

UNIT III - BUILDING CONSTRUCTION

Lesson 7: Roof Support Systems

Competency/Objective: Select a roof support system.

Study Questions

1. What is the difference between a truss and a rafter?
2. How is a roof system selected?
3. What is pitch?
4. How is the pitch of a roof figured?
5. What are the parts of a rafter?
6. How is a rafter laid out?
7. What is a top plate?
8. How is a top plate constructed?
9. How is a truss ordered?
10. What are the types of roof styles?

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit III.
2. Transparency Masters
 - a) TM 7.1: Sample Truss
 - b) TM 7.2: Rafters
 - c) TM 7.3: Pitch
 - d) TM 7.4: Parts of a Rafter
 - e) TM 7.5: Rafter Table
 - f) TM 7.6: Rafter Cuts
 - g) TM 7.7: Roof Styles
3. Job Sheet
 - a) JS 7.1: Rafter Layout

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TEACHING PROCEDURES

B. *Review*

Lesson 6 discussed the functions of walls, their different methods of construction, and their components. Most agricultural structures will also require a roof. A vital part of a roof is its support system. This lesson explores aspects of roof support systems and various options available as well. The process of laying out a rafter is also described.

C. *Motivation*

Prepare a model of a truss made of 2" × 4" boards, balsa, thin strips of pine, etc. Discuss the parts of the model with the class.

D. *Assignment*

E. *Supervised Study*

F. *Discussion*

1. If the model prepared for the motivation is available, use it to illustrate what a truss looks like. TMs 7.1 and 7.2 can also be used to show the differences between a truss and a rafter. Discuss these differences.

What is the difference between a truss and a rafter?

- a) Truss
 - 1) Structural assembly of lightweight material consisting of connected triangles used to create a system designed to support heavy loads over a considerable span
 - 2) Made of wood, wood products, metal, or a combination of any or all of these materials
 - 3) Vary in design depending on the needs of the structure
 - 4) Nearly always prefabricated units designed for a specific structure that are transported to the construction site and mechanically placed in position
 - b) Rafter
 - 1) Structural member that spans from a wall's top plate to the ridge board of the roof
 - 2) Generally describes a site-built truss-type system
2. Discuss load as an aspect of selecting a roof system. Point out that due to liability, more and more people are turning to professionals for information about load and roof support systems. Discuss the economics of labor and time involved in building a roof system.

How is a roof system selected?

- a) Ability to safely support roof loads
 - 1) The choice of a roof system will vary depending on the weather of the geographical area, which determines wind and snow loads.
 - 2) Different materials and roof designs have varying load capacities.
- b) Economics of cost and labor
 - 1) Truss companies will build to order and generally provide this service at a cost equal to or less than the cost of manufacturing a system on site.

- 2) Roof support systems of smaller structures may be built on site at a savings.
 - 3) The labor involved in cutting and assembling systems must be considered.
3. Ask students to define pitch. Use TM 7.3 to illustrate pitch. Again, the model suggested in the motivation section could be used as a tool for initiating this discussion.

What is pitch?

- a) Pitch is the steepness of a roof.
 - b) To calculate pitch, the rise and run for the roof must be known.
 - 1) Rise - vertical distance from the top plate to the ridge
 - 2) Run - horizontal distance covered by one rafter from the outside edge of the top plate to the exact center of the ridge
 - 3) Span - Total distance from the outside edge of one wall to the outside edge of the other wall; equal to twice the run
 - c) Pitch may be defined as a fraction that is a ratio of the rise to the span.
 - d) Pitch may also be expressed as slope in a ratio of the number of inches of rise per foot of run.
 - 1) Example: 6:12, meaning six inches of elevation for every twelve inches of length
 - 2) Shown using an inverted right triangle and the accompanying rise and run numbers
4. Write these formulas on the blackboard and discuss them. Have students work some sample problems to understand how pitch is calculated.

How is the pitch of a roof figured?

$$Pitch = \frac{Rise}{2 \text{ ' } Run}$$

5. Use TM 7.4 to illustrate the parts of a rafter. Discuss the different parts with the class.

What are the parts of a rafter?

