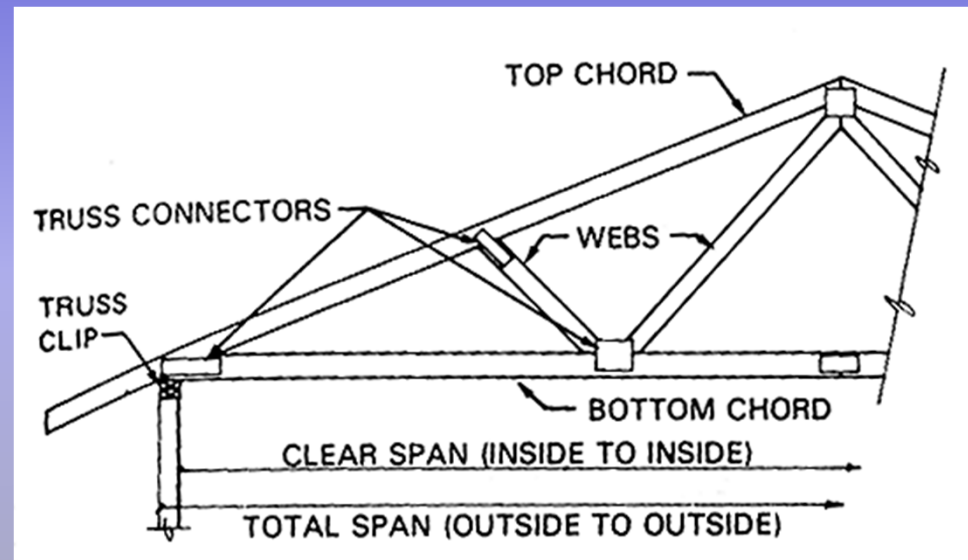
The horizontal member and resists the outward forces of the load

#### Webs

Transfer the weight out to the walls

#### Truss Clips

Hold the truss down on the wall  
Resist the forces of wind pushing upward at the eave.



# Roofing Construction Systems

## Truss Roof Construction

### Truss types

**King Post** - is the simplest type can span 25 ft

**Scissors Truss**- more interior volume. spans 40 ft

**Fink Truss** - is very common type truss in residential applications. spans up to 40 ft

**Parallel Chord Trusses** - used for flat roofs spans 30 ft.



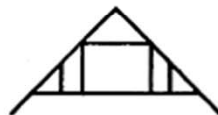
(a) SCISSOR



(b) KING POST



(c) W STANDARD  
OR FINK



(d) ATTIC



(e) HIP



(f) MONO



(g) PITCHED HOWE



(i) PITCHED PRATT



(k) PITCHED WARREN



(h) FLAT



(j) SCISSOR



(l) BOWSTRING

# Roofing Construction Systems

## Roof Types

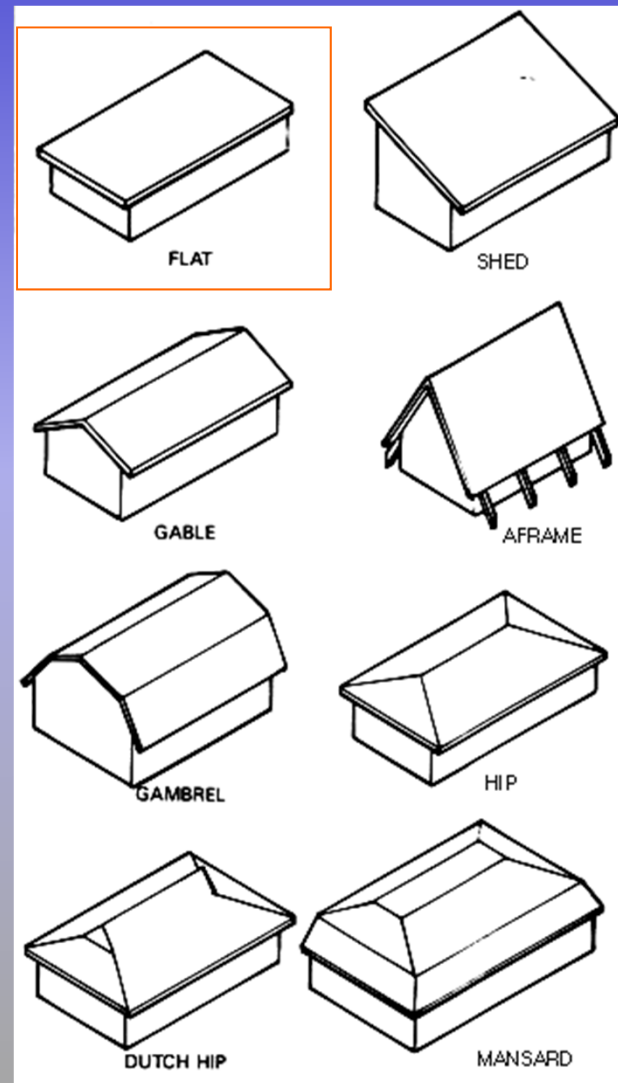
### Flat Roofs

The flat roof is a very common style of roof in areas with little rain or snow

Used in both residential construction and commercial structures

Economical to construct because ceiling joists are eliminated and rafters are used to support both the roof and ceiling loads

Often have a slight pitch in the rafters. A pitch of 1/8 inch per foot is often used to help prevent water from ponding on the roof.



