Lesson 7: Roof Support Systems

Roof support systems in agricultural structures generally involve some type of rafter system. This lesson will explore the different components of rafter systems, their function, and their construction. An overview of different styles of roofs will be presented as well since roof styles are determined by the roof support system's configuration.

Trusses and Rafters

A truss is a structural assembly of lightweight material consisting of connected triangles formed by rafters, joists, or beams that is used to create a system designed to support heavy loads over a considerable span. Trusses may be made of wood, wood products, metal, or a combination of any or all of these materials. Truss designs will vary depending on the needs of the structure. For the purposes of agricultural construction, trusses are nearly always prefabricated units The ability to safely support roof loads, including live loads from ice, snow, or wind and the dead load of the material, is critical to a roof support system. Load is therefore an important consideration when selecting a roof system. The choice of a roof system will vary depending on the weather of the geographical area, which will determine the wind and snow loads on the structure. Different materials and roof designs have varying load capacities. General information about load and roof systems is available from construction reference materials or in professionally prepared construction plans. In recent years, the industry of prefabricated trusses has eliminated much of the need for working with this information. Reputable truss companies have engineers or other professionals on hand to design roof support systems for specific structures.

Table 7.1 - Pitch and Slope

Pitch	Slope
1/8	3:12
1/6	4:12
1/4	6:12
1/3	8:12
1/2	12:12

designed for a specific structure that are transported to the construction site and mechanically placed in position on the structure. Figure 7.1 is an example of a truss.

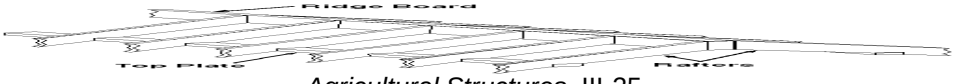
A rafter is a structural member that spans from a wall's top plate to the ridge board of the roof to support the roof, as shown in Figure 7.2. In common terminology, rafter generally describes a site-built truss-type system. As shown in the Figure 7.1, rafters are part of a truss system, and a "trussed rafter" is the correct term for a truss.

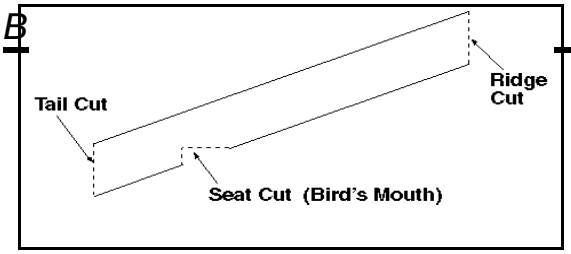
Selecting a Roof System

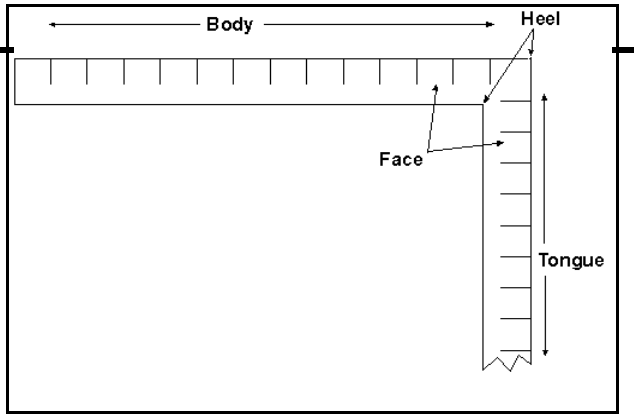
The economics of cost and labor are another factor to consider when selecting a roof system. Truss companies will build to order, and generally they provide this service at a cost equal to or less than the cost of manufacturing systems on site. Roof support systems for smaller structures may be built on site at a savings, however. When making these decisions, the labor involved in cutting and assembling systems as opposed to buying prefabricated units must be considered.

Pitch

Pitch is a term used to describe a roof's steepness. The pitch of a roof can be flat to very steep. Architects, engineers, or other building professionals can determine if a given pitch is acceptable for supporting loads and provides an efficient use of material.