- a) Tail (overhang) - part of the rafter that forms the part of the roof from the side of the building to the end of the roof
 - b) Tail cut - cut made at the end of the rafter, parallel with the wall
 - c) Seat cut (bird's mouth) - notch cut out of a rafter that allows the rafter to be seated on the top plate
 - d) Ridge cut (plumb cut) - cut made at the end of the rafter that fits against the ridge board and allows the rafter to fit flush against the ridge
6. A carpenter's framing square is almost essential to teach this part of the lesson. Show the class the rafter table on the framing square and discuss how it is used. Obtain three or four feet of 2" × 8" material and make the tail, ridge, and seat cuts. Have all the students observe how the numbers on the square were used to determine the exact places to cut. TMs 7.5 and 7.6 can also be used to illustrate the rafter table and how to make the cuts on the rafter. Hand out JS 7.1.

How is a rafter laid out?

- a) Determine the length of the rafter.
 - 1) Locate the number that indicates the rise per foot of run on the blade of the framing square.
 - 2) In the rafter table beneath this number is a number indicating the length of a common rafter per foot of run.
 - 3) Multiply this second number by the number of feet of run.
 - 4) Add the length of the tail and subtract one-half the thickness of the ridge board; round as needed to the nearest 1/4 inch.
 - 5) Divide by 12 to find the length in feet and inches.
- b) Make the tail cut at the end of the board that overhangs the structure.

- 1) Mark the measuring line in the center of the rafter material and then measure and mark the correct length of the rafter along the line.
 - 2) Place the square on the material and align the body's number 12 with the top of the board.
 - 3) Pivot the framing square until the number indicating the rise on the tongue 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.
 - 4) Mark the tail cut along the outside edge of the tongue and cut the rafter.
 - c) Make the ridge cut at the opposite end of the material.
 - 1) The ridge cut is made in the same manner as the tail cut.
 - 2) Take care to align the outside edge of the tongue with the mark indicating the length of the rafter found at this end of the measuring line.
 - d) Make the seat cut.
 - 1) Measure the length of the tail and mark this point on the measuring line.
 - 2) Lay the material with the edge to be cut facing the opposite direction.
 - 3) Place the framing square on the material with the body pointing to the right and the tongue pointing up.
 - 4) Align the inside edge of the tongue to the mark indicating the length of the tail; adjust the tongue until the rise corresponds with the edge of the board and the number 12 is on the inside edge of the body on the edge of the board.
 - 5) Mark and cut out the wedge-shaped section.
7. Use TM 7.2 to show what a top plate looks like. Discuss the function and location of this structural member.

What is a top plate?

- a) A top plate is a wall member that is usually made of the same material as a wall's studs.
 - b) It is attached to the top of the studs.
 - c) Rafter seat cuts fit over the top plate, connecting the wall to the roof support system.
8. Discuss how to construct a top plate.

How is a top plate constructed?

- a) Dimensional lumber of the same size used for the wall studs is attached to the tops of the studs.
 - b) Often a second piece of the same material is attached to increase strength and stability; the joints of the layers should not overlap.
9. Ask students to list information a truss manufacturer would need to know if trusses were ordered from the company. Discuss the information given below.

How is a truss ordered?

- a) Supply the truss manufacturer with a copy of the building's plans, which will provide all the technical information needed.
 - b) Tell the builder the type of roofing material that will be used.
 - c) Provide the desired delivery date, time, and exact directions to building site.
10. Ask students to list some roof styles used for agricultural structures. Use TM 7.7 while describing the characteristics of the different styles.

What are the types of roof styles?

- a) Shed
 - 1) Only a single pitch
 - 2) Usually found on smaller structures of 2,000 square feet or less

- 3) Inexpensive to construct
- 4) Simple to frame and install
- 5) Able to resist winds well because the slope of the roof is relatively shallow
- b) Hip
 - 1) Attractive appearance
 - 2) Difficult to frame and install
 - 3) Poor ventilation of attic areas
- c) Gable
 - 1) Often used for agricultural structures
 - 2) Relatively inexpensive and easy to frame
 - 3) May be extremely wind resistant if the pitch of the roof is not too steep
- d) Gambrel
 - 1) Two different pitches, with the top pitch being approximately 30 degrees and the bottom pitch around 60 degrees
 - 2) Used for barns, because the design provides the advantage of spacious overhead room for storage
 - 3) Expensive
 - 4) More difficult to construct
 - 5) Less resistant to damage from winds
- e) Mansard
 - 1) Attractive appearance
 - 2) Leaks more easily because of the shallow pitch of the roof
- f) Quonset
 - 1) No flat surfaces
 - 2) Forms a semicircle with an arching roof
 - 3) Usually sold as a package and are therefore easy to construct
- g) Gothic/arched
 - 1) Two curving arches meeting at a point
 - 2) Structures
 - (a) Similar to Quonset buildings in that they have no walls
 - (b) Other types of buildings, such as barns, that do have distinct walls
 - 3) Strong roof
 - 4) Large storage volume.