# Roofing Construction Systems

## Roof Types

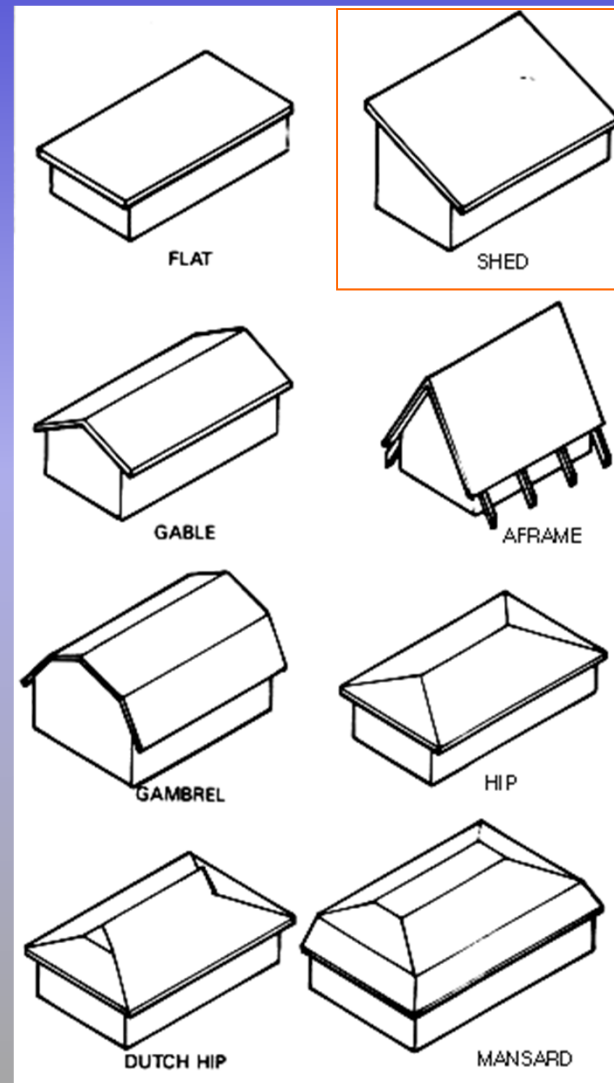
### Shed Roofs

The shed roof gets its name from its original use

Simplicity and economy of construction

Easy drainage.

A shed roof can be constructed at any pitch. The roofing material and the aesthetic requirements determine the pitch of the roof



# Roofing Construction Systems

## Roof Types

### Gable roofs

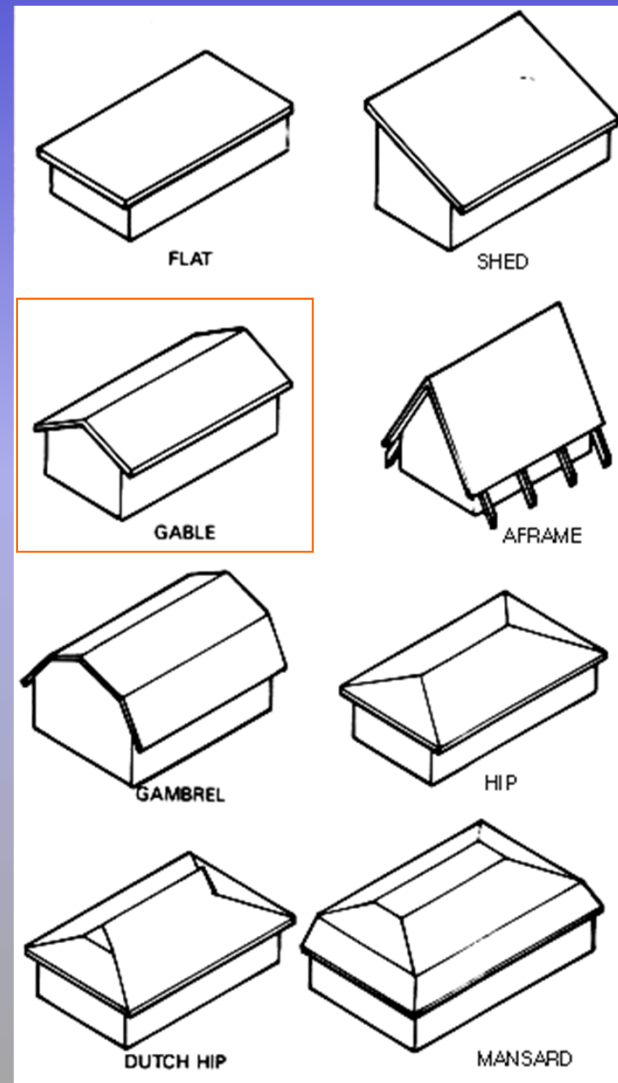
A gable roof is one of the most common types of roof used in residential construction.

A gable roof uses two shed roofs that meet to form ridge between the support walls

It is symmetrical and has a very strong sense of balance and axuality

The gable roof form is that of the architypical house/home

The gable can be constructed at any pitch. The choice of pitch is determined by roofing material and aesthetic desired





