California Vocational Agriculture Curriculum Guidelines Instructional Unit

CONSTRUCTION SKILLS

Introduction to Agriculture	
Agricultural Production	01.01
Agricultural Supplies/Services	01.02
Agricultural Mechanics	01.03
Agricultural Products/Processing	01.04
Ornamental Horticulture	01.05
Renewable Resources/ Rural Recreation	01.06
Forestry	01.07

J

Unit Goals

The goal of this unit is to develop the students knowledge of and ability to perform the tasks of framing a structure.

Unit Objectives

Upon completion of this unit the student will be able to:

1. Properly layout a building site with batter boards, line and stakes.

2. Properly form and pour concrete foundations.

3. Install floor joists and sills to specifications.

4. Layout, assemble, erect and plumb wall sections.

5. Cut and install common rafters and joists to specifications.

I. Concrete Work

   A. Laying Out Building

      1. Secure building permit and inspection schedule

      2. Establish base line (often the front of building) grade and approximate corners

      3. Set batter boards TM 1

      4. Install lines to exterior dimension of foundation

      5. Adjust lines from base line to equalize the diagonal measurements (square up building) then check dimensions

   B. Forms and Forming

      1. Excavate to undisturbed soil for footing (depth and width of footing to code) TM 2

      2. Plumbing must be installed and inspected if slab -- may stub plumbing under forms for wood floor construction   TM 3

      3. Form lumber must have tight fit (T & G or plywood) 2" needs vertical support every four feet -- 1" needs vertical support every two feet.
four feet -- 1" needs vertical support every two feet.

      4. Forms must be strong and well braced, TM 4   (concrete weighs approximately 150 lb/cu.ft., especially at ends

      5. Check diagonals to insure that the forms are square

      6. Check grade of top of forms (builders level) if forms extend above grade drive nail in at finished grade level

      7. Install and tie reinforcing after outside form is in place before inside form installed

      8. Install anchor bolts to code when concrete is setting up

      9. Position mud sill on anchor bolts when concrete set and tap with hammer to mark hole location -- drill and install

     10. Using builders level record cross hair mark on wooden stake, TM 5. Measure to piers to get length of pier posts

     11. Install floor joists and box sill on pier posts and mud sills TM-2,14

SUGGESTED LEARNING ACTIVITIES	SUGGESTED RESOURCE MATERIALS
I. 1. Have the class do a concrete project and go through the steps as if it were a house foundation.	1. Concrete unit
2. Discuss nail sizes and proper use of each size.	2. TM-14

II. Framing and Structures

    A. Sub-floor -- 1 1/8 ply -- TM 6

        1. Installation-stagger joints for strength, face nail

        2. Check diagonals and dimensions, correct errors for layout

        3. Layout walls and partitions with chalkline on sub-floor

    B. Walls

        1. Position bottom plate for all walls and partitions, extend through doors

        2. Layout studs, doors, windows, trimmers on bottom plate TM 7

        3. Position 1st top plate next to bottom plate and duplicate layout

        4. Install studs, headers and trimmers between top and bottom plate -- nail with 2/16d per stud top and bottom, TM 14

        5. With wall squared on sub-floor, lay braces on studs, mark edges, remove brace and cut marks with skill saw set to 3/4 " depth. Remove blocks so made with claws of ripping hammer. Cut brace to match slightly less than top and bottom plate and tack in place.

        6. Erect wall and brace to hold erect

        7. Align wall with lines on sub-floor and nail in place

        8. When walls are in place, plumb and install second top plate lapping over the first top plate where walls connect, nail braces in place. TM 8

    C. Joist and Rafters or Trusses

        1. The use of prefabricated trusses simplifies this section

        2. Mark out location of rafters and joists on top plate -- 2' centers usually work from each end and have any uneven measure at center

        3. Keep walls straight as joists are installed, TM 9

        4. Cut rafters and install, TM 10, 11, 12 , 14

            a. brace from wall to ridge to hold the first truss in place
            b. brace near ridge to hold suceeding trusses at proper spacing at top

    D. Roof Coverings

        1. Asphalt

            a. sheathing solid covering
            b. stagger joints to give more strength
            c. apply asphalt covering as per instructions for particular type (start at edge and work to top insuring adequate lap)

SUGGESTED LEARNING ACTIVITIES

SUGGESTED RESOURCE MATERIALS

II. 1. Some instructors arrange
with local people to build a
store room or garage as a
class project. (should be
within 5-8 minutes from school
and will require a full semester
with 2 hour time blocks).

2. Build dog house or doll house as
a scaled down construction project.

1. Local builders (insure local
builders approve before attempting
such a project).

II. D. 2. Wood Covering

    a. sheath with 1"X 6' spaced 4" apart
    b. sheath solid in areas of overhang or flashing
    c. apply wood covering as per instructions for particular material (start at edge and work to top insuring adequate lap

    3. Metal Covering

        a. Use 2"X 4" or 2"X 6" girts, TM 13

        b. In laying sheet metal roofing, start at the lower corner on the end away from the strongest winds. Corrugated sheets should be lapped one and one-half corrugations. End laps should be from 6" to 9" and the upper sheets should lap over all the sheets in the lower row. Roofs with 1/6 pitch should use 9", while steeper pitches could use shorter end laps.

        c. Zinc-coated ring-shank or screw-shank nails with lead washers should be used. The length should be selected to allow point penetration into the girt of at least one inch. On the ends of the building where the sheet laps over the trim boards, nails should be spaced 3". On each girt, nails are spaced a maximum of 5" apart. This would be every other corrugation for 2 - 1/2" corrugated roofing or every third corrugation for 1 1/4" corrugated roofing. Nails should always be driven on the ridge, and if they enter the wood at a slight angle they hold better, tending to make a tighter joint. Drive nails until the lead washers just touch the sheet. Do not overdrive nails. When nailed as described, from 1 to 1 - 1/4 pounds of nails will be required per square of roofing.