In order to calculate pitch, the rise and run of the roof must be known. Rise is the vertical distance from the top plate to the ridge. Run is the horizontal distance covered by one rafter from the outside edge of the top plate to the exact center of the ridge. Span is the total distance from the outside edge of one wall to the outside edge of the other wall. Span is equal to twice the run. All measurements of rafters are made relative to a measuring line that runs parallel to the side of the rafter and extends from the middle of the ridge board to the outer edge of the top plate.

Pitch may be defined as a fraction that is a ratio of the rise to the span. Pitch may also be expressed as slope in a ratio of the number of inches of rise per foot of run. Table 7.1 shows relationships between pitch and slope. An example of slope is 6 in 12, or 6:12, meaning six inches of elevation for every twelve inches of length, as shown in Figure 7.3. As illustrated in the diagram, slope is shown using an inverted right triangle and the accompanying rise and run numbers.

Common slopes for a roof are 4:12, 5:12, and 6:12. Buildings where snow buildup or storage space above trusses is not a concern commonly use 4:12 slopes, because the roof does not need to be as steep. A slope of 6:12 is used where storage space is desirable or snow loads are heavy.

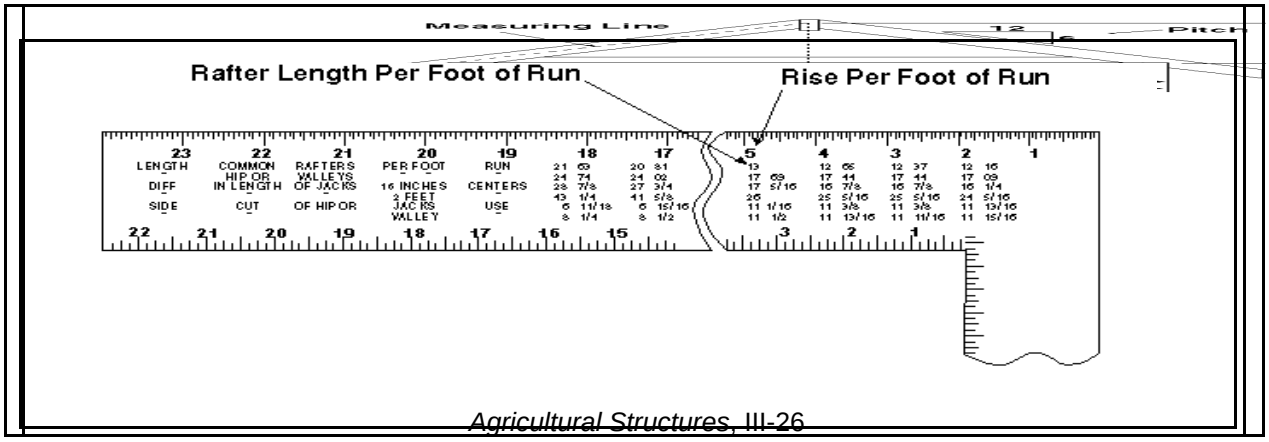
Calculating Pitch

$$Pitch = \frac{Rise}{2 \times Run}$$

When expressing pitch as a fraction, the degree of pitch is calculated using the formula shown. A roof with a rise of 6 feet and a run of 12 feet has a pitch of ¼.

Parts of a Rafter

A rafter is a piece of dimensional lumber that constitutes the main member of a roof support system. Rafters are commonly made of 2" × 8" or 2" × 10" boards in the desired lengths. The tail, or overhang, is the part of the rafter that forms the part of the roof from the side of the building to the end of the roof. The other parts of a rafter are the cuts made to allow the rafter to fit properly in the roofing system. Rafters have three kinds of cuts, as illustrated in Figure 7.4, which shows the positions and angles of these cuts. A tail cut is made at the end of the rafter and is parallel with the wall. A seat cut, sometimes referred to as a bird's mouth, is a notch cut out of a rafter that allows the rafter to be seated on the top plate. The ridge cut, also called a plumb cut, is made at the end of the



rafter that fits against the ridge board and allows the rafter to fit flush against the ridge.