# Roofing Construction Systems

## Roof Types

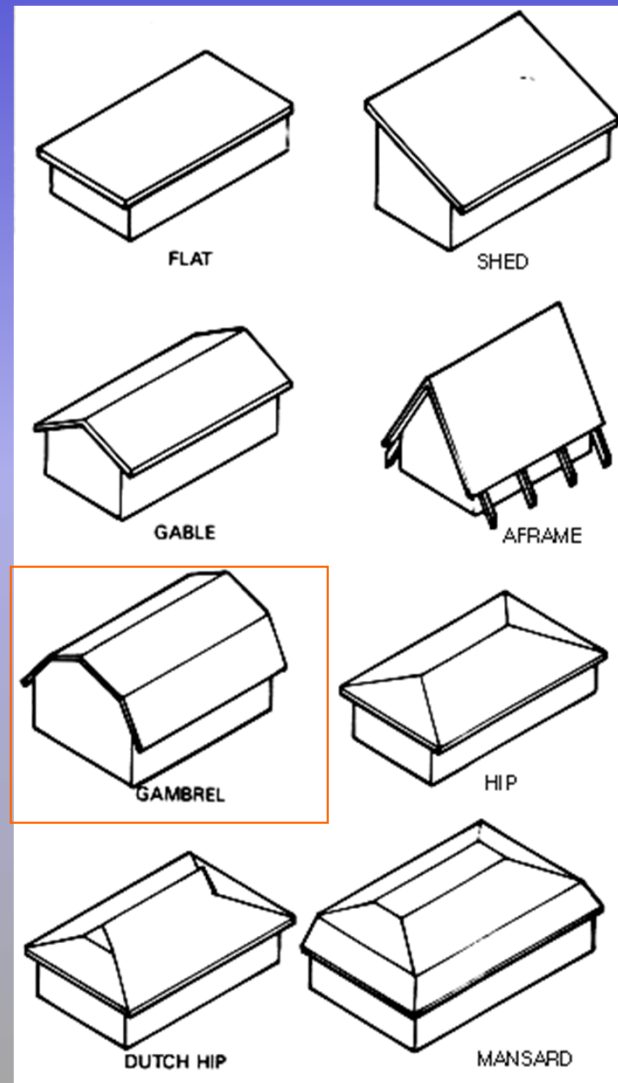
### Gambrel Roofs

A gambrel roof is often called a Dutch barn roof. It is a very traditional roof shape that dates back to the colonial period

Typically used on two story structures  
The upper level is covered with a steep roof surface which connects into a roof system with a slighter pitch

Covering the upper level with roofing material rather than siding, the height of the structure will appear shorter than it is

This roof system can also be used to reduce the cost of siding materials with less expensive roofing materials.



# Roofing Construction Systems

## Roof Types

### Hip roofs

The hip roof is a traditional roof shape

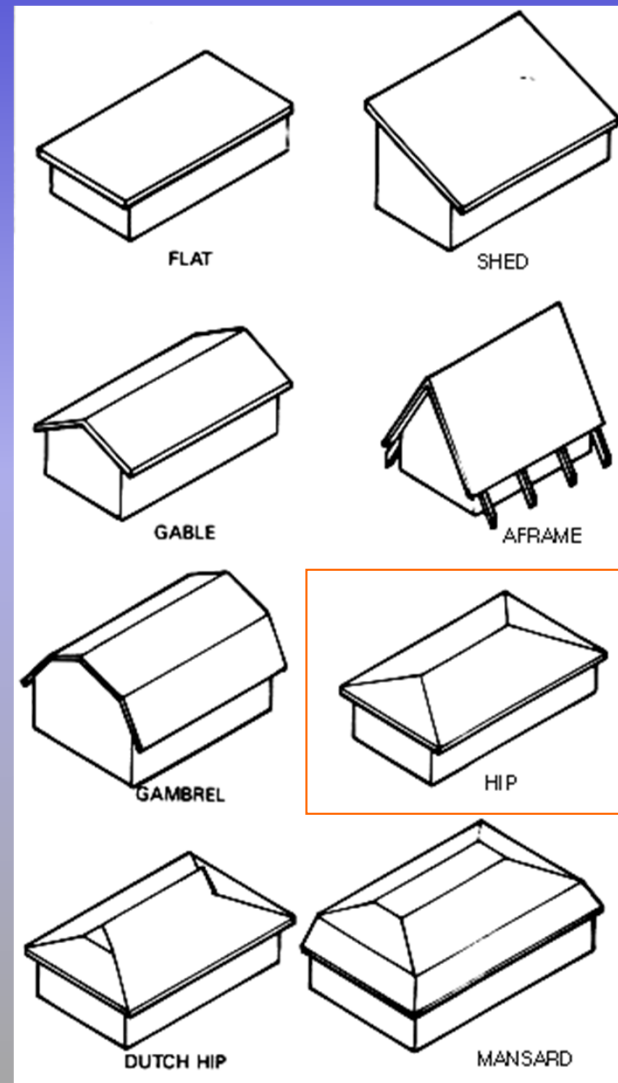
Eliminate some of the roof mass and create a smaller appearing structure with a horizontal emphasis

Similar to a gable roof but instead of having two surfaces the hip roof has four

The intersection between each surface is called a hip.

If built on a square structure the hips will come together to form a point.

If built on a rectangular structure the hips will form two points with a ridge spanning between them.