III. Utilities

    A. Electrical work can be done as soon as the walls are up and the ceiling joists are in place

    B. Plumbing work can be done as soon as the walls are up, vents should be installed after the roof is sheathed

SUGGESTED LEARNING ACTIVITIES   SUGGESTED RESOURCE MATERIALS
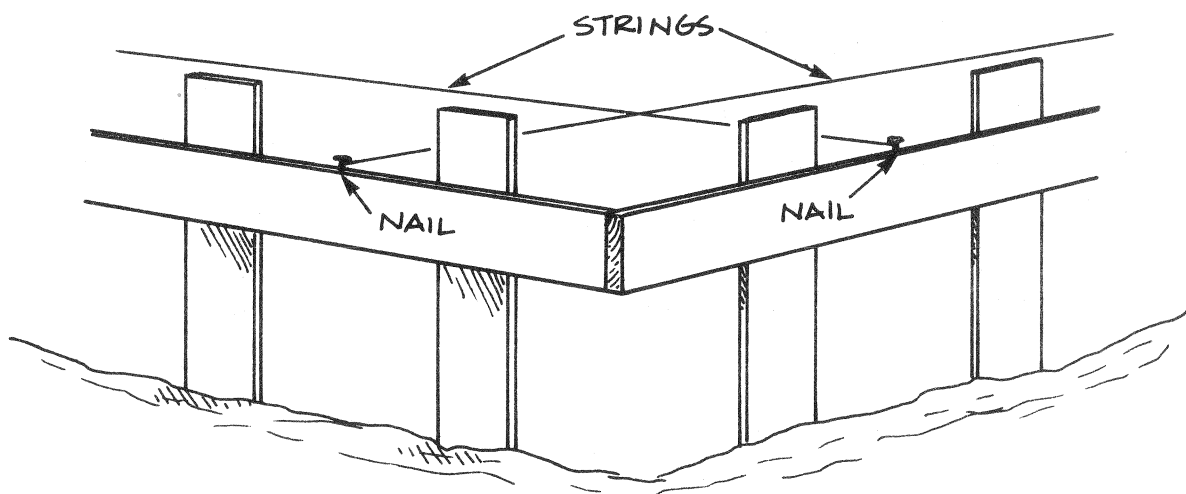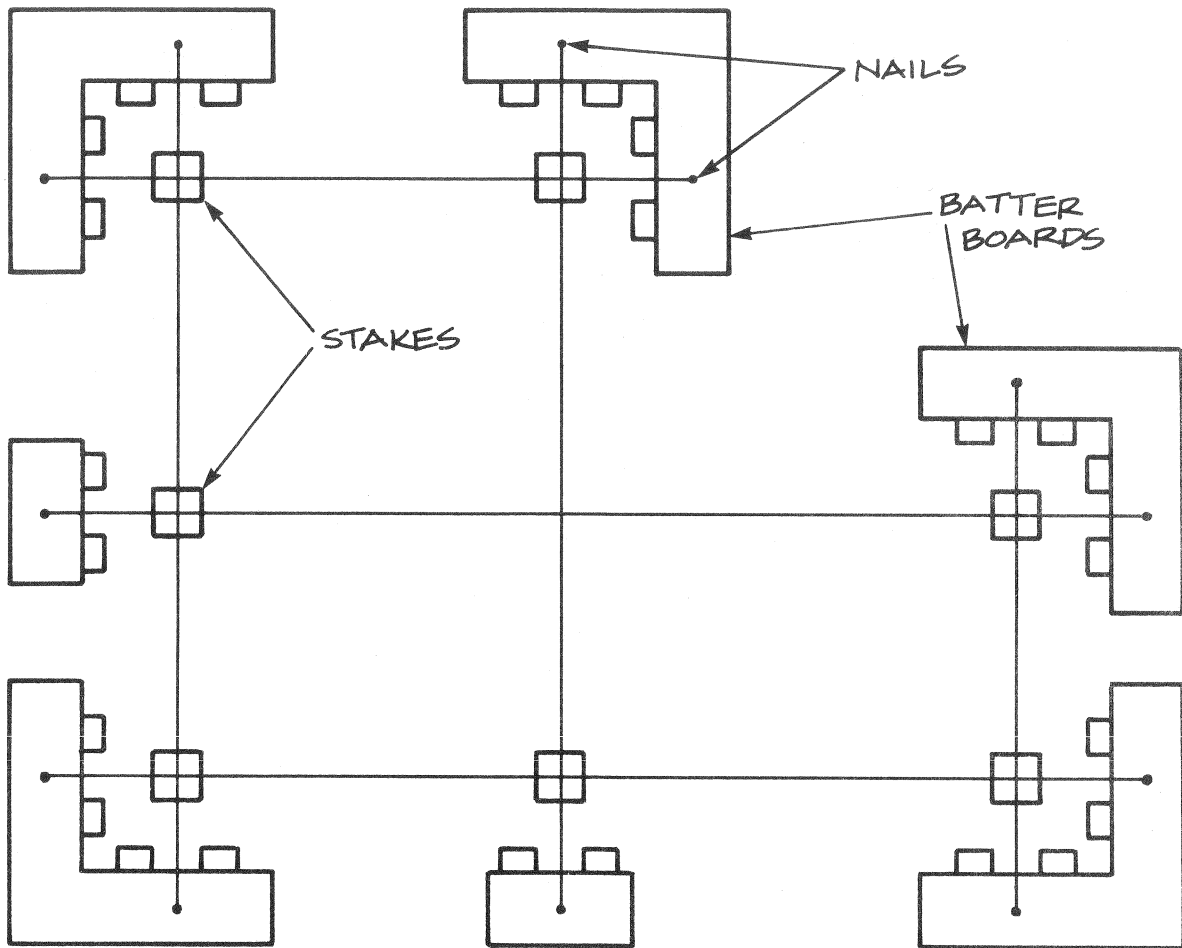
Student Evaluation

1. Sketch the foundation plan for a given building indicating dimensions.

2. Sketch the location and give dimensions of floor joists for a given plan.
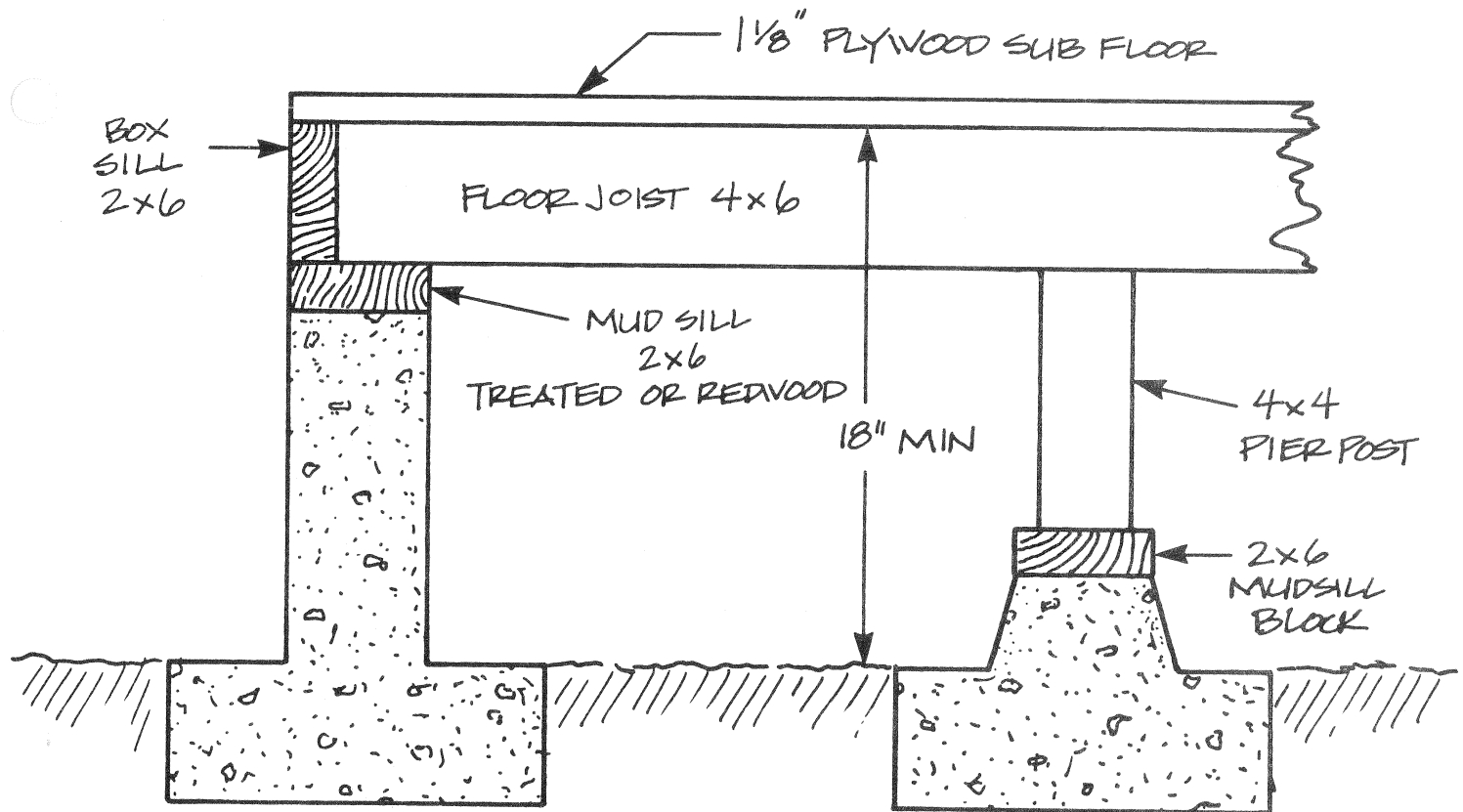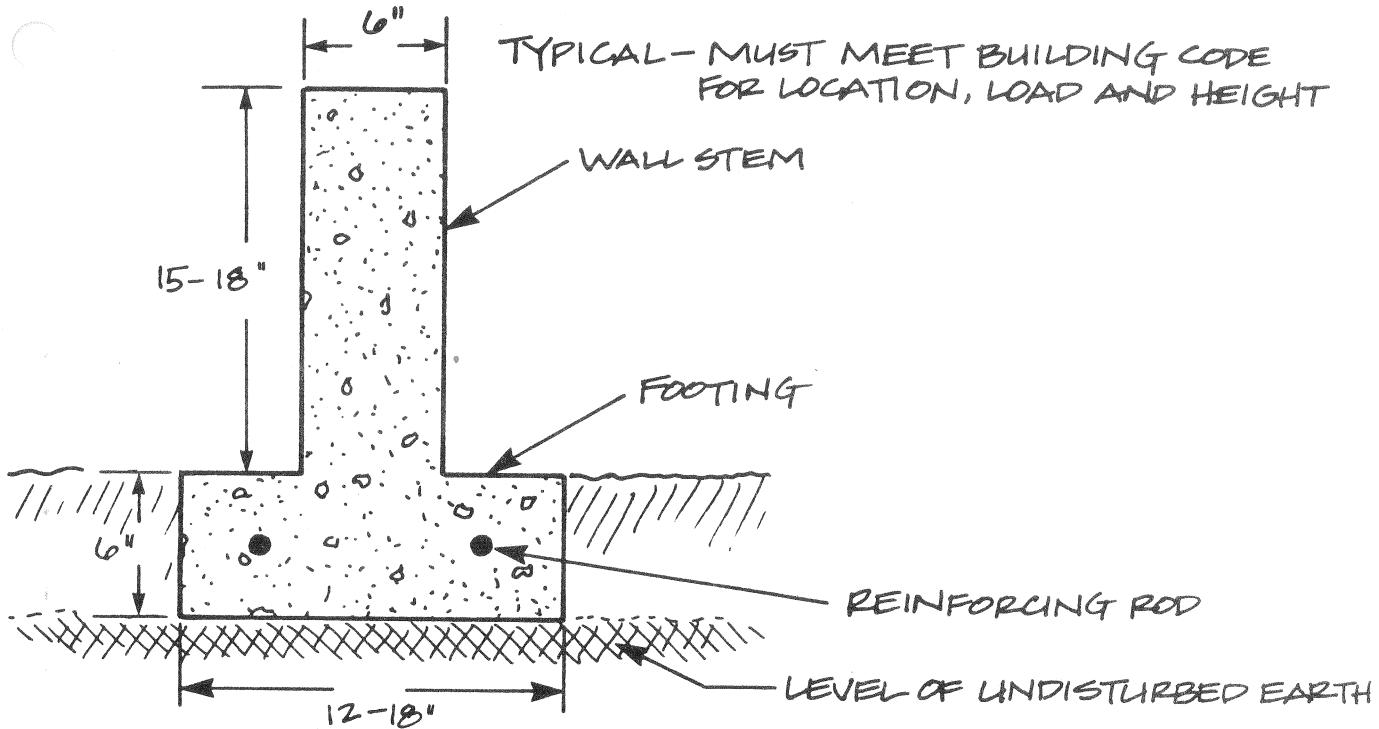