G. ***Other Activities***

Have students research and prepare reports on truss systems. They should describe (and diagram, if possible) some of the different styles and configurations available.

H. ***Conclusion***

Roof support systems consisting of trusses or rafters are vital parts of agricultural structures. Truss systems are generally prefabricated and brought to the building site; rafter systems are commonly built on site. Either system may work well if loads are carefully considered, and the choice of which system to use is often based on the economics of cost and labor.

I. ***Answers to Activity Sheet***

J. ***Answers to Evaluation***

- 1. d
- 2. b
- 3. c
- 4. a
- 5. c

6. Answers may include any two of the following: shed, hip, gable, gambrel, mansard, Quonset, and Gothic/arched.
7. To increase strength and stability
8. Answers may include any of the following: supply the truss manufacturer with a copy of the building's plans, tell the builder the type of roofing material that will be used, and provide the desired delivery date, time, and exact directions to building site.
9. The ability to safely support roof loads and the economics of cost and labor
10. —

EVALUATION

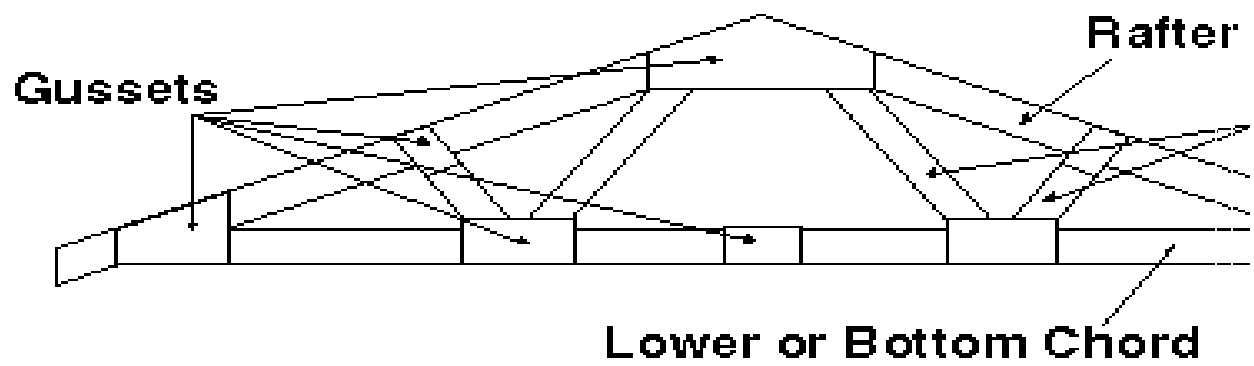
Circle the letter that corresponds to the best answer.