# Roofing Construction Systems

## Roof Types

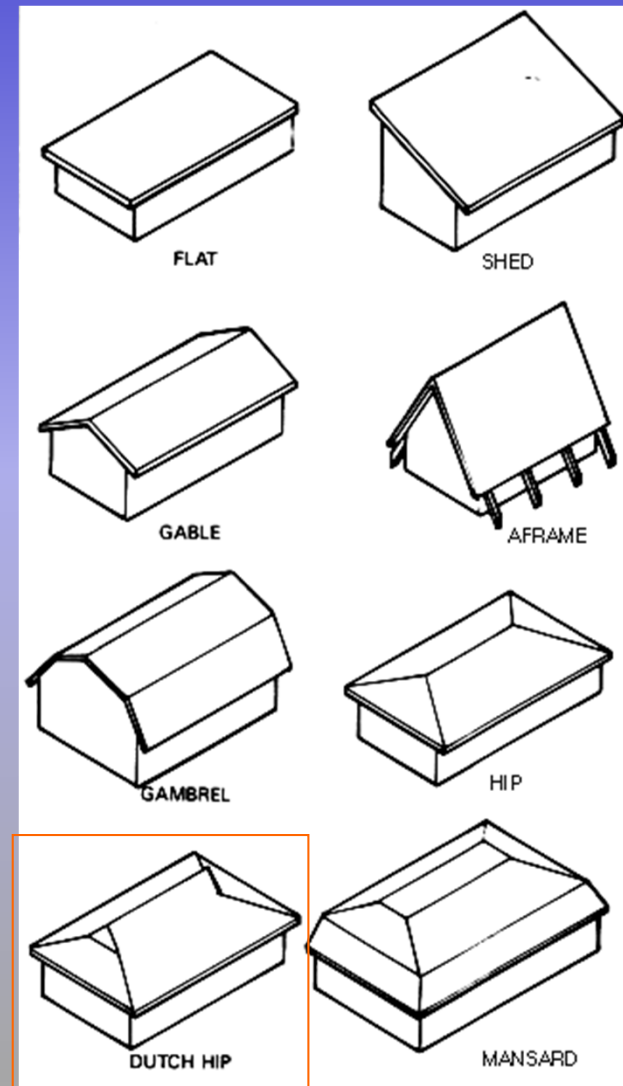
### Dutch Hip Roofs

The Dutch hip roof is the combination of a hip and gable roof

The center section of the roof is framed in a method similar to a gable roof. The ends of the roof are framed with a partial hip that blends into the gable roofs as seen in

The gable portion can provide location for attic daylighting or venting

On the roof plan, the shape, distance and wall location must be shown similar to the plan.



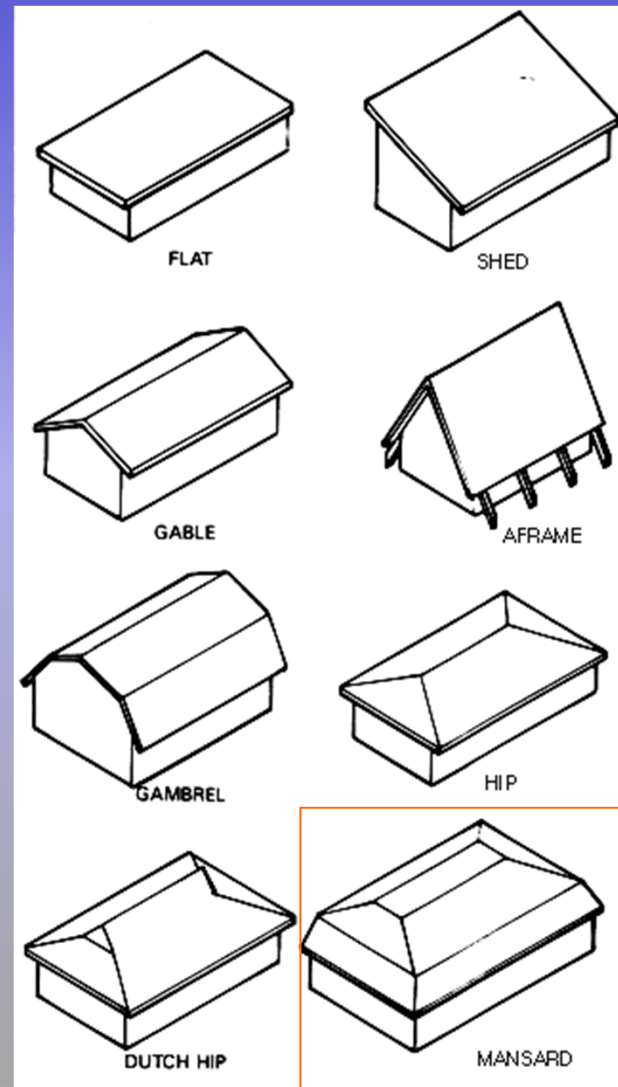
# Roofing Construction Systems

## Roof Types

### Mansard Roof

The mansard roof is similar to a gambrel roof but has the angled lower roof on all four sides rather than just two

The mansard roof is often used as a parapet wall to hide mechanical equipment on the roof or can be used to help hide the height of the upper level of a structure.



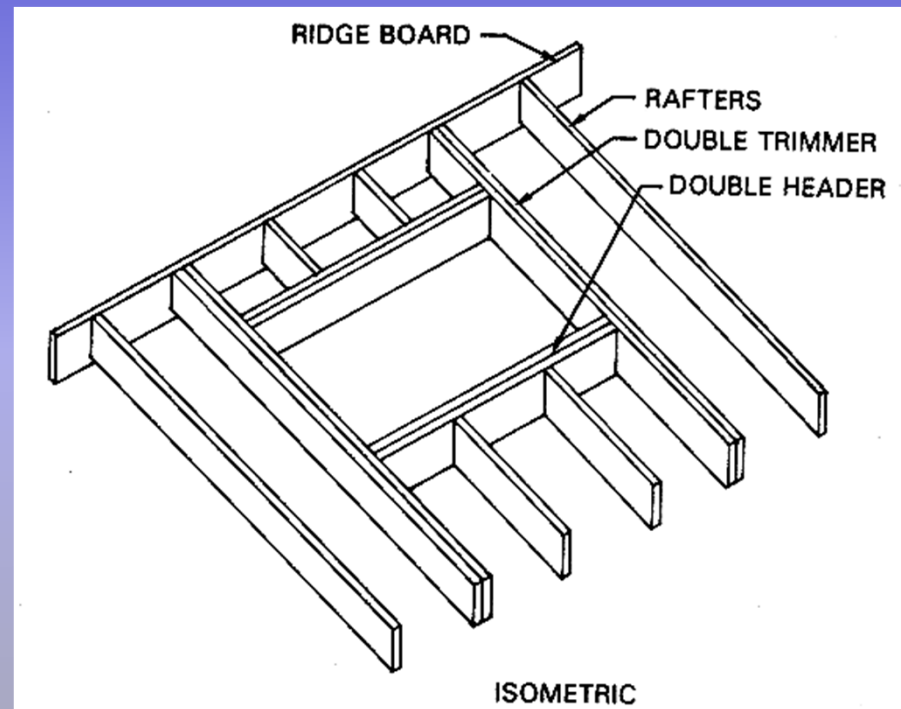
# Roofing Construction Systems

## Openings in Roof

Required when objects pass through the roof membrane such as skylights, dormers, vents chimneys etc

When opening extends beyond 2 or 3 rafters, the opening is framed like openings in floor

In truss roofs if opening is larger than two truss distances. The opening is more complicated.