Performance:

1. The student will take part in forming and pouring a concrete foundation.

2. Use a builders level to determine pier post length for a given foundation.

3. Layout, assemble, erect, and plumb a wall section.

4. Cut and install a common rafter to specifications.
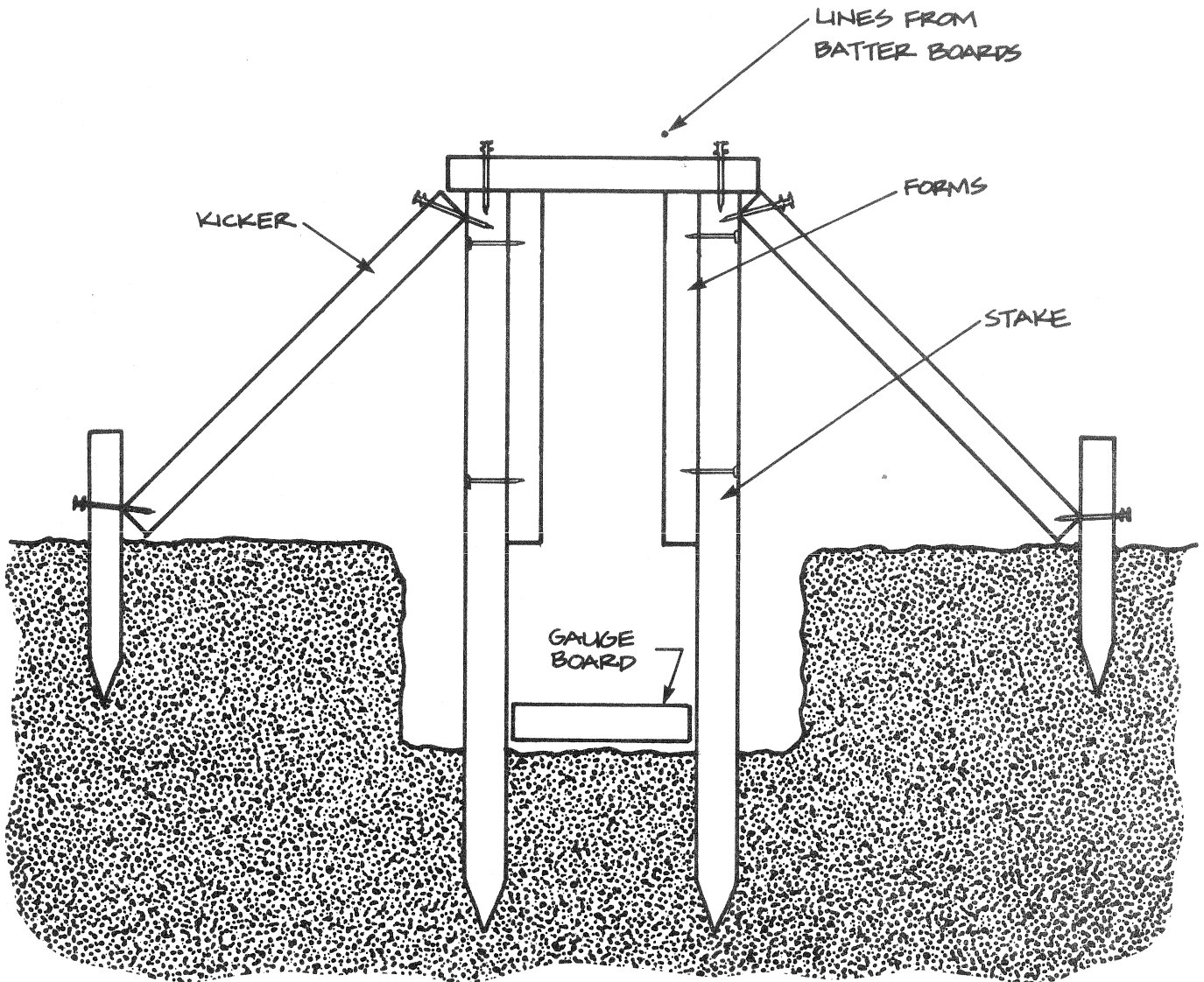
BATTER BOARD PLACEMENT

STAKES

NAILS

BATTER BOARDS

STRINGS

NAIL

NAIL

INVERTED TEE FOUNDATION ™2

6"

TYPICAL – MUST MEET BUILDING CODE
FOR LOCATION, LOAD AND HEIGHT

WALL STEM

15-18"

FOOTING

6"

REINFORCING ROD

12-18"

LEVEL OF UNDISTURBED EARTH

1⅛" PLYWOOD SUB FLOOR

BOX
SILL
2x6

FLOOR JOIST 4x6

MUD SILL
2x6
TREATED OR REDWOOD

18" MIN

4x4
PIER POST

2x6
MUDSILL
BLOCK

PIERS
5' ON
CENTER

NOTE: OLD STYLE (2" JOISTS 16" O.C.)
MINIMUM CLEARANCE 18" FROM
BOTTOM OF JOIST TO SOIL.