Rafter Layout

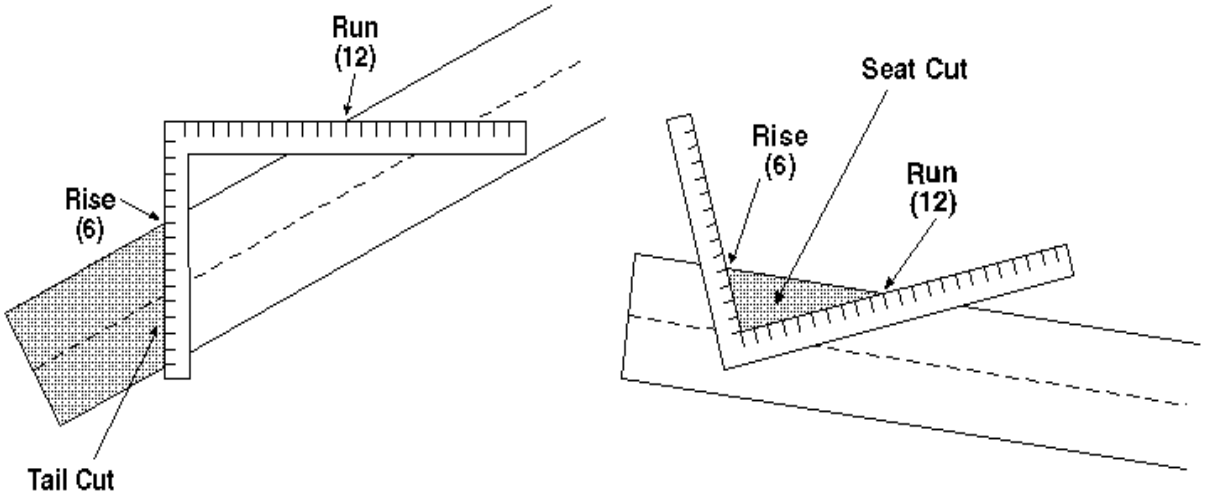
Rafter layout most commonly involves the use of a framing square (Figure 7.5). The face of the square is the side seen when holding the tongue of the square in the right hand with the body The rafter table, shown in Figure 7.6, is used to determine the length of the rafter. To lay out a rafter, the rise and the run are needed. First, the number that indicates the rise per foot of run on the "inch" line on the body of the framing square must be located. In the rafter table beneath this number is a number indicating the length of a common rafter per foot of run; a space between these numbers is read as a decimal point. This second number is multiplied by the number of feet of run. The desired length of the tail is added, and one-half the thickness of the ridge board is subtracted. After rounding as needed to the nearest ¼ inch, this number is divided by 12 to find the length in feet and inches.

As an example, suppose rise per foot of run is 5 inches. The table in Figure 7.6 indicates that the length of a common rafter with a rise of 5 inches is 13 inches per foot of run. The run for the roof, including the amount of projection, is 14 feet. Fourteen multiplied by 13 is 182 inches; subtracting 3/4 inches for half the thickness of the ridge board leaves 181.25 inches, or 15 feet, 1¼ inches.

Once the length has been established, the various cuts can be made on the rafter. The tail cut is made at the end of the board that overhangs the structure, as shown in Figure 7.7. The measuring line is marked in the center of the rafter material. Then the correct length of the rafter is measured and marked along the line. The square is placed on the material and the number 12 on the body is aligned with the top of the board to indicate the run. The framing square is pivoted until the number 5 on the tongue, indicating the rise, aligns to the top edge of the board. The outside edge of the tongue must be even with the mark made along the measuring line to represent the length of the rafter. The tail cut is marked along the outside edge of the tongue. The rafter is then cut.