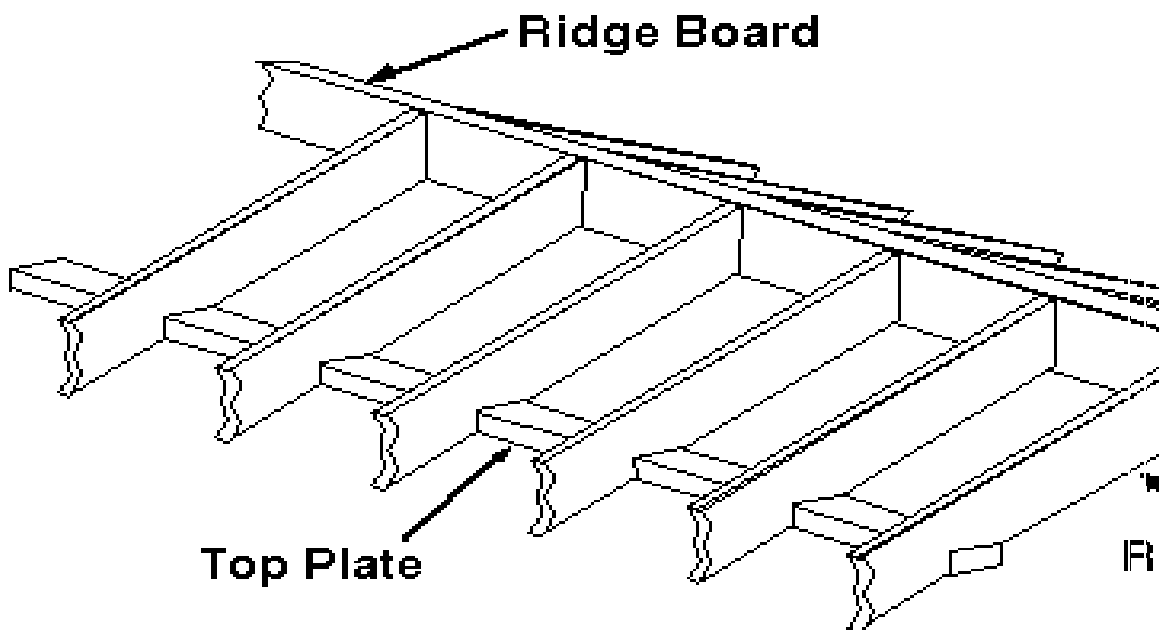
1. The structural member that connects the wall to the roof support system is the:
 - a. Ridge board.
 - b. Rafter.
 - c. Tail.
 - d. Top plate.
2. Which of the following is the part of the rafter that allows the rafter to be attached to the wall?
 - a. Ridge cut
 - b. Seat cut
 - c. Tail cut
 - d. Bird's tail
3. Pitch may be expressed as:
 - a. The ratio of the number of inches of run per foot of rise.
 - b. The rise divided by the run.
 - c. The ratio of the number of inches of rise per foot of run.
 - d. The run divided by the rise.
4. The structural member that spans from the wall to the ridge board of the roof is the:
 - a. Rafter
 - b. Tail
 - c. Seat
 - d. Truss
5. What is the first step in determining the length of the rafter?
 - a. Find the number on the rafter table indicating the length of a common rafter per foot of run.
 - b. Locate the number that indicates the run per foot of rise on the blade of the framing square.
 - c. Locate the number that indicates the rise per foot of run on the blade of the framing square.
 - d. Find the number on the rafter table indicating the length of a common rafter per foot of rise.

Complete the following short answer questions.

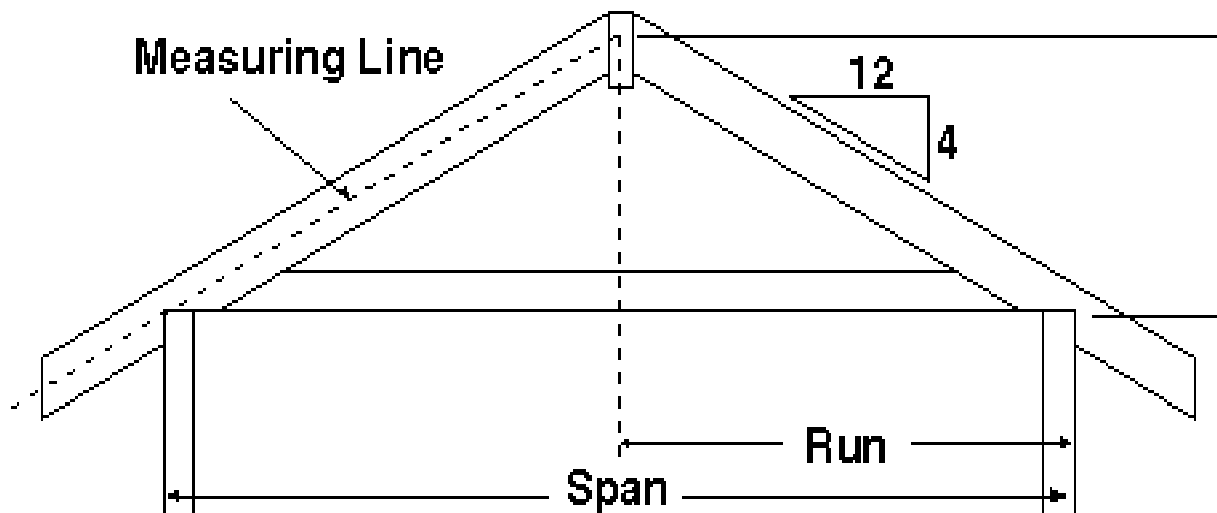
6. What are two types of roofs commonly used for agricultural structures?
 - a.
 - b.