SLAB FOUNDATION

FLOOR

MUD SILL
SERVES AS
BOTTOM PLATE

CONCRETE

FOUNDATION

FOOTING

PLUMBING LINE
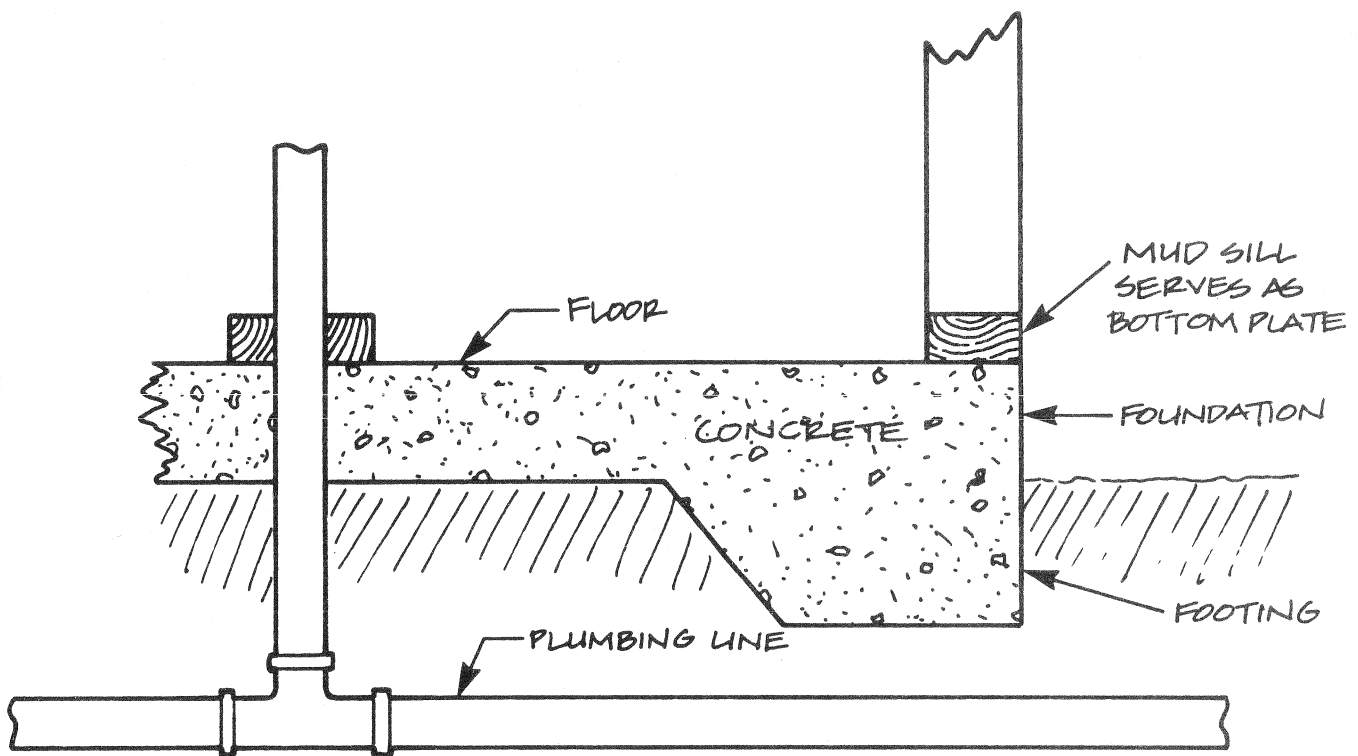
PLUMBING EXTENDS THROUGH
CONCRETE AT PARTITION

FOUNDATION FORMING

LINES FROM
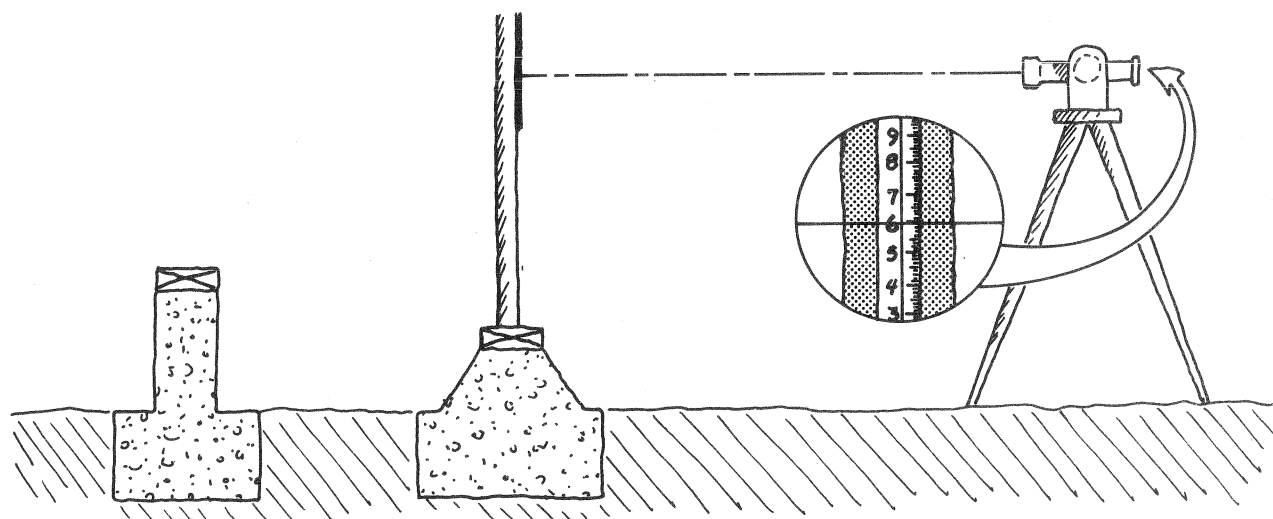BATTER BOARDS

FORMS

KICKER

STAKE

GAUGE
BOARD
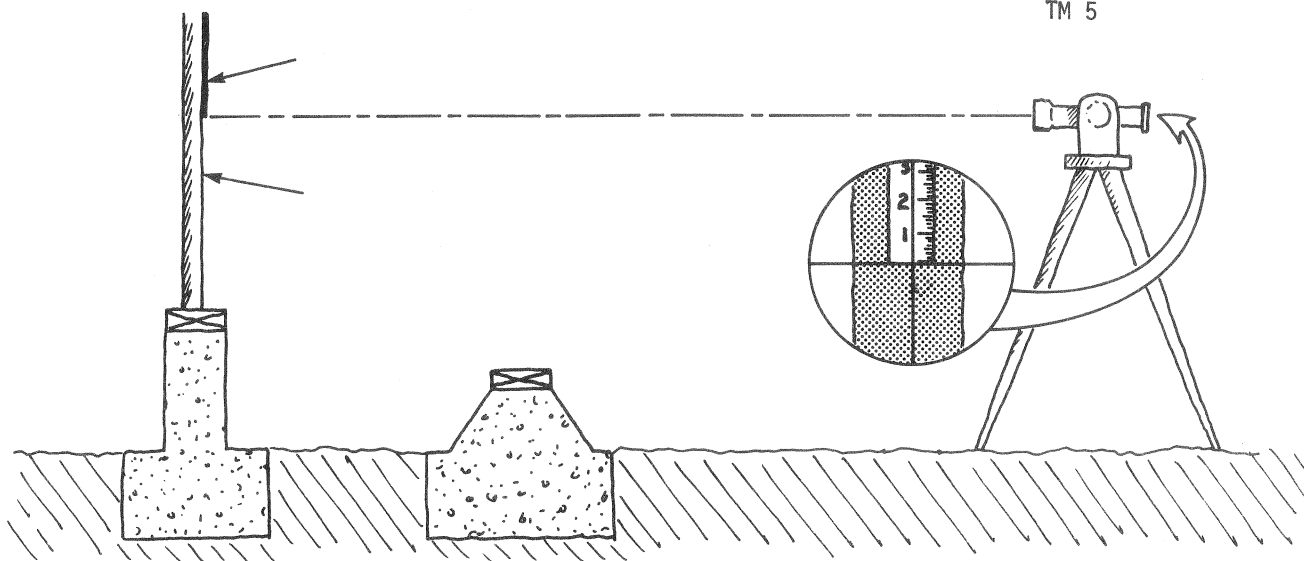