# Roofing Construction Systems

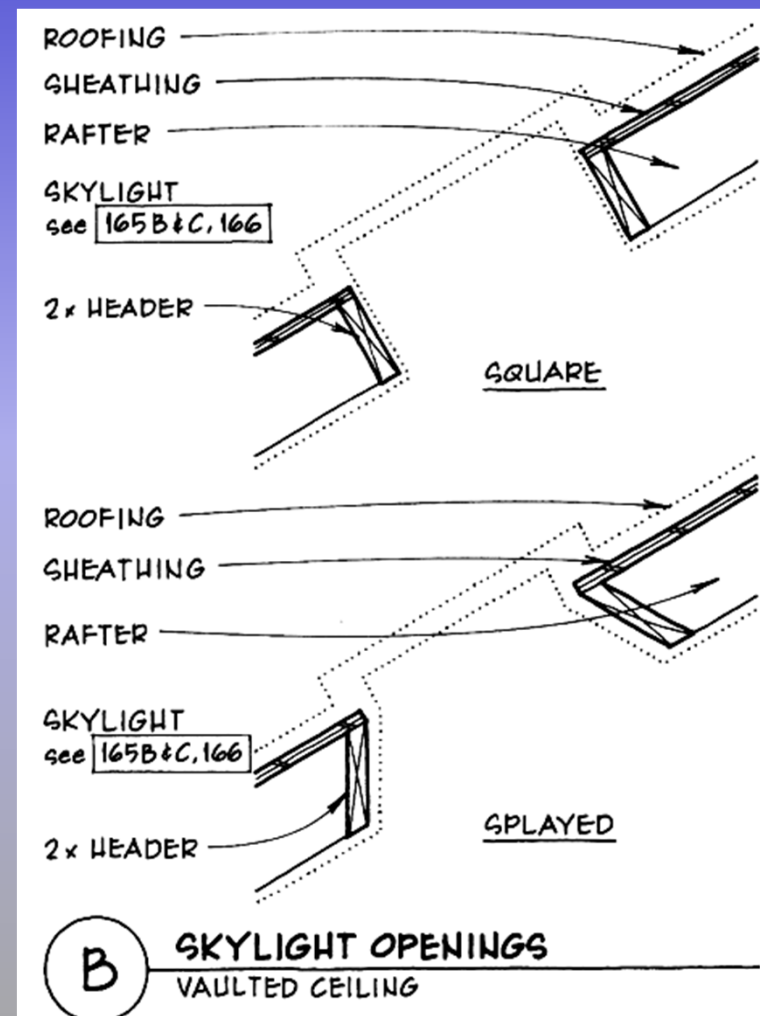
## Skylights

Skylights are openings in the roof which allow light penetration  
Skylights can light interior spaces that have no windows. This can cut down on electricity bills

Skylights can also be used to balance light in a space

The disadvantages of skylights are they can be a potential source unwanted heat gain in summer and lose in the winter.

Some of these problems can be eliminated by the proper placement and design of skylight