7. What is one thing that must be done when ordering a truss?
8. When constructing a top plate, why would it be doubled?
9. What are two things that must be considered when selecting a roof system?
 - a.
 - b.
10. What is the pitch of a roof with a rise of 8 feet and a run of 12 feet?





Pitch



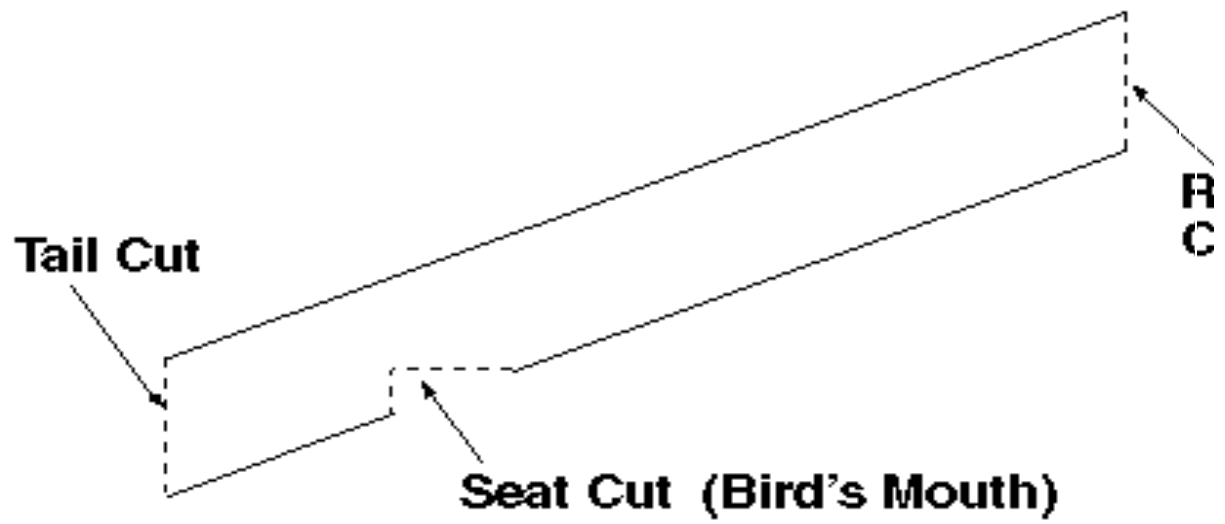
Span = 24 feet

Rise = 4 feet

Run = 12 feet

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

What is the pitch? What is the slope?