PIER POST LENGTHS
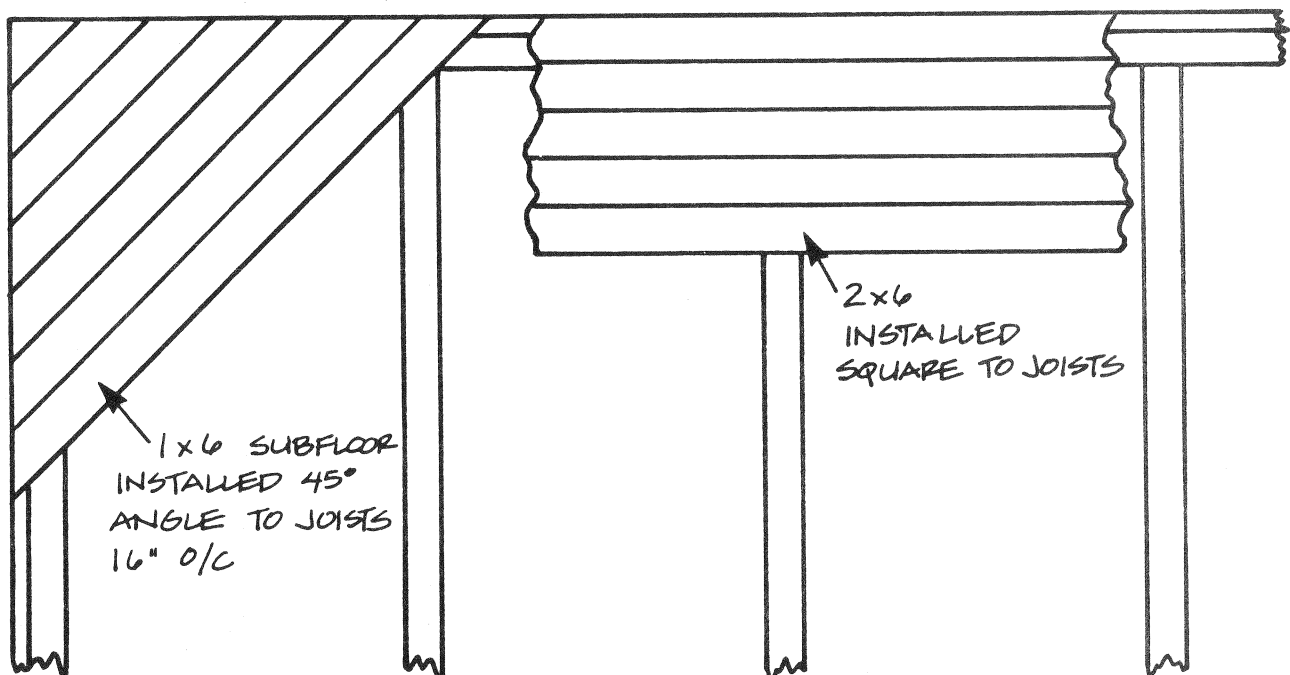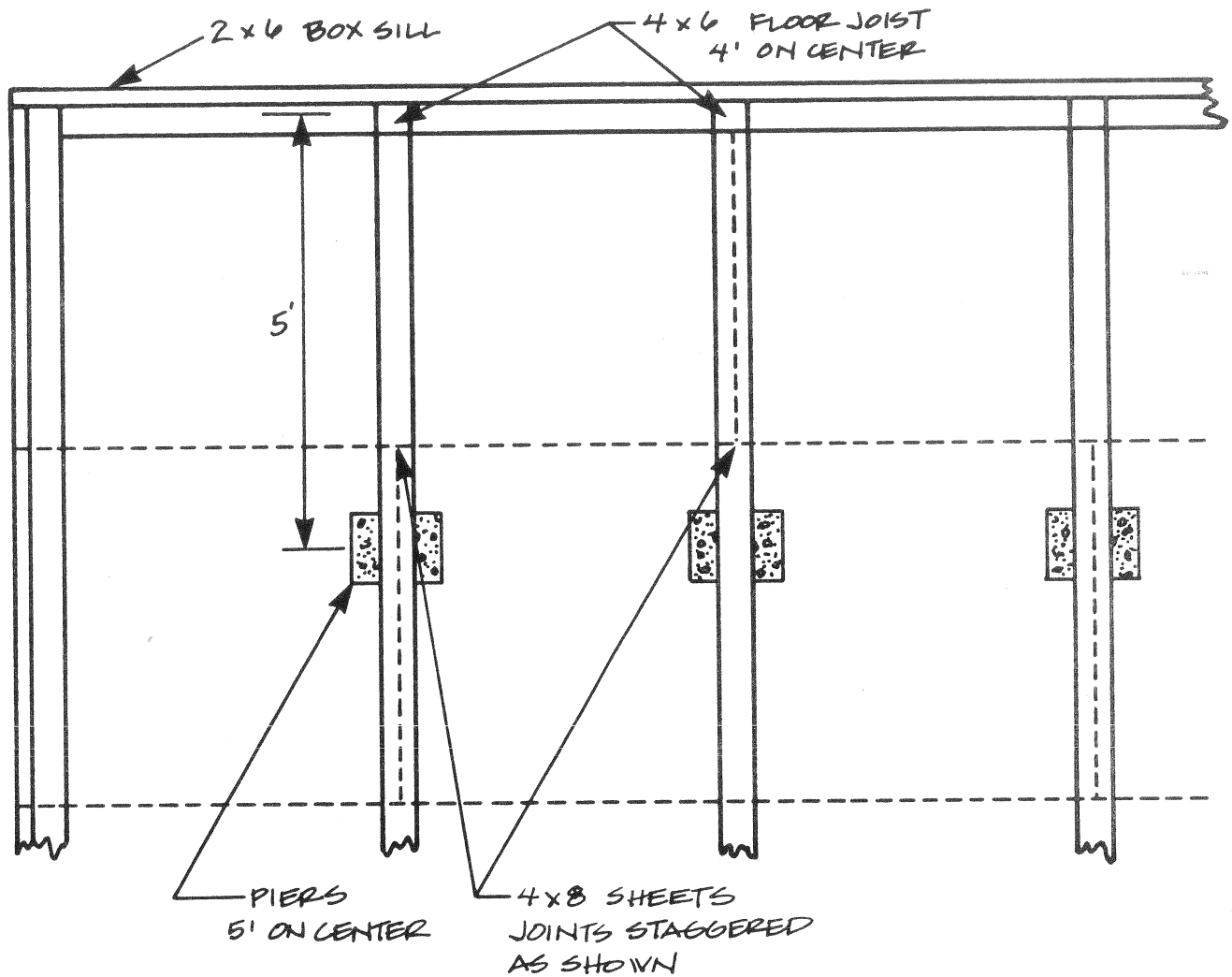
STEP 1. ESTABLISH GRADE ON MUD SILL

    A. Set up level on a firm location.

    B. Attach steel tape to scrap wood with "O" at cross hairs.

STEP 2. DETERMINE LENGTH OF PIER POSTS

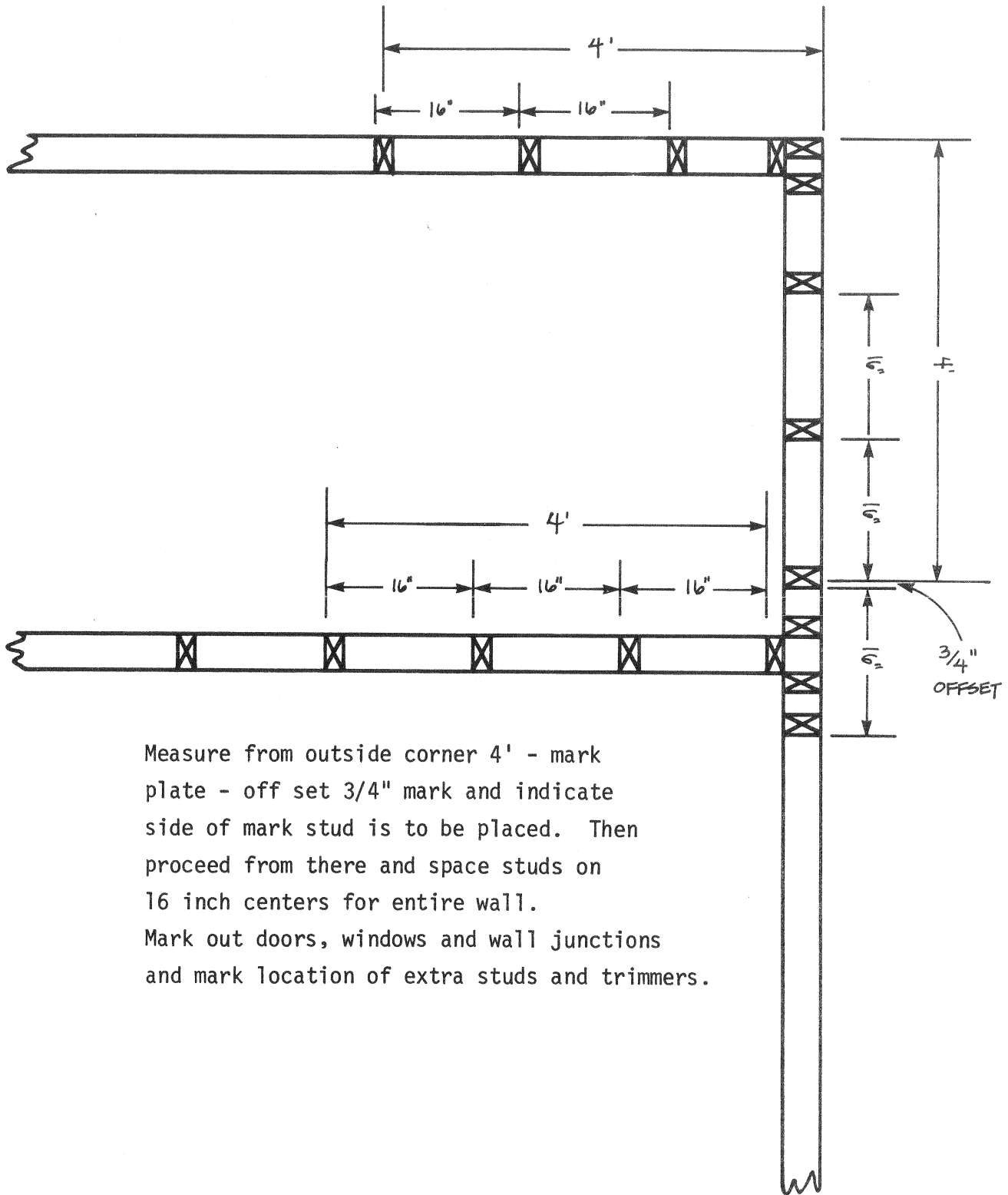   A. Move scrap with tape to pier.