# Roofing Construction Systems

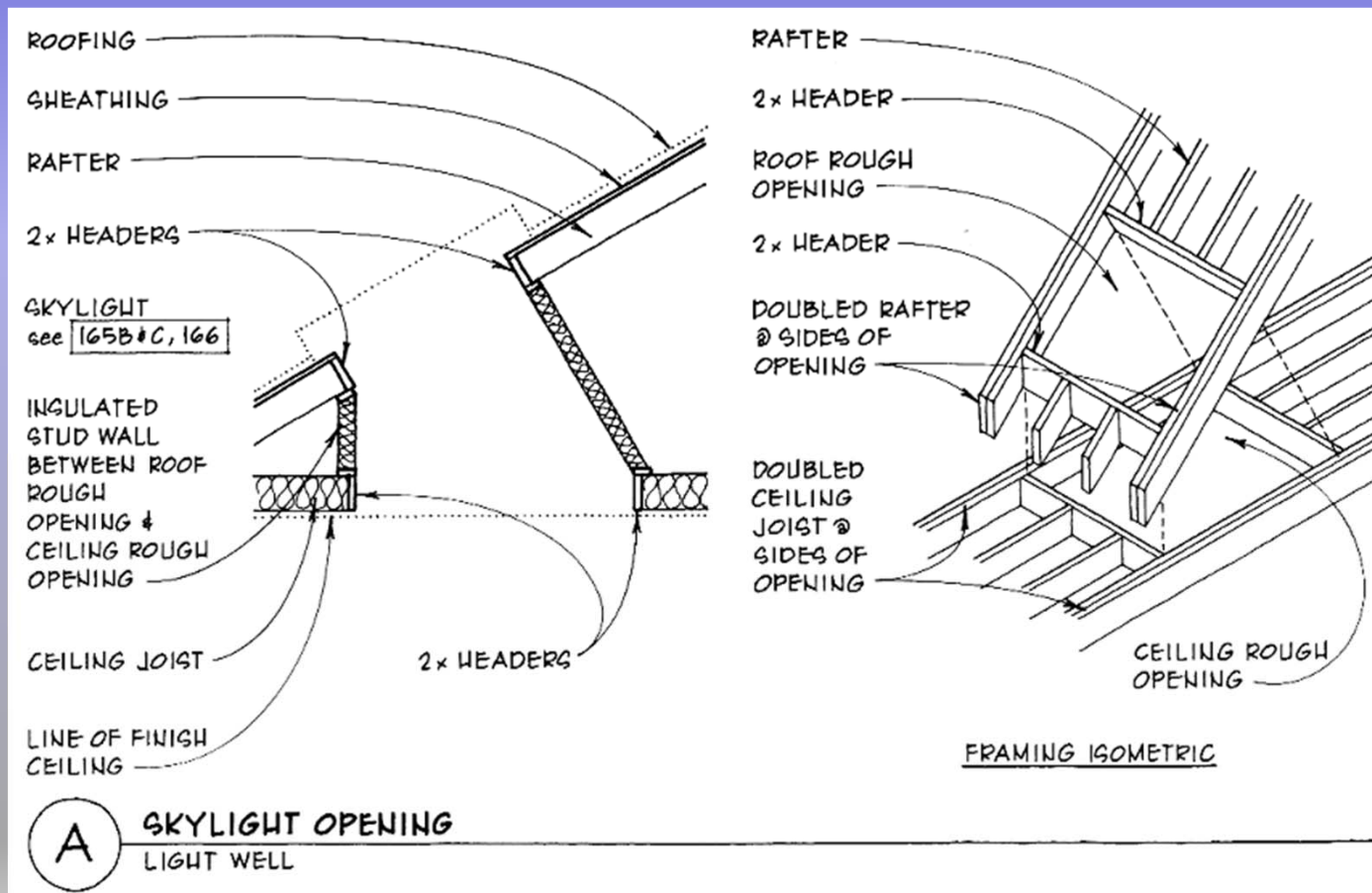
## Light Wells

Allow more light to penetrate

Less surface for radiant heat loss in winter

If made operable can provide vent shaft for summer cooling

In Florida, best to place on north side of building.



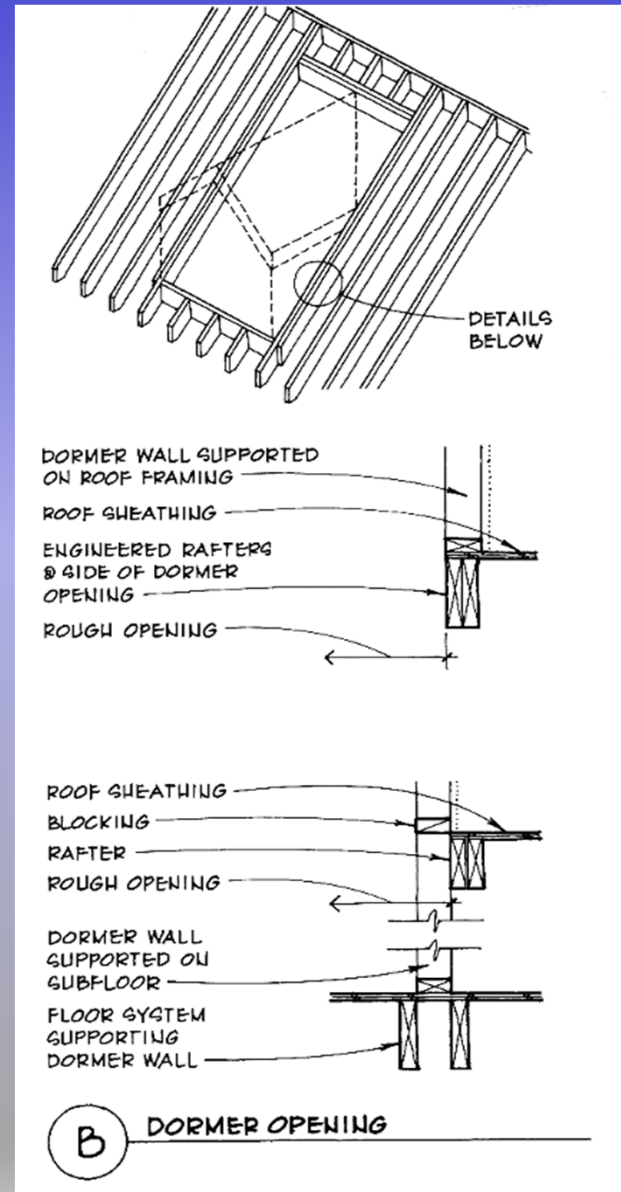
# Roofing Construction Systems

## Dormers

A dormer is an opening framed in the roof to allow for window placement. The window will provide added light and ventilation to rooms in what would normally be an attic space

The dormer consists of framed walls and a roof structure oriented perpendicular to the main roof structure

The walls of the dormer may stop at the rafters or may extend below the roof structure and be framed at the attic floor. In this case the floor takes the load of the dormer





# Roofing Construction Systems

## Finished Roofing

The finished roofing is the weather protection system. Typically roofing might include built up roofing, asphalt shingles, fiberglass shingles, cedar, tile, or metal panels

Material chosen depends on the pitch, aesthetics, weather and cost of structure

Square is the term often used to denote a area of roofing 100 ft x 100 ft.. The weight of roofing material is often described as 'lb. per square'. This information becomes valuable when choosing the size of structural members

# Roofing Construction Systems

## Roofing Materials

### Shingles, wood

Shingles is used to include wood shingles, and shakes, asphalt shingles slates, clay tiles and concrete tiles.