The ridge cut is made in the same manner as the tail cut but at the opposite end of the material. Again, the outside edge of the tongue must be aligned with the mark indicating the length of the rafter found at this end of the measuring line.

The seat cut is made by first measuring the length of the tail and marking this point on the measuring line. The depth of the seat cut is usually the same as the thickness of the piece of material used in the top plate, most commonly 1½ to 3 inches. The material with the edge to be cut is laid facing the opposite direction. The framing square is placed on the material with the body pointing to the right and the tongue pointing to the left, as in the illustration. Various tables and scales are found on this versatile tool. Even inexpensive squares include tables for rafters and graduated scales of 1/6, ½, _,and ¼, which are common pitches. These scales provide specific information on laying out cuts for these pitches.



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up. The inside edge of the tongue is aligned to the mark indicating the length of the tail and the tongue is adjusted until the rise and run correspond with the edge of the board. The wedge-shaped section is marked and cut out.

Constructing a Top Plate

Top plate construction is generally a simple procedure. Dimensional lumber of the same size used for the wall studs, usually 2" × 4" or 2" × 6" boards, is attached to the tops of the studs. Often a second piece of the same material is attached to increase strength and stability. If the top plate is doubled, the joints of the layers should not overlap; staggering the joints will further increase the strength of the structure.