    B. Site with level at same position.

    C. Record siting in inches on pier. This is to be the length of the pier post.

    D. Move to each pier.

SUB-FLOOR LAYOUT

2 x 6 BOX SILL

4 x 6 FLOOR JOIST
4' ON CENTER

5'

PIERS
5' ON CENTER

4 x 8 SHEETS
JOINTS STAGGERED
AS SHOWN

1 x 6 SUBFLOOR
INSTALLED 45°
ANGLE TO JOISTS
16" O/C

2 x 6
INSTALLED
SQUARE TO JOISTS

14

STUD LAYOUT

Measure from outside corner 4' - mark
plate - off set 3/4" mark and indicate
side of mark stud is to be placed. Then
proceed from there and space studs on
16 inch centers for entire wall.
Mark out doors, windows and wall junctions
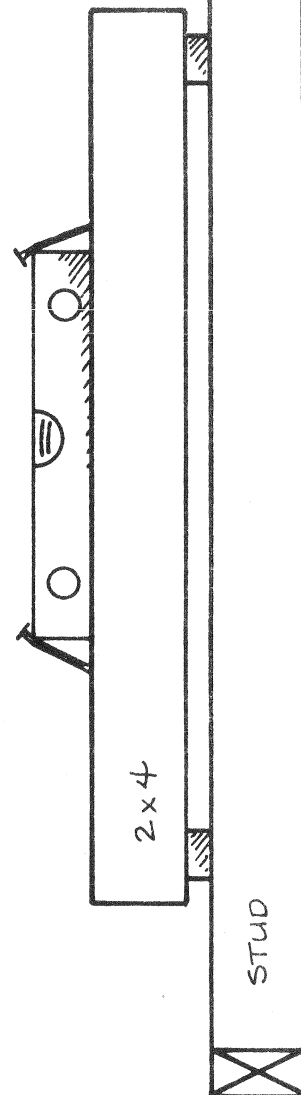and mark location of extra studs and trimmers.

14

PLUMB WALLS

1st or 2nd top plate - lap as shown
at any wall intersection.

Top plate joints must lap as shown -
check code for specific dimension.

To plumb walls - use straight 2x4, approx.
6' long, with equal size small blocks on
ends. Attach a good carpenters level as
shown - check both sides of first wall as
an accuracy check of level.
This reduces the chance of small stud
deformities misaligning walls.

2x4

STUD

15

KEEP WALLS STRAIGHT

Top view looking straight down on
joist and top plate.

JOIST

CHALK LINE
BLOCKED OUT
APPROX. 1"
FROM TOP PLATE

CHECK DIMENSION
AS JOIST IS INSTALLED

ATTACH
CHALK LINE
AT PLUMBED
CORNERS

TOP PLATE

16
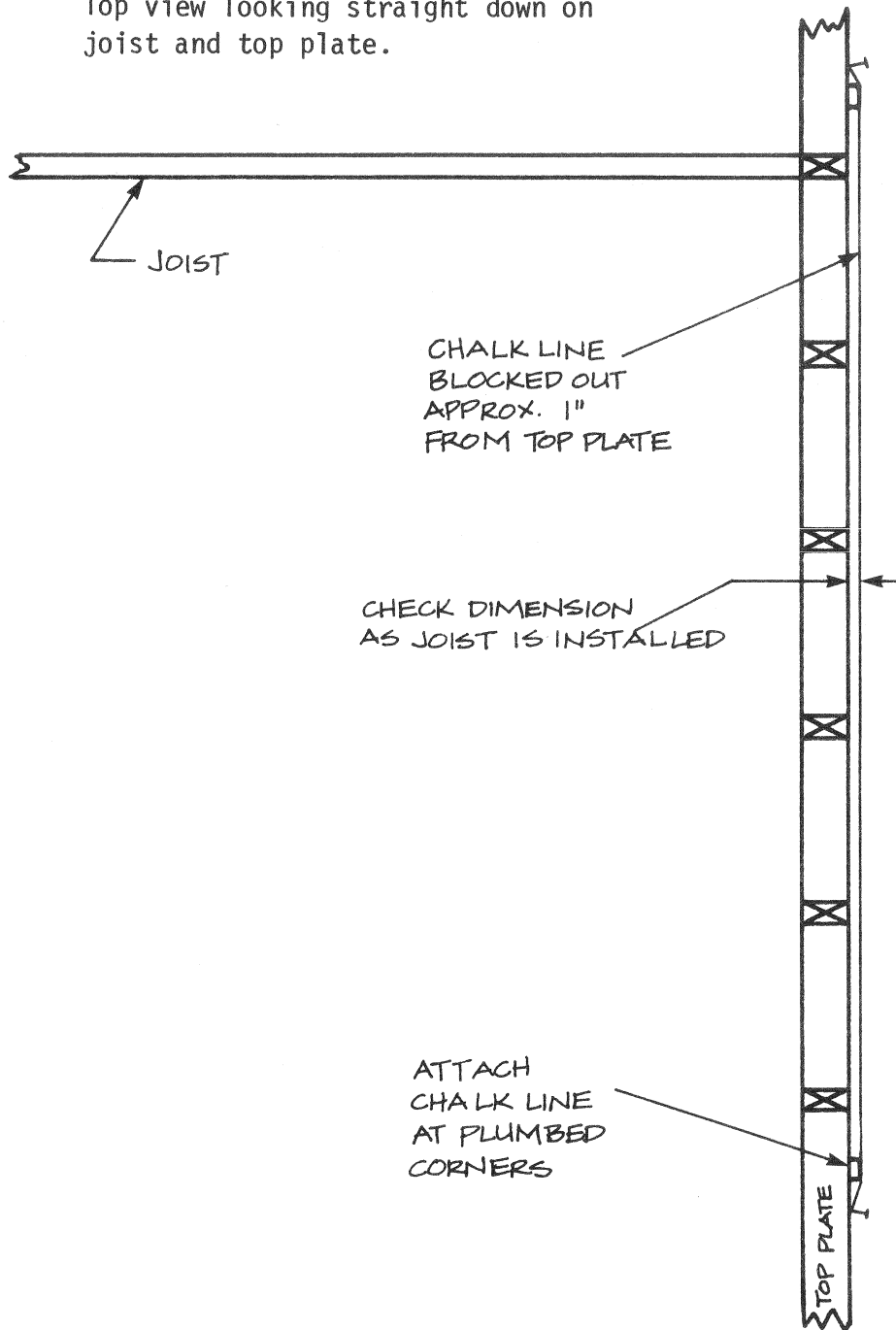
The slope of a roof can be expressed in one of two ways:
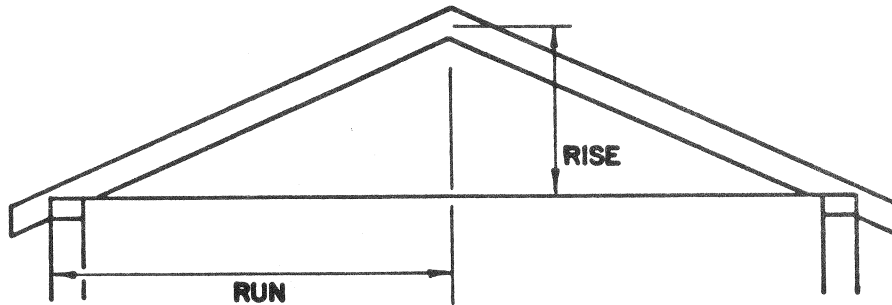
1. As pitch, which is defined as $\dfrac{\text{rise}}{2 \times \text{run}}$ and is expressed in fractions, 1/1, 1/2, 1/4, 1/6, etc.

