PART TWO

Masonry

7-1. The original idea of masonry was nothing more than placing stones in an orderly fashion normally by laying them in rows. As time continued, with improved quality and type of materials available, this orderly lying of stone has progressed into laying them with the use of masonry cements that bonds them together. Part two of this manual covers basic tools and equipment, properties, and mixing of mortar. Concrete masonry will include the characteristics of concrete blocks, construction procedures, and rubble stone masonry. The characteristics of brick, and brick laying methods are discussed in the final chapter.

Chapter 7

Basic Equipment and Components General

7-2. Many of the longest-lasting structures in the world are constructed with masonry materials, such as stones, bricks, or blocks. Masons are highly skilled people who use specialized equipment to lay out and construct masonry walls and other building features. Along with erecting these structures, masons are responsible for the care of their tools and equipment. They are also responsible for the correct mixing proportions of the mortar and the safe erection of scaffolding.

SECTION I. MASON'S TOOLS AND EQUIPMENT

DEFINITION

7-3. Masonry originally meant the art of building a structure from stone. Today, masonry means to build a structure from any building materials, such as, concrete blocks, stones, bricks, clay tile products, gypsum blocks, and sometimes glass blocks, that consist of units held together with mortar; The characteristics of masonry work are determined by the properties of the masonry units and mortar, and the methods of bonding, reinforcing, anchoring, tying, and joining the units into a structure.

TOOLS

7-4. Figure 7-1 shows a set of typical basic mason's tools. Care of the tools are extremely necessary. Be sure to keep wheelbarrows, mortar boxes, and mortar tools clean because hardened mortar is difficult to remove. Clean all tools and equipment thoroughly at the end of each day or when the job is finished. A full set includes--

- A trowel. A trowel is used to mix and pick up mortar from the board, to place mortar on the unit, to spread mortar, and to tap the unit down into the bed. A common trowel is usually triangular in shape ranging in size up to about 11 inches long and from 4 to 8 inches wide. Its length and weight depend on the mason. Generally, short, wide trowels are best because they do not put too much strain on the wrist. Trowels used to point and strike joints are smaller, ranging from 3 to 6 inches long and 2 to 3 inches wide.
- A chisel or bolster. A chisel is used to cut masonry units into parts. A typical chisel is 2 1/2 to 4 1/2 inches wide.
- A hammer. The mason's hammer has a square face on one end and a long chisel peen on the other. It weighs from 1 1/2 to 3 1/2 pounds. It is used to split and rough-break masonry units.
- A jointer. As its name implies, this tool is used to make various mortar joints. There are several different types of jointer-rounded, flat, or pointed, depending on the shape of the mortar joint you want.
- A square. The square that is shown in Figure 7-2 below is used to measure right angles and to lay out corners.
- A mason's level. The level is used to plumb and level walls. A level ranges from 42 to 48 inches in length and is made from either wood or metal. Figure 7-2 shows a level in both the horizontal and vertical positions. When you place it on the masonry horizontally and the bubble falls exactly in the middle of the center tube, the masonry is level. When you place the level against the masonry vertically and the bubbles fall exactly in the middle of the two end tubes, the masonry is plumb.
- A straightedge. A straightedge, shown in Figure 7-2, can be any length up to 16 feet, from 1 1/8 inches to 1 1/2 inches thick, and the middle portion of the top edge from 6 to 10 inches wide. The middle portion of the top edge must be parallel to the bottom edge. Use a straightedge to extend a level to either plumb or level distances longer than the level length.
- Miscellaneous tools. Other mason's tools and equipment include shovels, mortar hoes, wheelbarrows, chalk lines, plumb bobs, and a 200-foot ball of good quality mason's line.

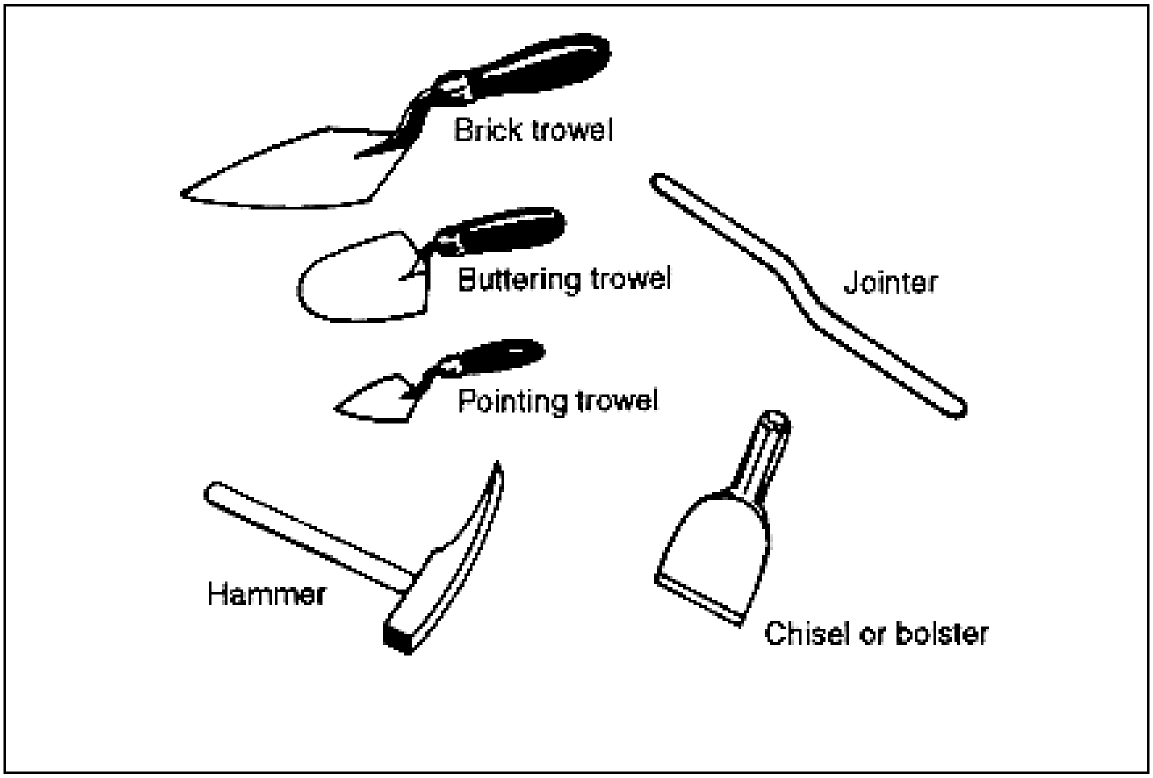


Figure 7-1. Basic Mason's Tools

EQUIPMENT

7-5. Mortar is mixed by hand in a mortar box. It should be as watertight as possible. A mortar board (see Figure 7-3) can range from 3 to 4 feet square. Wet down a mortar board thoroughly before placing any mortar on it to prevent the wood from drying it out and absorbing moisture from the mortar. Figure 7-3 shows the proper way to fill a mortar board. Note the mounds of mortar in the center of the board; this minimizes drying. After filling the

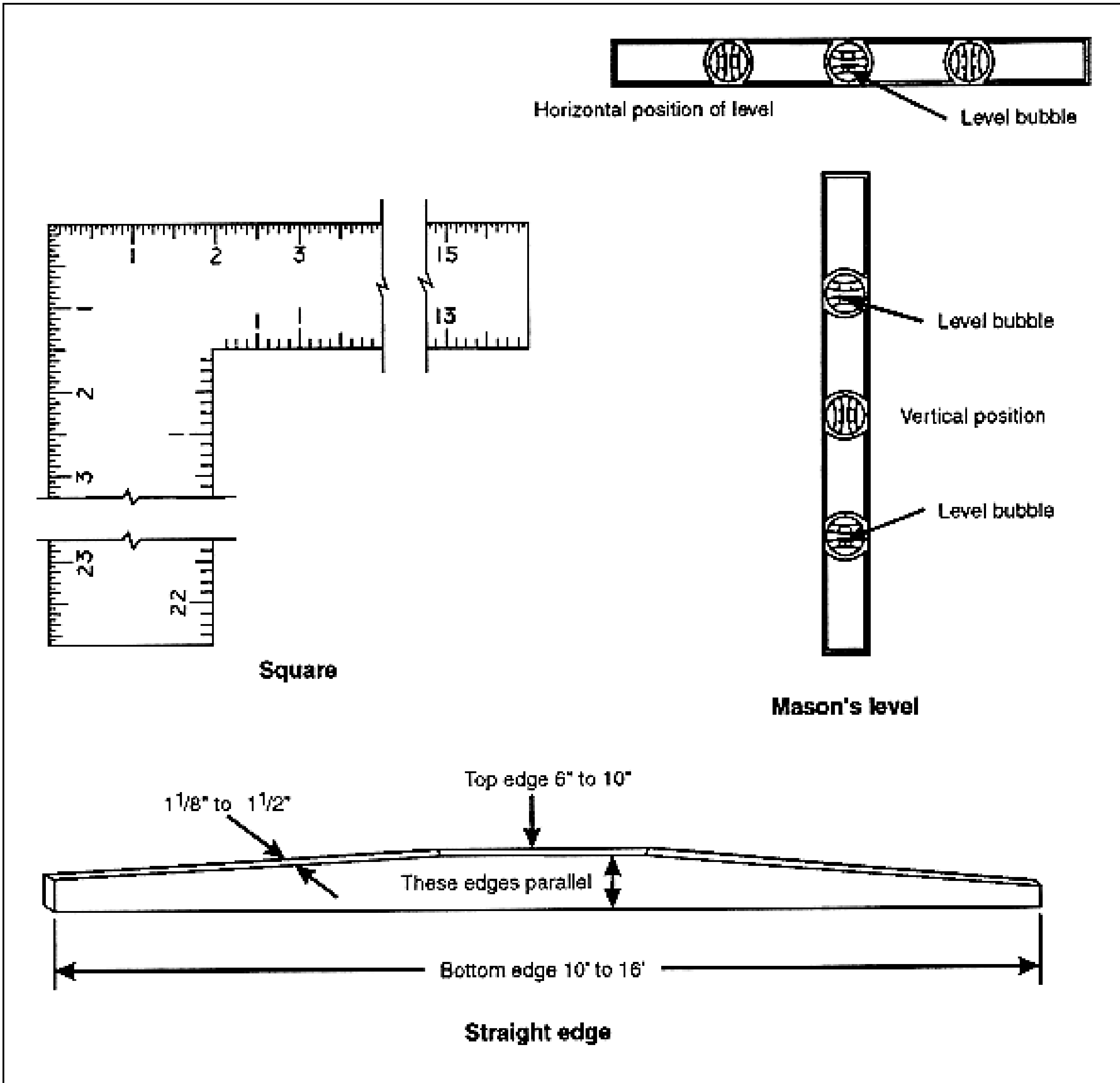


Figure 7-2. Square, mason's level, and straightedge

mortar board, keep the mortar rounded up in the center of the board and the outer edges of the board clean. Any mortar spread in a thin layer dries out quickly, and lumps form in it. Be sure to maintain the proper mortar consistency at all times.

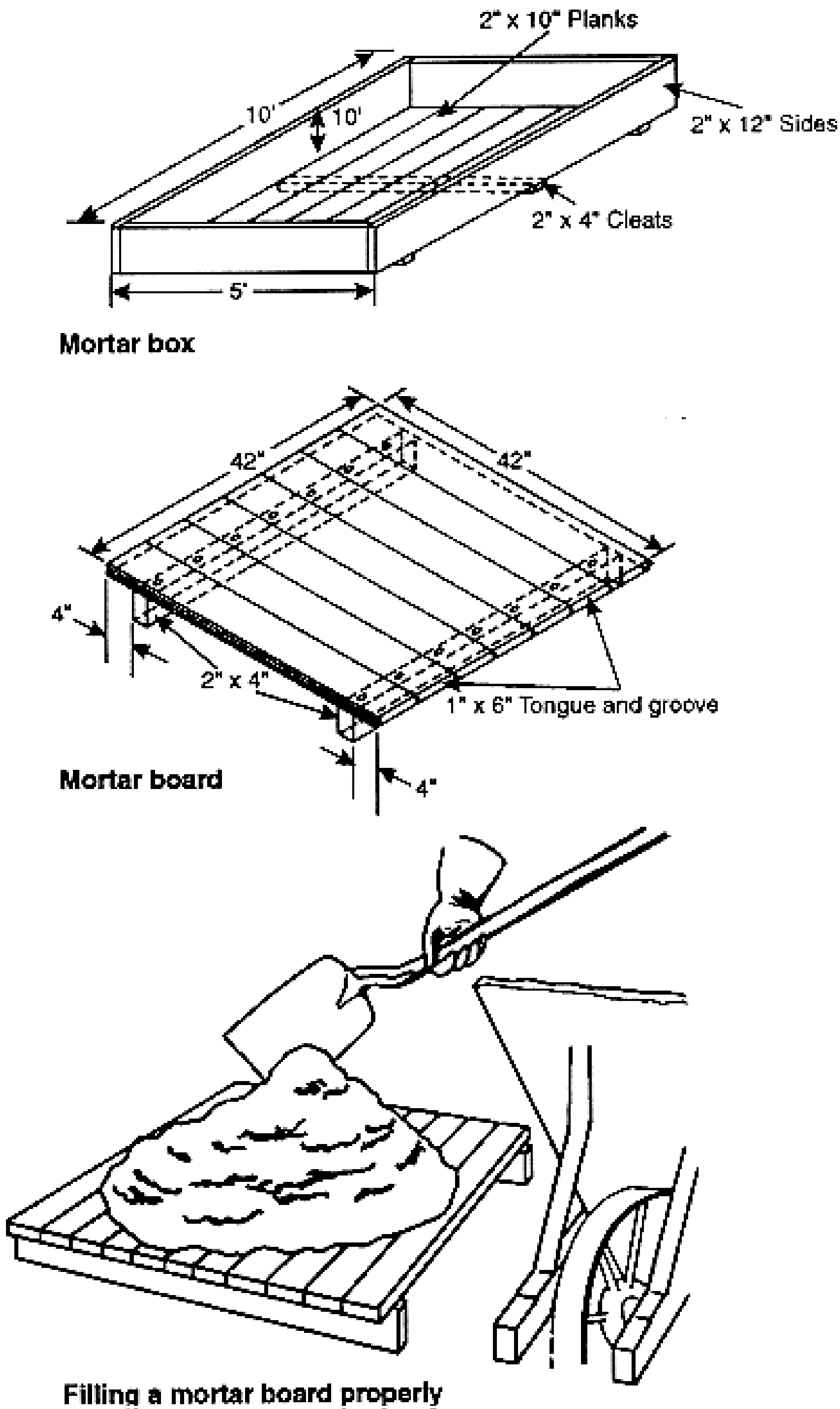


Figure 7-3. Motar Box and mortar board

SECTION II. MORTAR

DESIRABLE PROPERTIES

7-6. Good mortar is necessary for good workmanship and good masonry service because it must bond the masonry units into a strong well-knit structure.

BOND CONSIDERATIONS

7-7. The mortar that bonds concrete blocks,bricks, or clay tiles together will be the weakest part of the masonry unless you mix and apply it properly. When masonry leaks are encountered, they are usually through the mortar joints. The strength of masonry and its resistance to rain penetration depends largely on the strength of the bond between the masonry unit and the mortar. Various factors affect bond strength including the type and quantity of mortar, its workability or plasticity, its water retentivity, the surface texture of the mortar bed, and the quality of workmanship in laying the units. You can correct irregular brick dimensions and shape with a good mortar joint.

PLASTICITY

7-8. Mortar must be flexible enough to work with a trowel. You can obtain good plasticity or workability by-

- Using mortar having good water retentivity.
- Using the proper grade of sand and thoroughly mixing.
- Using less cementitious materials.

Mortar properties depend largely upon the type of sand the mortar contains. Clean, sharp sand produces excellent mortar; too much sand causes mortar to segregate, drop off the trowel, and weather poorly.

WATER RETENTIVITY

7-9. Mortar property resists rapid water loss to highly absorbent masonry units. Mortar must have water to develop the bond. If it does not contain enough water, the mortar will have poor plasticity and workability and the bond will be weak and spotty. Sometimes you must wet the brick to control water absorption before applying mortar, but never wet concrete masonry units.

STRENGTH AND DURABILITY

7-10. The type of service that the masonry must give determines the mortar's strength and durability requirements. For example, walls subject to severe stresses or to severe weathering must be laid with more durable, stronger mortars than walls for ordinary service. Table 7-1 below gives mortar mix proportions that provide adequate strength and durability for the conditions listed. You can convert the unit volume proportions to weight proportions by multiplying the unit volumes given by the weight per cubic foot of the materials. Those specifications are--

Masonry cement -------------------------- Weight printed on bag

Portland cement --------------------------- 94 lb

Hydrated lime ----------------------------- 50 lb

Mortar sand, damp and loose ------------- 85 lb

Table 7-1. Recommended mortar mix proportions by unit volume

Type of Services	Cement	Hydrated Lime	Mortar Sand in Damp, Loose Conditions
Ordinary	1 unit masonry cement or 1 unit portland cement	1/2 to 1 1/4	2 1/4 to 3 4 1/2 to 6
Isolated piers subjected to extremely heavy loads, violent winds, earthquakes, or severe frost action	1 unit masonry cement* plus 1 unit portland cement or 1 unit portland cement	0 to 1/4	4 1/2 to 6 2 1/4 to 3
*ASTM specification C91 type II.			

TYPES OF MORTAR

7-11. The following mortar types are proportioned on a volume basis:

- Type M mortar consist of one part portland cement, 1/4 part hydrated lime or lime putty and, 3 parts sand or 1 part portland cement, 1 part type II masonry cement, and 6 parts sand. Type M mortar is suitable for general use but is recommended specifically for below-grade masonry that contacts earth, such as foun-dations, retaining walls, and walks.
- Type S mortar consist of one part portland cement, 1/2 part hydrated lime or lime putty, and 4 1/2 parts sand, or 1/2 part portland cement, 1 part type II masonry cement, and 4 1/2 parts sand. Type S mortar is also suitable for general use, but is recommended where high resistance to lateral forces is required.
- Type N mortar consist of one part portland cement, 1 part hydrated lime or lime putty, and 6 parts sand, or 1 part type II masonry cement and 3 parts sand. Type N mortar is

suitable for general use in above- grade exposed masonry where high compressive and/or lateral strengths are not required.

- Type O mortar consist of one part portland cement, 2 parts hydrated lime or lime putty, and 9 parts sand, or 1 part type I or type II masonry cement and 3 parts sand. Type O mortar is recommended for load-bearing, solid-unit walls when the compressive stresses do not exceed 100 psi, and the masonry is not subject to freezing and thawing in the presence of a lot of moisture.

STORING MORTAR MATERIALS

7-12. Store all mortar materials, except sand and slaked quicklime, in a dry place. Sand and lime should be covered to prevent excessive losses or gains of surface moisture.

MIXING MORTAR

7-13. When blending or mixing mortar, always use the best consistency for the job.

MACHINE MIXING

7-14. Mix large quantities of mortar in a drum-type mixer, like a concrete mixer. Mix a minimum of 3 minutes. Place all dry ingredients in the mixer first, mix them for 1 minute before adding the water.

HAND MIXING

7-15. Mix small amounts of mortar by hand in a mortar box (see Figure 7-3). Mix all ingredients thoroughly to obtain a uniform mixture. Mix all dry materials together first before adding water. Keep a steel drum of water close to the mortar box to use as the water supply. Use a second drum of water to store shovels and hoes when not in use.

MORTAR MIXING WITH LIME PUTTY

7-16. When machine mixing, measure the lime putty using a pail and place it into the skip on top of the sand. When hand mixing, add the sand to the lime putty. Wet pails before placing mortar in them and clean them immediately after emptying them.

WATER QUALITY

7-17. Mixing water for mortar must meet the same requirements as mixing water for concrete. Do not use water con-taining large amounts of dissolved salts, because the salts will cause efflorescence and weaken the mortar.

RETEMPERING MORTAR

7-18. The workability of any mortar that stiffens on the mortar board due to evaporation by remixing can be restored. Add water as necessary, but discard any mortar stiffened by initial setting. It is difficult to tell the cause of stiffening; a practical guide is to use mortar within 2

1/2 hours after the original mixing when the air temperature is 80°F or higher, and within 3 1/2 hours when the air temperature is below 80°F. Discard any mortar not used within these limits.

ANTIFREEZE MATERIALS

7-19. Do not use an admixture to lower the freezing point of mortar during winter construction. The quantity of antifreeze materials necessary to lower the freezing point of mortar to any appreciable degree is so large that it would seriously impair the mortar's strength and other desirable properties. Never use frozen mortar; freezing destroys its bonding ability.

ACCELLERATORS

7-20. Make a trial mix to find the percentage of calcium chloride that gives the desired hardening rate. Do not add more than 2 percent calcium chloride, by weight of cement to mortar, to accelerate its hardening rate and increase early strength. Do not add more than 1 percent calcium chloride to masonry cements. Calcium chloride should not be used for steel-reinforced masonry. You can also accelerate hardening rate in mortars with high-early-strength portland cement.

REPAIRING AND TUCK-POINTING

7-21. Use the mortar mixes given in Table 7-1 when repairing and tuck-pointing old masonry walls. Compact the joints thoroughly by tooling after the mortar partially stiffens.

SECTION III. SCAFFOLDING

CONSTRUCTION AND SAFETY

7-22. Extreme care should be taken in building scaffolds because lives depend on them. Use rough lumber for wood scaffolding. Never nail scaffolding in a temporary manner; always nail it securely. When you no longer need the planks at a lower level, remove them to avoid falling mortar splash.

TYPES OF SCAFFOLDING

7-23. A *scaffold* is a temporary, movable platform built with planks to support workers and materials. It allows bricklayers to work at heights not reachable when standing on the floor or ground. Scaffolds can be used in several functions and come in different sizes and heights.

TRESTLE SCAFFOLD

7-24. Use a trestle scaffold shown in Figure 7-4 when laying bricks from the inside of a wall. Erect the scaffold when the wall reaches a height of 4 or 5 feet. The height of the trestles should range from 4 to 4 1/2 feet. The planks should be made using 2 by l0s. Place the trestle at least 3 inches from the wall so that it does not press against the newly laid bricks and force them out of line. Build the wall to the next floor level working from the scaffold. When the rough flooring for the next floor is in place, repeat the procedure.

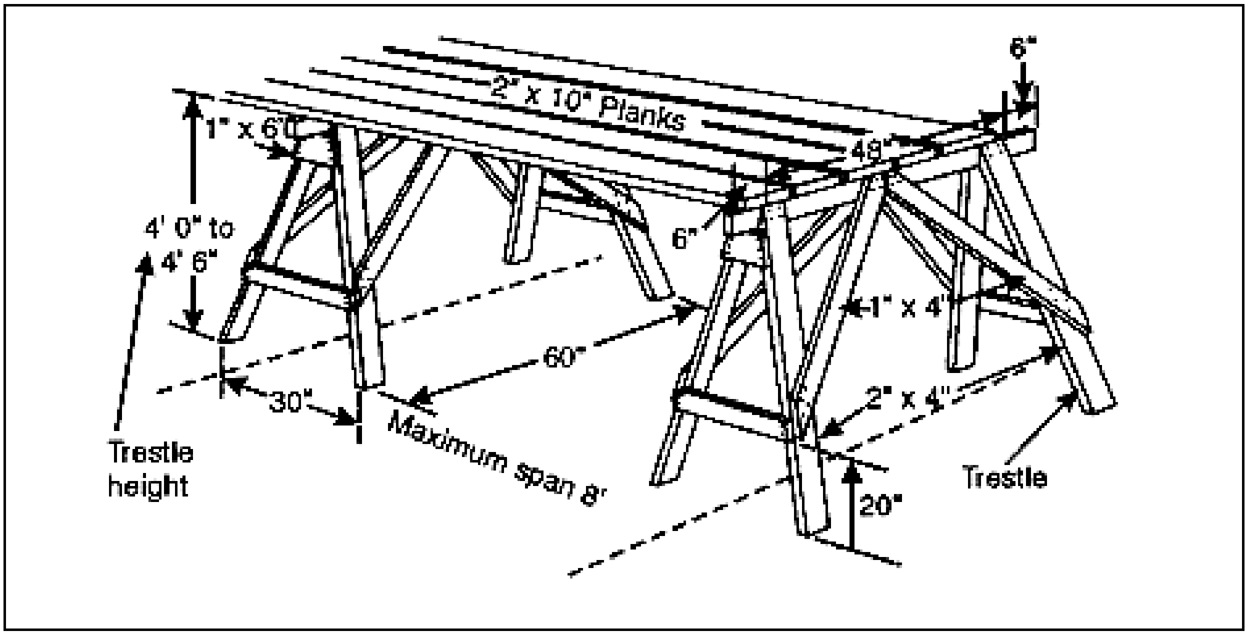


Figure 7-4. Trestle scaffold

FOOT SCAFFOLD

7-25. When reaching lower than a trestle scaffold permits, use a foot scaffold like the one shown in Figure 7-5. Place 2 by 10 planks on blocks supported by the trestle scaffold. A foot scaffold should not exceed 18 inches in height.

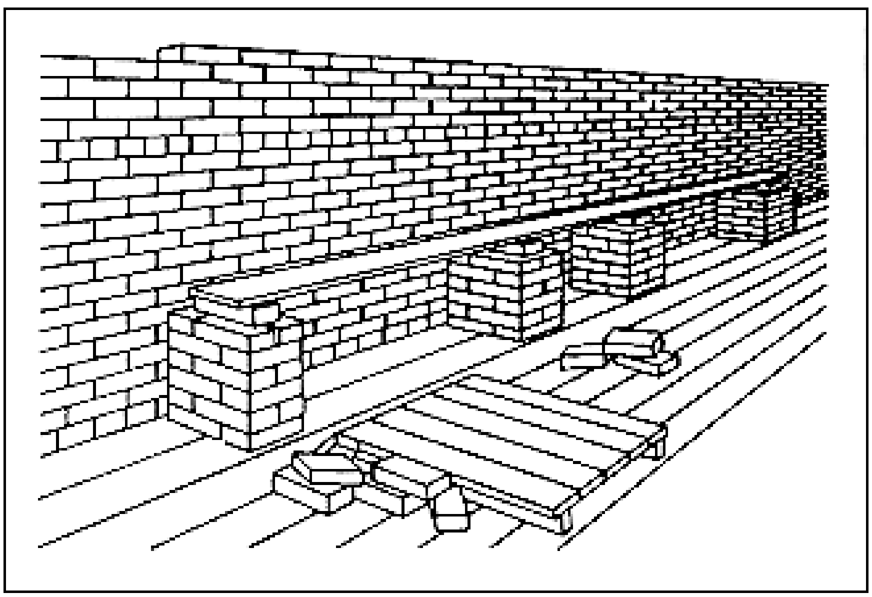


Figure 7-5. Foot scaffold

PUTLOG SCAFFOLD

7-26. A putlog scaffold (see Figure 7-6) reaches from the ground to the height required. Its uprights are 4 by 4s supported on a 2 by 12 by 12 plank for bearing on the soil. Space the uprights on 8-foot centers and allow 4 1/2 feet of space between the wall and the uprights, as shown in Figure 7-6. The putlog is 3-by 4-inch lumber that spans the gap between the wall and the ledger. One end of the putlog rests on top of the ledger and against the 4 by 4 uprights, while the other end fits into the wall (one brick is omitted to make an opening for it). Do not fasten the putlog to the ledger. Place five 2 by 12 planks on top of the putlog to form the scaffold platform. Do not nail the planks to the putlog. Two ways to use stays are-

- Tie the uprights to the wall with stays. You can either pass the stays through a window opening and fasten them to the inside structure or use spring stays as shown in Figure 7-6. To make spring stays, omit one brick from the wall and insert the ends of two 2 by 6s in the opening. Then insert a brick between the 2 by 6s and force the brick toward the wall. Bring the other ends of the 2 by 6s together and nail them securely to the ledger.
- Use the putlog as a stay. You can also use the putlog as a stay by driving a wood wedge above the putlog into its hole in the wall. Then, nail the wedge to the putlog and nail the putlog to the ledger. Install longitudinal cross bracing as shown in Figure 7-6.

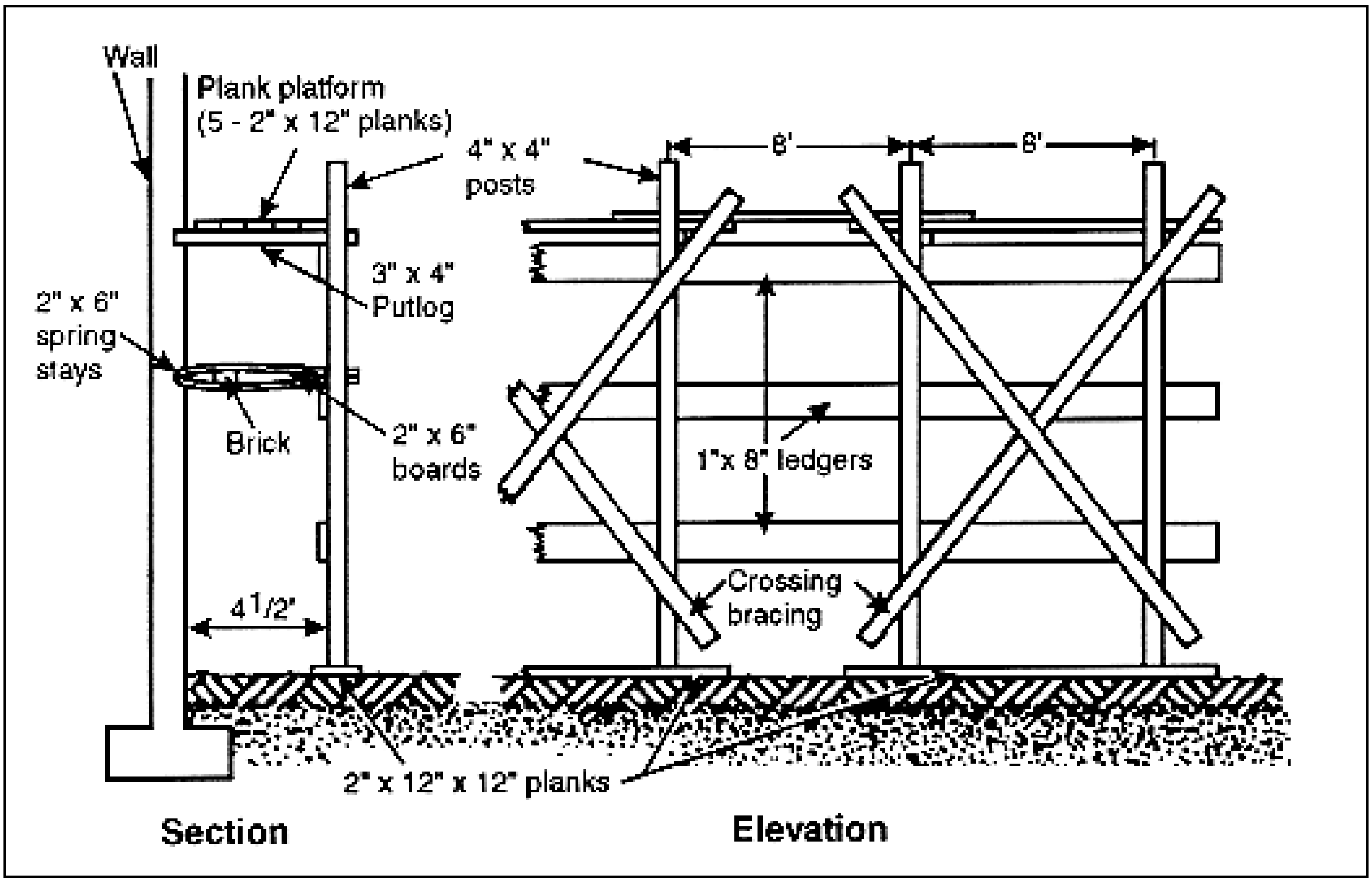


Figure 7-6. Putlog scaffold

OUTRIGGER SCAFFOLD

7-27. An outrigger scaffold (see Figure 7-7) consists of a wood outrigger beam projecting from a window sill that supports 2 by 10 planks. Figure 7-7 shows how to brace a wood beam, but if you use a steel outrigger beam, fasten it to the structure's formwork using threaded U-bolts.

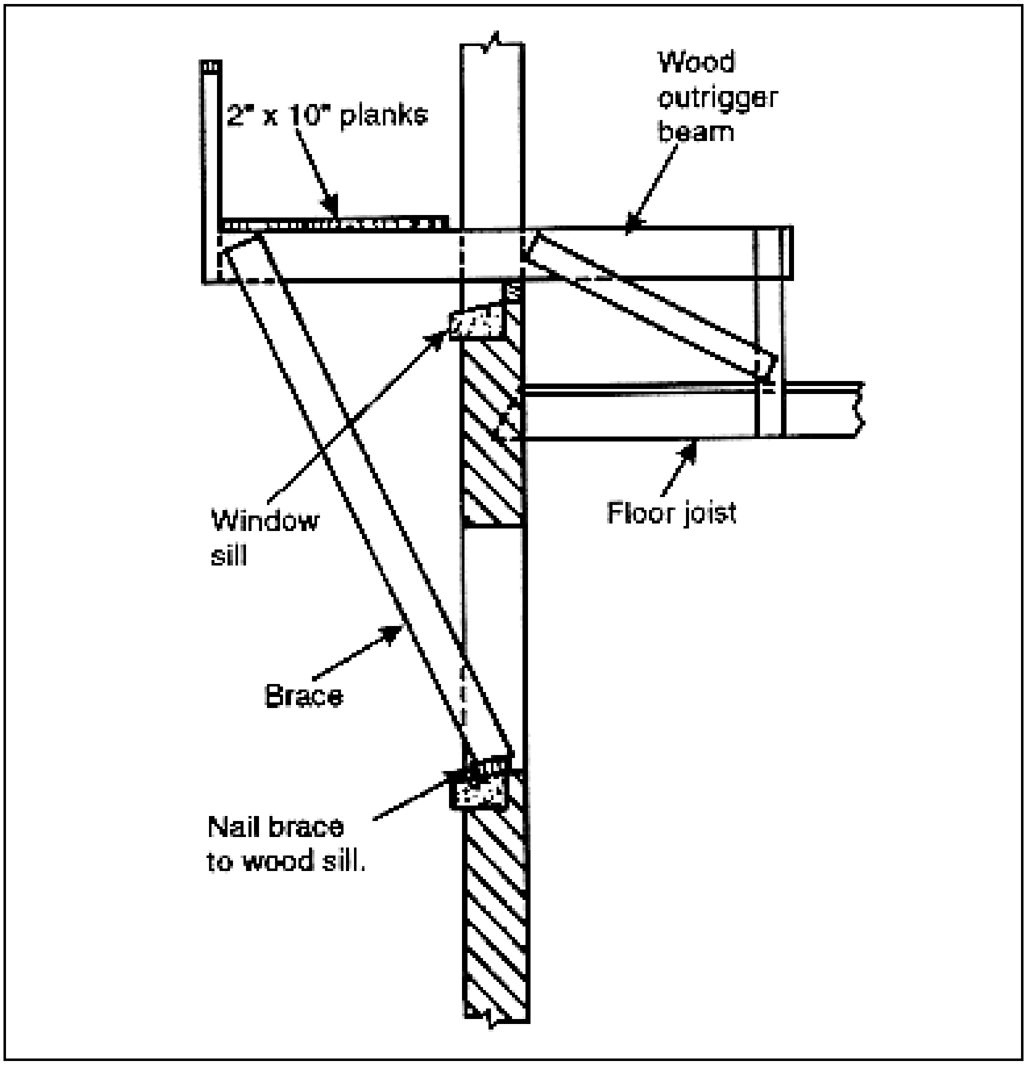


Figure 7-7. Outrigger scaffold

PREFABRICATED STEEL SCAFFOLD

7-28. If it is available, use prefabricated steel scaffolding (see Figure 7-8) rather than building a scaffold.