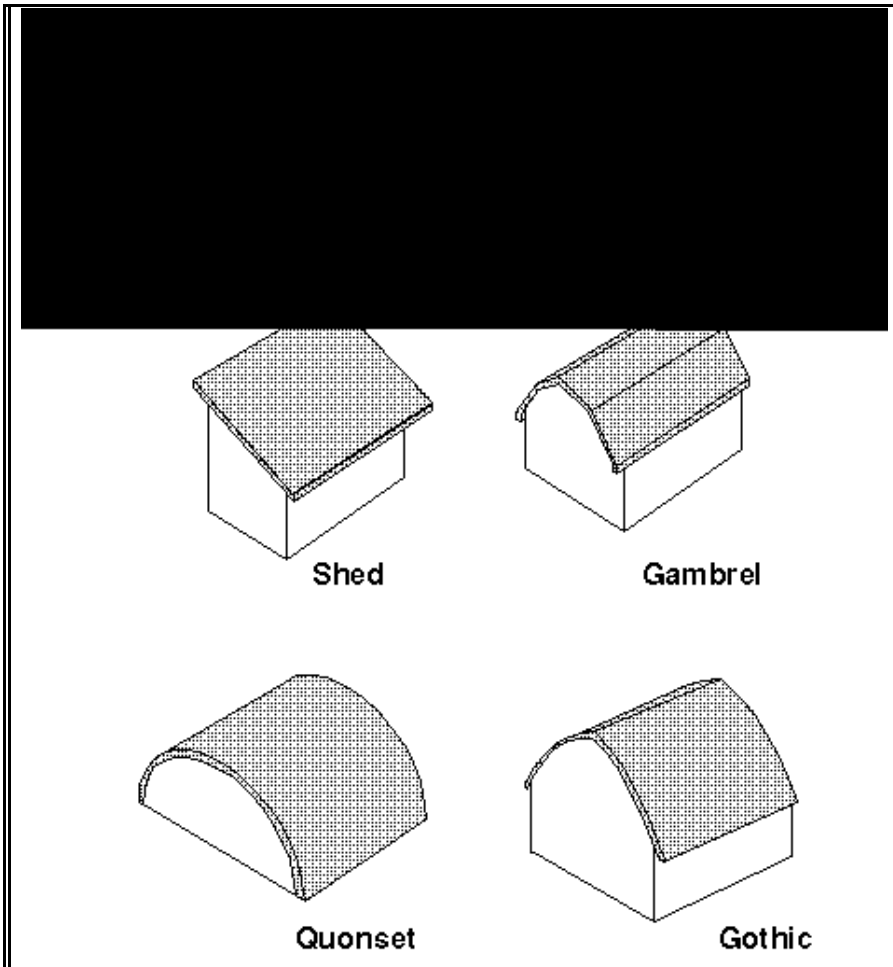
Ordering Trusses

Ordering trusses is made easy with the help of professional representatives from the manufacturer. These people are able to make suggestions and explain the options. Perhaps the most important information to supply to a truss manufacturer is a copy of the building's plans, which will provide all the technical information needed, including span, run, rise, and pitch. The builder will probably also want to be told the type of roofing material to be used, although this information may not affect the design. Other important information the truss manufacturer will need is the desired delivery date and time and, if a representative has not been on the building site, exact directions.

The top plate is a wall member that is usually made of the same material as a wall's studs. It is attached to the top of the studs. Rafter seat cuts fit over the top plate, connecting the wall to the roof support system.

Roof Styles

The most common types of roof styles used in agricultural structures are shed, hip, gable, gambrel, mansard, quonset, and gothic, or



arched. (Figure 7.8). These roof types were introduced in Lesson 2 of this unit. Any of these styles or combinations of styles may be found in most areas. As was previously discussed, the choice of a particular roof style is based on the structure's function, personal preferences, and affordability. If proper planning and materials are utilized, all the roof styles are comparable in function in regard to protection from the elements.

Shed - A shed roof has only a single pitch. This type of roof is usually found on smaller structures of 2,000 square feet or less. It has the advantage of being inexpensive to construct and simple to frame and install. Because the slope of the roof is relatively shallow, it is able to resist winds well.

Hip - Hip roofs have an attractive appearance. However, they are difficult to frame and install. Poor ventilation of attic areas can also be a problem.

Gable - Gable roofs are very common and are often used for agricultural structures. They are relatively inexpensive and easy to frame. If the pitch of the roof is not too steep, this design may be extremely wind resistant.

Gambrel - Gambrel roofs use two different pitches, with the top pitch being approximately 30 degrees and the bottom pitch around 60 degrees. It is used for barns, because the design provides the advantage of spacious overhead room for storage. However, these roofs can be expensive and are more difficult to construct. They also are less resistant to damage from winds.

Mansard - Like hip roofs, the mansard roof style is regarded as having an attractive appearance. One potential problem with this type of roof is that it leaks more easily because of the shallow pitch of the roof.

Quonset - A Quonset structure has no flat surfaces. Instead, the structure forms a semicircle with an arching roof. Quonset buildings are usually sold as a package and are therefore easy to construct.

Gothic/arched - In a Gothic or arched roof, two curving arches meet at a point. Some structures with this type of roof are similar to Quonset buildings in that they have no walls; the arches make up the sides of the building as well as the roof. However, a Gothic roof may be used for other types of buildings, such as barns, that do have distinct walls. The arches create a strong roof with large storage volume.

Summary

Roof support systems generally consist of either trusses or some other type of rafter system. Systems may be prefabricated and ordered from a manufacturer or built on site. The type of roof system chosen will depend on load, cost, and labor considerations. One important aspect to consider for any roof is its pitch, or steepness. Several different roof styles may be used.

Credits

Ball, John E. *Tools, Steel Square, and Joinery*. Vol. 1 of *Carpenters and Builders Library*. Revised by John Leeke. New York: Macmillan Publishing Co., Inc., 1991.

Boyd, James S. *Practical Farm Buildings.* 3rd ed. Revised by Joshua L. Reynolds. Danville, Ill.: Interstate Publishers, Inc., 1993.

Burch, Monte. *How to Build Small Barns and Outbuildings*. Pownal, Vt.: Storey Communications, Inc., 1992.

Huth, Mark W. *Construction Technology*. 2nd ed. Albany, N.Y.: Delmar Publishers, Inc., 1989.

Lindley, James A., and James H. Whitaker. *Agricultural Buildings and Structures.* Rev. ed. St. Joseph, Mich.: American Society of Agricultural Engineers, 1996.