What these materials share in common is their small unit size and their application to the roof in overlapping layers with staggered vertical joints

### Wood Shingles

Thin tapered slabs of wood sawed from short pieces of tree trunk with the grain of the wood running approximately parallel to the face of the shingle

### Shakes

Split from the wood rather than sawn, and exhibit a much rougher face texture than wood shingles. Most wood shingles and shakes are made of red cedar

### *Fire hazard*

*Wood roof coverings are highly susceptible to fire and should only be used in areas of low fire danger.*

# Roofing Construction Systems

## Roofing Materials

### Asphalt shingles

Die cut form heavy sheets of asphalt impregnated felt faced with mineral granules that act as a wearing layer and decorative finish

The most common type of asphalt shingle is 12"x 36" in size

Each shingle is slotted twice to produce a roof that looks like it was made of smaller shingle

Asphalt shingles are inexpensive to buy, quick to install, moderately fire resistant, and have an expected life time of 10 to 20 years

# Roofing Construction Systems

## Roofing Materials

### Roll Roofing

The same sheet material from which asphalt shingles are cut can be purchased in rolls 3' feet wide and is known as asphalt roll roofing

Roll roofing is very inexpensive and is used primarily on storage sheds and farm building roofs

Its draw backs are that thermal expansion of the roofing or shrinkage of the wood deck can cause unsightly ridges to form in the roofing and that thermal contraction can tear it.

# Roofing Construction Systems

## Roofing Materials

### Clay Tiles

Used on roofs for thousands of years

Now the same patterns are available in concrete as well

Tile roofs are generally heavy durable and have a high fire resistance

All shingle types of tile must be laid on a roof deck that slopes sufficiently to assure leak proof performance

Minimum slopes for each material are specified by the manufacturer and often by building codes

Slopes greater than the minimum are suggested for areas where water is likely to get driven back up the tiles by high winds.

# Roofing Construction Systems

## Roofing Materials

### **Metal**

Sheets of lead and copper have been used as roofing material for centuries

These types of metals are self protecting and last for many decades

Today galvanized or painted metal roofing is commonly used.

They are installed in 8' or 12' long and 2' wide sheets.

The seams are usually standing or batten seams and provide for a strong visual stripping of the roof.

# Roofing Construction Systems

## Roofing Materials And Building Codes

Manufacturing standards and installation procedures for roofing materials are specified by many building codes

Building codes also regulate the type of roofing that may be used on a building, based on a required level of fire resistance as measured by ASTM testing procedure E108.

Roofing materials are grouped into four categories:

- 1. Class A** roofing materials are effective against severe fire exposure. They include slate tiles, concrete tiles, clay tiles
- 2. Class B** roof coverings are effective against moderate fire exposure, and include sheet metal roofing and some composition shingles. These are the minimum class that may be used on building of type 1 construction.

# Roofing Construction Systems

## Roofing Materials And Building Codes

Roofing materials are grouped into four categories:

- 3. Class C** roof coverings are effective against light fire exposure. They include most asphalt and fire retardant treated wood shingles and shakes. These are the minimum class that may be used on types 2,3, and 4a construction
- 4. Non classified** roof coverings such as untreated wood shingles may be used on type 4b construction and on some agricultural, accessory and storage buildings

The required class of roofing for a particular building may also be affected by an urban fire zone in which the building is located and by the proximity of the building to its neighbors.



# Roofing Construction Systems

## Thermal And Moisture Barriers

### Moisture

#### Flashing:

Flashing is generally 20 to 26 gage metal used at wall and roof intersections to keep water from seeping or blowing into joints.

#### Gutters

Carry the water that runs down the slope out to the down spouts

#### Down spouts

Carry water down to the drainage system that in turn runs it out to the storm sewage system in the street.

#### Ventilation

# Roofing Construction Systems

## Thermal And Moisture Barriers

### Moisture Condensation

**When there is a difference in temperature between inside and out side, moisture will tend to condense on the warm side**

**Insulation** has a foil or Kraft paper lining on the warm side to keep moisture from condensing on that side and creating a problem with mold growth

**Roof Venting** keeps condensation from building up underneath the sheathing. It also helps deter the problems described below.

# Roofing Construction Systems

## Roof Plan Layout

The design of a roof plan is considered early in the design process of a structure

The actual drawing of the roof plan for the working drawings; be completed once the design has been finalized.

The size of the overhang varies

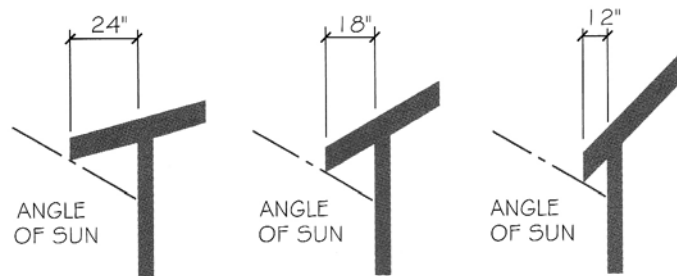


FIGURE 21.1 ■ The steeper the roof pitch, the more shadow will be cast. Typically the overhang is decreased as the pitch is increased.

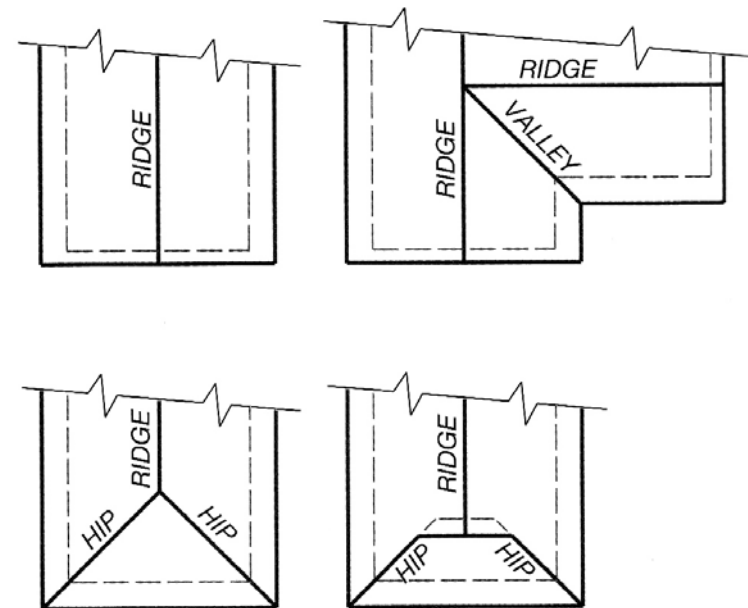


FIGURE 21.3 ■ Changes in roof shape are shown with thick, solid lines.