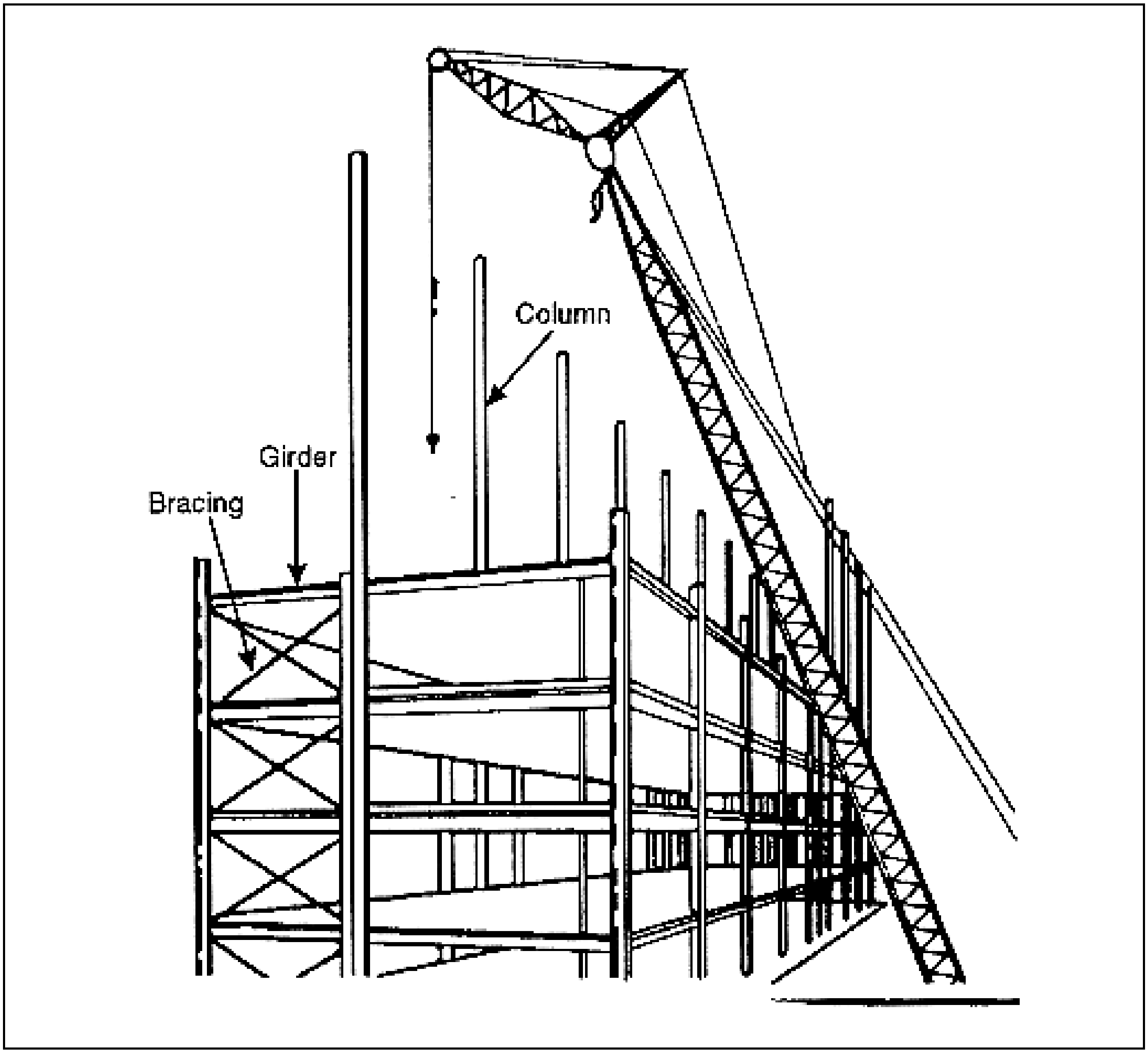


Figure 7-8. Prefabricated steel scaffold

MATERIALS TOWER

7-29. Use a steel material tower if construction details are available because it is easier to erect and generally safer. Otherwise, you can construct a wood tower to hoist materials to the working height, like the one shown in Figure 7-9. Locate the tower where you can bring materials to it over the shortest haul, but far enough away from the structure to clear any external scaffolding. A clearance of 6 feet 8 inches is enough for scaffold platforms 5 feet wide. Construct the tower footing using two 2 by 12s, 2 feet long, placed under each 4 by 4 post. The height of the tower should extend at least 15 feet above the highest point where you need a landing. Then construct landings extending from the tower to the floors and scaffold platforms as needed. Use 2 by 10s or 2 by 12s for the landings.

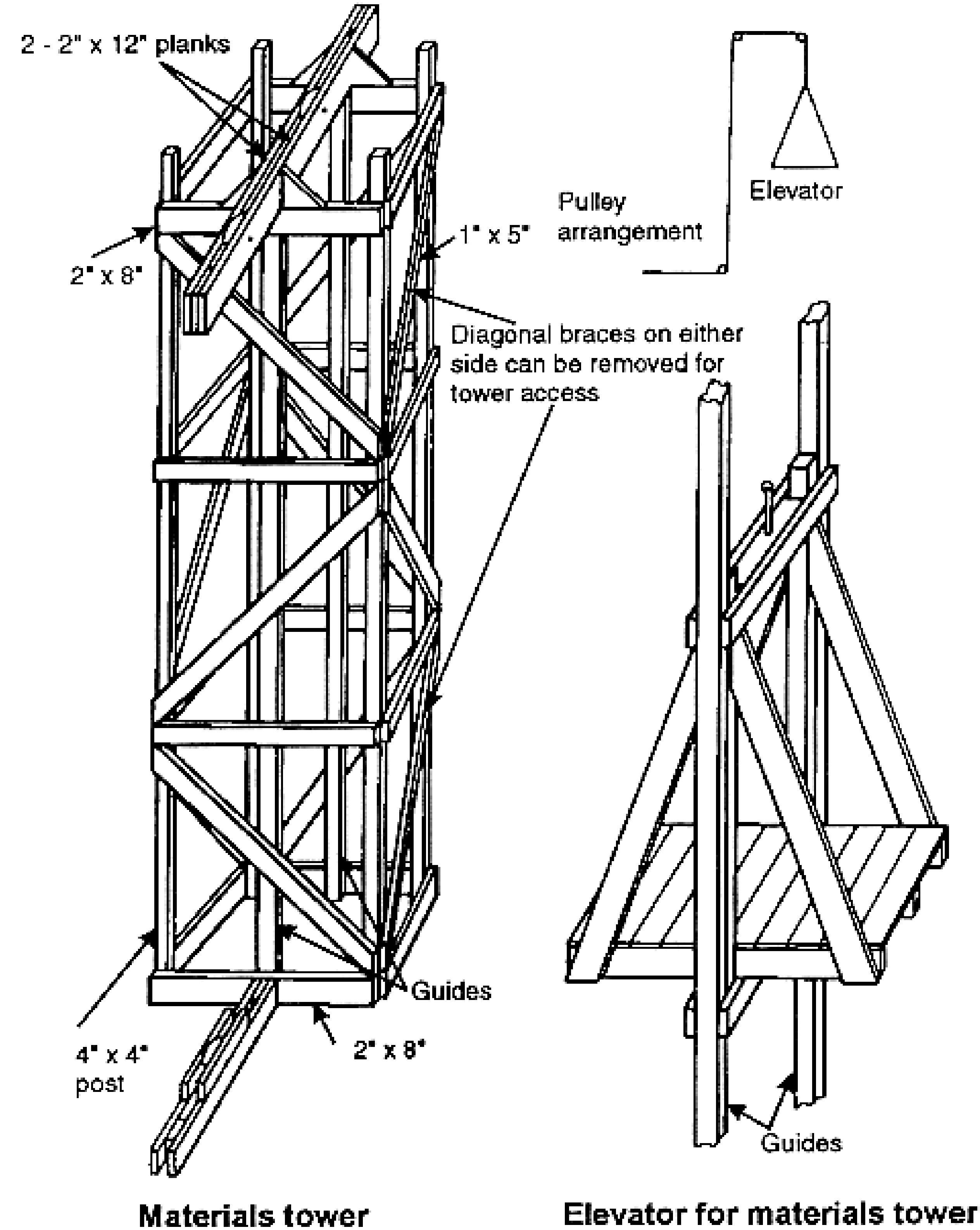


Figure 7-9. Materials tower and elevator

ELEVATOR

7-30. Figure 7-9 also shows the elevator, rope, and pulley arrangement that serves the materials tower. Note the guides at the base of the elevator that fit onto the guides running up from the base of the tower.

Chapter 8

Concrete Masonry

8-1. When portland cement, water, and suitable aggregates, such as sand, gravel, crushed stone, cinders, burned shale, or slag, are mixed and formed into individual pieces to be used in laying up walls and other structural details, the pieces thus formed are known as unit masonry, or units. However, most masons refer to them as concrete blocks. Concrete blocks will vary in size and shape as well as style. They are typically used for house foundations, decorative blocks for strong garden, or retaining walls. Rubble stone masonry is strong, durable, and offers an incomparable beauty and range of effect. Construction of concrete masonry is time consuming and requires highly skilled personnel.

SECTION I. CHARACTERISTICS OF CONCRETE BLOCK

NATURE AND PHYSICAL PROPERTIES

8-2. A concrete block is a masonry unit that either contains single or multiple hollows, or is solid. It is made from conventional cement mixes and various types of aggregate, including sand, gravel, crushed stone, air-cooled slag, coal cinders, expanded shale or clay, expanded slag, volcanic cinders (pozzolan), pumice, and scoria (refuse obtained from metal ore reduction and smelting). The term *concrete blocks* was formerly limited to only hollow masonry units made with such aggregates as sand, gravel, and crushed stone. But today the term covers all types of concrete blocks (both hollow and solid) made with any kind of aggregate. Concrete blocks are also available with applied glazed surfaces, various pierced designs, and a wide variety of surface textures. Although a concrete block is made in many sizes and shapes (see Figure 8-1 below) and in both modular and nonmodular dimensions, its most common unit size is 7 5/8 by 7 5/8 by 15 5/8, known as 8- by 8- by 16-inch block nominal size. All concrete blocks must meet certain specifications covering size, type, weight, moisture content, compressive strength, and certain other special characteristics. Concrete masonry is an increasingly important type of construction due to technological developments in both the manufacture and the use of concrete blocks. Properly designed and constructed concrete masonry walls satisfy many building requirements, including fire prevention, safety, durability, economy, appearance, utility, comfort, and acoustics.

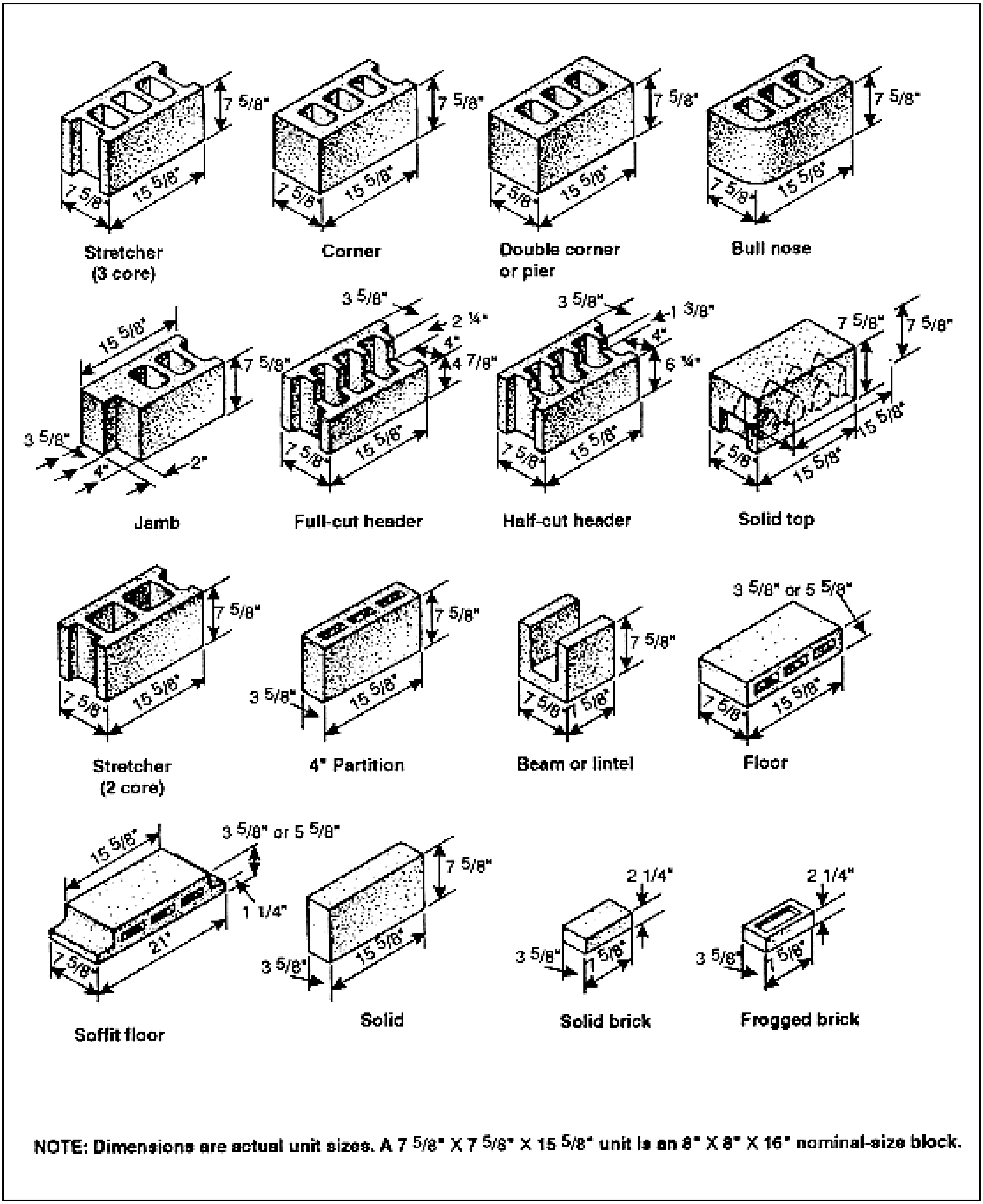


Figure 8-1. Typical unit sizes and shapes of concrete masonry units

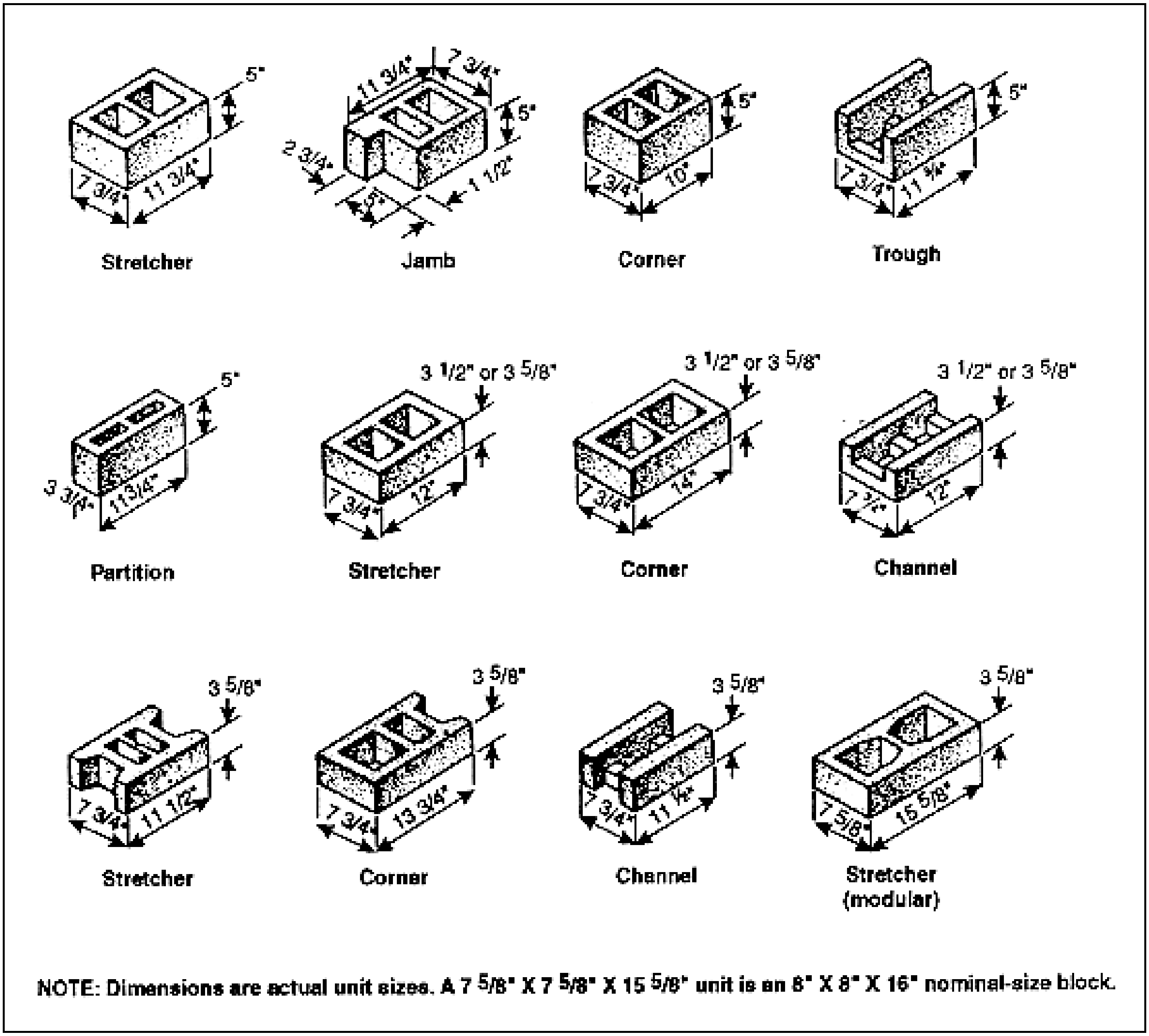


Figure 8-1. Typical unit sizes and shapes of concrete masonry units (continued)

CONCRETE BLOCK MASONRY UNIT

8-3. Concrete blocks are used in all types of masonry construction, such as--

- Exterior load-bearing walls (both below and above grade).
- Interior load-bearing walls.
- Fire walls and curtain walls.
- Partitions and panel walls.
- Backing for bricks, stones, and other facings.
- Fireproofing over structural members.
- Fire-safe walls around stairwells, elevators, and enclosures.

- Piers and columns.
- Retaining walls.
- Chimneys.
- Concrete floor units.

TYPES OF UNITS

8-4. The main types of concrete masonry units are--

- Hollow, load-bearing concrete block.
- Solid, load-bearing concrete block.
- Hollow, nonload-bearing concrete block.
- Concrete building tile.
- Concrete brick.

8-5. The load-bearing types of blocks have two grades. Grade N is for general use, such as exterior walls both above and below grade that may or may not be exposed to moisture penetration or weather, and for back-up and interior walls. Grade S is for above-grade exterior walls with weather-protective coating and for interior walls. The grades are further subdivided into two types: type I moisture-controlled units (for use in arid climates) N-I and S-I, and type II nonmoisture-controlled units N-II and S-II.

HEAVYWEIGHT ANDF LIGHTWEIGHT UNITS

8-6. The concrete masonry units made with either heavyweight or lightweight aggregates are referred to as such. A hollow, load-bearing concrete block is 8 by 8 by 16 inches with nominal-size weight from 40 to 50 pounds. These types of blocks are normally made with heavyweight aggregate such as sand, gravel, crushed stone, or air-cooled slag. The same type and nominal-size block weighs only from 25 to 35 pounds when made with coal cinders, expanded shale, clay, slag, volcanic cinders, or pumice. Your choice of masonry units depends on both availability and the requirements of the intended structure.

SOLID AND HOLLOW UNITS

8-7. ASTM specifications defines a solid concrete block as having a core area not more than 25 percent of the gross cross-sectional area. Most concrete bricks are solid and sometimes have a recessed surface like the frogged brick shown in Figure 8-1 above. In contrast, a hollow concrete block has a core area greater than 25 percent of its gross cross-sectional area--generally 40 to 50 percent.

SIZES AND SHAPES

8-8. Concrete masonry units are available in many sizes and shapes to fit different construction needs. Both full- and half-length sizes are shown in Figure 8-1. Because concrete block sizes usually refer to nominal dimensions, a unit actually measuring 7 5/8 by 7 5/8 by 15 5/8 inches is called an 8- by 8- by 16-inch block. When laid with 3/8-inch mortar joints, the unit will then occupy a space exactly 8 by 8 by 16 inches. Before designing a structure, contact local manufacturers for a schedule of their available unit sizes and shapes.

MAKING BLOCKS BY MACHINE

8-9. To precast concrete blocks, use a power-tamping machine available from several manufacturers. Tamp the concrete into the mold, then immediately strip off the mold. This way you can make many blocks rapidly using a single mold. The mix should be dry enough for the block to retain its shape.

MAKING BLOCKS BY HAND

8-10. To precast blocks by hand, pour concrete of fluid consistency into sets of iron molds, then strip off the molds when the concrete hardens. This procedure makes dense block with little labor; however, it requires a large number of molds.

MAKING WEATHER-EXPOSED BLOCKS

8-11. Make blocks subject to weathering with a concrete mix of at least six sacks of cement per cubic yards of mix. When using lightweight, porous aggregate, premix it with water for 2 minutes before adding the cement.

CURING CONCRETE BLOCKS

8-12. Steam is the best way to cure concrete blocks because it takes less time. Concrete blocks cured in wet steam at 125° F for 15 hours have 70 percent of their 28-day strength. If steam is not available, cure the blocks by protecting them from the sun and keeping them damp for 7 days.

SECTION II. CONSTRUCTION PROCEDURES

MODULAR COORDINATION AND PLANNING

8-13. *Modular coordination* is when the design of a building, its components, and the building-material units all conform to a dimensional standard based on a modular system. *Modular measure* is the system of dimensional standards for buildings and building components that permit field assembly without cutting. The basic unit is a 4-inch cube that allows a building to be laid around a continuous three-dimensional rectangular grid having 4-inch spacing. The modular system of coordinated drawings is based on a standard 4-inch grid placed on the width, length, and height of a building, as shown in Figure 8-2.

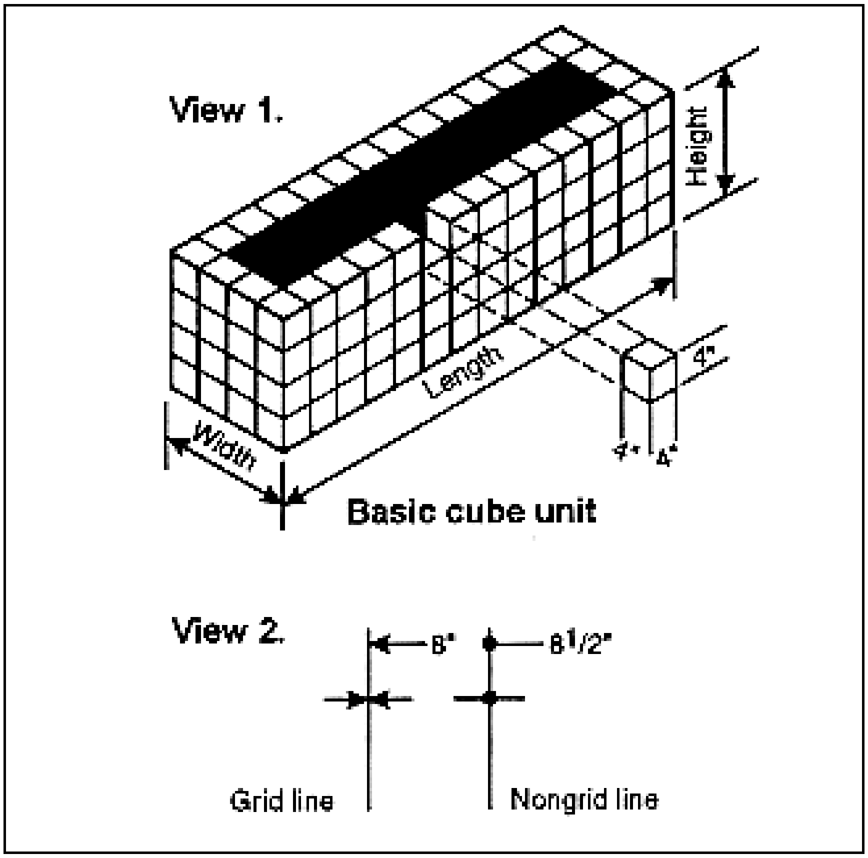


Figure 8-2. Elements of modular design

Step 1. Use the grid on preprinted drawing paper for both small-scale plans and large-scale details. Do not use drawing paper with a scale less than 3/4 inch which equals 1 foot to show grid lines at 4-inch spacing.

Step 2. Select a larger planning module that is a multiple of 4 inches. For floor plans and elevations, for example, the module may be 2 feet 8 inches, 4 feet, 5 feet, 6 feet 4 inches, and so forth.

Step 3. Show materials actual size, or to scale, and locate them on or related to a grid line by reference dimensions. Dimensions falling on grid lines are shown by arrows; those not falling on grid lines, by dots (see Figure 8-2 above).

- Maintain constant awareness of standard modular dimensions in planning, and preplan the work to make use of as many standard- sized building materials as possible. Such planning saves considerable labor, time, and materials.
- Make maximum use of full- and half-length units when laying out concrete masonry walls to minimize cutting and fitting units on the job.
- Plan the wall length and height, the width and height of openings, and wall areas between doors, windows, and corners to use full- and half-size units as shown in Figure 8-3. Remember that window and door frames must have modular dimensions to fit modular full- and half-size masonry units.
- Keep all horizontal dimensions in multiples of nominal full-length masonry units. Both horizontal and vertical dimensions should be designed in multiples of 8 inches. Table 8-1 below gives the nominal lengths of modular-concrete masonry walls in the number

of stretchers, and Table 8-2 below gives the nominal heights of modular-concrete masonry walls in the number of courses.

- Plan the horizontal dimensions in multiples of 8 inches (half-length units) and the vertical dimensions in multiples of 4 inches, when using 8 by 4 by 16 blocks. If the wall thickness is either greater or less than the length of one half-length unit, use a special length unit at each corner in each course.

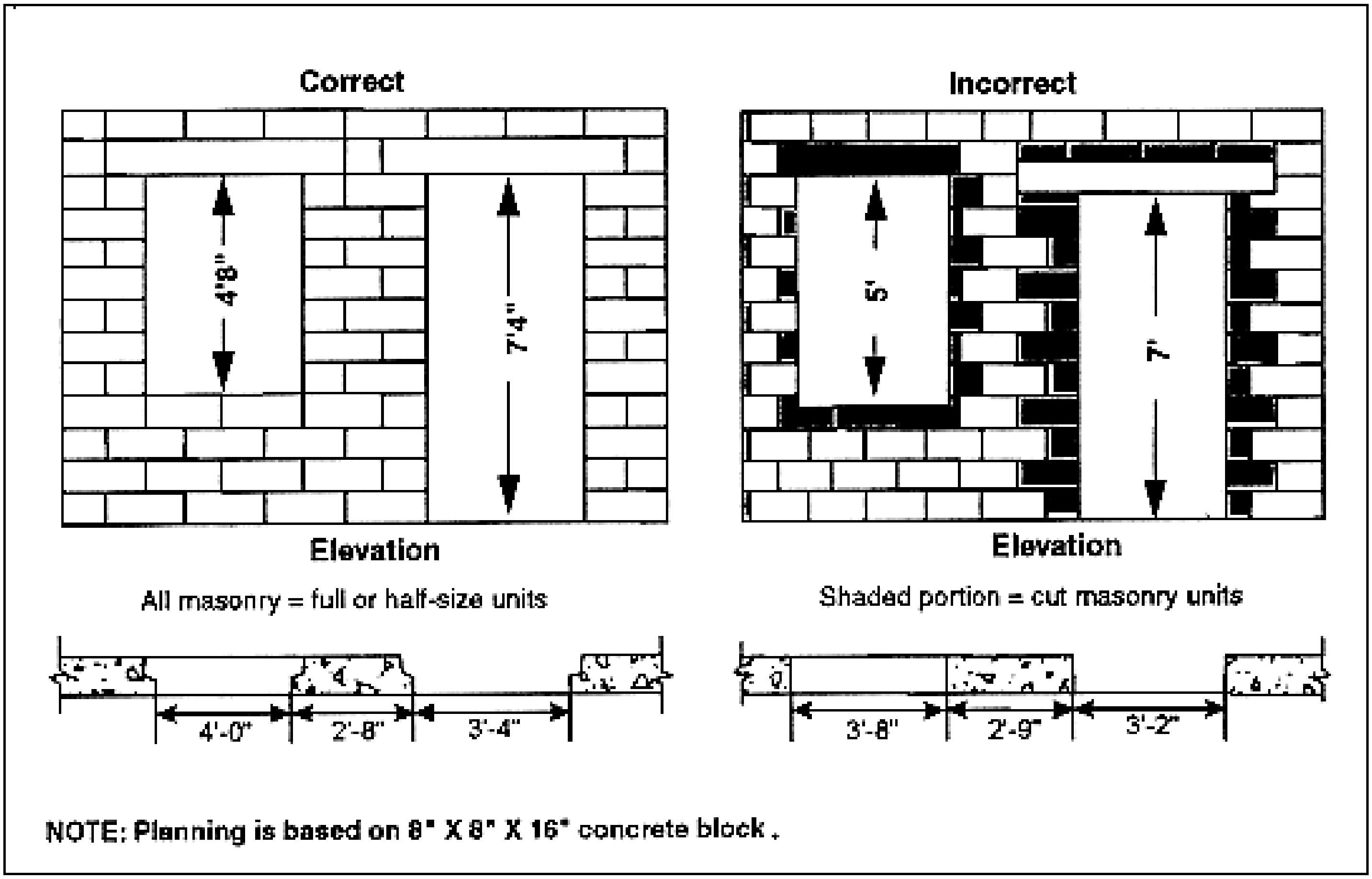


Figure 8-3. Planning concrete masonry wall openings

Table 8-1. Nominal length of modular-concrete masonry walls in stretchers

Number of Stretchers	Nominal Length of Concrete Masonry Walls	
	Units 15 5/8" Long and Half Units 7 5/8" Long With 3/8" Thick Head Joints	Units 11 5/8" Long and Half Units 5 5/8" Long With 3/8" Thick Head Joints
1 1 1/2 2	1' 4" 2' 0" 2' 8"	1' 0" 1' 6" 2' 0"
2 1/2 3 3 1/2	3' 4" 4' 0" 4' 8"	2' 6" 3' 0" 3' 6"

4 4 1/2 5	5' 4" 6' 0" 6' 8"	4' 0" 4' 6" 5' 0"
5 1/2 6 6 1/2	7' 4" 8' 0" 8' 8"	5' 6" 6' 0" 6' 6"
7 7 1/2 8	9' 4" 10' 0" 10' 8"	7' 0" 7' 6" 8' 0"
8 1/2 9 9 1/2	11' 4" 12' 0" 12' 8"	8' 6" 9' 0" 9' 6"
10 10 1/2 11	13' 4" 14' 0" 14' 8"	10' 0" 10' 6" 11' 0"
11 1/2 12 12 1/2	15' 4" 16' 0" 16' 8"	11' 6" 12' 0" 12' 6"
13 13 1/2 14	17' 4" 18' 0" 18' 8"	13' 0" 13' 6" 14' 0"
14 1/2 15 20	19' 4" 20' 0" 26' 8"	14' 6" 15' 0" 20' 0"
NOTE: Actual wall length is measured from outside edge to outside edge of units and equals the nominal length minus 3/8" (one mortar joint).		

Table 8-2. Nominal height of modular-concrete masonry walls in courses

Number of Stretchers	Nominal Length of Concrete Masonry Walls

	Units 7 5/8" High and 3/8" Thick Bed Joints	Units 3 5/8" High and 3/8" Thick Bed Joints
1 2 3	8" 1' 4" 2' 0"	4" 8" 1' 0"
4 5 6	2' 8" 3' 4" 4' 0"	1' 4" 1' 8" 2' 0"
7	4' 8"	2' 4"
8	5' 4"	2' 8"
9	6' 0"	3' 0"
10	6' 8"	3' 4"
15	10' 0"	5' 0"
20	13' 4"	6' 8"
25	16' 8"	8' 4"
30	20' 0"	10' 0"
35	23' 4"	11' 8"
40	26' 8"	13' 4"
45	30' 0"	15' 0"
50	33' 4"	16' 8"
NOTE: For concrete masonry units 7 5/8" and 3 5/8" in height laid with 3/8" mortar joints. Height is measured from center to center of mortar joints.		

WALLS AND WALL FOOTINGS

8-14. Place masonry wall footings on firm, undisturbed soil having adequate load-bearing capacity to carry the design load and below frost penetration. Unless local requirements or codes specify otherwise, make the footings for small buildings twice as wide as the thickness of the walls they support. Table 8-3 below gives both the unit weights and quantities for modular-concrete masonry walls. Footing thickness equals wall width (see Figure 8-4 below).

Table 8-3. Unit weight and quantities for modular concrete masonry walls

Actual Unit Size (Width x Height x Length), in Inches	Nominal Wall Thick-ness, in Inches	For 100 Sq Ft of Walls				
		Num-ber of Units	Average Weight of Finished Wall			
			Heavy-weight Aggregate, in Lb*	Lightweight Aggregate, in Lb*	Mortar,*in Cu Ft	
3 5/8 x 3 5/8 x 15 5/8	4	225	3,050	2,150	9.5	6
5 5/8 x 3 5/8 x 15 5/8	6	225	4,550	3,050	9.5	6
7 5/8 x 3 5/8 x 15 5/8	8	225	5.700	3,700	9.5	6
3 5/8 x 7 5/8 x 15 5/8	4	112.5	2,850	2,050	6.0	7
5 5/8 x 7 5/8 x 15 5/8	6	112.5	4,350	2,950	6.0	7
7 5/8 x 7 5/8 x 15 5/8	8	112.5	5,500	3,600	6.0	7
11 5/8 x 7/5/8 x 15 5/8	12	112.5	7,950	4,900	6.0	7

NOTES: 1. Table is based on 3/8-inch mortar joints.
2. Actual weight of 100 sq ft of wall can be computed by formula W (n) + 150(M).
where--
W = actual weight of a single unit.
n = number of units for 100 sq ft of wall.
M = cu ft of mortar for 100 sq ft of wall.
*Actual weight within ± 7% of average weight. With face-shell mortar bedding. Mortar quantities should include 10% allowance for waste.