2. As inches rise per 12 inches of runs, such as 3:12, 4:12, 5:12

The relationship between the two systems is as follows:

| Pitch	Inches Rise/12" of Run
1	24
3/4	18
1/2	12
1/3	8
1/4	6
1/6	4

Roofs with very low slope are often referred to as flat roofs. The slope is designated as a fraction of an inch per foot -- 1/4 inch per foot, 1/10 inch per foot, etc.

LAYING OUT A COMMON RAFTER

Gable roofs have probably the widest range of sizes from 12-foot-wide garages to 80-foot-wide clear-span buildings.
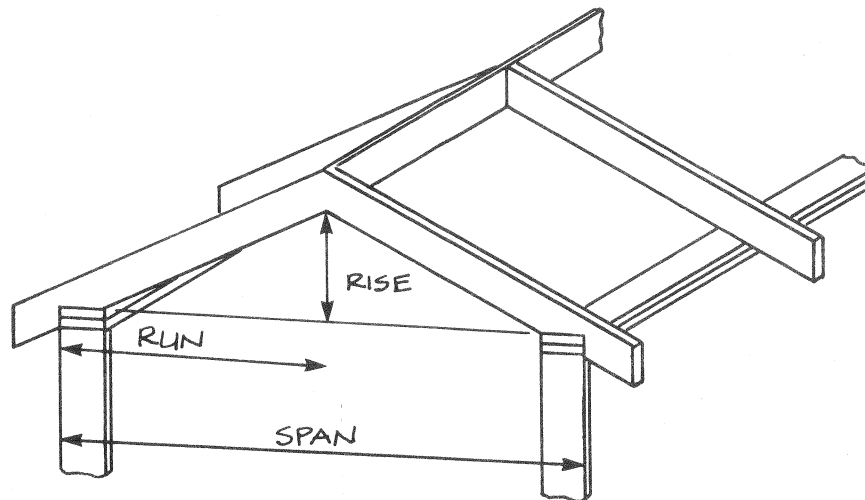
RELATIONSHIP BETWEEN
RISE, RUN, AND SPAN IN
A COMMON RAFTER
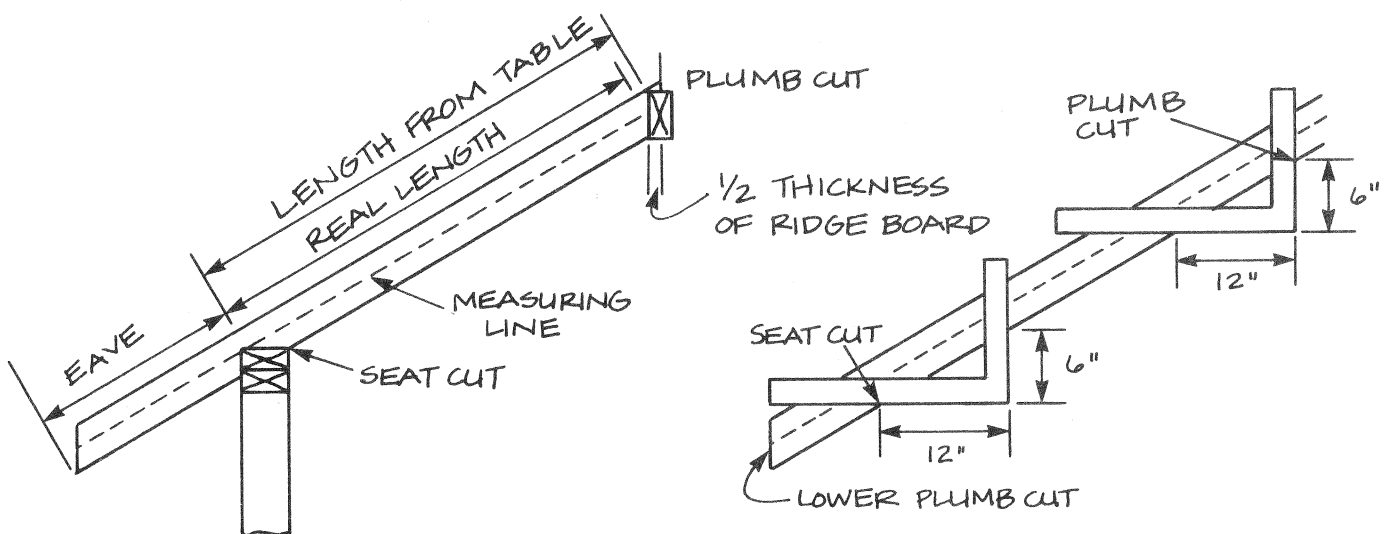
CUTS TO MAKE AND LENGTH
OF A COMMON RAFTER

POSITION OF SQUARE FOR
LAYING OUT A 6"/12"
SLOPE RAFTER

Laying out a common rafter involves the cutting of angles so that the cuts are correct and fit when the rafters are erected. When plans are drawn, the dimensions must be such that a carpenter can lay out the rafter with available tools. The tool in a carpenter's tool box that can be used for making angles is a standard framing square.

Summary of Procedure

1. Determine the inches of rise per foot of run for the rafter.

2. Determine the length of the rafter.

3. Mark off the length of the rafter as calculated from the rafter table.

4. Mark out the plumb cut.

5. Mark out the seat cut.

6. Make an allowance for the thickness of the ridge piece.

7. Add the amount of stock needed for the rafter tail.

8. Cut the rafter and check the fit of the seat and plumb cuts.

Explanation of Procedure: Sample Problem

Let it be required to cut a common rafer for a building which has a span of 24 feet. The pitch of the roof is 1/4. The ridge piece is 2 inches thick. A 2 foot tail is needed. The seat cut is to be cut a depth equal to one-half rafter width.

Step 1. Determine the inches of rise per foot of run.

It is necessary to determine the inches of rise per foot of run before the length of the rafter can be calculated from the rafter table. The rise in feet can be obtained from the relationship:

$$\text{Pitch} \quad \frac{\text{Rise}}{2 \text{ X Run}}$$

Therefore, Rise = Pitch X 2 Run
Therefore, Rise = 1/4 X 24 = 6 feet

Since the span is 24 feet, the run is 12 feet. The rafter has a rise of 6 feet, or 6 X 12 = 72 iches. The inches of rise per foot of run can be obtained from the following relationship:

$$\text{Rise per foot of run} = \frac{\text{Rise in Inches}}{\text{Feet of Run}} = \frac{72}{12} = 6 \text{ inches}$$

With this information, the length of the rafter can be calculated from the rafter tables.

Step 2. Determine the length of the rafter.

The length of a rafter calculated from the rafter table is not the _actual_ length of the rafter.

The rafter length obtained from the rafter table is to the center line of the ridge. The actual rafter length is shorter -- to allow for one half the ridge board thickness.

The rafter table is found on the face of the body. The table extends from the 2 inch mark to the 18 inch mark. The inch marks correspond to the inches of rise per foot of run. The first horizontal line of the rafter table gives the length of the rafter for each foot of run. The rafter lengths are given in inches and hundredths of an inch. The rafter length is found by multiplying the rafter length per foot of run by the number of feet in the run.

To determine the length of a rafter, first find on the "inch line," on the top edge of the body, the figure that is equal to the rise in inches per foot of run. In this case, the rise is 6 inches. On the first line under the number 6 will be found the figure 13.42. This is the length of the rafter for each foot of run. Since the run is 12 feet, the total rafter length will be 13.42 X 12 = 161.04 inches. A division of 12 will give the rafter length in feet. Therefore, the rafter is 13.42 feet long.

Step 3. Mark off the length of the rafter.