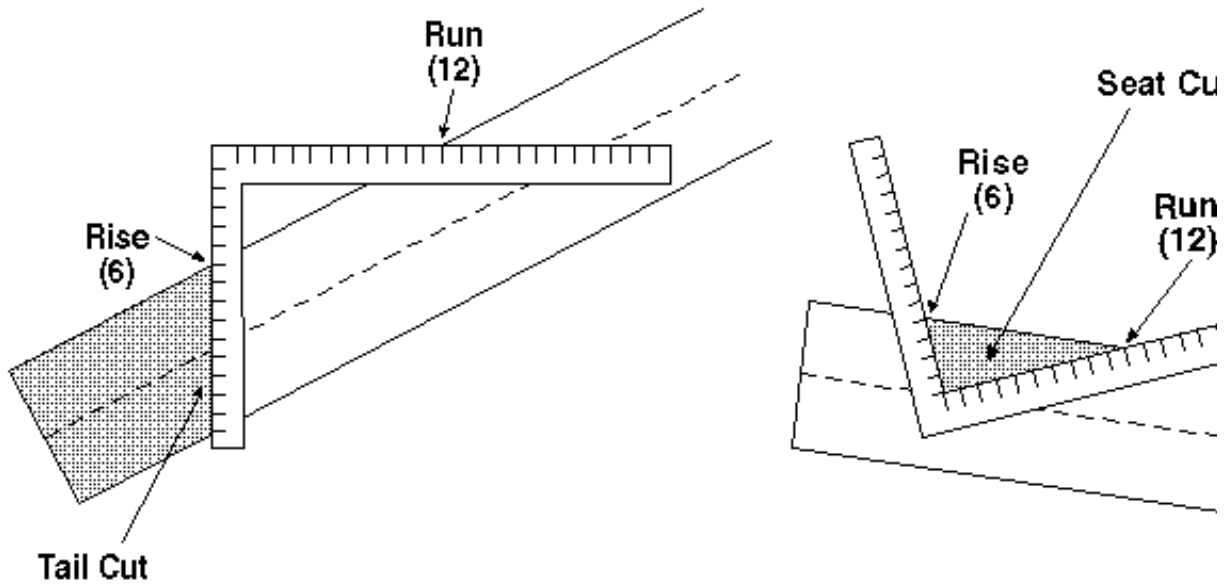
Rafter Table

Rafter Length Per Foot of Run

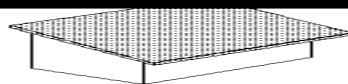
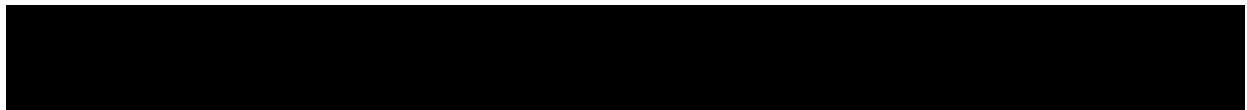
Rise P

23	22	21	20	19	18	17	5	4	
LENGTH	COMMON	RAFTERS	PER FOOT	RUN	21 63	20 81	13 63	12 66	
	HIP OR	VALLEYS			24 74	24 02	17 63	17 44	
DIFF	IN LENGTH	OF JACKS	16 INCHES	CENTERS	28 7/8	27 3/4	17 5/16	16 7/8	
			2 FEET		43 1/4	41 5/8	26	25 5/16	
SIDE	CUT	OF HIP OR	JACKS	USE	6 11/16	6 15/16	11 1/16	11 3/8	
		VALLEY			8 1/4	8 1/2	11 1/2	11 13/16	
22	21	20	19	18	17	16	15	3	2

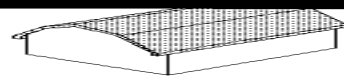
Rafter Cuts



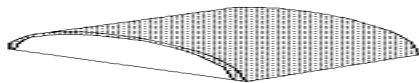
Roof Styles



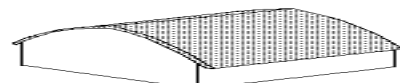
Shed



Gambrel



Quonset



Gothic

Lesson 7: Roof Support Systems

Name _____

Rafter Layout**Objective:** Lay out a rafter.**Materials and Equipment:**

Pencil and paper

Carpenter's framing square

Boards, strips of construction paper, cardboard, or rolls of fax paper

Procedure:

For this problem, lay out a rafter for a building that has a span of 10 feet and a rise of 5 feet. Using rafter material provided, lay out the ridge cut, seat cut, and tail cut. Assume that the overhang is 12 inches long. The slope is 6:12, because the rafter will have 6 inches of rise for every foot of run.

1. Using the rafter material, begin at one end by marking the ridge cut. For this exercise, you will use the step method of using a framing square.
2. Place the square so that the 6-inch mark on the tongue is on the edge of the square and the same side of the tongue crosses at the corner of the board.
3. Align the 12-inch mark on the body with the edge of the board to form the correct angle for the ridge cut.
4. Mark a line along the edge of the tongue of the square.
5. Where the 12-inch mark rests on the edge of the board, make a small mark. This mark will be used in the next step.
6. Line up the 6-inch mark on the tongue with the mark you just made.
7. Line up the square so the 12-inch mark on the body is at the edge of the board.
8. Make another small mark where the 12-inch mark meets the edge.
9. Repeat steps 6 to 8 four more times.
10. Draw a line across the board next to the tongue of the square to mark the seat cut.
11. From this line, measure another 12 inches down the board and mark the location for the overhang.
12. At this mark, repeat steps 6 to 8 again to indicate the tail cut.
13. On the seat cut line, measure $1\frac{1}{2}$ inches up from the bottom and make a mark on the line to indicate the depth of a seat cut (commonly the thickness of a 2" board).
14. At the mark, use the framing square to make a 90-degree angle to the edge of the board. Mark the line to form the seat cut.
15. If a ridge board is used, $\frac{3}{4}$ of an inch needs to be cut off the ridge cut (half the thickness of a 2" board) at the same angle as the ridge cut.