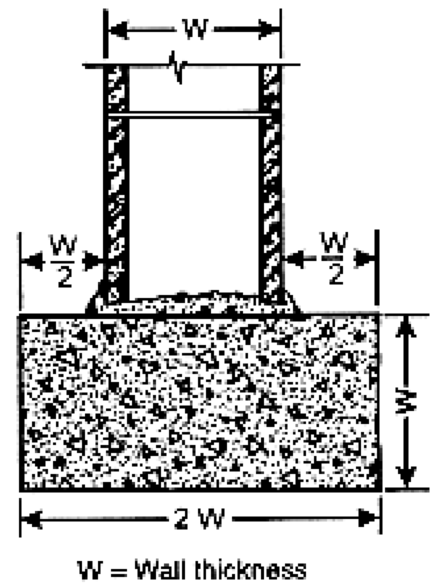


Figure 8-4. Dimensions of masonry wall footings

SUBSURFACE DRAINAGE

8-15. If you expect the groundwater level during a wet season to reach the basement floor elevation, place a line of drain tile along the exterior side of the footings. The tile line should fall at least 1/2 inch in 12 feet and drain to a suitable outlet. Place pieces of roofing felt over the joints to keep out sediment during backfilling. Cover the tile line to a depth of 12 inches with a permeable fill of coarse gravel or crushed stone ranging from 1 to 1 1/2 inches in size. When the first floor is in place, fill the balance of the trench with earth from the excavation.

BASEMENT WALLS

8-16. Always give exterior concrete masonry basement walls two 1/4-inch thick coats of parging, using either portland cement mortar (1:2 1/2 mix by volume) or joint mortar.

Step 1. In hot, dry weather dampen the wall surface very lightly with a fog water spray before applying the first parging coat.

Step 2. Roughen the first coat when it is partly hardens, to provide a bond for the second parging coat.

Step 3. Wait for the first coat to harden for 24 hours, then dampen it lightly just before applying the second coat. Keep the second coat damp for at least 48 hours following application.

Step 4. For below-grade parged surfaces in very wet soils, use two continuous coatings of bituminous mastic brushed over a suitable priming coat. Make sure that the parging is dry before you apply the primer and that the primer is dry when you apply the bituminous mastic. Do not backfill against concrete masonry walls until the first floor is in place.

FLOOR AND ROOF SUPPORT

8-17. Use solid masonry courses to support floor beams or floor slabs to help distribute the loads over the walls as well as provide a termite barrier. Use either solid masonry units or fill the cores of hollow block with concrete or mortar. If using blocks that are filled with mortar, lay strips of expanded metal lath in the bed joint underneath to support the fill.

WEATHERTIGHT CONCRETE MASONRY WALLS

8-18. Good workmanship is a very important factor in building weathertight walls.

Step 1. Lay each masonry unit plumb and true.

Step 2. Fill both horizontal and vertical joints completely; compact them by tooling when the mortar partly stiffens.

Step 3. Add flashing at vertical joints in copings and caps, at the joints between the roofs and walls, and below cornices and other members that project beyond the wall face.

Step 4. Shed water away from the wall surface by providing drips for chimney caps, sills, and other projecting ledges. Make sure that drains and gutters are large enough so that overflowing water does not run down masonry surfaces.

FIRST COURSE

8-19. The first step in building a concrete masonry wall is to locate the corners of the structure. Then check the layout by placing the first course blocks without mortar (see Figure 8-5).

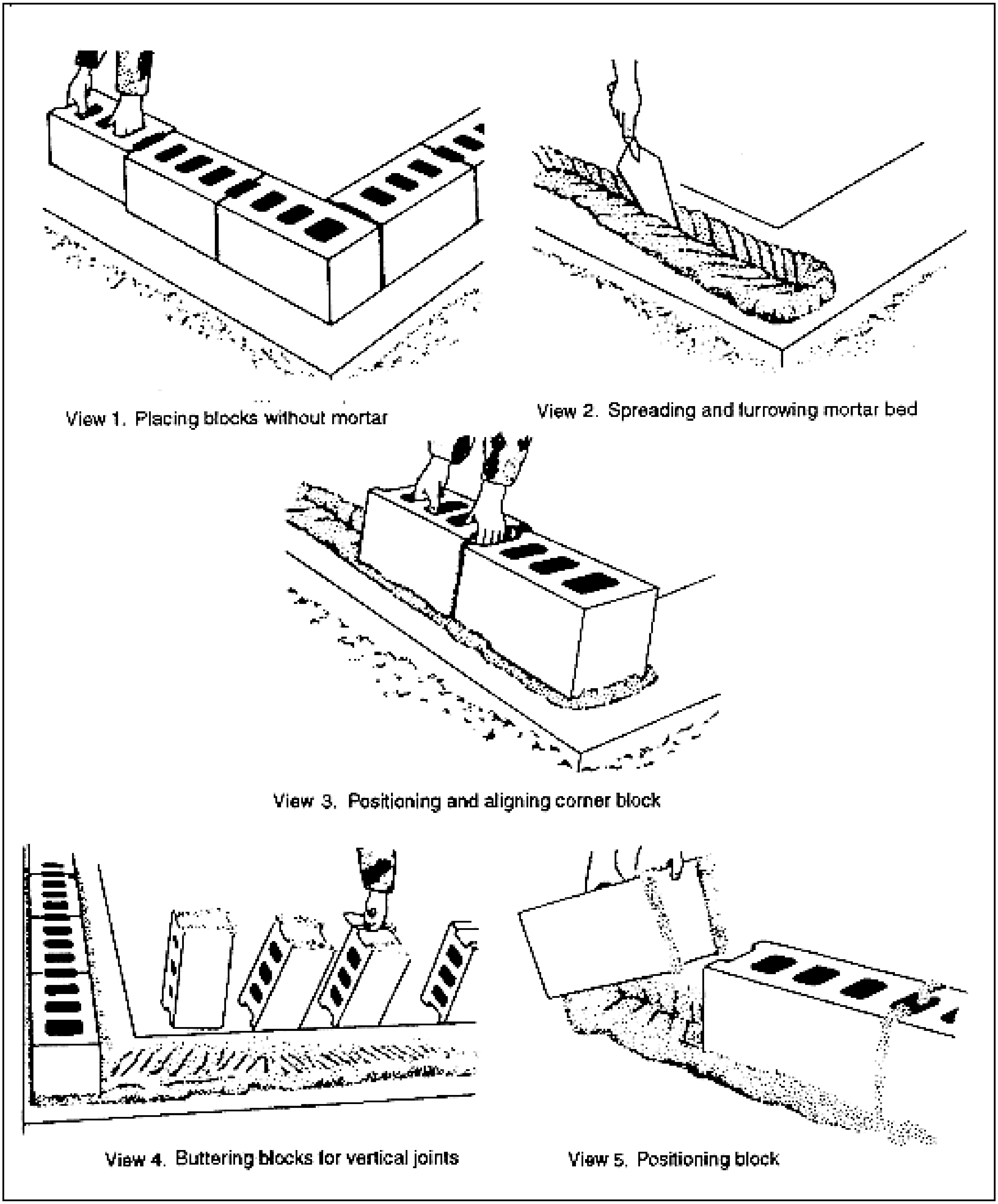


Figure 8-5. Laying first course of blocks for a wall

Step 1. Use a chalked snapline to mark the footing and align the blocks accurately.

Step 2. Replace the loose blocks with a full bed of mortar, spreading and furrowing it with a trowel to ensure plenty of mortar under the bottom edges of the first course.

Step 3. Use care to position and align the corner block first.

Step 4. Lay the remaining first course blocks with the thicker end up to provide a larger mortar-bedding area.

Step 5. Apply mortar to the block ends for the vertical joints by placing several blocks on end and buttering them all in one operation. Make the joints 3/8 inch thick.

Step 6. Place each block in its final position and push it down vertically into the mortar bed and against the previously laid block to obtain a well-filled vertical mortar joint.

Step 7. Use a mason's level after laying three or four blocks as a straightedge to check correct block alignment (see Figure 8-6).

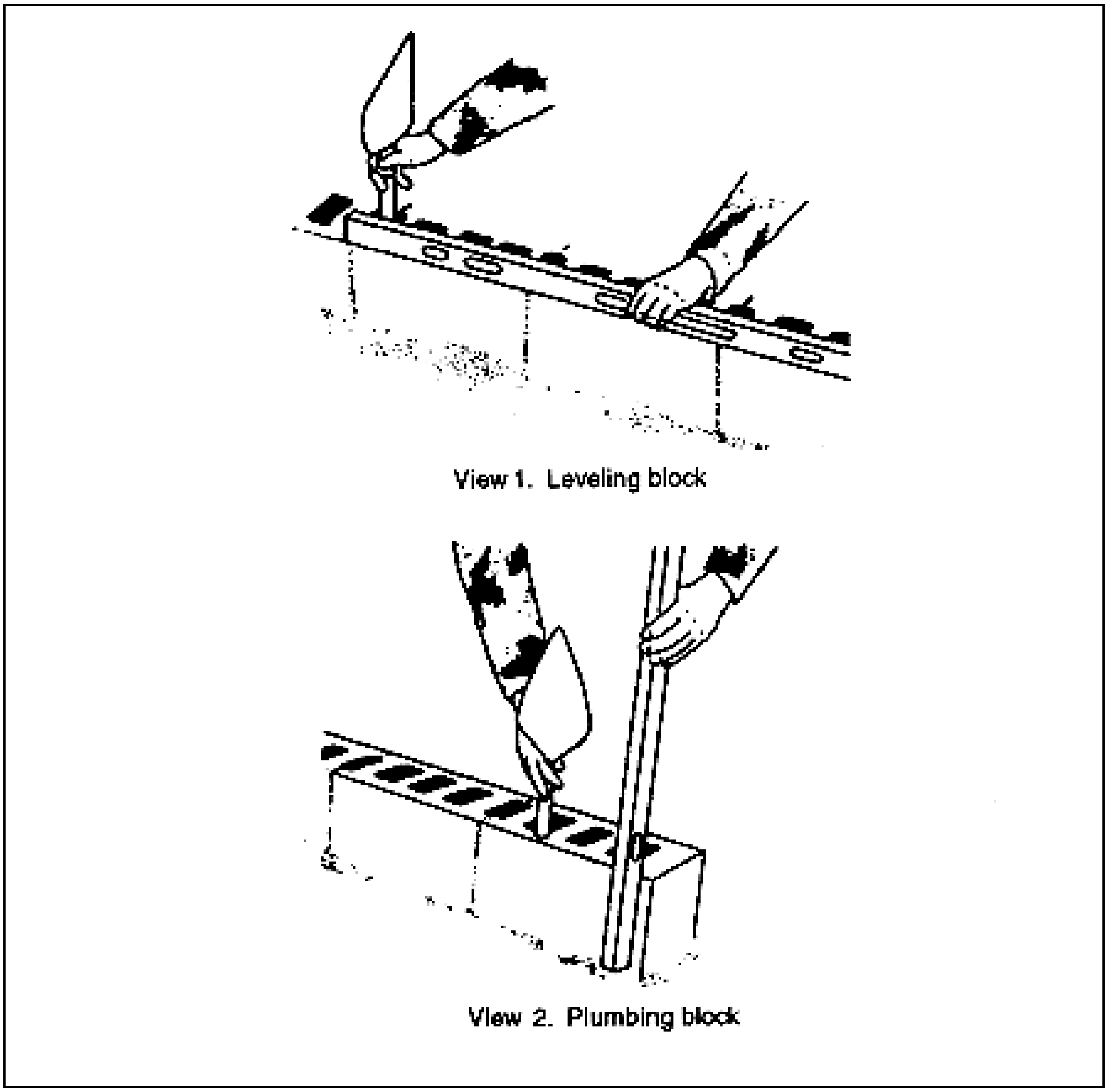


Figure 8-6. Leveling and plumbing first course of blocks for a wall

Step 8. Use the level to bring the blocks to proper grade and make them plumb by tapping with a trowel handle as shown in Figure 8-6.

Step 9. Lay out the first course of concrete masonry very carefully, making sure that it is properly aligned, level, and plumb. This ensures that succeeding courses and the final wall are both straight and true.

LAYING UP THE CORNERS

8-20. After laying the first course, build up the corners of the wall next, usually four or five courses high.

Step 1. Move back each course one-half block.

Step 2. Apply mortar only to the tops of the blocks of the horizontal joints already laid.

Step 3. Apply mortar to the vertical joints either to the ends of the new block or the end of the block previously laid, or both, to ensure well-filled joints (see Figure 8-7).

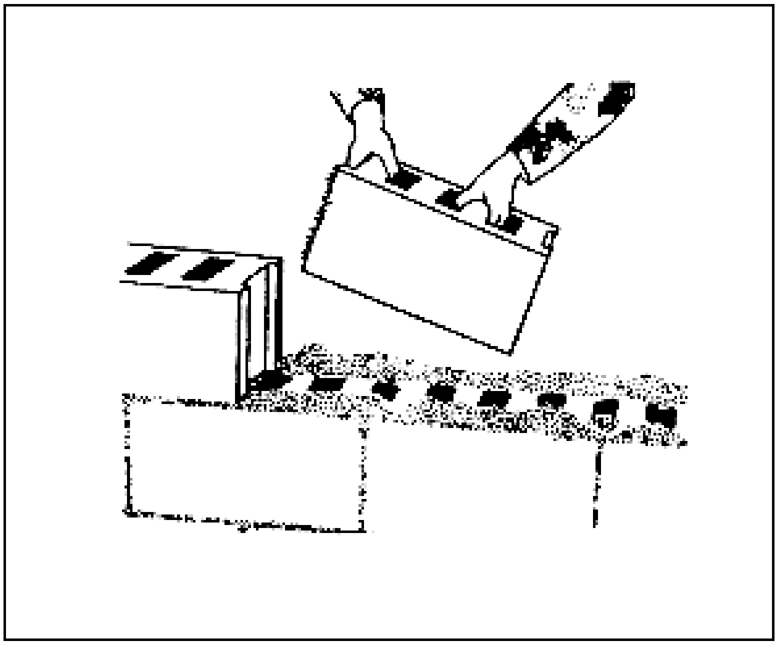


Figure 8-7. Vertical joints

Step 4. Lay each course at the corner, check it with a level for alignment for leveling and for ensuring that it is plumb (see Figure 8-8).

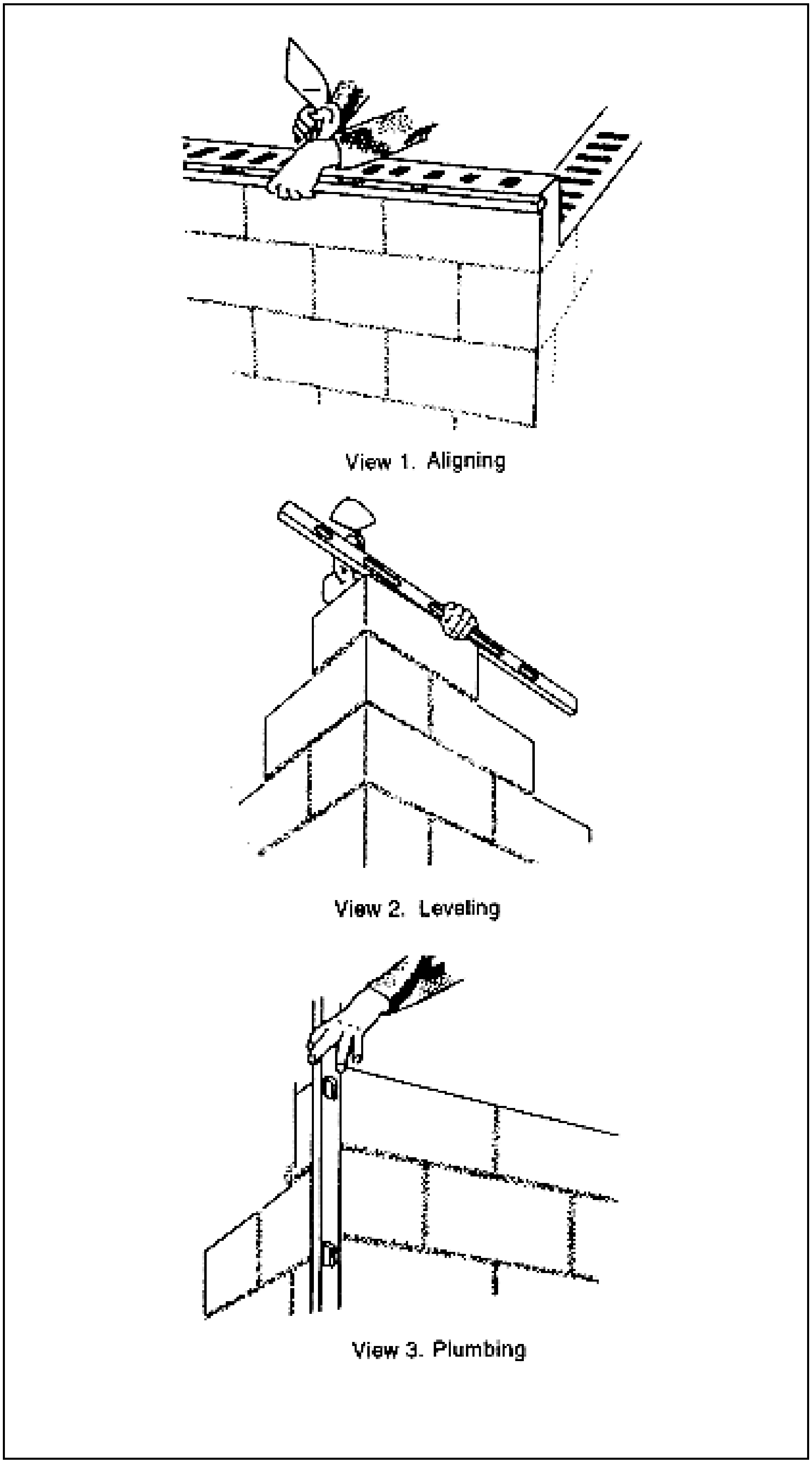


Figure 8-8. Checking each course at the corner

Step 5. Use care to check each block with a level or straightedge to make sure that all the block faces are in the same plane to ensure true, straight walls. A story or course pole, which is a board with markings 8 inch apart as shown in Figure 8-9 helps to accurately determine the top of each masonry course.

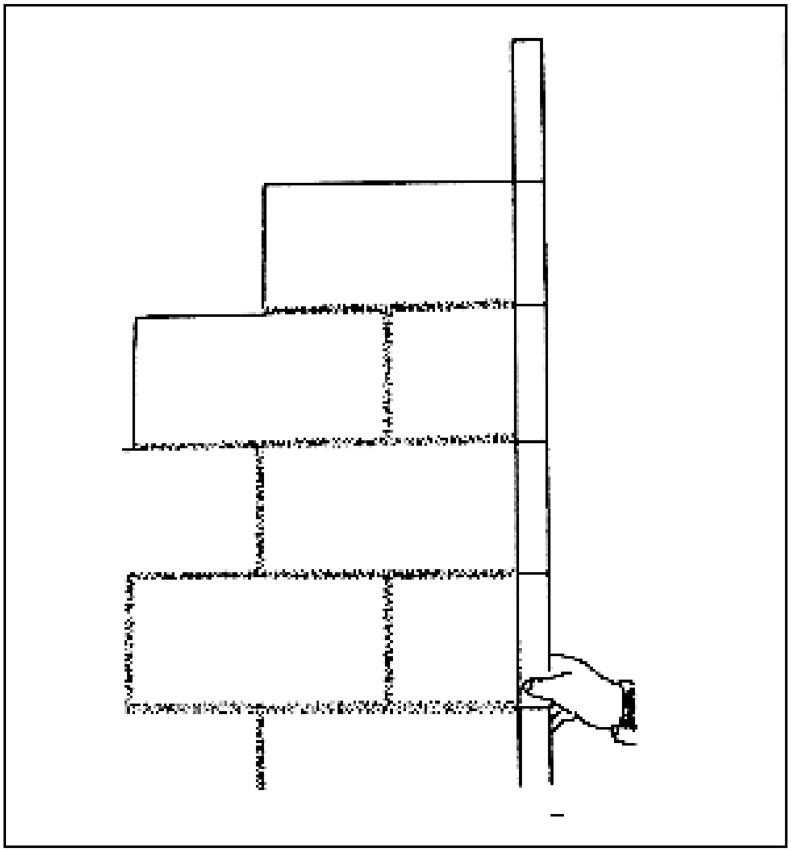


Figure 8-9. Using a story or course pole

Step 6. Check the horizontal block spacing by placing a level diagonally across the corners of the blocks as shown in Figure 8-10.

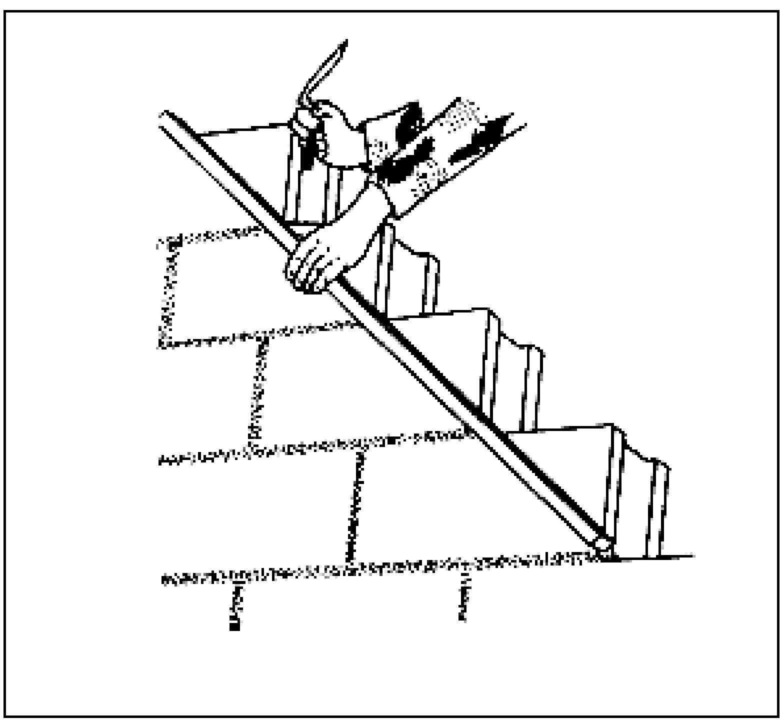


Figure 8-10. Checking horizontal block spacing

LAYING BLOCKS BETWEEN CORNERS

8-21. When filling in the wall between the corners, follow the procedures below.

Step 1. Stretch a mason's line along the exterior block edges from corner to corner for each course.

Step 2. Lay the top outside edge of each new block to this line (see Figure 8-11 below). How you grip a block before laying it is important.

- First, tip it slightly toward you so that you can see the edge of the course below.
- Place the lower edge of the new block directly on the edges of the blocks comprising the course below, as shown in Figure 8-11.
- Next, make all final position adjustments while the mortar is soft and plastic, because any adjustments you make after the mortar stiffens will break the mortar bond and allow water to penetrate.
- Finally, level each block and align it to the mason's line by tapping it lightly with a trowel handle.

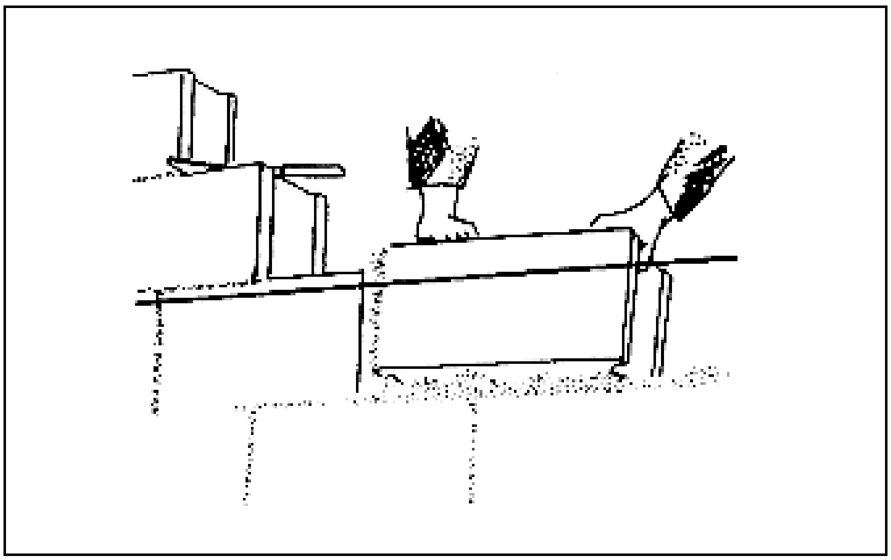


Figure 8-11. Filling in the wall between corners

CLOSURE BLOCK

8-22. Before installing the closure block, butter both edges of the opening and all four vertical edges of the closure block with mortar. Then lower the closure block carefully into place as shown in Figure 8-12. If any mortar falls out leaving an open joint, remove the block and repeat the procedure.

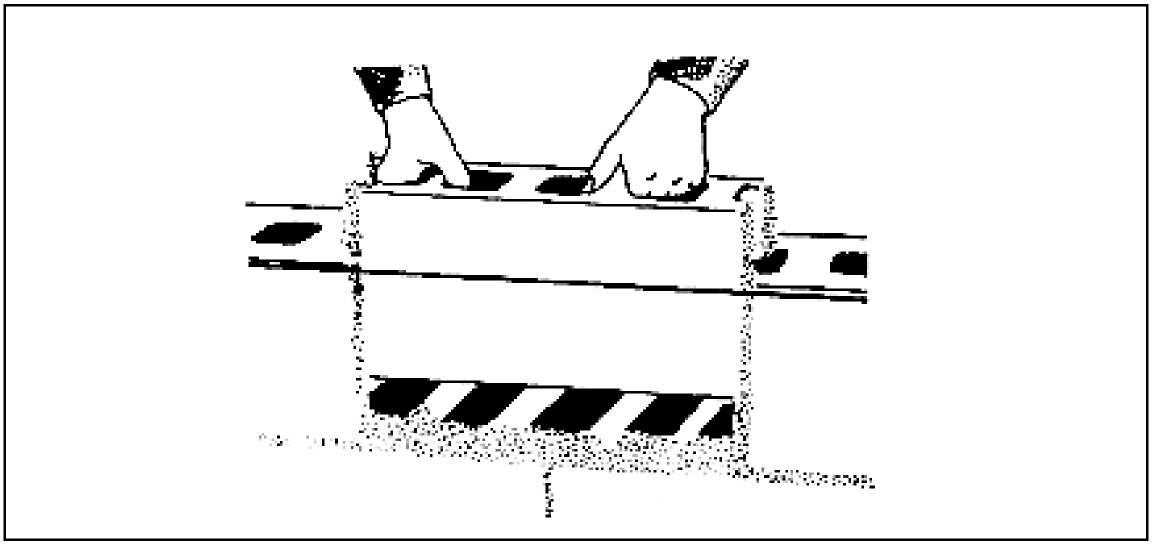


Figure 8-12. Installing a closure block

MORTAR JOINTS

8-23. To ensure a good bond, do not spread mortar too far ahead of actually laying blocks or it will stiffen and lose its plasticity. The recommended width of mortar joints for concrete masonry units is approximately 3/8 inch thick which--when properly made--helps to produce a weathertight, neat, and durable concrete masonry wall. As you lay each block, cut off excess mortar extruding from the joints using a trowel (see Figure 8-13) and throw it back on the mortar board to rework into the fresh mortar. Do not, however, rework any dead mortar from the scaffold or floor.

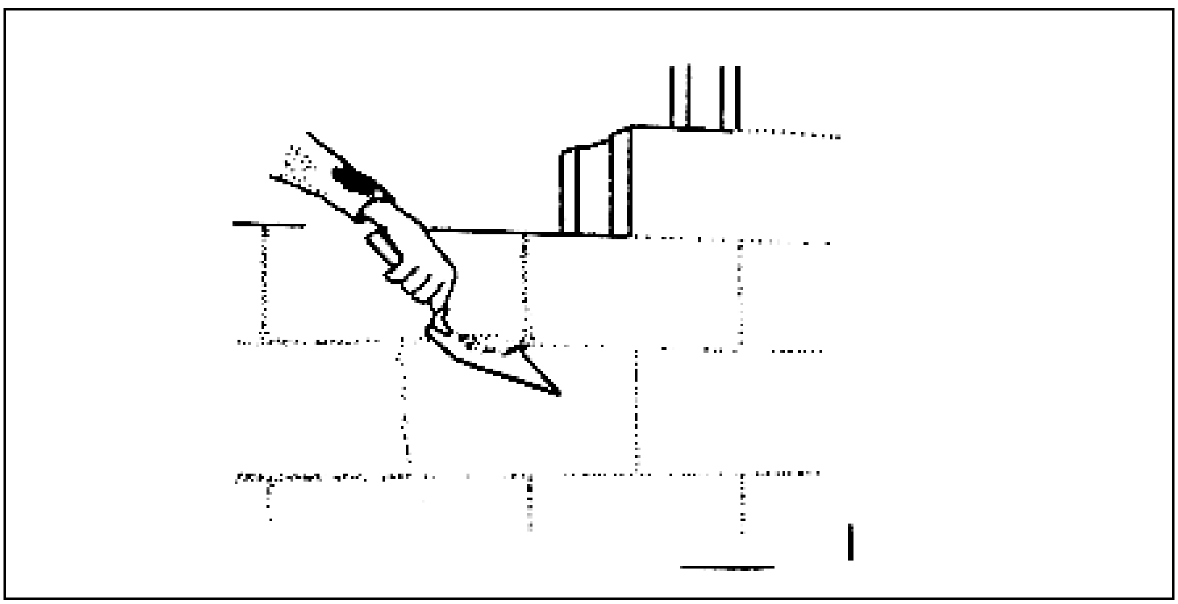


Figure 8-13. Cutting off excess mortar from the joints

TOOLING

8-24. Weathertight joints and the neat appearance of concrete masonry walls depend on proper tooling. After laying a section of the wall, tool the mortar joints when the mortar becomes thumbprint hard. Tooling compacts the mortar and forces it tightly against the masonry on each side of the joint. Use either concave or V-shaped tooling on all joints (see Figure 8-14). Tool vertical joints first, followed by striking the horizontal joints with a long jointer (see Figure 8-15 below). Trim off mortar burrs from the tooling flush with the wall face using a trowel or soft bristle brush, or by rubbing with a burlap bag.