Because the seat cut is to be cut to a depth equal to one half the rafter width, a measuring line is drawn on the side of the rafter so that the rafter width is divided into two. This will bring the rafter length to the center of the ridge piece.

At one end of the rafter, mark the location of the plumb cut on the measuring line. Label this point "A."

Along the measuring line, measure the length of the rafter from point "A." Mark the other end of the rafter at the correct length with point "B." There should be enough remaining stock to take care of the rafter tail which will be added later.

The rafter length just measured is not the actual length of the rafter. From the length just determined, an allowance for the ridge board must be made. This will be done in Step t.

Step 4. Mark out the plumb cuts.

Locate the 6 inch mark on the tongue of the square and the 12 inch mark on the body. The 6 inches on the tongue represent a rise of 6 ft. The 12 inches on the body represent 1 foot of run.

Lay the square on the rafter with the heel toward yourself so that:

(1) the 12 inch mark at the outer edge of the body coincides with the nearer edge of the rafter,

(2) the 6 inch mark on the outer edge of the tongue coincides with the same edge of the rafter, and

(3) the outer edge of the tongue passes through point "A" on the measuring line.

Draw a line on the rafter along the outer edge of the tongue. The plumb cut is made on a line parallel to this line after the allowance for the ridge piece has been made.

Step 5. Mark out the seat cut.

Through the point which marks the outer end of the rafter, point "B," lay the outer edges of the square in the same manner as   done for the plumb cut. Draw a line on the rafter along the outer edge of the body of the square from the measuring line to the nearer edge of the rafter. This is the ling along which the seat cut is made.

To complete marking out the seat cut, lay out a 90-degree angle with the seat cut line. This completes the marking of the seat cut.

Step 6. Make an allowance for the thickness of the ridge piece.

The lengths of rafters obtained from the rafter table are to the center line of the ridge. Therefore, one half of the thickness of the ridge board must be deducted from the total length computed from the rafter table before the plumb cut is made.

From point "A," measure at a right angle, from the plumb cut line previously drawn, a distance equal to one half the thickness of the ridge board. After this is done, draw a line parallel to the original plumb line and use this new line for cutting the plumb cut.

Step 7. Mark out the rafter tail.

From point "B," measure 2 feet along the measuring line toward the end of the work piece. Mark this length by placing point "C" on the measuring line. Mark the angle
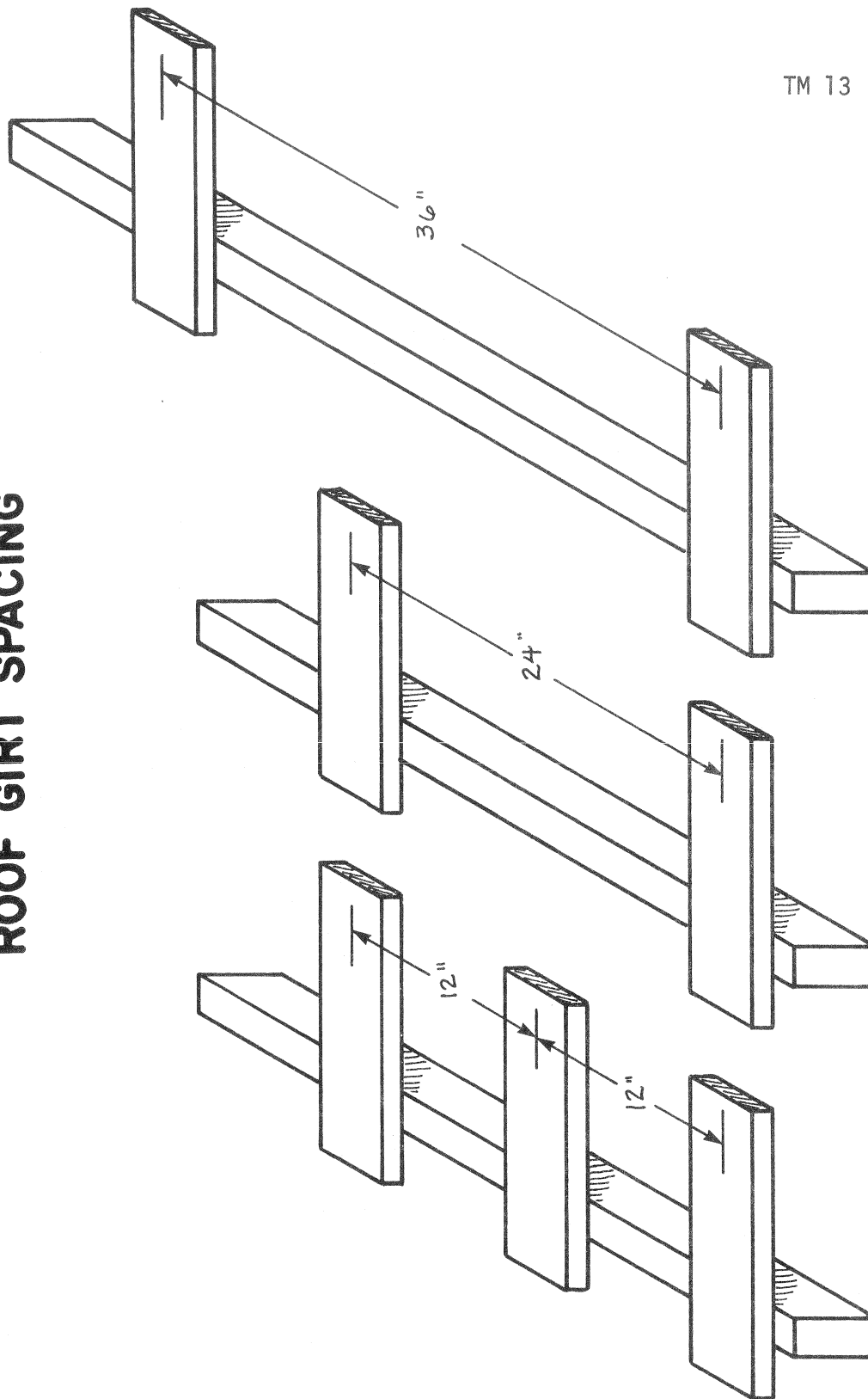
passing through "C" in the same manner as was done in laying out the plumb cut. The upper plumb cut and the cut on the rafter tail are parallel.

Step 8. Cut the rafter.

After all angles have been laid out carefully, the various cuts may be made. These should be sawn out carefully, as tight-fitting roof members are necessary for a sturdy roof.

ROOF GIRT SPACING

36"

24"

12"

12"

2 ½" CORRUGATED
AND OTHER DEEP
SIMILAR SHAPES

1 ¼" CORRUGATED

V CRIMP AND
OTHER SHAPES
WITH LARGE
FLAT SECTIONS

RECOMMENDED NAILING SCHEDULE
For Common Nails

```
Joist to sill or girder, toe nail......................  3-8d
Bridging to joist, toe nail each end...................  2-8d
Ledger strip on girder.................................  3-16d
                                                         at each joist

1" X 6" subfloor or less to each joist, face nail......  2-8d
Over 1" X 6" subfloor to each joist, face nail.........  3-8d
2" subfloor to joist or girder, blind and face nail....  2-16d
Sole plate to joist or blocking, face nail.............  16d@16" oc
Top plate to stud, end nail............................  2-16d
Stud to sole plate, toe nail...........................  4-8d
Doubled studs, face nail...............................  16d@24" oc
Doubled top plates, face nail..........................  16d@16" oc
Top plates, laps and intersections, face nail..........  2-16d
Continuous header, two pieces..........................  16d@16" oc
                                                         along each edge

Ceiling joists to plate, toe nail......................  3-8d
Continuous header to stud, toe nail....................  4-8d
Ceiling joists, laps over partitions, face nail........  3-16d
Ceiling joists to parallel rafters, face nail..........  3-16d
Rafter to plate, toe nail..............................  3-8d
1-inch brace to each stud and plate face nail..........  2-8d
1" X 8" sheathing or less to each bearing, face nail...  2-8d
Over 1" X 8" sheathing to each bearing, face nail......  3-8d
Built-up corner studs..................................  16d@24" oc
Built-up girders and beams.............................  20d@32" oc
                                                         along each edge
```

General References

Ashby, Dodge, Shedd <u>Modern Farm Builders</u>, Prentice Hall, New Jersey.

Wakeman <u>Modern Agricultural Mechanics</u>, Interstate.