# Roofing Construction Systems

## Roof Plan Layout

When two perpendicular roofs intersect each other, a valley will be formed at  $45^\circ$  to the walls.

Each valley is drawn at an angle equal to half of the angle between the supporting walls

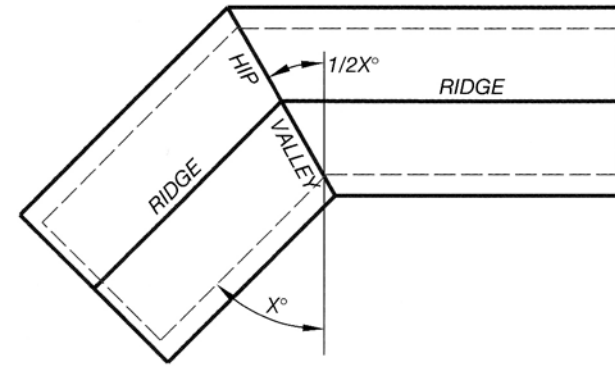
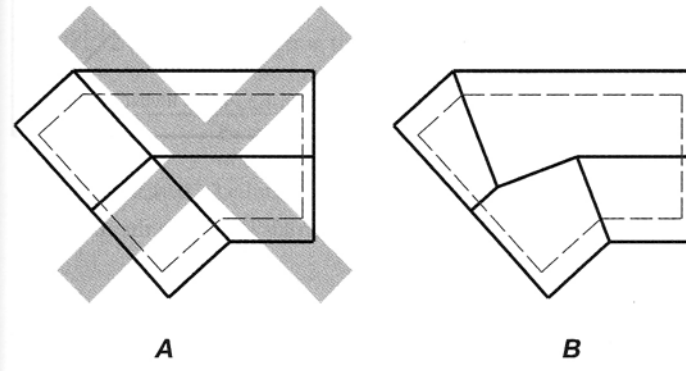


FIGURE 21.9 ■ When walls are equally spaced but not perpendicular, the roof surfaces occur along a line, as shown.



# Roofing Construction Systems

## Roof Plan Layout

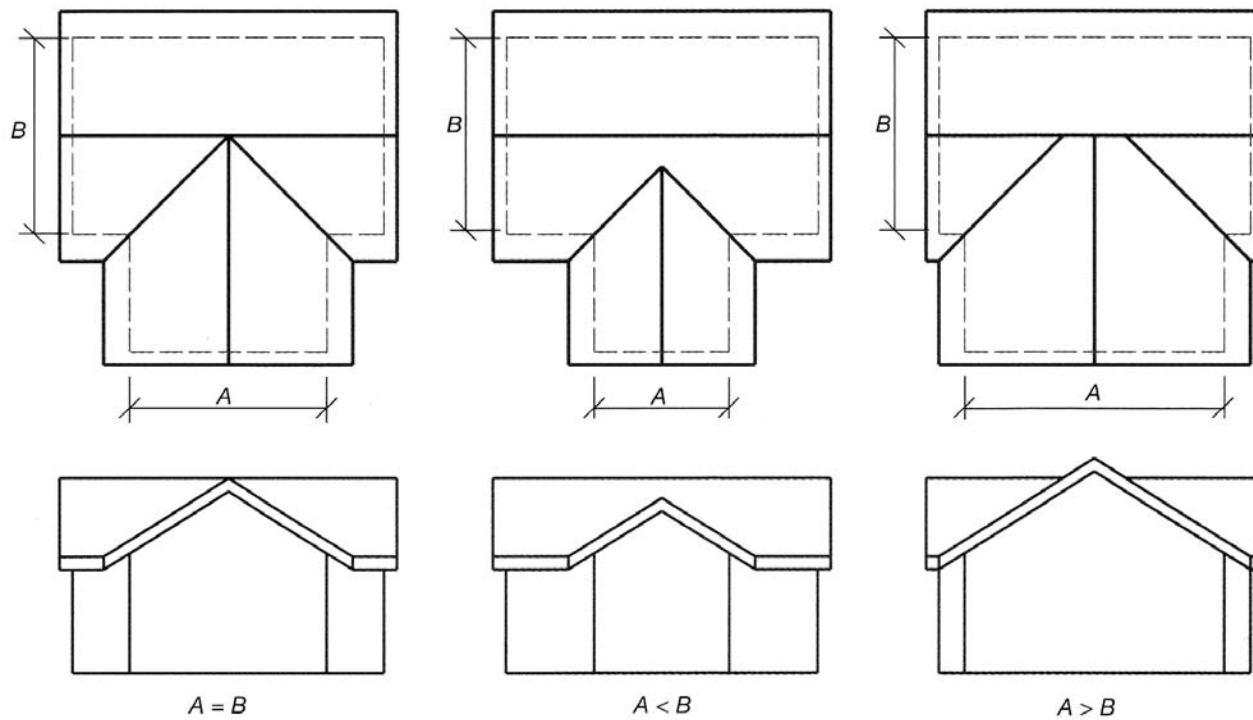


FIGURE 21.7 ■ Although the basic shape remains the same, the roof plan and elevations change as the distance between walls varies.