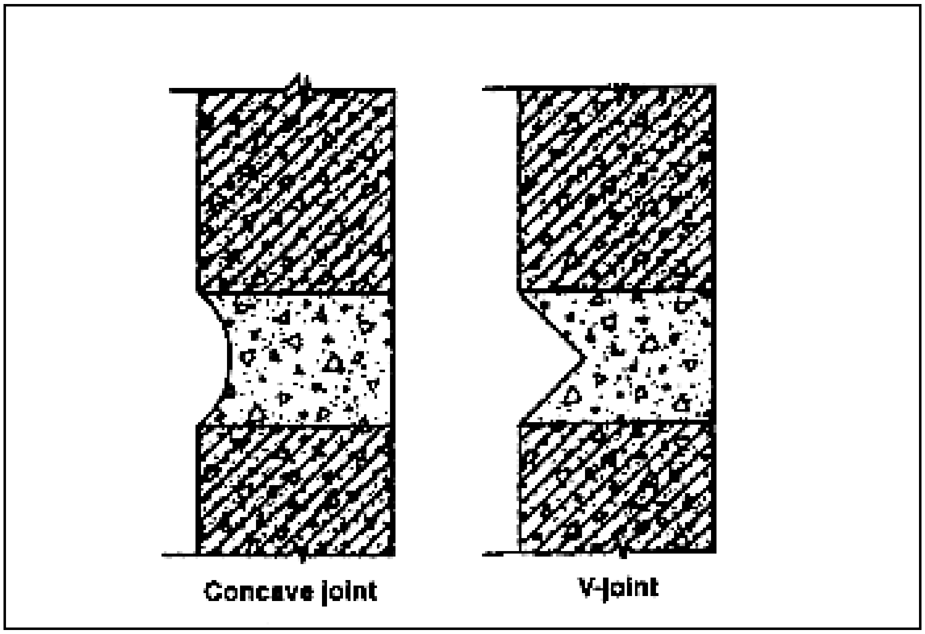
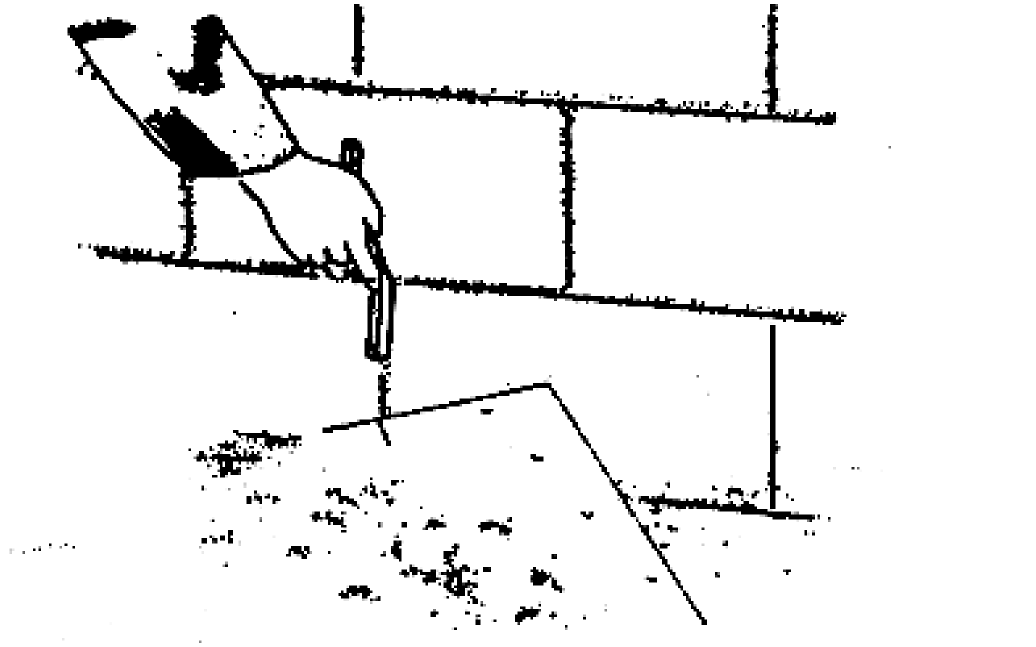
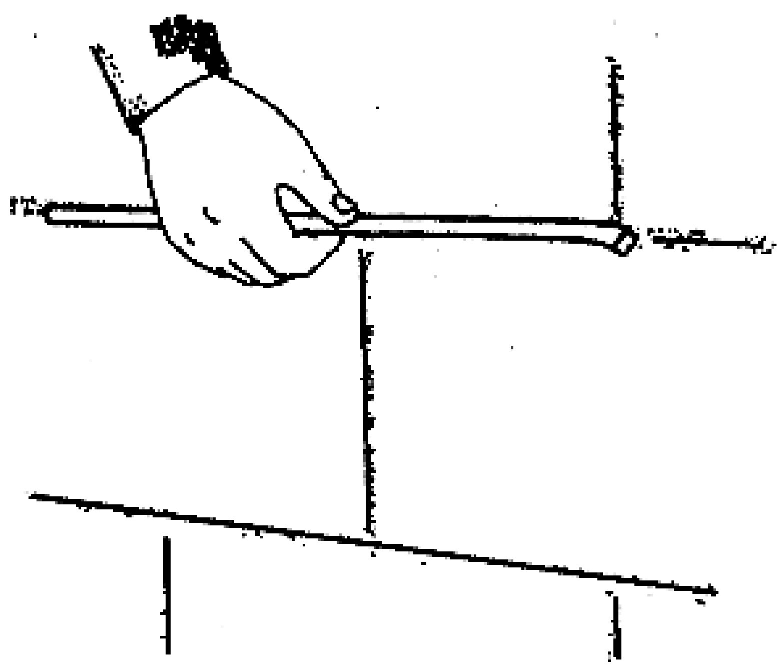


Figure 8-14. Tooling mortar joints for weathertight exterior walls



View 1. Striking vertical joints



View 2. Striking horizontal joints

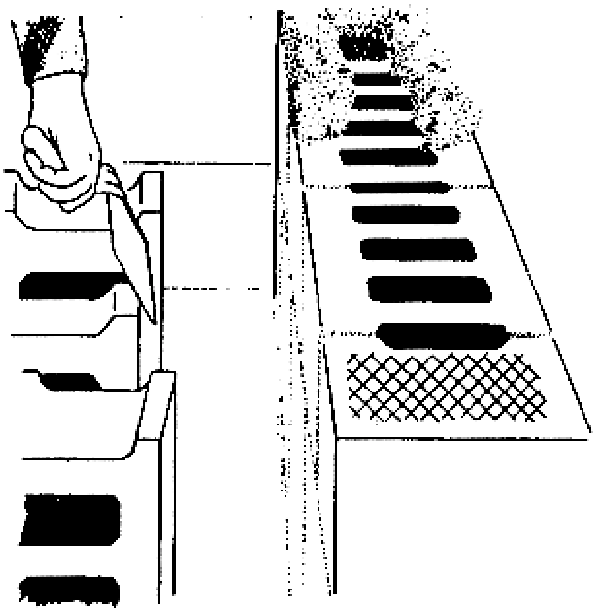
Figure 8-15. Tooling mortar joints

ANCHOR BOLTS

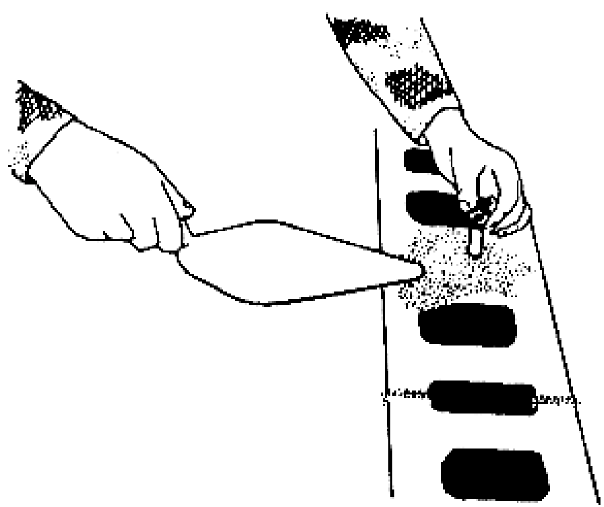
8-25. You must prepare in advance for installing wood plates on top of hollow concrete masonry walls with anchor bolts. To do this, place pieces of metal lath in the second horizontal mortar joint from the top of the wall under the cores that will contain the bolts. Use anchor bolts 1/2 inch in diameter and 18 inches long, spacing them up to a maximum of 4 feet apart. When you complete the top course, insert the bolts into the cores of the top two courses, and fill the cores with concrete or mortar. The metal lath underneath holds the concrete or mortar filling in place. The threaded end of the bolt should extend above the top of the wall as shown in Figure 8-16.

CONTROL JOINTS

8-26. *Control joints* are continuous vertical joints that permit the masonry wall to move slightly under unusual stresses without cracking. A combination of full-and half-length blocks form the continuous vertical joint as shown in view 1 of Figure 8-17. Lay up control joints in mortar just as any other joint, but if they are exposed to either the weather or to view, caulk them as well. After the mortar is quite stiff, rake it out to a depth of about 3/4 inch to make a recess for the caulking compound as shown in view 2 of Figure 8-17.

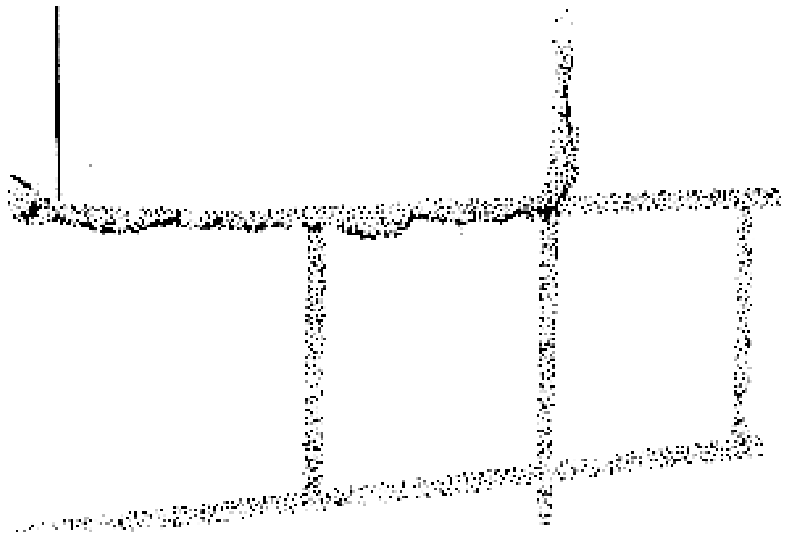


View 1. Placing metal lath under cores

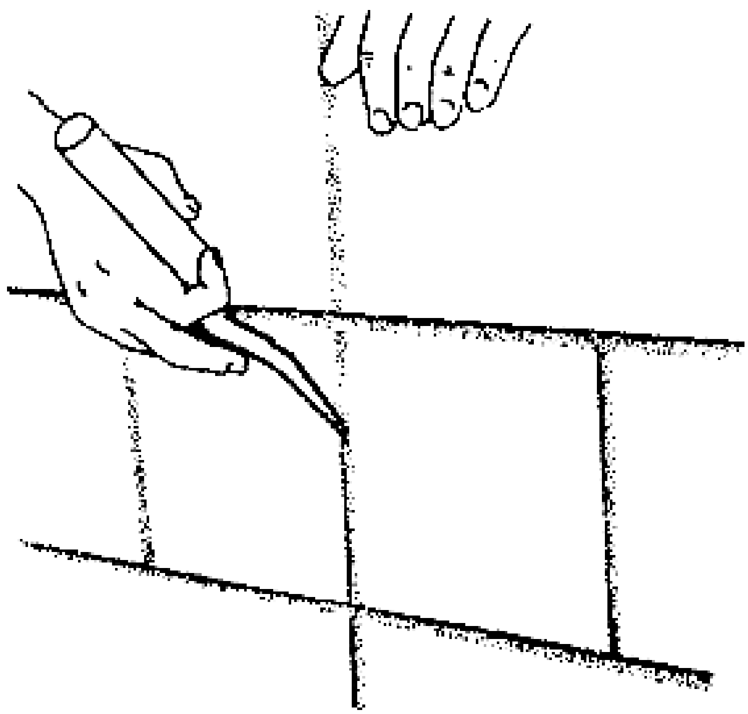


View 2. Threaded bolt extends above wall top

Figure 8-16. Installing anchor bolts for wood plates



View 1. Full- and half-length block make up joint



View 2. Raking joint to prepare for caulking

Figure 8-17. Making a control joint

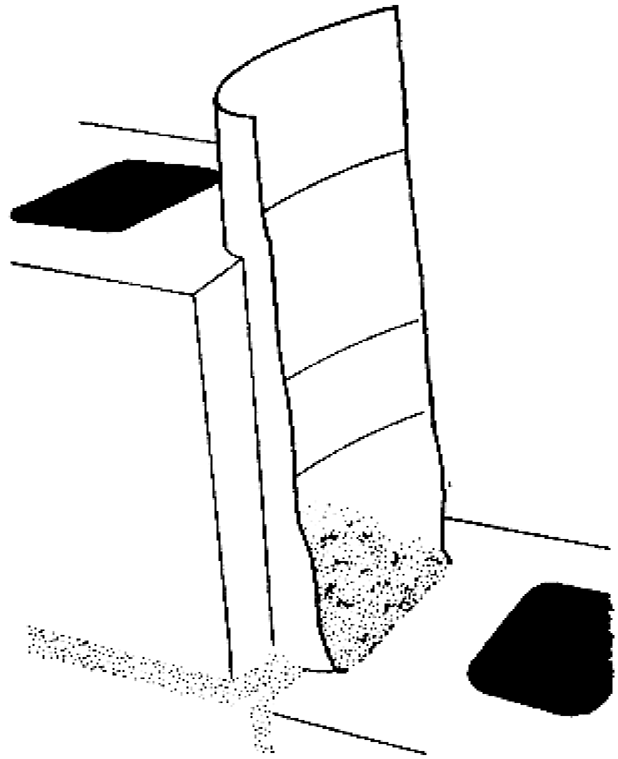
Use a thin, flat caulking trowel to force the compound into the joint. You can make a second type of control joint by inserting building paper or roofing felt into the block end cores extending the full height of the joint (see Figure 8-18). Cut the paper or felt to convenient lengths, but wide enough to extend across the joint. The paper or felt material prevents the mortar from bonding on that side of the joint. Use control joint blocks, if available (see Figure 8-18).

INTERSECTING WALLS

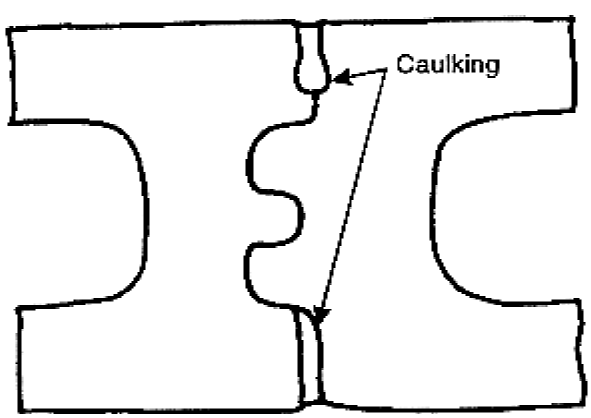
8-27. The two types of intersecting walls are bearing and nonbearing.

BEARING WALLS

8-28. Do not join intersecting concrete block-bearing walls with a masonry bond, except at the corners. Instead, terminate one wall at the face of the second wall with a control joint. Tie the intersecting walls together with Z-shaped metal-tie bars 1/4 by 1 1/4 by 28 inches in size, having a 2-inch right angle bend on each end (see Figure 8-19). Space the tie bars no more than 4 feet apart vertically, and place pieces of metal lath under the block cores that will contain the tie-bar ends (see Figure 8-16). Embed the right angle bends in the cores by filling them with mortar or concrete (see Figure 8-19)

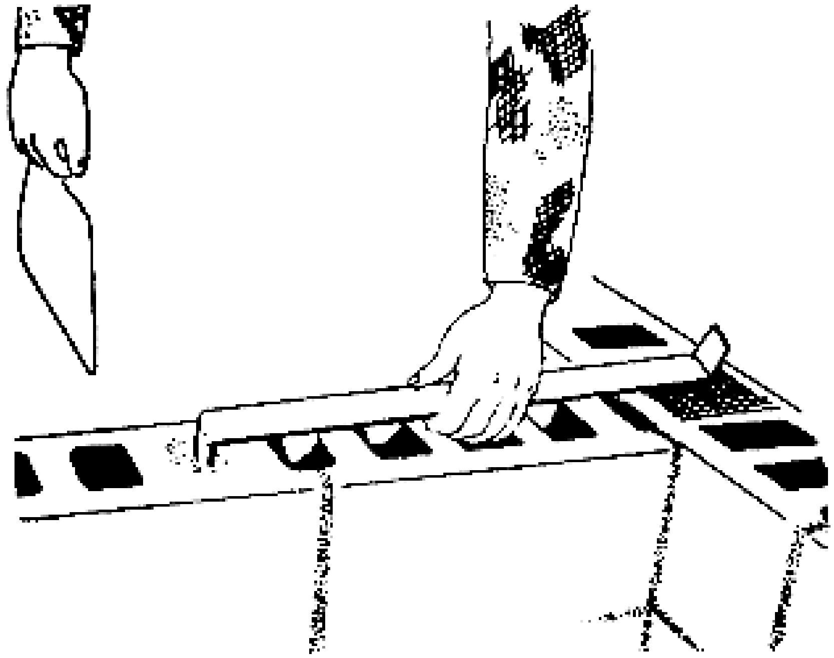


1. Roofing felt

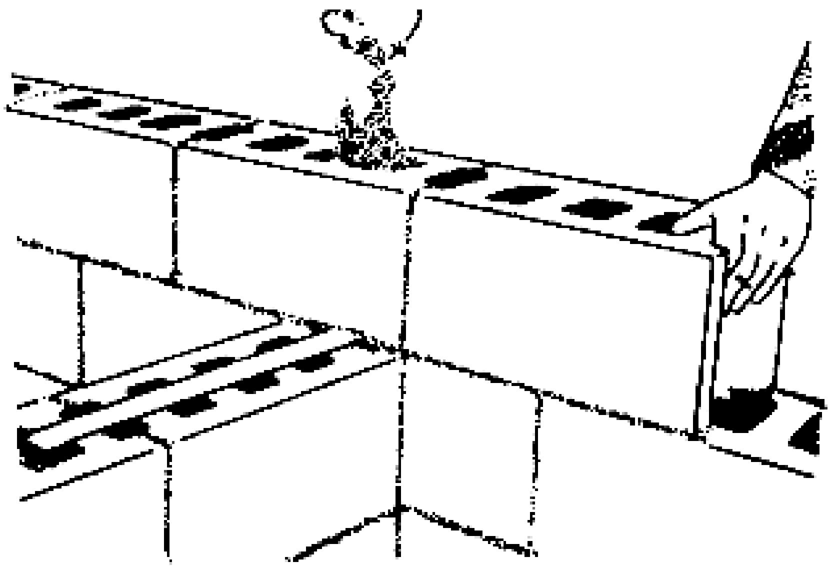


2. Control joint blocks

Figure 8-18. Control joints made using roofing felt or control joint blocksVertical joints



View 1. Z-shaped tie bar has right angle bends at each end

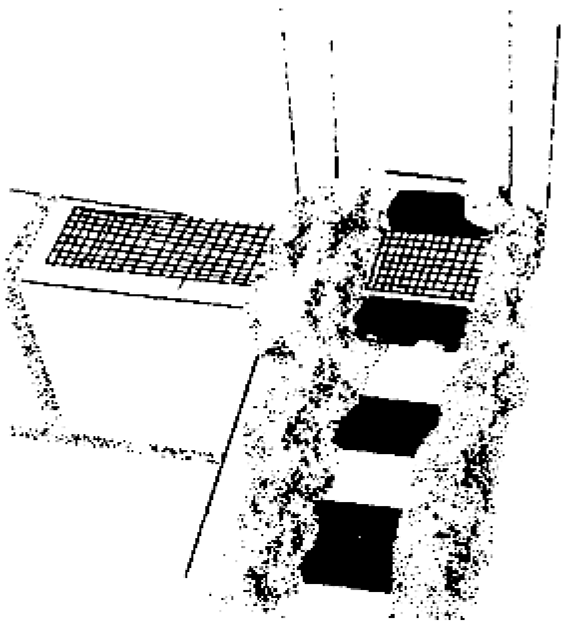


View 2. Filling core with mortar or concrete

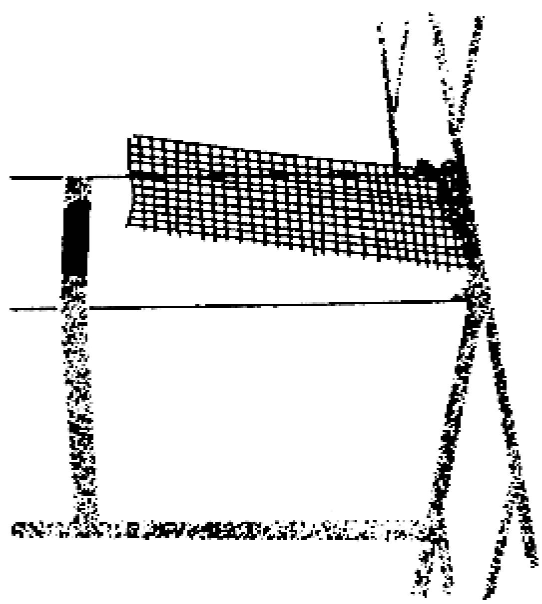
Figure 8-19. Tying intersecting bearing walls

NONBEARING WALLS

8-29. To join intersecting nonbearing block walls, terminate one wall at the face of the second with a control joint. Place strips of metal lath or 1/4-inch mesh galvanized hardware cloth across the joint between the two walls in alternate courses. Insert one half of the metal strips into one wall as you build it; tie the other halves into mortar joints as you lay the second wall



View 1. Metal lath spans the joint between the walls



View 2. Set lath in the mortar joint as you construct the second wall

Figure 8-20. Tying intersecting nonbearing walls

LINTELS

8-30. Modular door and window openings usually require lintels to support the blocks over the openings. Use precast concrete lintels that contain an offset on the underside to fit the modular openings or use steel-lintel angles that you install with an offset on the underside (see Figure 8-21) to fit modular openings. In either case, place a noncorroding metal plate under the lintel ends at the control joints to allow the lintel to slip and the control joints to function properly. Apply a full bed of mortar over the metal plate to uniformly distribute the lintel load.

SILLS

8-31. Install precast concrete sills following wall construction (see Figure 8-22). Fill the joints tightly at the ends of the sills with mortar or a caulking compound.

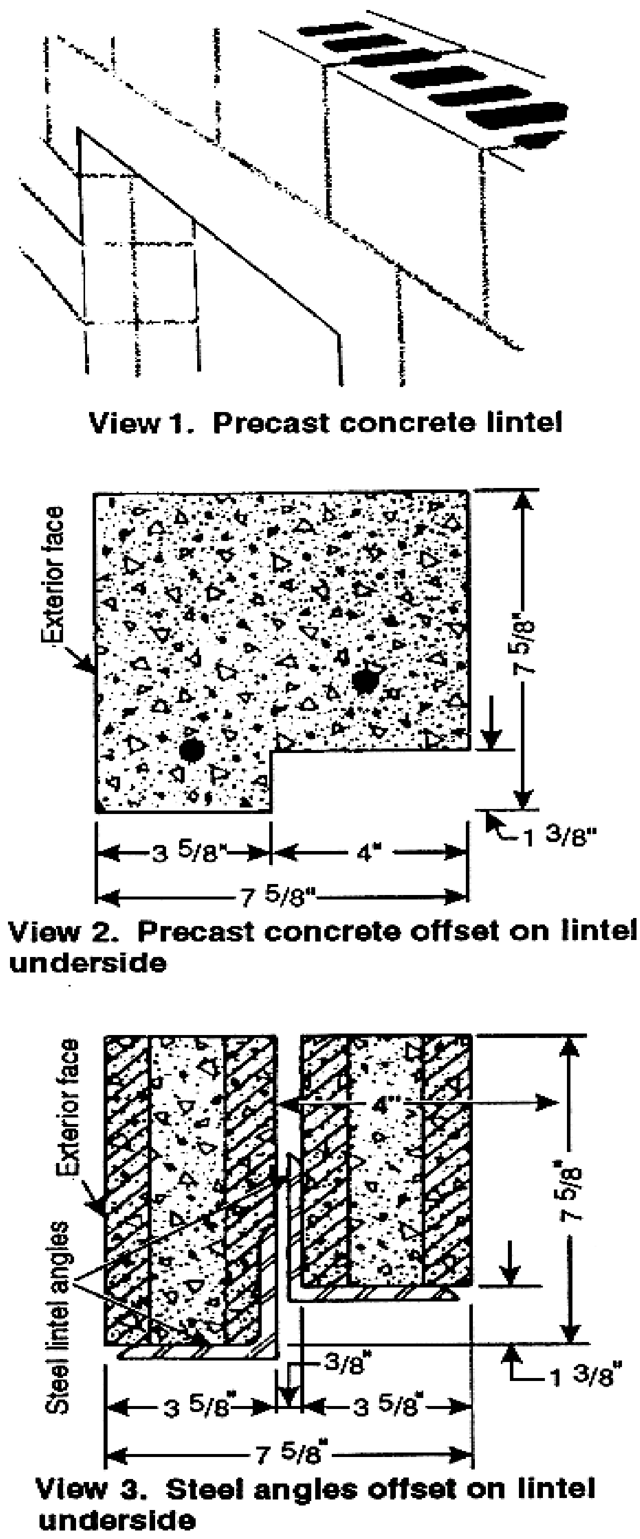


Figure 8-21. Installing precast concrete lintels without and with steel angles

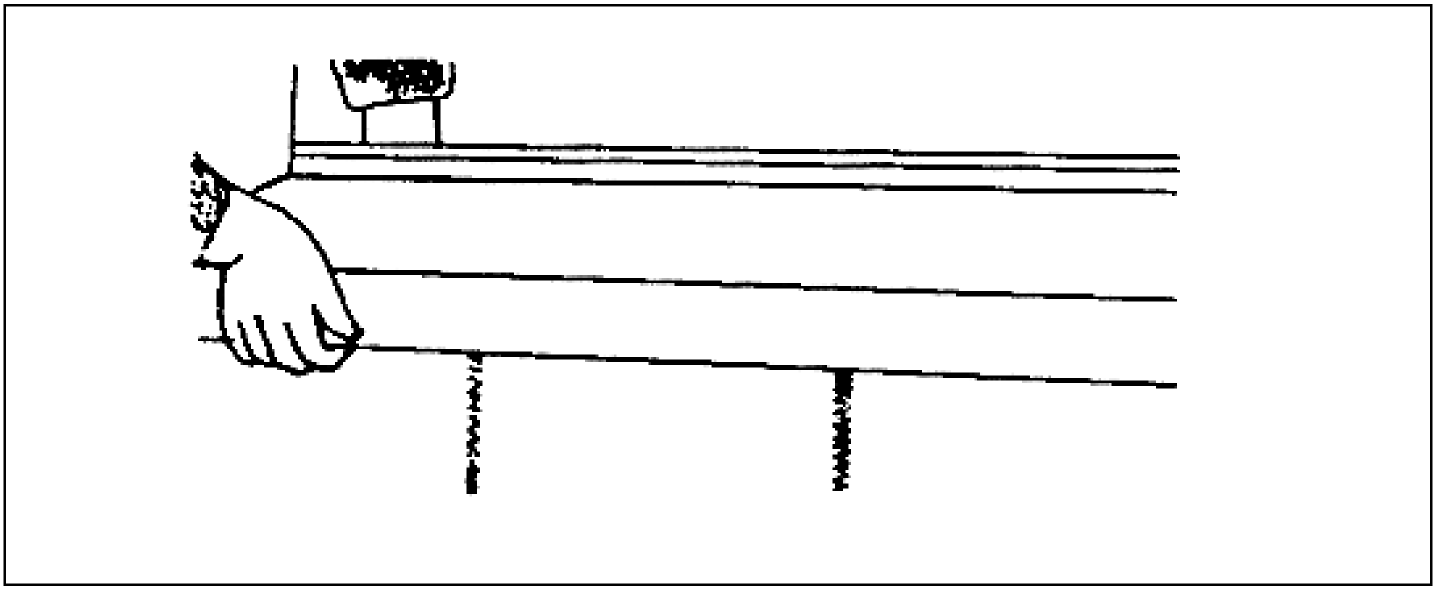


Figure 8-22. Installing precast concrete sills

PATCHING AND CLEANING BLOCK WALLS

8-32. When laying concrete masonry walls, be very careful not to smear mortar into the block surfaces, because you cannot remove hardened, embedded mortar smears, even with an acid wash; also paint will not cover them. Allow any droppings to dry and harden. You can then chip off most of the mortar with a small piece of broken concrete block (see Figure 8-23), or with a trowel. A final brushing of the spot will remove practically all of the mortar. Always patch mortar joints and fill holes made by nails or line pins with fresh mortar.

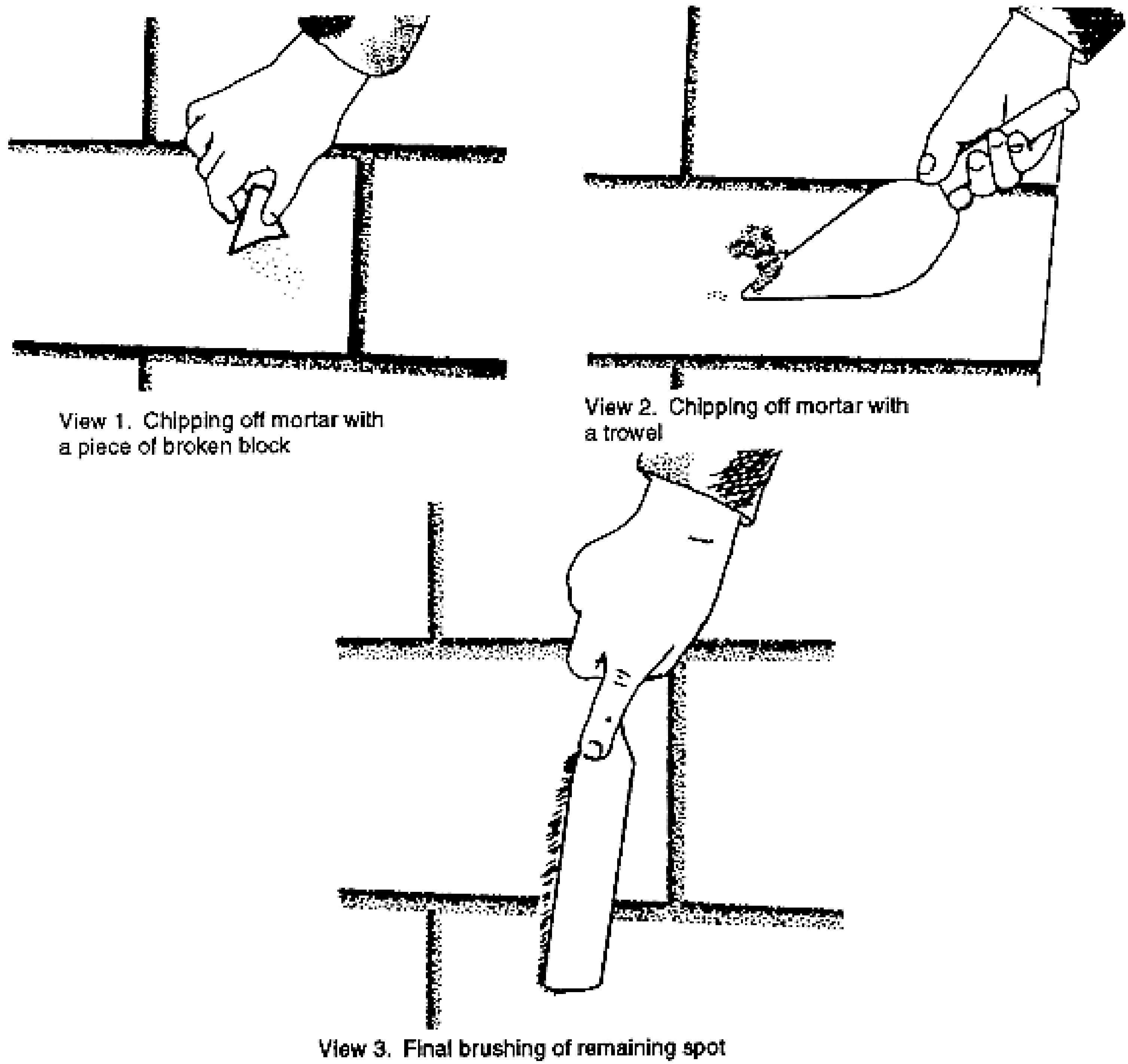


Figure 8-23. Cleaning mortar droppings from concrete block wall

8-33. The mason is responsible for laying out the job to do the work properly. Masons must make sure that the walls are plumb and that courses are level. They are also responsible for the quality of all the detail work such as cutting and fitting masonry units, making joints, and installing anchor bolts and ties in intersecting walls.

8-34. The mason's helper mixes mortar, keeps it tempered, and supplies concrete blocks and mortar to the mason as needed. Helpers aid the mason in laying out the job and sometimes lay out blocks ahead on an adjacent course to expedite the mason's work.

SECTION III. RUBBLE

RUBBLE STONE MASONRY

8-35. You can use rubble stone masonry (see Figure 8-24 below) for walls--both above and below ground--and for bridge abutments, particularly when form lumber or masonry units are not available. You can lay up rubble masonry with or without mortar, but for strength and stability use mortar. There are two types of rubble-stone masonry: random and coursed.

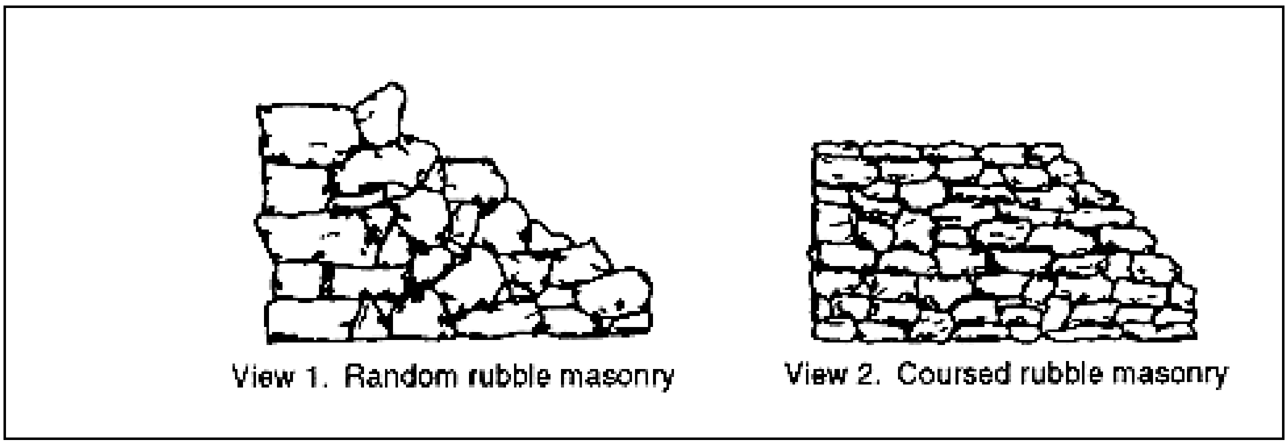


Figure 8-24. Rubble stone masonry

RANDON STONE MASONRY

8-36. This type is the crudest of all types of stonework. It does not require laying the stone in courses (see Figure 8-24 above), but each layer must contain bonding stones that extend through the wall (as shown in Figure 8-25) to tie the walls together. Make the bed joints horizontal for stability; the build or head joints can run in any direction.

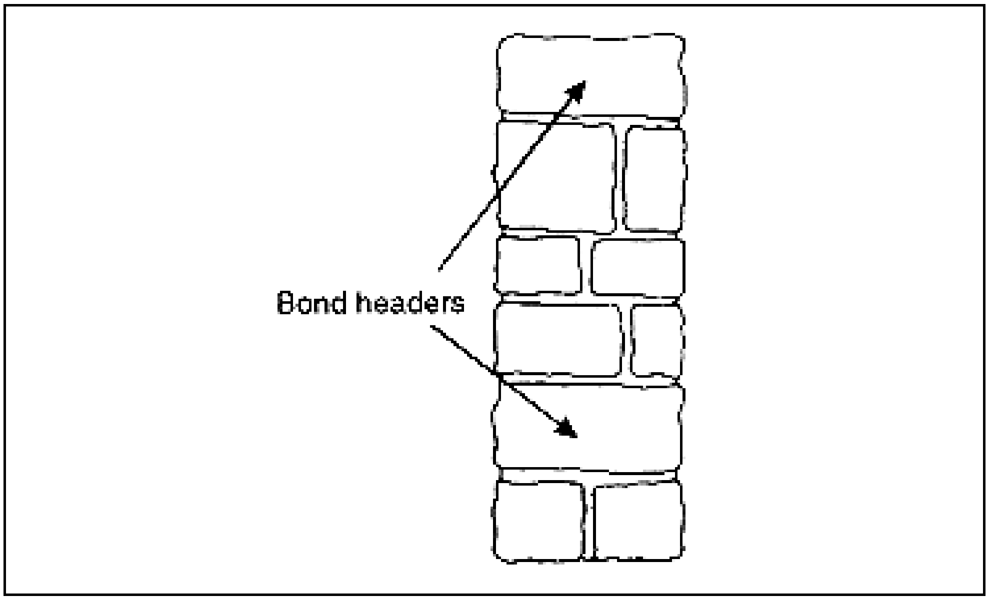


Figure 8-25. Bonding stones extend through a rubble stone masonry wall

COURSED RUBBLE MASONRY

8-37. This type contains roughly squared stones laid in nearly continuous horizontal bed joints as shown in Figure 8-24.

RANDOM RUBBLE MASONRY MATERIALS

8-38. The two main random rubble masonry materials are stones and mortar. Some of the more common suitable stones are limestone, sandstone, granite, and slate.

STONES

8-39. Use stones that are strong, durable, and cheap for random rubble masonry. Durability and strength depend on the stone's chemical composition and physical structure. Use unsquared stones or fieldstones from nearby ledges or quarries. No stones should be larger than what two persons can handle easily. The larger the variety of sizes you select, the less mortar you need.

MORTAR

8-40. Table 7-1 gives the proportions of the portland-cement-lime mortar mixture to use with random rubble masonry. Mortar made with ordinary portland cement stains most types of stone. To prevent staining, substitute nonstaining white portland cement. Lime usually does not stain the stone.

LAYING RUBBLE STONE MASONRY

8-41. The quality of workmanship affects the economy, durability, and strength of a rubble stone masonry wall more than any other factor. Lay out the wall--

- By eye. If the wall does not have to be exactly plumb and true to line, lay it out by eye without using a level and line. This requires frequent sighting.

- By line. If the wall must be exactly plumb and true to line, erect wood corner posts to serve as corner leads, and lay the stone with a line. Remember that some parts of the stone will extend farther away from the line than other parts. Do not try to lay the stone in level courses.

RULES FOR LAYING

8-42. Lay each stone on its broadest face. If appearance is important, place the larger stones in the lower courses. Lay stones of increasingly smaller sizes as you build to the top of the wall.

- Moistening. Moisten porous stones before placing them in mortar to prevent water absorption from the mortar, thereby weakening the bond.
- Packing and filling. Pack adjoining stones as tightly as practicable, completely filling any spaces between them with smaller stones and mortar.
- Removing. If removing a stone after placing it on the mortar bed, lift it clear and reset it.

FOOTINGS

8-43. Because a footing is always larger than the wall itself, use the largest stones in the footing to give it greater strength and lessen the risk of unequal settlement. Select footing stones as long as the footing is wide, if possible. Lay them in a mortar bed about 2 inches deep, and fill all the spaces between them with smaller stones and mortar.

BED JOINTS

8-44. Bed-joint thickness varies with the stone you use. Spread enough mortar on top of the lower course stone to completely fill the space between it and the stone you are placing. Take care not to spread mortar too far ahead of the stonelaying.

HEAD JOINTS OR BUILDS

8-45. Form the head joints before the bed joint mortar sets up. After laying three or four stones, make the head joints by slushing the small spaces with mortar and filling the larger spaces with both small stones and mortar.

BONDING STONES

8-46. Be sure to use one bonding stone for every 6 to 10 square feet of wall. Bonding stones pass all the way through the wall as shown in Figure 8-25. Offset each head joint from adjacent head joints above and below it as much as possible (see Figure 8-25) to bond the wall together and make it stronger.

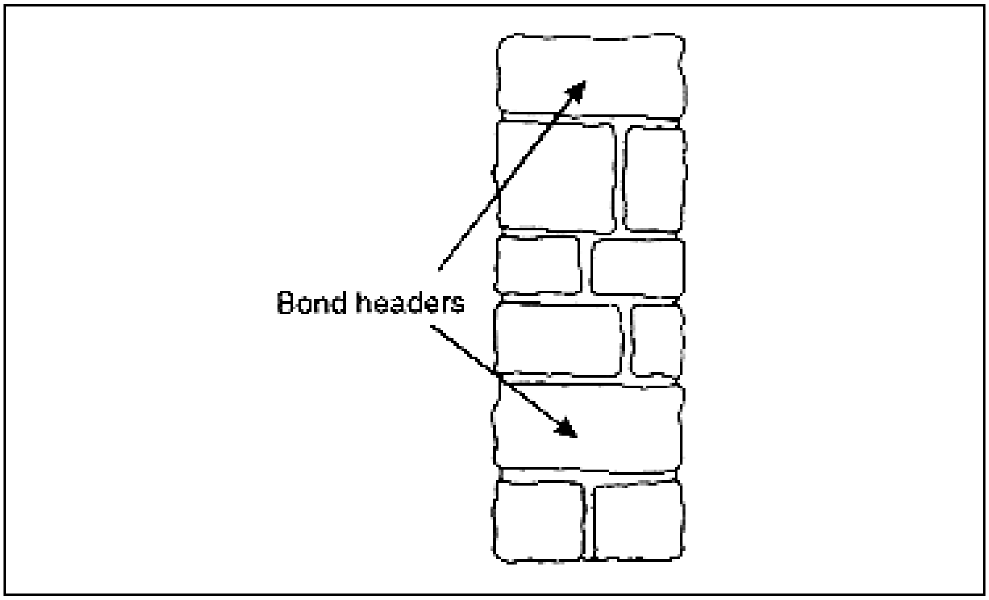


Figure 8-25. Bonding stones extend through a rubble stone masonry wall

Chapter 9

Brick and Tile Masonry

9-1. For at least 5000 years, bricks have been popular for their strength, durability, and beauty. Although traditionally made of natural clay that is heated in a kiln at high temperatures, many bricks today are made from compressed concrete and come in a wide variety of shapes and colors. Bricks can be used for a variety of structures including house walls, garden walls, retaining walls, chimneys and fireplaces, and also pavers for driveways, walkways, and patios.

SECTION I. CHARACTERISTICS OF BRICK

PHYSICAL PROPERTIES AND CLASSIFICATION

9-2. Structural clay products includes brick, hollow tile of all types, and architectural terra cotta, but exclude thin wall tile, sewer pipe, flue linings, and drain tile.

BRICK MASONRY UNITS

9-3. Bricks are small masonry units that are either solid or cored but not more than 25 percent. They are kiln-fired (baked) from various clay and shale mixtures. The chemical and physical characteristics of the ingredients change considerably and combine with the kiln temperature to produce the brick in a variety of colors and hardnesses. The clay or shale pits in some regions yield a product that is simply ground, moistened, formed, and baked into durable brick. In other regions, the clay or shale from several pits must be mixed to produce durable brick. Bricks are small enough to place with one hand. Uniform units can be laid in courses with mortar joints to form walls of almost unlimited length and height.

BRICK SIZES AND WEIGHT

9-4. Standard United States (US) bricks are 2 1/4 by 3 3/4 by 8 inches actual size. They may have three core holes or ten core holes. Modular US bricks are (2 2/3 by 4 by 8 inches) nominal size, normally having three core holes. English bricks are 3 by 4 1/2 by 9 inches, Roman bricks are 1 1/2 by 4 by 12 inches, and Norman bricks are 2 3/4 by 4 by 12 inches nominal size. Actual brick dimensions are smaller, usually by an amount equal to mortar joint width. Brick weighs from 100 to 150 pounds per cubic foot, depending on its ingredients and firing duration. Well-burned brick is heavier than underburned brick.

CUT SHAPES

9-5. Sometimes you must cut a brick into various shapes to fill in spaces at corners and other locations where a full brick does not fit. Figure 9-1 shows the more common cut shapes: half or bat, three-quarter closure, quarter closure, king closure, queen closure, and split.

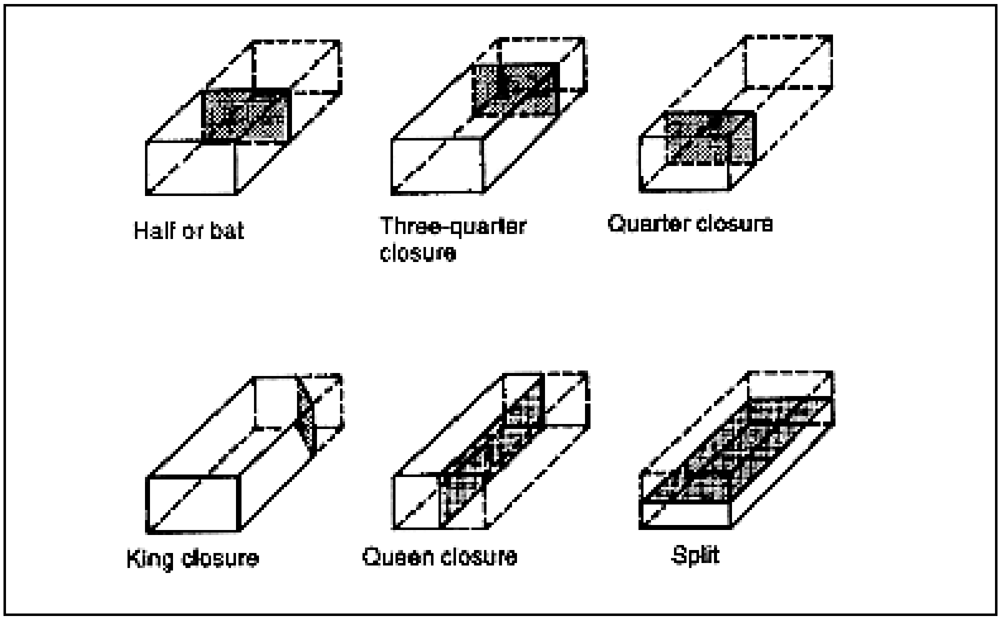


Figure 9-1. Common cut brick shapes

SURFACE NAMES

9-6. The five surfaces of a brick are called face, side, cull, end, and beds as shown in Figure 9-2.

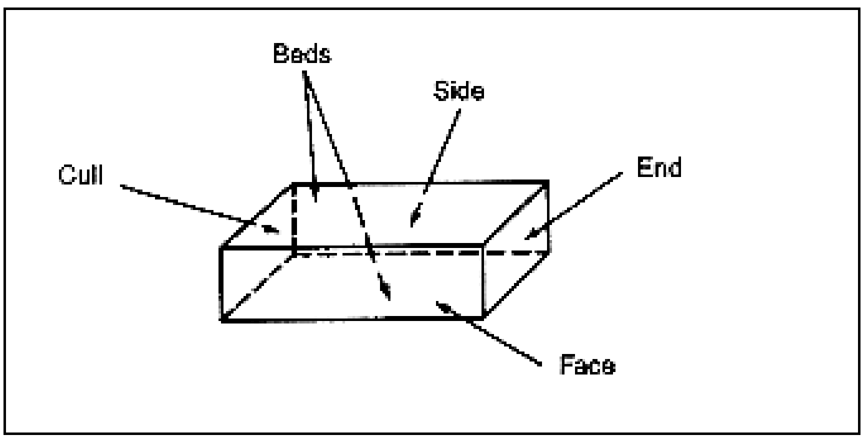


Figure 9-2. Names of brick surfaces

BRICK CLASSIFICATION

9-7. The three general types of structural brick-masonry units are solid, hollow, and architectural terra cotta. All three can serve a structural function, a decorative function, or a combination of both. The three types differ in their formation and composition, and are specific in their use. Bricks commonly used in construction are--

- Building bricks. Also called common, hard, or kiln-run bricks, these bricks are made from ordinary clays or shales and fired in kilns. They have no special scoring, markings, surface texture, or color. Building bricks are generally used as the backing courses in either solid or cavity brick walls because the harder and more durable kinds are preferred.
- Face bricks. These are better quality and have better durability and appearance than

building bricks because they are used in exposed wall faces. The most common face brick colors are various shades of brown, red, gray, yellow, and white.

- Clinker bricks. These bricks are oven-burnt in the kiln. They are usually rough, hard, durable, and sometimes irregular in shape.
- Pressed bricks. These bricks are made by the dry-press process rather than by kiln-firing. They have regular smooth faces, sharp edges, and perfectly square corners. Ordinarily, they are used as face bricks.
- Glazed bricks. These have one surface coated with a white or other color of ceramic glazing. The glazing forms when mineral ingredients fuse together in a glass-like coating during burning. Glazed brick is particularly suited to walls or partitions in hospitals, dairies, laboratories, and other structures requiring sanitary conditions and easy cleaning.
- Fire bricks. These are made from a special type of fire clay to withstand the high temperatures of fireplaces, boilers, and similar constructions without cracking or decomposing. Fire brick is generally larger than other structural brick, and often is hand-molded.
- Cored bricks. These bricks have ten holes (two rows of five holes each) extending through their beds to reduce weight. Walls built from all cored bricks are not much different in strength than walls built from all solid bricks, and both have about the same resistance to moisture penetration. Whether cored or solid, use the more easily available brick that meets building requirements.
- European bricks. Their strength and durability (particularly English and Dutch bricks) are about the same as US clay bricks.
- Sand-lime bricks. These bricks are made from a lean mixture of slaked lime and fine sand containing a lot of silica. They are molded under mechanical pressure and hardened under steam pressure. These are used extensively in Germany.

STRENGTH OF BRICK MASONRY

9-8. The strength of a single brick masonry unit varies widely, depending on its ingredients and manufacturing method. The main factors governing the strength of brick masonry are--

- Brick strength.
- Mortar strength and elasticity.
- Bricklayer workmanship.
- Brick uniformity.
- Bricklaying method used.

RANGES

9-9. Bricks can have an ultimate compressive strength as low as 1,600 psi, whereas some well-burned bricks have compressive strengths exceeding 15,000 psi.

PORTLAND-CEMENT-LIME MORTAR

9-10. Brick masonry laid with portland-cement-line mortar is stronger than an individual brick unit because this mortar is normally stronger than the brick. The load-carrying capacity of a wall or column made with plain lime mortar is much less than half that made with portland-cement-lime mortar. The compressive working strength of a brick wall or column laid with cement-lime mortar normally ranges from 500 to 600 psi.

DRY BRICK

9-11. In order for mortar to bond to brick, sufficient water must be present to completely hydrate the portland cement in the mortar. Bricks sometimes have high absorption and, if not corrected, will suck the water out of the mortar preventing complete hydration. A field test to determine if the brick has absorptive qualities is as follows: Using a medicine dropper, place 20 drops of water in a 1-inch circle (about the size of a quarter). If the brick absorbs all the water in less than 1 1/2 minutes, then it will suck the water out of the mortar when laid. To correct this condition, thoroughly wet the bricks and allow time for the surfaces to air-dry before placing.

WEATHER RESISTANCE

9-12. A brick's resistance to weathering depends almost entirely upon its resistance to water penetration, because freeze-thaw action is almost the only type of weathering that affects it.

9-13. A brick wall made with superior workmanship will resist rain water penetration during a storm lasting as long as 24 hours accompanied by a 50 to 60 mile per hour wind.

9-14. Two important factors in preventing water penetration are tooled-mortar joints and caulking around windows and door frames. Mortar joints that bond tightly to the brick resist moisture penetration better than joints with loose bonds. Slushing or grouting the joints after laying the brick does not fill the joint completely. Fill the joints between the brick solidly, especially in the face tier. Tool the joint to a concave surface before the mortar sets up. When tooling, use enough force to press the mortar tightly against the brick on both sides of the joint. Although good bricklaying workmanship does not permit water penetration, it provides some means of removing moisture that does penetrate the masonry, such as properly designed flashing or the use of cavity walls.

FIRE RESISTANCE

9-15. Table 9-1 gives the hours of fire resistance for various thicknesses of brick walls determined by tests conducted on brick walls laid with portland-cement-lime mortar. The ASTM standard method for conducting fire tests was used.

Table 9-1. Fire resistance of brick load-bearing walls laid with portland-cement-lime mortar

Normal Wall Thickness, in Inches	Types of Wall	Material	Ultimate Fire-Resistance Period. Incombustible Members Framed into Wall or not Framed in Members		
			No Plaster, in Hours	Plaster on One Side, in Hours	Plaster on Two SIdes, in Hours
4	Solid	Clay or shale	1 1/4	1 3/4	2 1/2
8	Solid	Clay or shale	5	6	7

12	Solid	Clay or shale	10	10	12
8	Hollow rowlock	Clay or shale	2 1/2	3	4
12	Hollow rowlock	Clay or shale	5	6	7
9 to 10	Cavity	Clay or shale	5	6	7
4	Solid	Sand lime	1 3/4	2 1/2	3
8	Solid	Sand lime	7	8	9
12	Solid	Sand lime	10	10	12
NOTE: Not less than 1/2 inch of 1-3 sanded gypsum plaster is required to develop these rating.					

ABRASION RESISTANCE

9-16. A brick's resistance to abrasion depends largely upon its compressive strength, which is determined by how well it was fired. Well-burned brick has excellent wearing qualities.

INSULATING QUALITIES OF BRICK MASONRY

9-17. A brick masonry wall expands and contracts with temperature change. However, because the wall itself takes up a lot of the expansion and contraction, the amount of movement calculated theoretically does not actually occur. Therefore, walls up to 200 feet long do not need expansion joints, but longer walls require one expansion joint for every 200 feet.

HEAT

9-18. Solid-brick masonry walls provide very little insulation from heat and cold. A cavity wall or a brick wall backed with hollow clay tile gives much better insulating value.

SOUND

9-19. Brick walls are massive and provide good sound insulation. Generally, the heavier the wall, the better its sound-insulating value. However, the sound insulation provided by a wall more than 12 inches thick is not much greater than a wall 10 to 12 inches thick. Dividing a wall into two or more layers, such as a cavity wall, increases its resistance to sound transmission from one side of the wall to the other. Brick walls poorly absorb sound originating within the walls and reflect much of the sound back into the structure. However, impact sounds, such as a hammer striking the wall, travel a long way along the wall.

SECTION II. BRICKLAYING METHODS

FUNDAMENTALS

9-20. Good bricklaying procedures depend on good workmanship and efficiency. Efficiency means to do the work with the fewest possible motions. Each motion should have a purpose and accomplish a particular result. After learning the fundamentals, study your own work to eliminate unnecessary motions, thereby achieving maximum efficiency. Organize your work to ensure a continual supply of brick and mortar. Plan the scaffolding before the work begins, and build it so that it interferes as little as possible with other workers. Paragraphs 7-3 and 7-4 describe mason's tools and equipment, which are generally the same as, or similar to, those used in bricklaying.

BRICK MASONRY TERMS

9-21. You need to know the specific terms that describe the position of masonry units and mortar joints in a wall (see Figure 9-3). These terms include--

- Course. One of several continuous, horizontal layers (or rows) of masonry units bonded together.
- Wythe. Each continuous, vertical section of a wall, one masonry unit thick, such as the thickness of masonry separating flues in a chimney. Sometimes called a tier.
- Stretcher. A masonry unit laid flat on its bed along the length of a wall with its face parallel to the face of the wall.
- Header. A masonry unit laid flat on its bed across the width of a wall with its face perpendicular to the face of the wall. Generally used to bond two wythes.
- Rowlock. A header laid on its face or edge across the width of a wall.
- Bull stretcher. A rowlock brick laid with its bed parallel to the face of the wall.
- Bull header. A rowlock brick laid with its bed perpendicular to the face of the wall.
- Soldier. A brick laid on its end with its face perpendicular to the face of the wall.

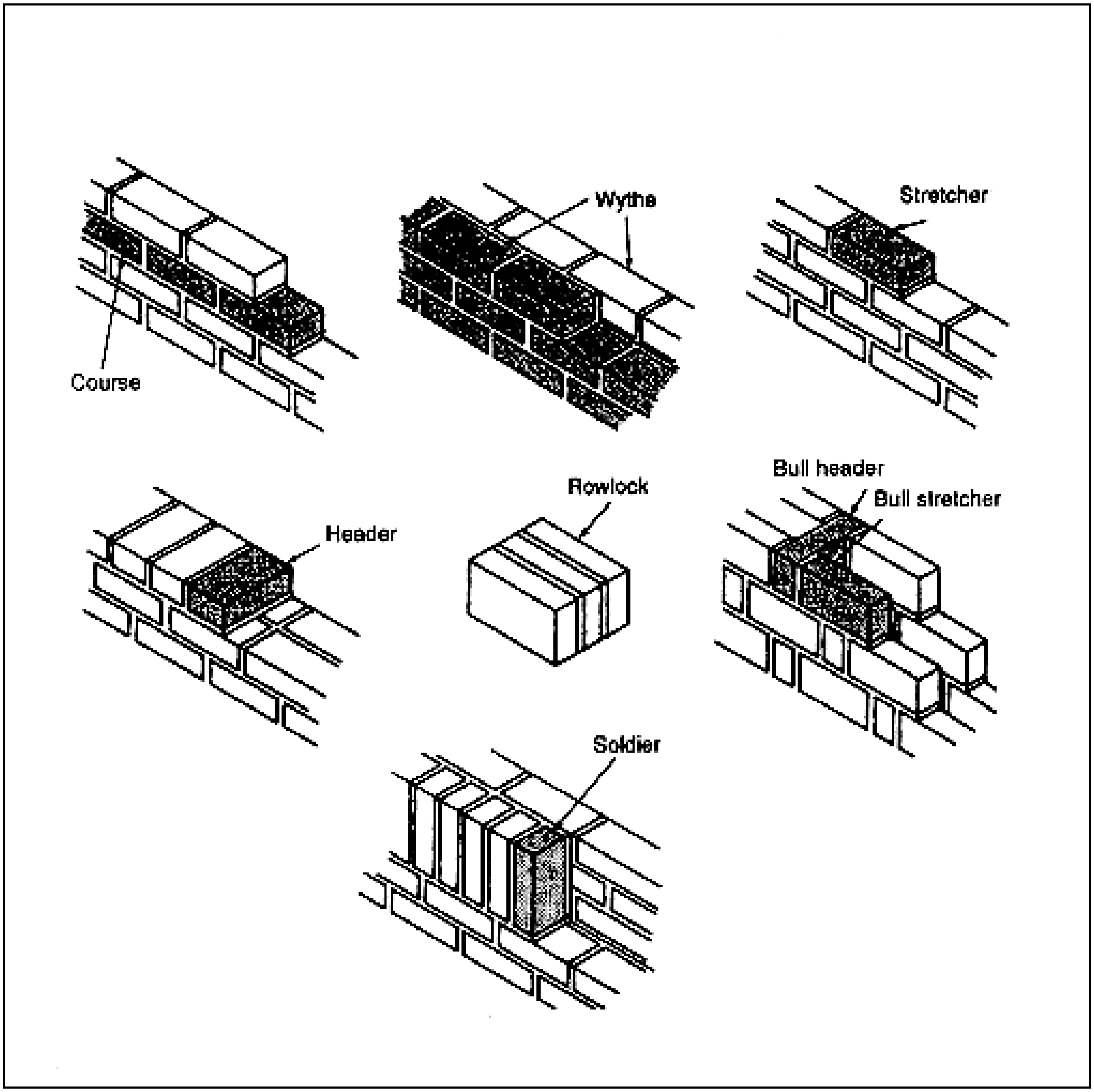


Figure 9-3. Masonry units and mortar joints

TYPES OF BONDS

9-22. The term bond as used in masonry has three different meanings: structural bond, mortar bond, or pattern bond. Metal ties are also used as bonds.

- Structural bond. This means how the individual masonry units interlock or tie together into a single structural unit. You can achieve structural bonding of brick and tile walls in one of three ways:

  - Overlapping (interlocking) the masonry units.
  - Embedding metal ties in connecting joints.
  - Using grout to adhere adjacent wythes of masonry.

- Mortar bond. This is adhesion of the mortar joint to the masonry units or to the reinforcing steel.

- Pattern Bond. This is pattern formed by the masonry units and mortar joints on the face of a wall. The pattern may result from the structural bond or may be purely decorative and unrelated to the structural bond. Figure 9-4 shows the six basic bond patterns in common use today: running bond, common or American bond, Flemish bond, English bond, stack bond, and English cross or Dutch bond.

  -Running bond. This is the simplest of the six bonds, consisting of all stretchers. The bond has no headers, therefore metal ties usually form the structural bond. The running bond is used largely in cavity wall construction, brick veneer walls, and facing tile walls made with extra wide stretcher tile.
  - Common or American bond. This is variation of the running bond having a course of full-length headers at regular intervals that provide the structural bond as well as patterns. Header courses usually appear at every fifth, sixth, or seventh course, depending on the structural bonding requirements or the common bond that will vary with a Flemish header course. In laying out any bond pattern, be sure to start the corners correctly. In a common bond, use a three-quarter closure at the corner of each header course.
  - Flemish bond. Each course consists of alternating headers and stretchers. The headers in every other course center over and under the stretchers in the courses in between. The joints between stretchers in all stretcher courses align vertically. When headers are not required for structural bonding, use bricks called blind headers. Start the corners two different ways; in the Dutch corner, a three-quarter closure starts each course, and with the English corner, a 2-inch or quarter closure starts the course.
  - English bond. This pattern consists of alternating courses of headers and stretchers. The headers center over and under the stretchers. The joints between stretchers in all stretcher courses do not align vertically. Use blind headers in courses that are not structural bonding courses.
  - Stack bond. This is purely a pattern bond, with no overlapping units and all vertical joints aligning. You must use dimensional-accurate or prematched units to achieve good vertical joint alignment. You can vary the pattern with combinations and modifications of the basic patterns shown in Figure 9-4. This pattern usually bonds to the backing with rigid steel ties, or 8-inch-thick stretcher units when available. In large wall areas or for load-bearing construction, insert steel-pencil rods into the horizontal mortar joints as reinforcement.
  - English cross or Dutch bond. A variation of the English bond, the English cross or Dutch bond differs only in that the joints between the stretchers in the stretcher courses align vertically. These joints center on the headers in the courses above and below.

- Metal ties. When a wall bond has no header courses, use metal ties to bond the exterior wall brick to the backing courses. Figure 9-5 shows three typical metal ties.

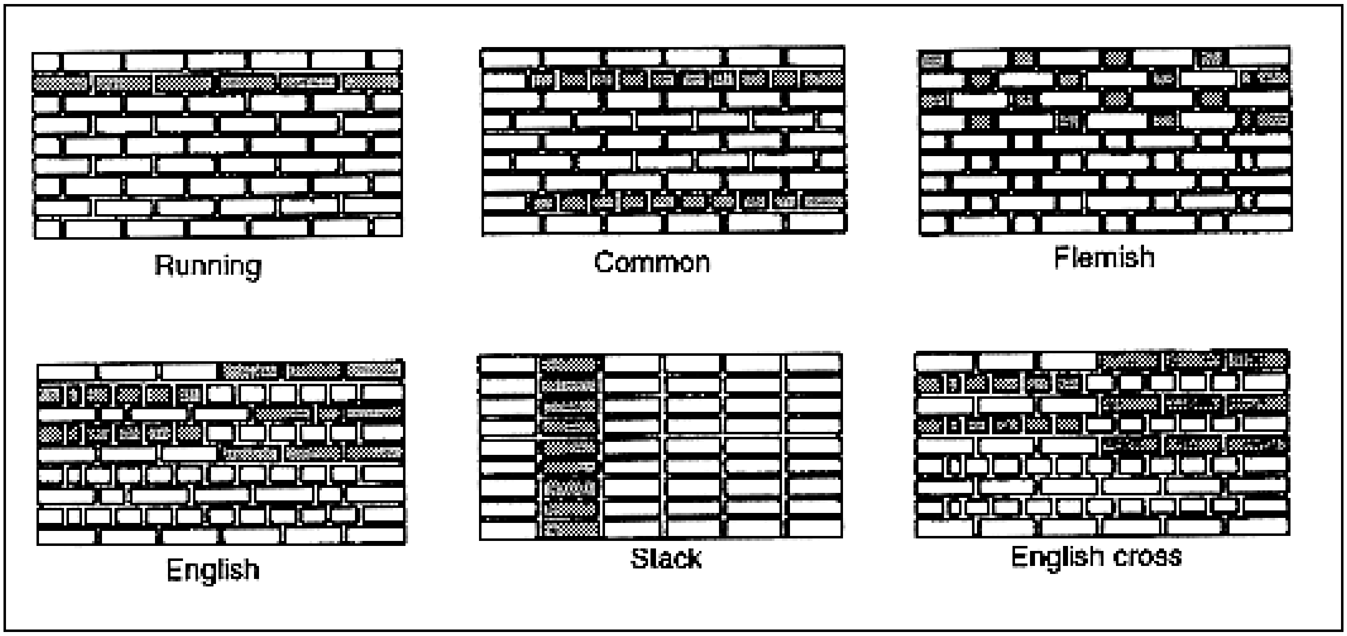


Figure 9-4. Types of masonry bond

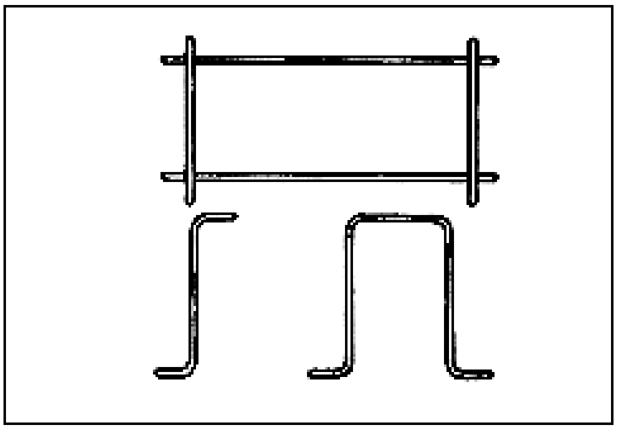


Figure 9-5. Metal ties

FLASHING

9-23. Install flashing at any spot where moisture is likely to enter a brick masonry structure. Flashing diverts the moisture back outside. Always install flashing under horizontal masonry surfaces such as sills and copings and at intersections between masonry walls and horizontal surfaces. This also includes roof and parapet or a roof and chimney, above openings such as doors and windows, and frequently at floor lines, depending on the type of construction. The flashing should extend through the exterior wall face and then turn downward against the wall face to form a drop. Provide weep holes at intervals of 18 to 24 inches to drain water that accumulates on the flashing to the outside. Weep holes are even more important when appearance requires the flashing to stop behind the wall face instead of extending through the wall. This type of concealed flashing with tooled mortar joints often retains water in the wall for long periods and, by concentrating the moisture at one spot it does more harm than good.

MAKING AND POINTING MORTAR JOINTS

9-24. *Pointing* is filling exposed joints with mortar immediately after laying a wall. You can also fill holes and correct defective mortar joints by pointing, using a pointing trowel.

MORTAR JOINT

9-25. There is no rule governing the thickness of a brick masonry mortar joint. Irregularly shaped bricks may require mortar joints up to 1/2 inch thick to compensate for the irregularities. However, mortar joints 1/4 inch thick are the strongest. Use this thickness whenever the bricks are regular enough in shape to permit it.

9-26. A slush joint is made simply by depositing the mortar on top of the head joints allowing it to run down between the bricks to form a joint. You cannot make solid joints this way. Even if you fill the space between the bricks completely, there is no way you can compact the mortar against the brick faces, and a poor bond will result.

PICKING UP AND SPREADING MORTAR

9-27. Figure 9-6 shows the correct way to hold a trowel firmly in the grip with your thumb resting on top of the handle, not encircling it. If you are right-handed, pick up mortar from the outside of the mortar-board pile with the left edge of your trowel (see Figure 9-7 below). You can pick up enough mortar to spread one to five bricks depending on the wall space and your skills. A pickup for one brick forms only a small pile along the left edge of the trowel, however, a pickup for five bricks is a full load for a large trowel as shown in view 2 of Figure 9-7.

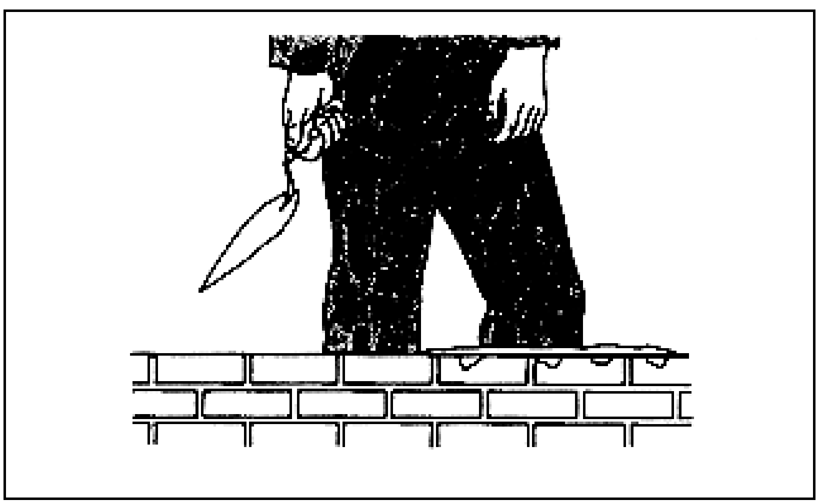


Figure 9-6. Correct way to hold a trowel

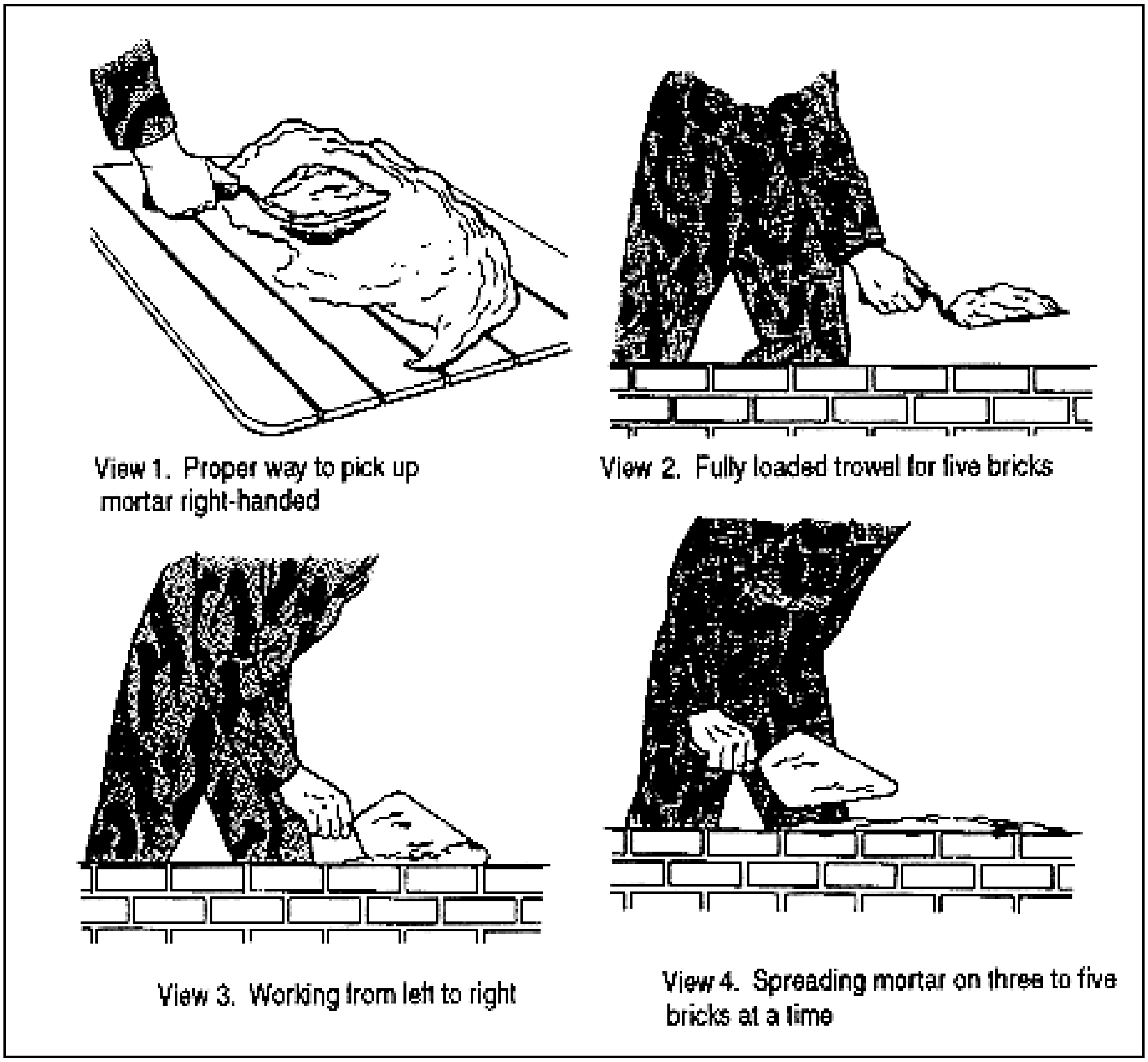


Figure 9-7. Picking up and spreading mortar

9-28. If you are right-handed, spreading the mortar working from left to right along the wall. Holding the left edge of the trowel directly over the centerline of the previous course, tilt the trowel slightly and move it to the right (see view 3 Figure 9-7) dropping an equal amount of mortar on each brick until the course is completed or the trowel is empty. Return any leftover mortar to the trowel mortarboard.

MAKING BED AND HEAD JOINT

9-29. Do not spread the mortar for a bed joint too far ahead of laying (the length of 4 or 5 bricks is best). Mortar spread out too far ahead dries out before the bricks bedded in it and causes a poor bond as shown in Figure 9-8. The mortar must be soft and plastic so that the brick beds in it easily. Spread the mortar about 1 inch thick, and then make a shallow furrow in it (see Figure 9-9 below). A furrow that is too deep leaves a gap between the mortar and the bedded brick, which will reduce the wall's resistance to water penetration.

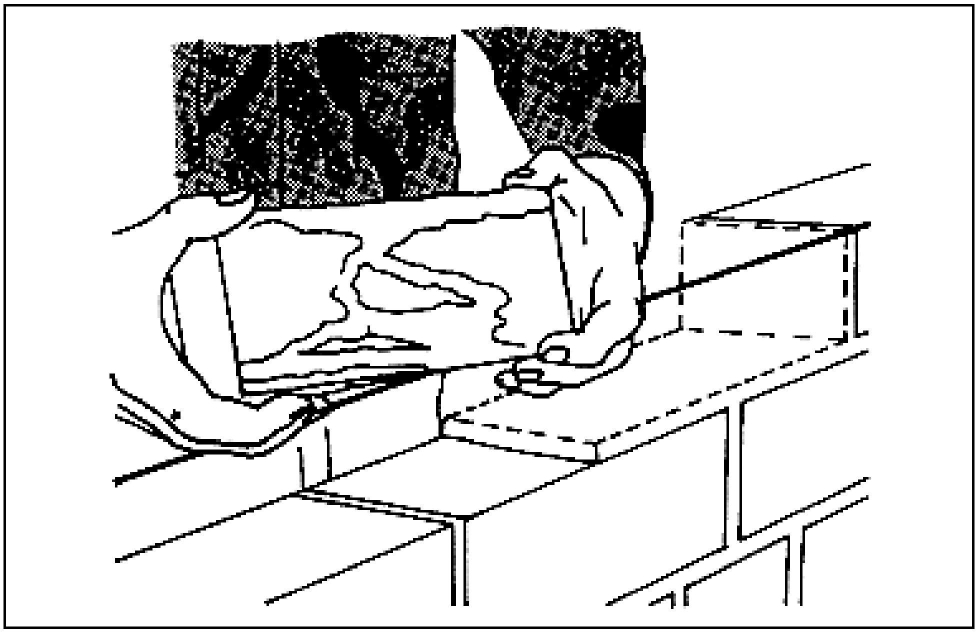


Figure 9-8. A poorly bonded brick

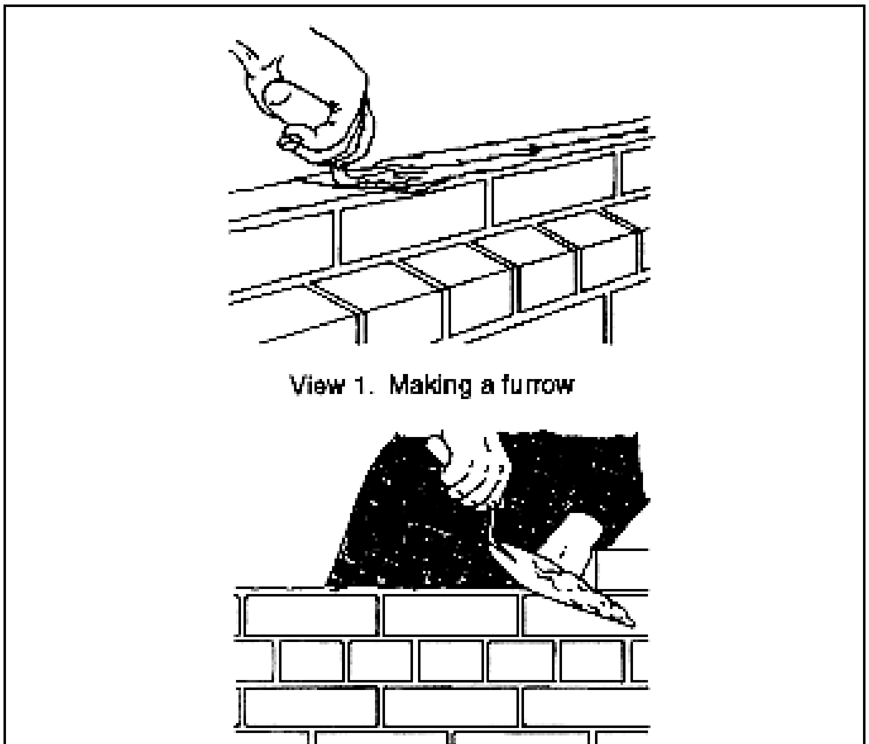


Figure 9-9. Making a bed joint in a stretcher course

9-30. Cut off any mortar projecting beyond the wall line with the edge of the trowel (see Figure 9-9 above). Use a smooth, even stroke. Retain enough mortar on the trowel to butter the left end of the first brick you will lay in the fresh mortar and throw the rest back on the mortar board.

9-31. Placing your thumb on one side of the brick and your fingers on the other, pick up the first brick to be laid (see Figure 9-10). Apply as much mortar as will stick to the end of the brick and then push it into place, squeezing out excess mortar at the head joint and at the sides as shown in Figure 9-11 below. Make sure that the mortar completely fills the head joint. After bedding the brick, cut off the excess mortar and use it to start the next end joint. Throw any surplus mortar on the back of the mortar board for retampering if necessary.

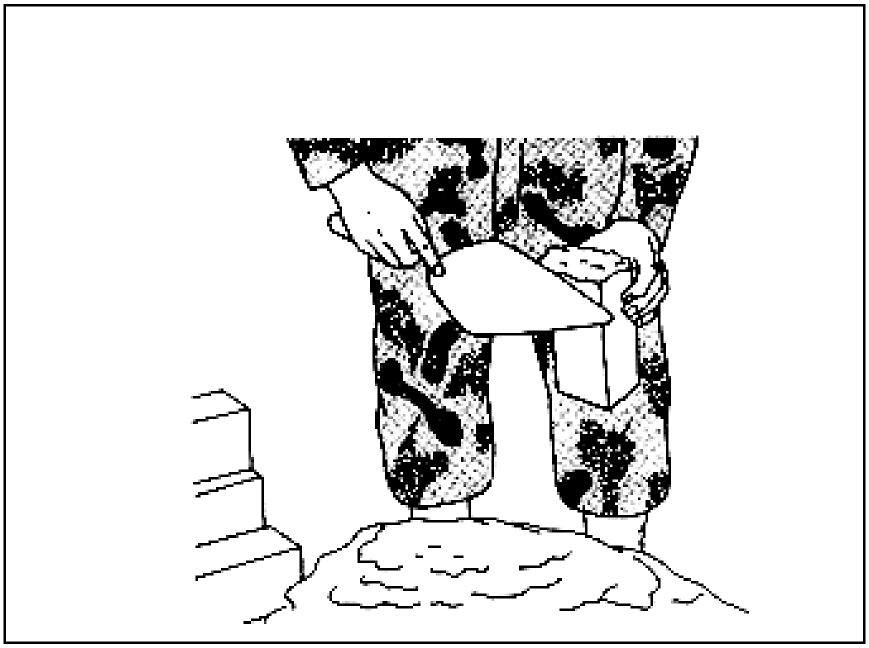


Figure 9-10. Proper way to hold a brick when buttering the end

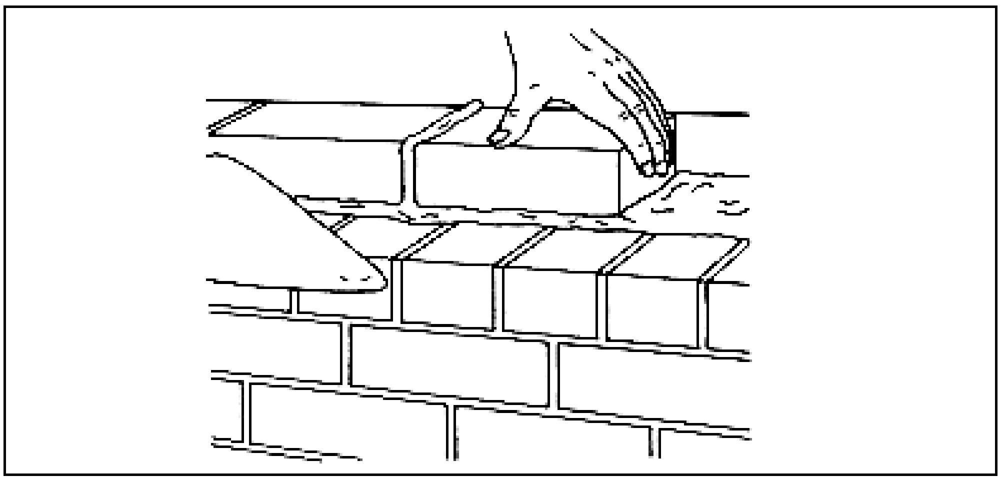


Figure 9-11. Making a head joint in a stretcher course

INSERTING A BRICK IN A WALL

9-32. Figure 9-12 shows how to insert a brick in a space left in a wall. First, spread a thick bed of mortar (see Figure 9-12), and then shove the brick into it (see view 2 of Figure 9-12) until mortar squeezes out of the four joints (see view 3 of Figure 9-12). In doing so you are assured that the joints are full of mortar at every point.

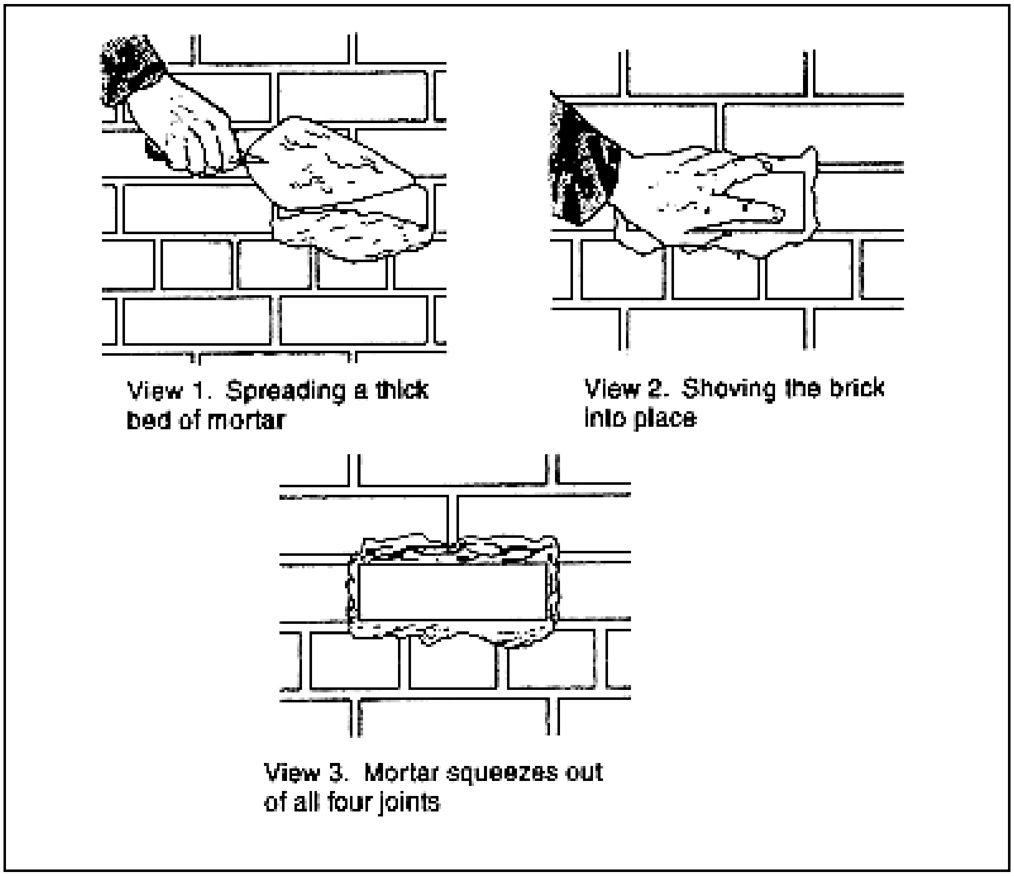


Figure 9-12. Inserting a brick in a wall

MAKING CROSS JOINTS AND JOINTS CLOSURE

9-33. Spread the bed-joint mortar several brick widths in advance. Then spread mortar over the face of the header brick before placing it in the wall (see view 1 of Figure 9-13). Next shove the brick into place, squeezing out mortar at the top of the joint. Finally cut off the excess mortar as shown in view 2 of Figure 9-13.

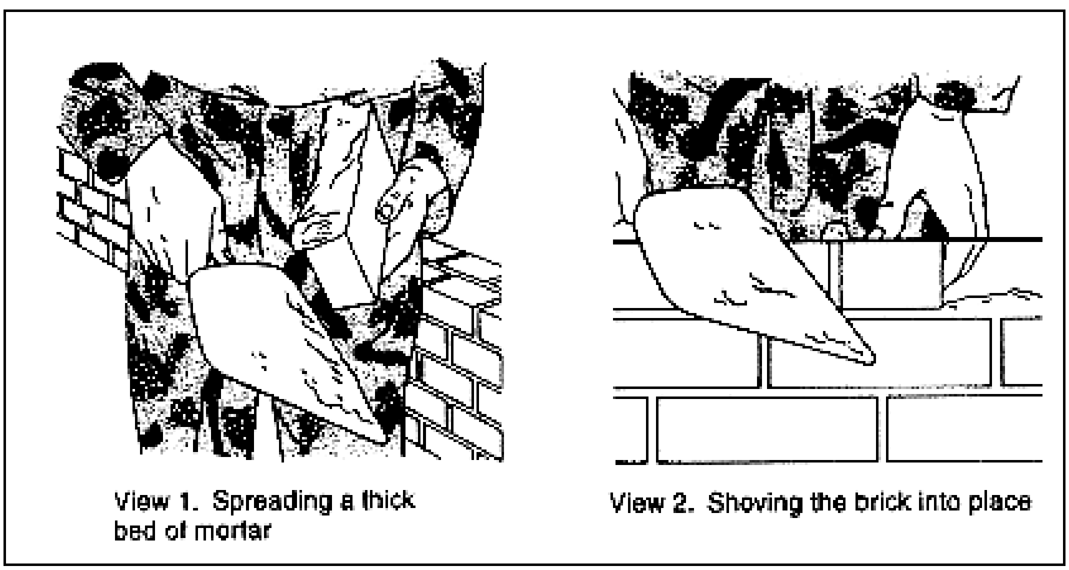


Figure 9-13. Making a cross joint in a header course

9-34. Figure 9-14 shows how to lay a closure brick in a header course. Spread about 1 inch of mortar on the sides of the brick already in place (see view 1 of Figure 9-14), as well as on both sides of the closure brick (see view 2 of Figure 9-14). Then lay the closure brick carefully into position, without disturbing the brick already laid (see view 3 of Figure 9-14).

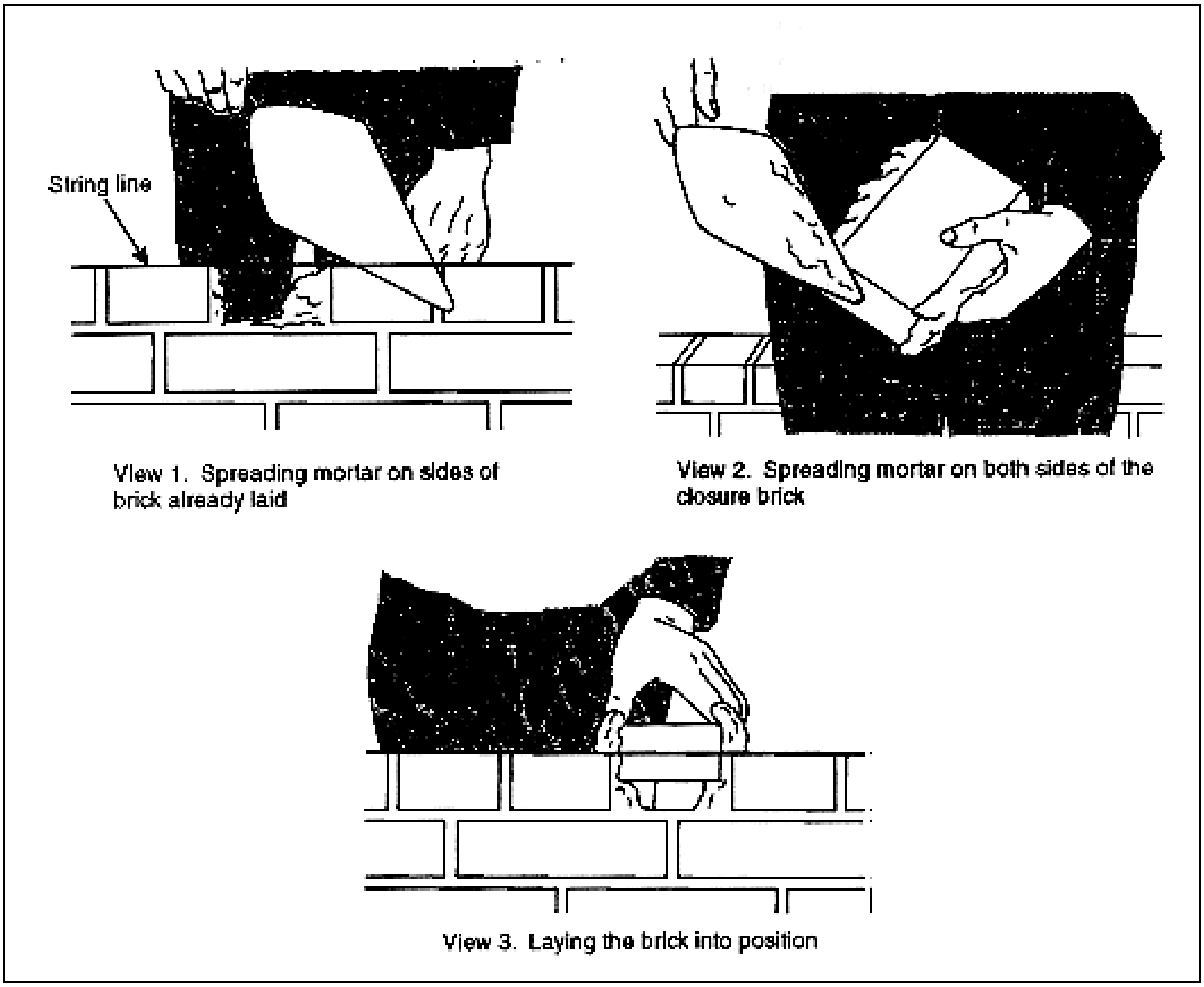


Figure 9-14. Making a closure joint in a header couse

9-35. To make a closure joint in stretcher courses, first spread plenty of mortar on the ends of the brick already in place (see view 1 of Figure 9-15), as well as both ends of the closure brick (see view 2 of Figure 9-15). Then carefully lay the closure brick without disturbing the brick already in place (see view 3 of Figure 9-15). If you do disturb any adjacent bricks, you must remove and relay them. Otherwise, cracks will form between the brick and mortar, allowing moisture to penetrate the wall.

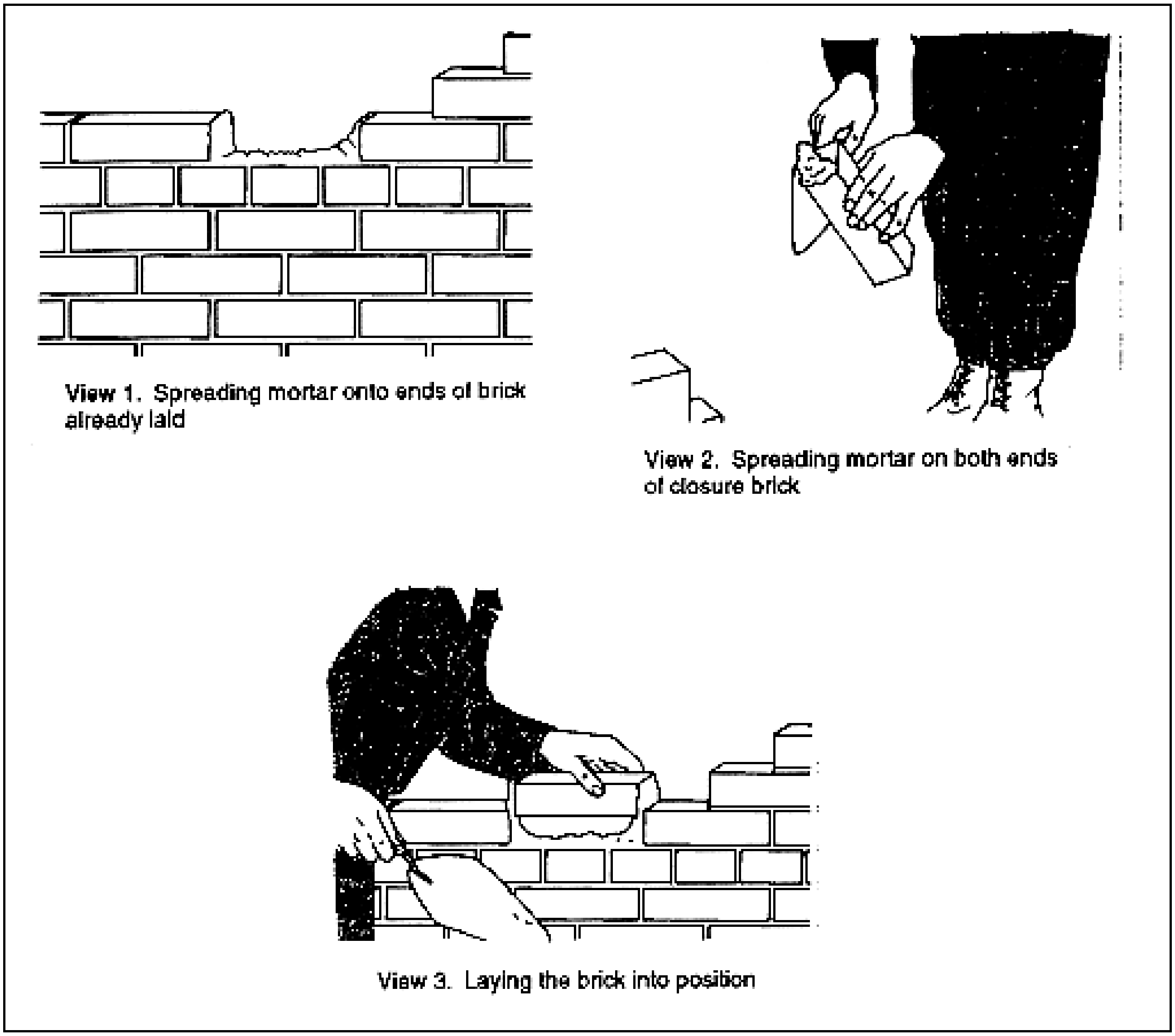


Figure 9-15. Making a closure joint in a stretcher course

CUTTING BRICK

9-36. Bricks will either be cut with a bolster or a brick set, using a brick hammer.

- Using a bolster or brick set. When you must cut a brick to exact line, use a bolster (see Figure 9-16) or brick set. The straight side of the tool's cutting edge should face both the part of the brick to be saved, and the bricklayer. One mason's hammer blow should break the brick. For an extremely hard brick, first cut it roughly using the brick hammer head, but leave enough brick to cut accurately with the brick set.
- Using a brick hammer. Use a brick hammer for normal cutting work, such as making the closure bricks and bats around wall openings or completing corners. Hold the brick firmly while cutting it. First cut a line around the brick using light blows. Hitting a sharp blow to one side of the cutting line should split the brick at the cutting line (see view 1 of Figure 9-17). Trim rough spots using the hammer blade as shown in view 2 of Figure 9-17.

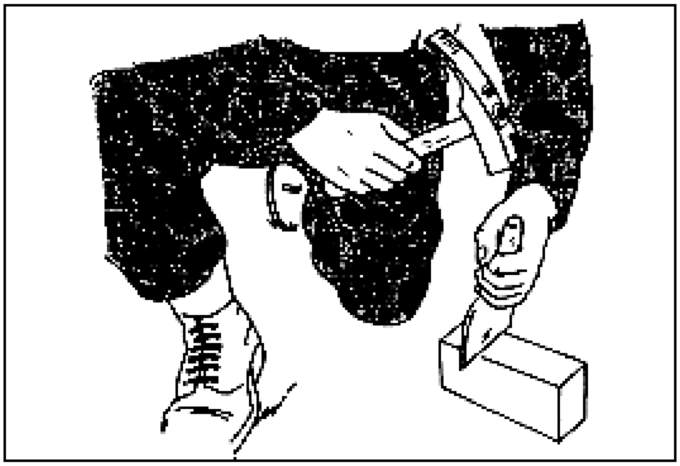


Figure 9-16. Cutting brick with a bolster

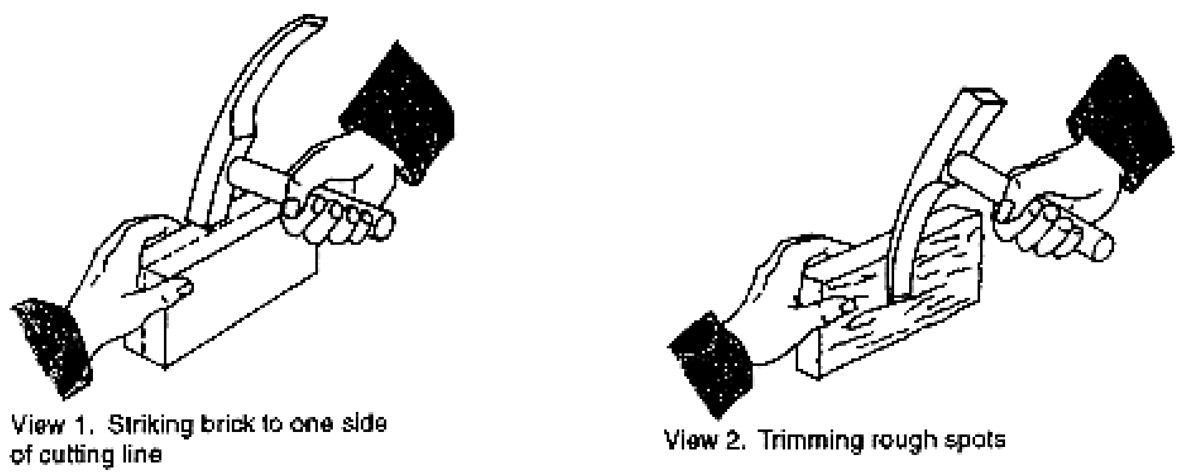


Figure 9-17. Cutting a brick with a hammer

FINISHING JOINTS.

9-37. Purpose. The exterior surfaces of mortar joints are finished to make brick masonry more waterproof and give it a better appearance. If joints are simply cut flush with the brick and not finished, shallow cracks develop immediately between the brick and the mortar. Finishing or tooling the joint using the jointer shown in Figure 7-1 , Chapter 7, prevents such cracks. Always finish a mortar joint before the mortar hardens too much. Figure 9-18 shows several types of joint finishes, the more important of which are discussed below.

- Concave joint. It is very weather tight. After removing the excess mortar with a trowel, make this joint using a jointer that is slightly larger than the joint. Use force against the tool to press the mortar tight against the brick on both sides of the mortar joint.
- Flush joint. It is made by holding the trowel almost parallel to the face of the wall while drawing its point along the joint.
- Weather joint. It sheds water from a wall surface more easily. To make it, simply push downward on the mortar with the top edge of the trowel.

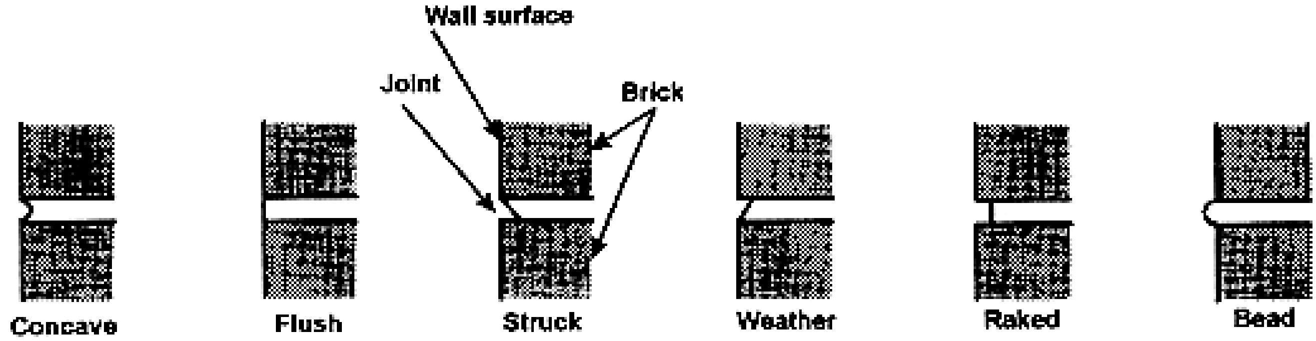


Figure 9-18. Joint finishes

SECTION III. BRICK CONSTRUCTION

BRICKLAYER'S DUTIES

9-38. The bricklayer actually lays the brick and is responsible for laying out the job so that the finished masonry has the proper quality and appearance. In wall construction, the bricklayer must make sure that the walls are plumb and the courses are level.

BRICKTENDER'S DUTIES

9-39. The bricktender mixes mortar and carries brick, mortar, and supplies material to the bricklayer, as needed. The bricktender fills the mortar board and places it in a convenient spot for the bricklayer. He assists in layout and rapid backup bricklaying by laying out bricks in a line on an adjacent course so that the bricklayer only has to move each brick a few inches to lay them. He also wets brick during warm weather. There are four reasons why bricks must be wet just before laying them:

- A better bond is created between the brick and the mortar.
- Dust and dirt are washed from the brick surfaces because mortar adheres better to a clean brick.
- Mortar spreads more evenly under a wet brick surface.
- Dry brick absorbs water from the mortar rapidly, particularly portland-cement mortar. To harden properly, cement requires suf-ficient moisture to complete the hydration process. Therefore, if the brick absorbs too much water from the mortar, the cement will not harden properly.

LAYING FOOTINGS

9-40. A qualified engineer must determine actual footing width and thickness for high walls and walls that will carry a heavy load. A footing must rest below the frost line to prevent foundation heaving and settlement.

WALL FOOTINGS

9-41. A wall requires a footing when the supporting soil cannot withstand the wall load without a further means of load redistribution. The footing must be wider than the wall thickness as shown in Figure 9-19. For an ordinary one- story building having an 8-inch-thick wall, a footing 16 inches wide and approximately 8 inches thick is usually large enough. Although brick masonry footings are satisfactory, footings are normally made from concrete leveled on top to receive the brick or stone foundation walls. After preparing the subgrade, place a mortar bed about 1 inch thick on the subgrade to compensate for all irregularities. Lay the first course of the foundation on the mortar bed followed by succeeding courses (see Figure 9-19).

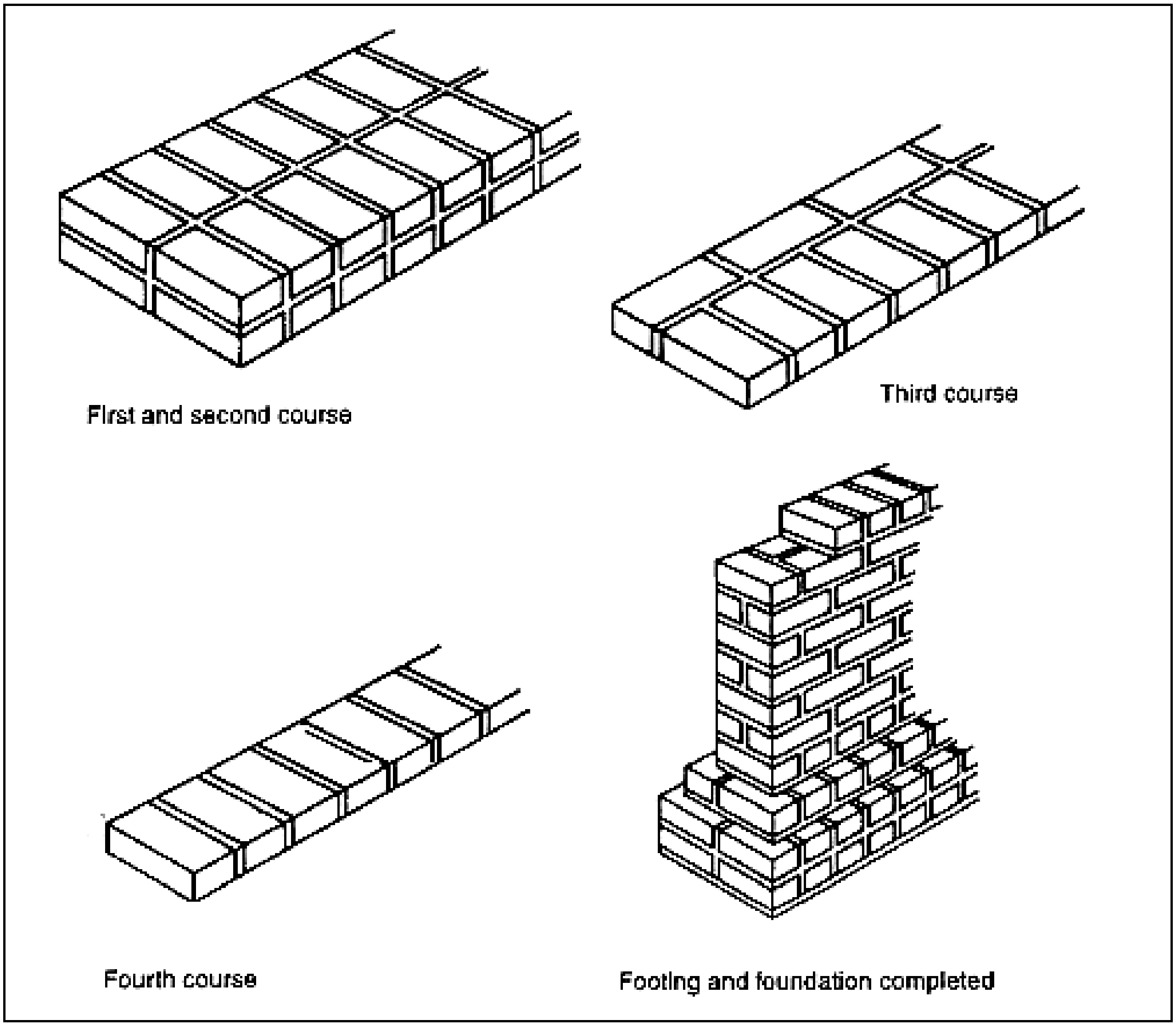


Figure 9-19. Laying a wall footing

COLUMN FOOTINGS

9-42. Figure 9-20 shows a footing for a 12 by 16-inch brick column. This footing requires the same construction method as the wall footing.

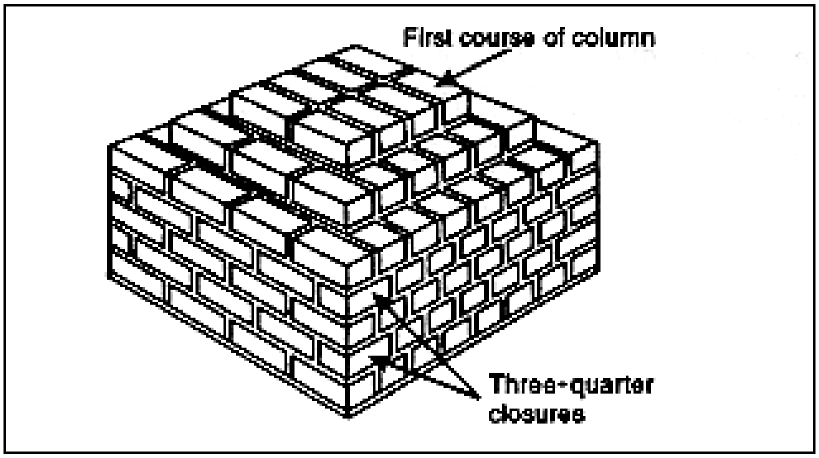


Figure 9-20. Column footing

LAYING AN 8-INCH COMMON-BOND BRICK WALL

9-43. You can build both solid and hollow walls from brick masonry. The solid 8- and 12-inch walls in common bond are the most familiar ones in the US.

LAYING OUT THE WALL

9-44. To build a wall of a given length, adjust the width of the head joints so that a particular number of bricks or a particular number plus a half-brick will equal the given length. To do this use the following steps:

Step 1. Lay out the bricks for the foundation without mortar first, as shown in Figure 9-21.

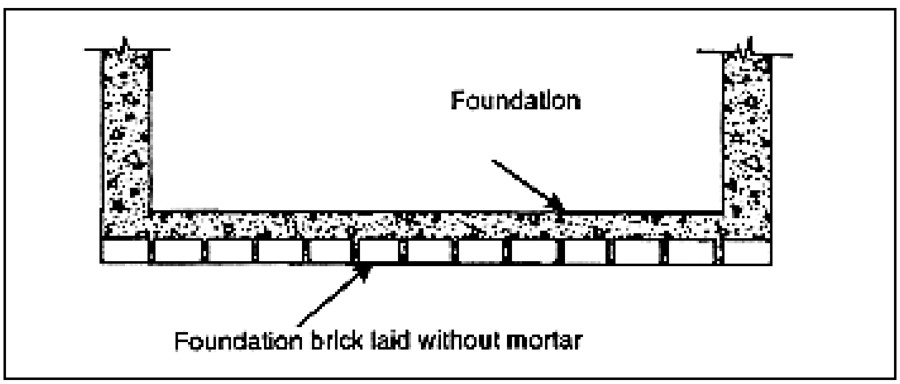


Figure 9-21. Determining number of bricks in one course and head-joint widths

Step 2. Space them equally. The distance between them will equal the thickness of the head joints. Tables 9-2, 9-3, and 9-4 below give the number of courses in a wall of a given height using standard brick and different joint widths.

Table 9-2. Height of course using 2 1/4-inch brick, 3/8 inch joint

Course	Height	Course	Height	Course	Height	Course	Height	Course	Height
1	0' 2 5/8"	21	4' 7 1/8"	41	8' 11 5/8"	61	13' 4 1/8"	81	17' 8 5/8"

2	0' 5 1/4"	22	4' 9 3/4"	42	9' 2 1/4"	62	13' 6 3/4"	82	17' 11 1/4"
3	0' 7 7/8"	23	5' 0 3/8"	43	9' 4 7/8"	63	13' 9 3/4"	83	18' 1 7/8"
4	0' 10 1/2"	24	5' 3"	44	9' 7 1/2"	64	14' 0"	84	18' 4 1/2"
5	1' 1 1/8"	25	5' 5 5/8"	45	9' 10 1/8"	65	14' 2 5/8"	85	18' 7 1/8"
6	1' 3 3/4"	26	5' 8 1/4"	46	10' 0 3/4"	66	14' 5 1/4"	86	18' 9 3/4"
7	1' 6 3/8"	27	5' 10 7/8"	47	10' 3 3/8"	67	14' 7 7/8"	87	19' 0 3/8"
8	1' 9"	28	6' 1 1/2"	48	10' 6"	68	14' 10 1/2"	88	19' 3"
9	1' 11 5/8"	29	6' 4 1/8"	49	10' 8 5/8"	69	15' 1 1/8"	89	19' 5 5/8"
10	2' 2 1/4"	30	6' 6 3/4"	50	10' 11 1/4"	70	15' 3 3/4"	90	19' 8 1/4"
11	2' 4 7/8"	31	6' 9 3/8"	51	11' 1 7/8"	71	15' 6 3/8"	91	19' 10 7/8"
12	2' 7 1/2"	32	7' 0"	52	11' 4 1/2"	72	15' 9"	92	20' 1 1/2"
13	2' 10 1/8"	33	7' 2 5/8"	53	11' 7 1/8"	73	15' 11 5/8"	93	20' 4 1/8"
14	3' 0 3/4"	34	7' 5 1/4"	54	11' 9 3/4"	74	16' 2 1/4"	94	20' 6 3/4"
15	3' 3 3/8"	35	7' 7 7/8"	55	12' 0 3/8"	75	16' 4 7/8"	95	20' 9 3/8"
16	3' 6"	36	7' 10 1/2"	56	12' 3"	76	16' 7 1/2"	96	21' 0"
17	3' 8 5/8"	37	8' 1 1/8"	57	12' 5 5/8"	77	16' 7 1/2"	97	21' 2 5/8"
18	3' 11 1/4"	38	8' 3 3/4"	58	12' 8 1/4"	78	17' 0 3/4"	98	21' 5 1/4"
19	4' 1 7/8"	39	8' 6 3/8"	59	12' 10 7/8"	79	17' 3 3/8"	99	21' 7 7/8"
20	4' 4 1/2"	40	8' 9"	60	13' 1 1/2"	80	17' 6"	100	21' 10 1/2"

Table 9-3. Height of course using 2 1/4-inch brick, 1/2-inch joint

Course	Height	Course	Height	Course	Height	Course	Height	Course	Height
1	0' 2 3/4"	21	4' 9 3/4"	41	9' 4 3/4"	61	13' 11 3/4"	81	18' 6 3/4"

2	0' 5 1/2"	22	5' 0 1/2"	42	9' 7 1/2"	62	14' 2 1/2"	82	18' 9 1/2"
3	0' 8' 1/4"	23	5' 3 1/4"	43	9' 10 1/4"	63	14' 5 1/4"	83	19' 0 1/4"
4	0' 11"	24	5' 6"	44	10' 1"	64	14' 8"	84	19' 3"
5	1' 1 1/4"	25	5' 8 3/4"	45	10' 3 3/4"	65	14' 10 3/4"	85	19' 5 3/4"
6	1' 4 1/2"	26	5' 11 1/2"	46	10' 6 1/2"	66	15' 1 1/2"	86	19' 8 1/2"
7	1' 7 1/4"	27	6' 2 1/4"	47	10' 9 1/4"	67	15' 4 1/4"	87	19' 11 1/4"
8	1' 10"	28	6' 5"	48	11' 0"	68	15' 7"	88	20' 2"
9	2' 0 3/4"	29	6' 7 3/4"	49	11' 2 3/4"	69	15' 9 3/4"	89	20' 4 3/4"
10	2' 3 1/2"	30	6' 10 1/2"	50	11' 5 1/2"	70	16' 0 1/2"	90	20' 7 1/2"
11	2' 6 1/4"	31	7' 1 1/4"	51	11' 8 1/4"	71	16' 3 1/4"	91	20' 10 1/4"
12	2' 9"	32	7' 4"	52	11' 11"	72	16' 6"	92	21' 1"
13	2' 11 3/4"	33	7' 6 3/4"	53	12' 1 3/4"	73	16' 8 3/4"	93	21' 3 3/4"
14	3' 2 1/2"	34	7' 9 1/2"	54	12' 4 1/2"	74	16' 11 1/2"	94	21' 6 1/2"
15	3' 5 1/4"	35	8' 0 1/4"	55	12' 7 1/4"	75	17' 2 1/4"	95	21' 9 1/4"
16	3' 8"	36	8' 3"	56	12' 10"	76	17' 5"	96	22' 0"
17	3' 10 3/4"	37	8' 5 3/4"	57	13' 0 3/4"	77	17' 7 3/4"	97	22' 2 3/4"
18	4' 1 1/2"	38	8' 8 1/2"	58	13' 3 1/2"	78	17' 10 1/2"	98	22' 5 1/2"
19	4' 4 1/4"	39	8' 11 1/4"	59	13' 6 1/4"	79	18' 1 1/4"	99	22' 8 1/4"
20	4' 7"	40	9' 2"	60	13' 9"	80	18' 4"	100	22' 11"

Table 9-4. Height of course using 2 1/4-inch brick, 5/8-inch joint

Course	Height	Course	Height	Course	Height	Course	Height	Course	Height
1	0' 2 7/8"	21	5' 0 3/8"	41	9' 9 7/8"	61	14' 7 3/8"	81	19' 4 7/8"
2	0' 5 3/4"	22	5' 3 1/4"	42	10' 0 3/4"	62	14' 10 1/4"	82	19' 7 3/4"

3	0' 8 5/8"	23	5 ' 6 1/8"	43	10' 3 5/8"	63	15' 1 1/8"	83	19' 10 5/8"
4	0' 11 1/2"	24	5' 9"	44	10' 6 1/2"	64	15' 4"	84	20' 1 1/2"
5	1' 2 3/8"	25	5' 11 7/8"	45	10' 9 3/8"	65	15' 6 7/8"	85	20' 4 3/8"
6	1' 5 1/4"	26	6' 2 3/4"	46	11' 0 1/4"	66	15' 9 3/4"	86	20' 7 1/4"
7	1' 8 1/8"	27	6' 5 5/8"	47	11' 3 1/8"	67	16' 0 5/8"	87	20' 10 1/8"
8	1' 11"	28	6' 8 1/2"	48	11' 6"	68	16' 3 1/2"	88	21' 1"
9	2' 1 7/8"	29	6' 11 3/8"	49	11' 8 7/8"	69	16' 6 3/8"	89	21' 3 7/8"
10	2' 4 3/4"	30	7' 2 1/4"	50	11' 11 3/4"	70	16' 9 1/4"	90	21' 6 3/4"
11	2' 7 5/8"	31	7' 5 1/8"	51	12' 2 5/8"	71	17' 0 1/8"	91	21' 9 5/8"
12	2' 10 1/2"	32	7' 8"	52	12' 5 1/2"	72	17' 3"	92	22' 0 1/2"
13	3' 1 3/8"	33	7' 10 7/8"	53	12' 8 3/8"	73	17' 5 7/8"	93	22' 3 3/8"
14	3' 4 1/4"	34	8' 1 3/4"	54	12' 11 1/4"	74	17' 8 3/4"	94	22' 6 1/4"
15	3' 7 1/8"	35	8' 4 5/8"	55	13' 2 1/8"	75	17' 11 5/8"	95	22' 9 1/8"
16	3' 10"	36	8' 7 1/2"	56	13' 5"	76	18' 2 1/2"	96	23' 0"
17	4' 0 7/8"	37	8' 10 3/8"	57	13' 7 1/8"	77	18' 5 3/8"	97	23' 2 7/8"
18	4' 3 3/4"	38	9' 1 1/4"	58	13' 10 3/4"	78	18' 8 1/4"	98	23' 5 3/4"
19	4' 6 5/8"	39	9' 4 1/8"	59	14' 1 5/8"	79	18' 11 1/8"	99	23' 8 5/8"
20	4' 9 1/2"	40	9' 7"	60	14' 4 1/2"	80	19' 2"	100	23' 11 1/2"

LAYING CORNER LEADS

9-45. The following steps should be used in laying the corner leads:

Step 1. Erect the wall corners first. This is called laying the leads.

Step 2. Use the leads as a guide when laying the rest of the wall.

Step 3. Lay the face tier.

Step 4. Build the corner leads up about six or seven courses, or to the height of the next header course.

Header course

9-46. Normally, the first course is a header course. Step 1 of Figure 9-22 below shows how to start laying a corner lead.

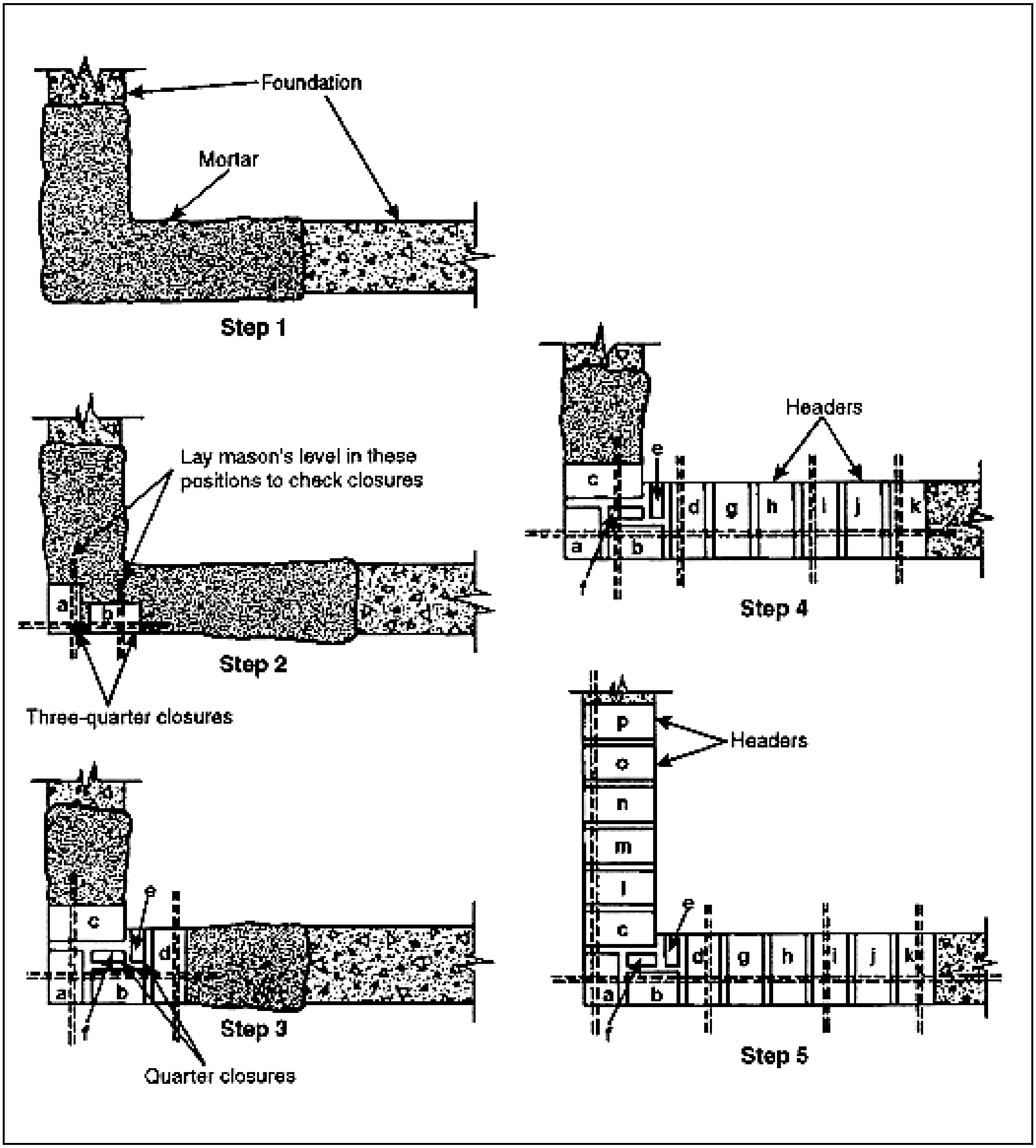


Figure 9-22. Laying first course of corner lead for 8-inch common-bond brick wall

Step 1. Lay a 1-inch mortar bed on the foundation.

Step 2. Cut two three-quarter closures and press one into the mortar bed until it makes a bed joint 1/2 inch thick (see a in step 2 of Figure 9-22.

Step 3. Spread mortar on the end of the second three-quarter closure and form a 1-inch thick head joint as described in paragraph 9-29 (see b in step 2 of Figure 9-22).

Step 4. Cut off the mortar that squeezes out of the joints.

Step 5. Lay a mason's level in the two positions shown in step 2 of Figure 9-22, and check the levels of the two three-quarter closures. The exterior edges of both closures must be flush with the exterior face of the foundation.

Step 6. Spread mortar on one bed of a whole brick (see c in step 3 of Figure 9-22) and lay it as shown.

Step 7. Check its level using the mason's level in the positions shown in step 3 of Figure 9-22. The end of this brick must also be flush with the exterior face of the foundation.

Step 8. After laying this brick in the proper position, cut the quarter closures e and f, and lay them as described in paragraph 9-34, for laying closure bricks.

Step 9. Remove all excess mortar and check the tops of the quarter closures to make sure that they are flush with bricks a and b.

Step 10. Spread mortar on brick g (see step 4 of Figure 9-22), shove it into position as shown, and remove any excess mortar.

Step 11. Lay bricks h, i, j, and k the same way. Check their levels by placing the mason's level in the positions shown in step 4 of Figure 9-22. All brick ends must be flush with the foundation surface.

Step 12. Lay bricks l, m, n, o, and p in the same manner (see step 5 of Figure 9-22). You must lay 12 header bricks in the first course of the corner lead--six bricks on each side of the three-quarter closures a and b.

Stretcher course

9-47. Lay the second course of the corner lead (a stretcher course) as shown in steps 1 and 2 of Figure 9-23 below.

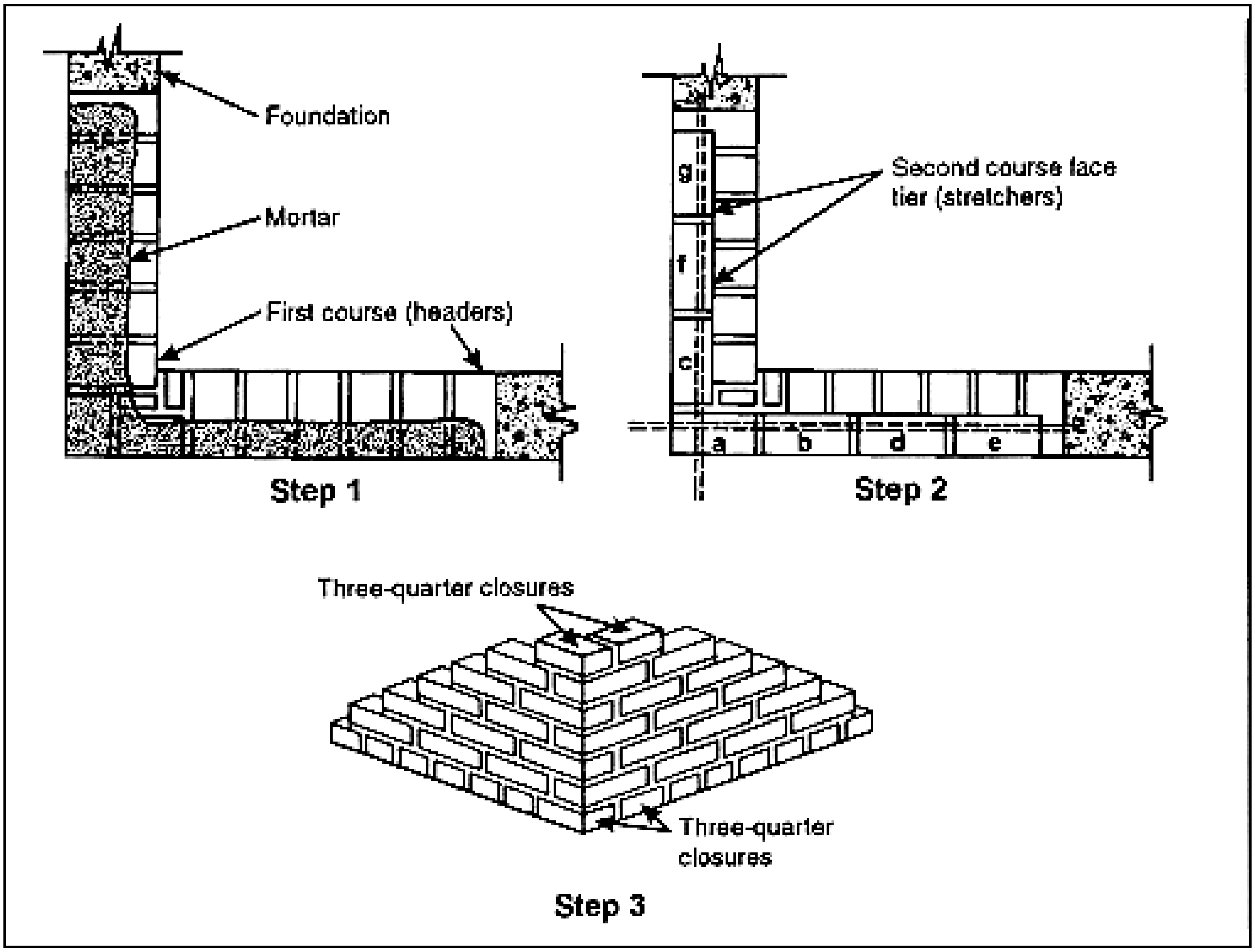


Figure 9-23. Laying second course of corner lead for 8-inch common-bond brick wall

Step 1. Spread a 1-inch mortar bed over the first course and make a shallow furrow in it.

Step 2. Push brick (a) (see step 2 of Figure 9-23) into the mortar bed until it makes a joint 1/2 inch thick.

Step 3. Spread mortar on the end of the brick and shove it into place. Remove the excess mortar and check the joints for thickness.

Step 4. Lay bricks c, d, e, f, and g the same way. Check them by placing the mason's level in the position shown in step 2 of Figure 9-23 to make sure they are level.

Step 5. Plumb the corners in several places by placing the mason's level in the vertical position as shown in Figure 9-24 below. As step 3 of Figure 9-23 shows, the second course requires seven bricks.

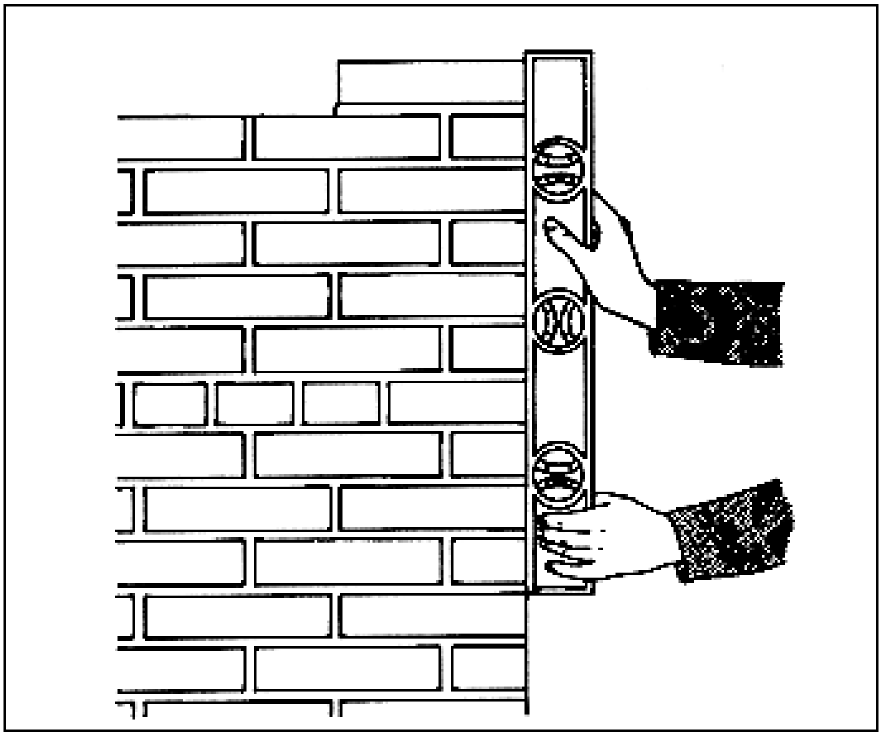


Figure 9-24. Plumbing a corner

Step 6. Lay the remaining bricks in the corner lead as you did the bricks in the second course.

Leveling

9-48. It is not good practice to move brick after it is laid in the mortar. Take great care to place the bricks accurately the first time. Be sure to finish or tool the joints before the mortar sets.

Step 1. Lay the portion of the wall between the leads using the leads as a guide.

Step 2. Check the level of the lead courses continuously.

Step 3. Plumb the lead after laying the first few courses. If the masonry is not plumb, move the bricks either in or out until the lead is exactly plumb.

Opposite Corner Leads

9-49. Build the opposite corner lead the same way. Make sure that the tops of corresponding courses are the same level in each lead. For example, the top of the second course in one corner lead must be the same height above the foundation as the second course in the opposite corner. Mark a long 2-by 2-inch pole with the correct course heights above the foundation, and then use it to check the course height in the corner leads as you build them.

LAYING THE FACE TIER BETWEEN THE CORNER LEADS

9-50. Use a line, as shown in Figure 9-25 to lay the face tier of brick for the wall between the leads.

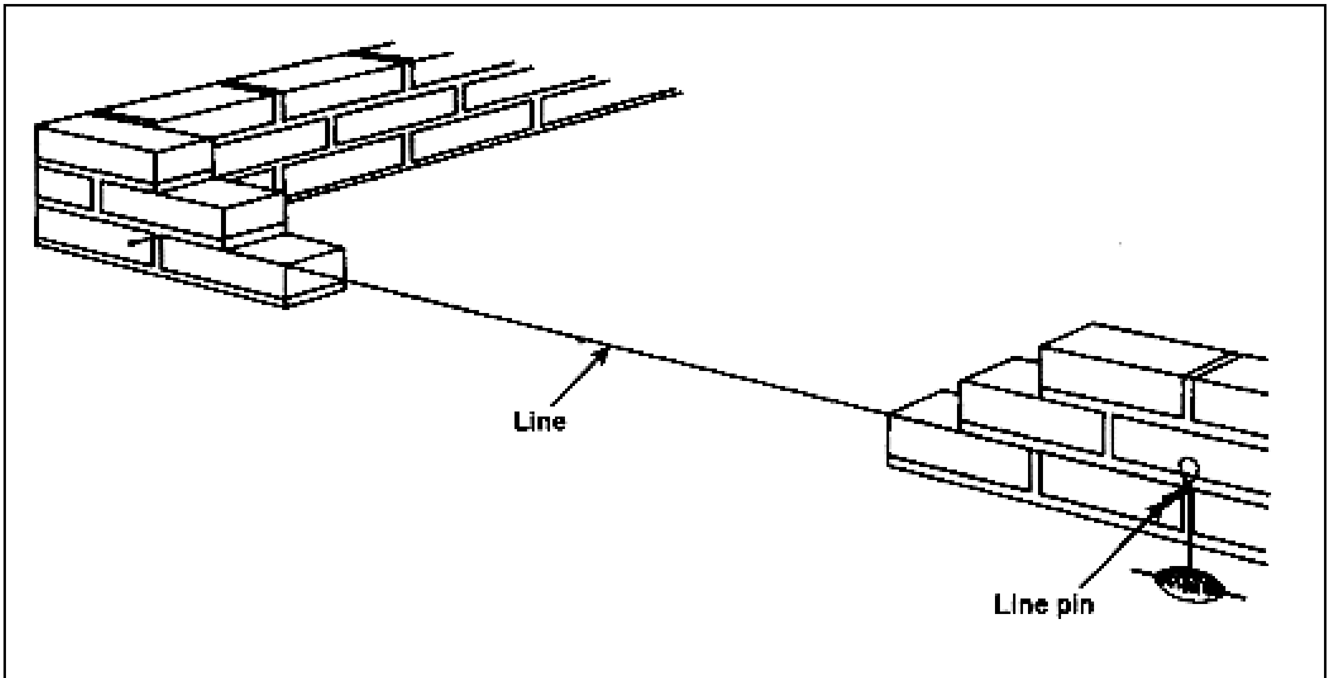


Figure 9-25. Using a line to lay face tier of brick between corner lead

Step 1. Drive nails into the top of the cross joints.

Step 2. Attach the line to the nail in the left-hand lead, pull it taut, and attach it to the nail in the right-hand lead. Position the line 1/16 inch outside the wall face, level with the top of the brick. It is better to use a tool called a line pin that resembles a triangular-shaped nail to attach the line at the right-hand or pull end. The line pin prevents the taut line from unwinding.

Step 3. Lay the first or header course in between the two corner leads as described in paragraph 9-46, when the line is in place.

Step 4. Push the brick into position with its top edge 1/16 inch behind the line. Be sure not to crowd the line. If the corner leads are built accurately, the entire wall will be level and plumb. You need not use a mason's level continually when laying the wall between the leads, but check it occasionally at several points.

Step 5. Move the line to the top of the next mortar joint for the second or stretcher course.

Step 6. Lay the stretcher course as described in paragraph 9-47, and finish the face joints before the mortar hardens.

Step 7. Lay the face tier of the wall between the leads up to, but not including, the second header course (normally five stretcher courses). Then lay the backup tier.

LAYING THE BACKUP TIER BETWEEN THE CORNER LEADS

9-51. Lay the backup brick for the corner leads first, as shown in Figure 9-26, followed by the remaining brick. For an 8-inch wall, you do not need to use a line for the backup brick as you do in a 12-inch wall. After laying the backup tier up to the height of the second header course, lay the second header course in the face tier.

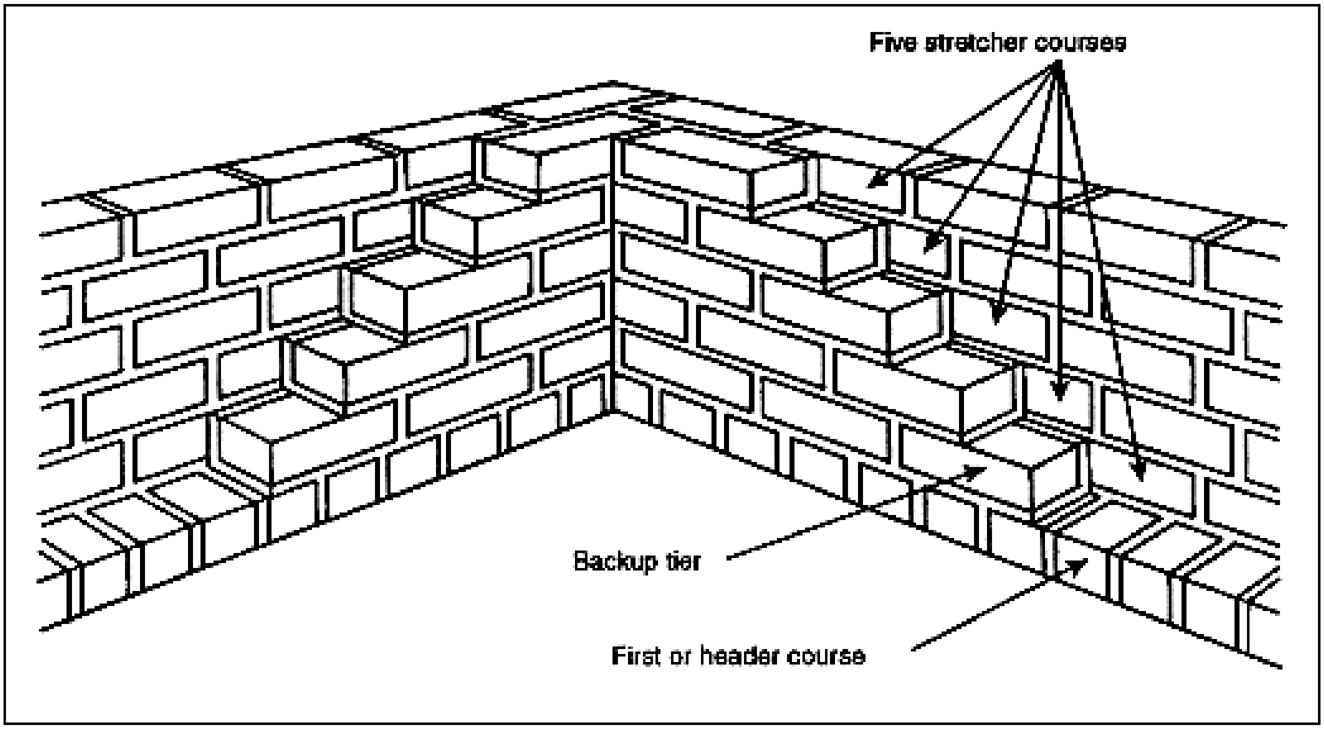


Figure 9-26. Laying backup brick for the corner lead of an 8-inch common bond brick wall

9-52. When the wall for the entire building is laid up to a height that includes the second header course, continue laying the corner leads up six more courses. Then construct the wall between the leads as described above. Repeat the entire procedure until the wall is laid to the required height.

LAYING A 12-INCH COMMON-BOND BRICK WALL

9-53. Figure 9-27 below shows how to lay the first three courses of a 12-inch common bond-brick wall. Note that the construction is similar to that of an 8-inch wall, except that it includes a second tier of backup brick (see view 3 of Figure 9-27).

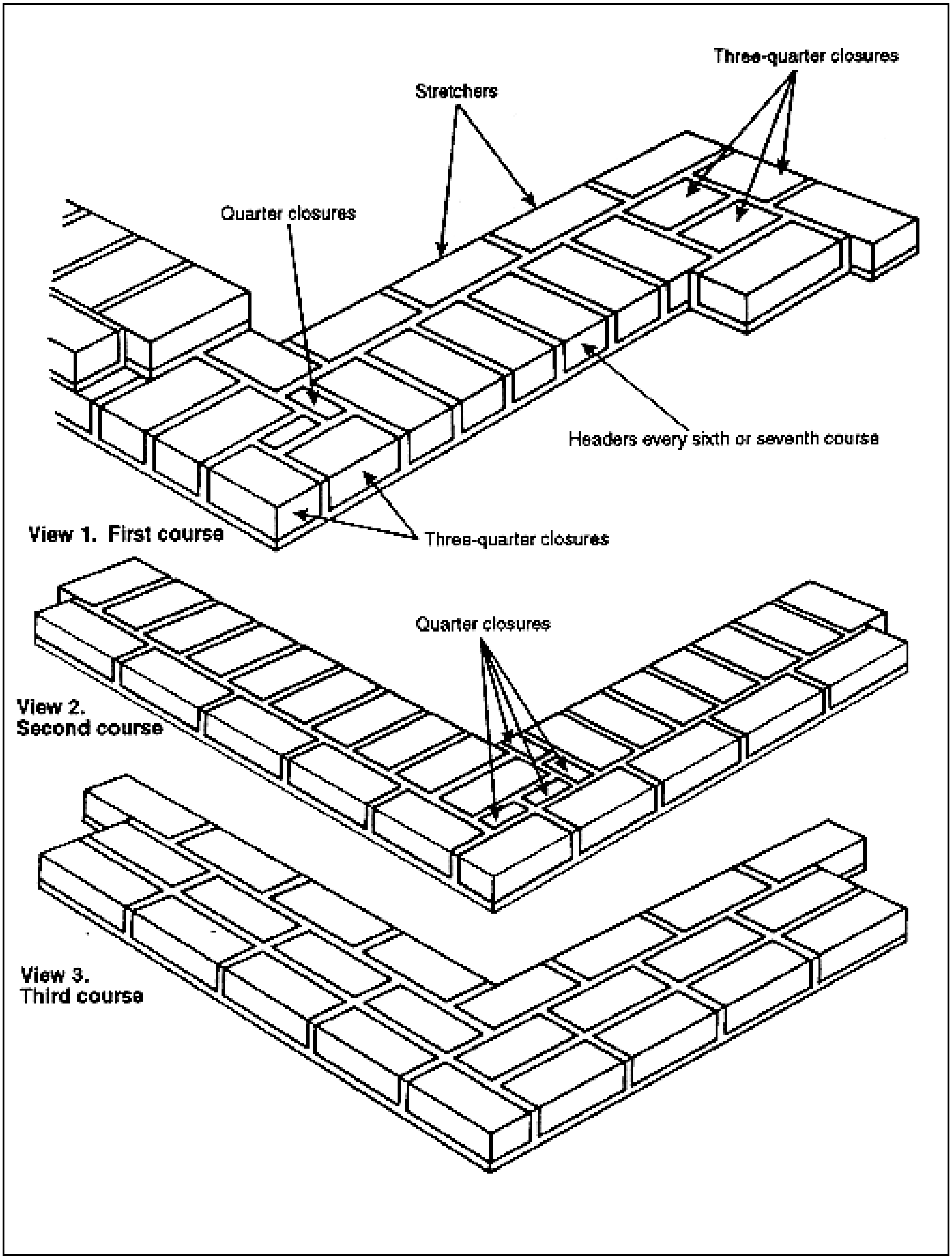


Figure 9-27. Laying a 12-inch common-bond brick wall

Step 1. Lay two overlapping header courses first (see view 1 of Figure 9-27), and build the corner leads.

Step 2. Lay the two tiers of backing brick, using a line for the inside tier.

Step 3. Lay the second course as shown in view 2 of Figure 9-27, and the third course as shown in view 3 of Figure 9-27.

PROTECTING WORK INSIDE WALLS

9-54. Each night cover the tops of all work completed inside the brick walls to protect them from weather damage. Use the boards or tarpaulins secured by loose bricks.

USING A TRIG

9-55. When building a long wall, erect a third lead between the corner leads. Then stretch a line from the left-hand lead to the middle lead to the right-hand lead. Now use a trig to keep the line from sagging or being windblown toward or away from the wall face. A *trig* (see Figure 9-28) is a second short piece of line that loops around the main line and fastens to the top edge of a previously laid brick in the middle lead. A piece of broken brick rests on top of the trig to hold it in position.

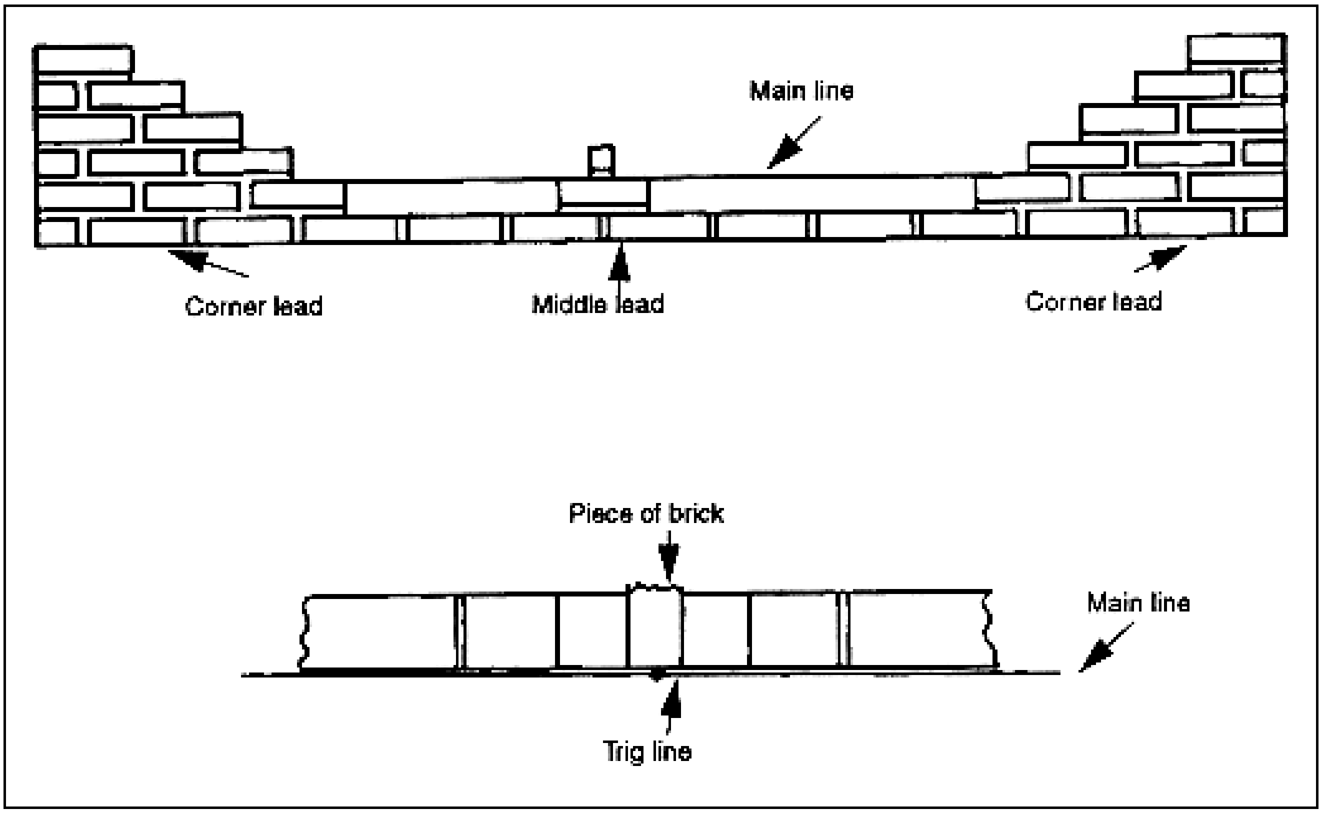


Figure 9-28. Use a trig to support the line when building a long wall

CONSTRUCTING WINDOW AND DOOR OPENINGS

9-56. You must plan ahead when laying any wall containing windows, making sure to leave openings of the correct size as the bricklaying proceeds.

WINDOW OPENINGS

9-57. Procedures to use when constructing window openings are as follows:

- Planning. First, find out the specified distance from the foundation to the bottom of the window sill. The height of the wall to the top of a full course must equal that distance. Now, calculate how many courses will bring the wall up to that height. For example, if the sill is 4 feet 4 1/4 inches above the foundation using 1/2-inch mortar joints, you must lay 19 courses before you reach the bottom of the sill. Calculate it this way: each brick plus one mortar joint equals 2 1/4 plus 1/2 equals 2 3/4 in per course, and 4 feet 4 1/4 inches divided by 2 3/4 inches equals 19 courses.
- Marking. Lay the corner leads and the wall in between them so that the top of the last course is not more than 1/4 inch above the top of the window frame. Use a pencil to mark the top of each course on the window frame itself. If the mark for the top of the last course does not come out to the proper level, change the joint thickness you plan to use until it does.
- Laying the brick. Lay the corner leads with joints of the calculated thickness. When the corner leads are built, install a line as described earlier and stretch it across the bottom of the window openings. Lay the brick for the wall between the leads up to sill height using the calculated joint thickness. If the window openings are planned properly, you can lay the face tier brick with a minimum of cutting.
- Laying the rowlock sill course. When the wall reaches sill height, lay the rowlock sill course as shown in Figure 9-29 below. Pitch the course downward away from the window. The rowlock normally takes up a vertical space equal to two courses of brick. Finish the exterior joint surfaces carefully to make them watertight.
- Placing the frame. As soon as the mortar sets, place the window frame on the rowlock sill course, bracing it firmly until the masonry reaches about ingathered of the way up the frame. (But do not remove the braces for several days so that the wall above the window frame sets properly). Now lay the rest of the wall around the frame until the top of the last course is not more than 1/4 inch above the window frame

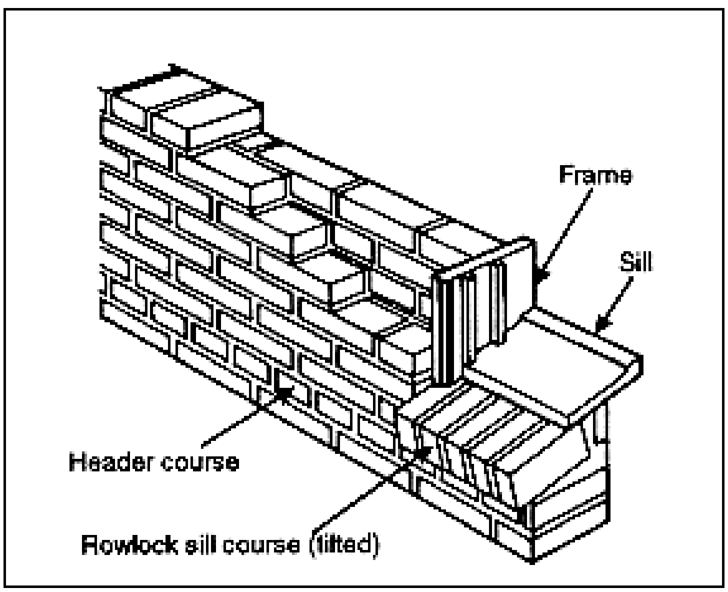


Figure 9-29. Constructing a window opening

DOOR OPENING

9-58. Use the same procedure to construct a door opening (see Figure 9-30) as for a window opening. To anchor the door frame to the masonry using screws or nails, cut pieces of wood to the size of a half closure and lay them in mortar the same as brick. Place the wood blocks at several points along the top and sides of the door opening.

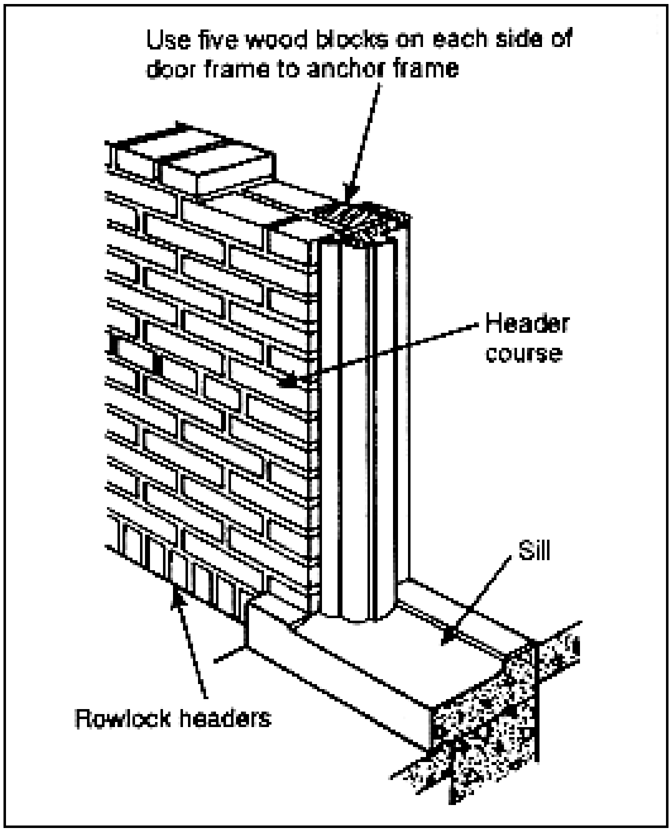


Figure 9-30. Constructing a door opening

LINTELS

9-59. The lintel above a window or door carries the weight of the wall above it. It rests on top of the last brick course that is almost level with the top of the window or door frame, and its sides bed firmly in mortar. Close any space between the window or door frame and the lintel with blocking, and weather-strip it with bituminous materials. Then continue the wall above the window or door when the lintel is in place.

CONSTRUCTION

9-60. Lintels are made from steel, precast reinforced-concrete beams, or wood. Do not use wood lintels if possible. In reinforced brick masonry, properly installed steel reinforcing bars support the brick above wall openings.

INSTALLATION

9-61. The placement and relative positioning of lintels are determined by both the wall thickness and the type of window or door specified. This information is usually on the building drawings. If the lintel size is not specified, Table 9-5 gives size and quantities of double-angle steel and wood lintels to use for various opening widths in both 8- and 12-inch walls. Figures 9-31 and 9-32 below show how to place different kinds of lintels in different wall thickness. Figure 9-31 shows how to install a doubleness steel lintel in an 8-inch wall. The angle is 1/4-inch thick, which allows the two angle legs that project up into the brick to fit exactly into the 1/2-inch joint between the face and backing ties.

Table 9-5. Lintel sizes for 8-inch and 12-inch walls

Wall Thickness, in Inches	Span				
	3 Feet		4 Feet, Steel Angles*	5 Feet, Steel Angles*	6 Feet, Steel Angles*
	Steel Angles	Wood			
8	2-3 x 3 x 1/4	2 x 8 2-2 x 4	2-3 x 3 x 1/4	2-3 x 3 x 1/4	2-3 1/2 x 3 1/2 x 1/4
12	3-3 x 3 x 1/4	2 x 12 2-2 x 6	3-3 x 3 1/4	3-3 1/2 x 3 1/2 x 1/4	3-3 1/2 x 3 1/2 x 1/4
				7 Feet, Steel Angles*	8 Feet, Steel Angles*
				2-3 1/2 x 3 1/2 x 1/4 3-4 x 4 x 1/4	2-3 1/2 x 3 1/2 x 1/4 3-4 x 4 x 4 1/4

*** Wood lintels should not be used for spans over 3 feet since they will burn out in case of fire and allow the bricks to fall.**

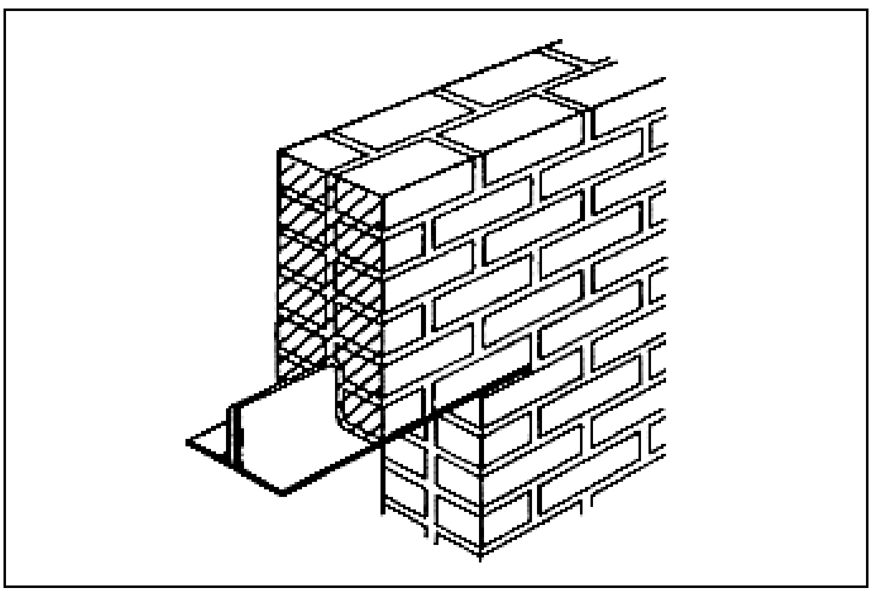


Figure 9-31. Installing a double-angle steel lintel in an 8-inch wall

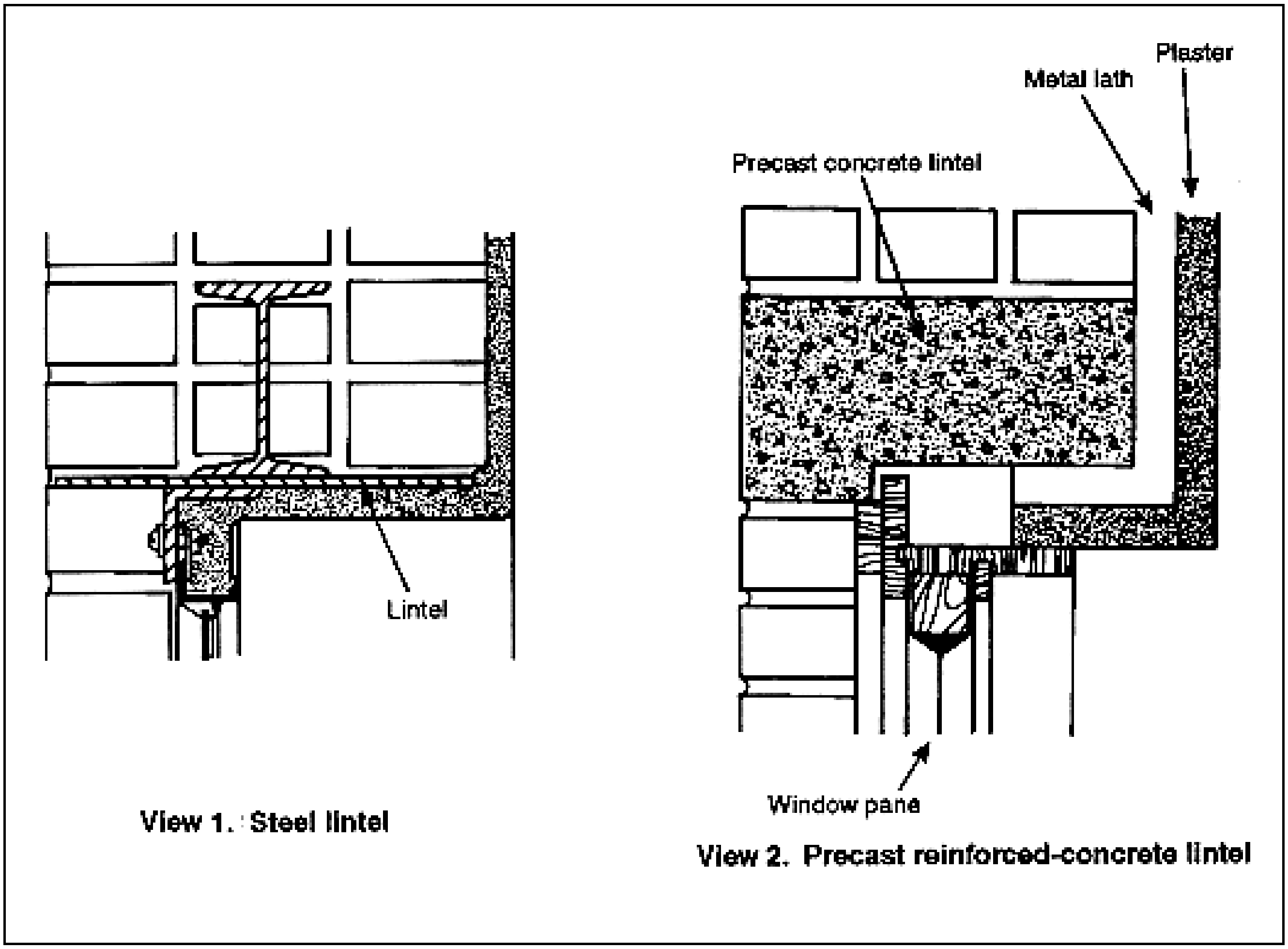


Figure 9-32. Installing lintels in a 12-inch wall

CORBELING

9-62. Corbeling consists of brick courses projecting beyond the wall face to increase its thickness or form a self-supporting shelf or ledge (see Figure 9-33). The portion of a chimney exposed to weather is frequently corbeled to increase its thickness for better weather resistance. Corbeling usually requires various-sized bats (a broken brick with one end whole, the other end broken off). Use headers as much as possible, but the first projecting course can be a stretcher course if necessary. No course should extend more than 2 inches beyond the course underneath it, and the total corbel projection should not be greater than the wall thickness.

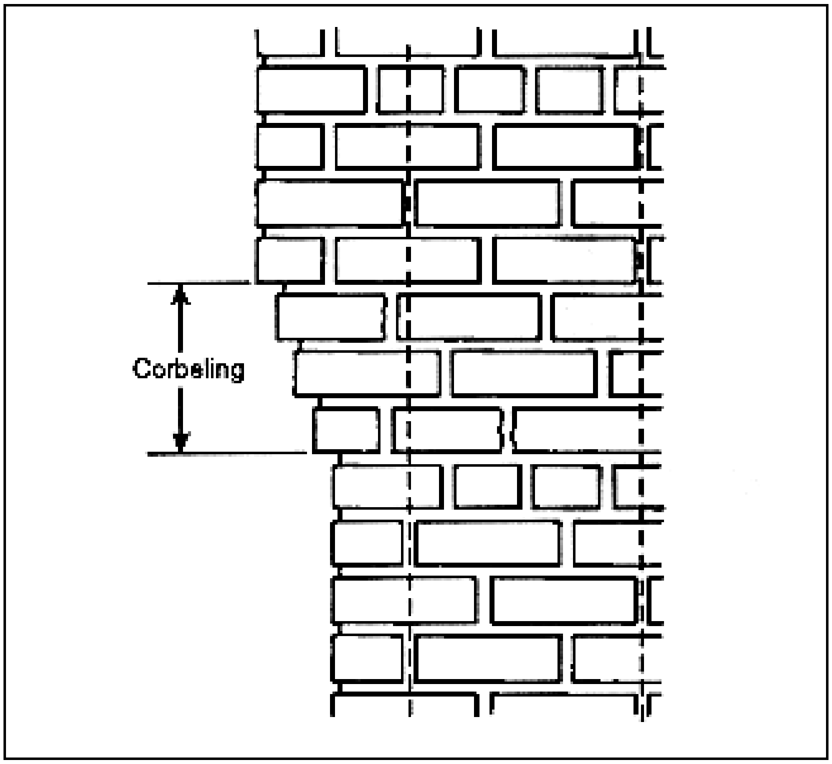


Figure 9-33. Constructing a corbeled brick wall

9-63. Corbel construction requires good workmanship for maximum strength. Make all mortar joints carefully and fill them completely with mortar. When the corbel must withstand large loads, consult a qualified engineer.

ARCHES

9-64. A well-constructed brick arch can support a heavy load, mainly due to its curved shape. Figure 9-34 shows two common arch shapes.

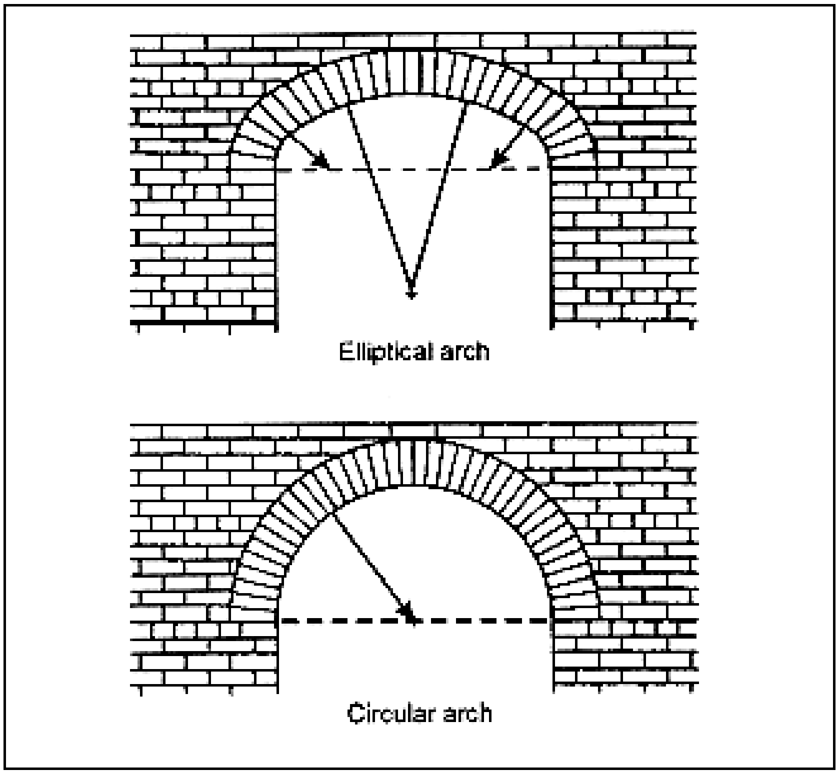


Figure 9-34. Common shapes

Brick arches require full mortar joints. Note that the joint width is narrower at the bottom of the arch than at its top, but it should not narrow to less than 1/4 inch at any point. As laying progresses, make sure that the arch does not bulge out of position.

BUILDING A TEMPLET

9-65. Construct a brick arch over a temporary wood support called a templet (see Figure 9-35) that remains in place until the mortar sets.

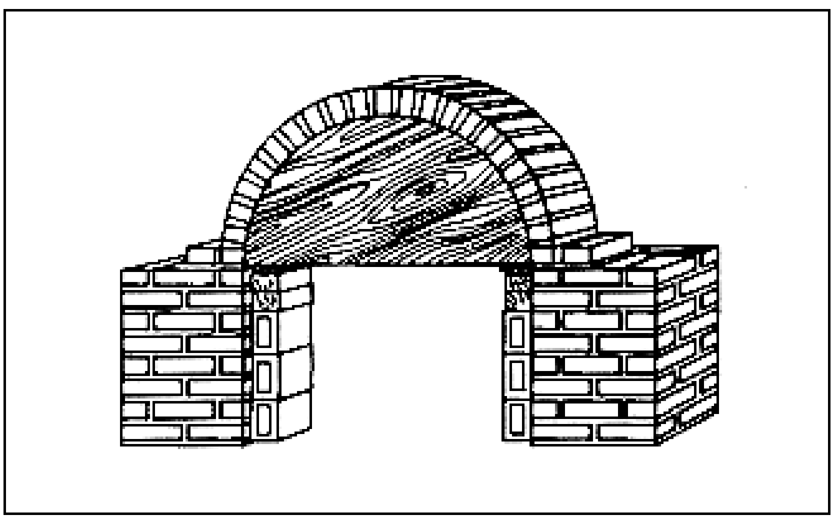


Figure 9-35. Using a templet to construct an arch

You can obtain the templet dimensions from the construction drawings. For arches spanning up to 6 feet, use 3/4-inch plywood to make the templet. Cut two pieces to the proper curvature and nail them to 2 by 2 spaces that provide a surface wide enough to support the brick. Use wedges to hold the templet in position until the mortar hardens enough to make the arch self-supporting. Then drive out the wedges.

LAYING OUT THE ARCH

9-66. Lay out the arch carefully to avoid cutting the brick. Use an odd number of bricks so that the key or middle brick falls into place at the exact arch center or crown. The key or middle brick is the last one laid. To determine how many bricks an arch requires, lay the templet on its side on level ground and set a trial number of bricks around the curve. Adjust the number of bricks and the joint spacing (not less than 1/4 inch) until the key brick is at the exact center of the curve. Mark the positions of the bricks on the templet and use them as a guide when laying the brick.

WATERTIGHT WALLS

9-67. Water does not usually penetrate brick walls through the mortar or brick, but through cracks between the brick and the mortar. Cracks are more likely to occur in head joints than in bed joints.

PREVENTING CRACKS

9-68. Sometimes a poor bond between the brick and the mortar causes cracks to form and sometimes mortar shrinkage is responsible. Do not change the position of a brick after the mortar begins to set, because this destroys the bond between the brick and mortar and a crack will result. Wet high-suction bricks and other bricks as necessary during hot weather so that they do not absorb too much moisture from the mortar and cause it to shrink. You can reduce both the size and number of cracks between the mortar and the brick by tooling the exterior faces of all mortar joints to a concave finish. To obtain watertightness, completely fill all head and bed joints with mortar.

PARGING

9-69. Figure 9-36 shows a good way to produce a watertight wall called parging or back plastering. Parging means to plaster the back of the brick in the face tier with not less than 3/8 inch of rich cement mortar before laying the backing bricks. Because you cannot plaster over mortar protruding from the joints, first cut all joints flush with the back of the face tier.

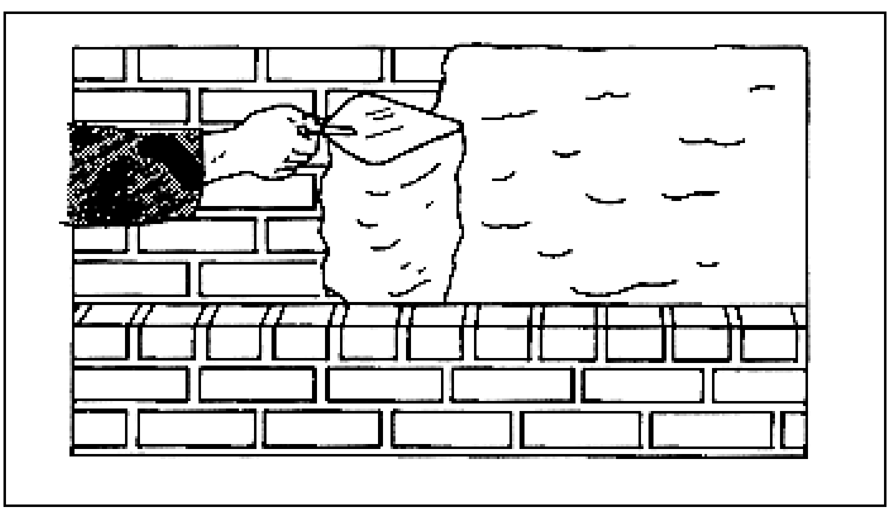


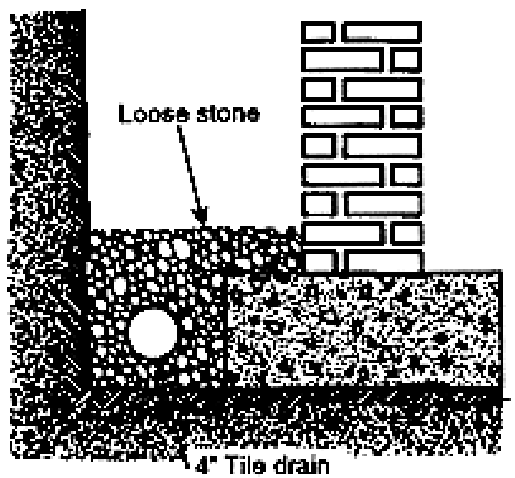
Figure 9-36. Parging the back of the face tier for watertightness

WATERPROOF WITH MEMBRANES

9-70. If a wall is subject to much water pressure, use a membrane to waterproof it. A properly installed membrane adjusts to any shrinkage or settlement without cracking.

CONSTRUCTING DRAINS

9-71. If the wall is subject to much groundwater, or the surrounding soil does not drain well, construct tile drains or French drains around the wall base (see Figure 9-37). If drainage tile is not available, an 8-inch layer of coarse loose rock or stone will do the job. This is called a French drain.



NOTE: A French drain would omit the tile drain

Figure 9-37. Draining a wall around its foundation

REPAIRING CRACKS

9-72. Before applying waterproof or portland-cement paints, repair all cracks. To repair mortar joint cracks, first chip out the mortar around the full width of the crack to a depth of about 2 inches. Carefully scrub the hole with clean water. While the hole surfaces are still wet, apply a coating of cement mortar made with enough water to form a thick liquid. Before the coating sets, fill the hole with prehydrated mortar, which is recommended for tuck-pointing in paragraph 9-90.

NOTE: Repair cracks in bricks the same way as cracks in concrete (see paragraphs 5-95 and 5-105).

USING WATERPROOF COATING

9-73. Walls can be waterproofed in three ways:

- Bituminous mastic. To make a below-grade foundation wall watertight, apply two coats of bituminous mastic to the exterior brick surface. You can apply asphalt or coal tar pitch using a mop.
- Waterproof paints. You can improve the watertightness of above-grade brick walls by

applying a transparent, waterproof paint, such as a water solution of sodium silicate. Varnish, certain white and color waterproof paints, and high-quality oil-base paints are also effective. Apply them according to the directions.

- Portland-cement paint. This paint generally gives excellent results if you apply it when the wall is at least 30 days old. Use type 2, class A portland-cement paint and follow the manufacturer's instructions for mixing and applying it. Remove all efflorescence from the surface (see paragraph 9-95) and dampen the surface with a water spray before applying the paint. Use white-wash or calcimine-type brushes or a spray gun, but spraying reduces the paint's rain resistance.

FIRE-RESISTANT BRICK

9-74. To line furnaces, incinerators, and so forth, use fire-resistant brick to protect the supporting structure or outer shell from intense heat. The outer shell probably consists of common brick or steel, neither of which has good heat resistance.

TYPES

9-75. The two types of fire-resistant brick are fire bricks and silica bricks.

- Fire bricks are made from a special clay, called fire clay, or that withstand higher temperatures and are heavier and usually larger than common brick. Their standard size is 9 by 4 1/2 by 2 1/2 inches.
- Silica bricks resist acid gases; however, do not use silica brick if it will be alternately heated and cooled. Therefore, you should line most incinerators with fire brick rather than with silica brick.

LAYING FIRE BRICK

9-76. Fire brick requires thin mortar joints, especially if the brick is subject to such high temperatures as those in incinerators. Store the bricks in a dry place until you use them.

Mortar

9-77. Use a mortar made from fire clay and water mixed to the consistency of thick cream. Obtain fire clay by grinding used fire brick.

Laying procedure

9-78. To lay fire bricks, use the following proedures:

Step 1. Dip the brick in the mortar, covering all surfaces except the top bed.

Step 2. Lay the brick and tap it firmly into place with a bricklayer's hammer.

Step 3. Make the mortar joints as thin as possible, and fit the bricks together tightly. Remember that any heat that migrates through the cracks between the fire bricks will damage the outside shell of the incinerator or furnace.

Step 4. Stagger the head joints the same way you do in ordinary brick construction. The bricks in one course should lap those in the course underneath by one-half brick.

LAYING SILICA BRICK

9-79. Lay silica bricks without mortar, fitting them so close together that they fuse at the joints at high tempera-tures. Stagger the head joints as you do in ordinary brick construction.

TYPES OF WALLS

9-80. The basic types of walls are: hollow and partition.

HOLLOW

9-81. Hollow walls consist of an inner and an outer wythe separated by an air space. The two most important types of hollow walls are the cavity wall and the rowlock wall. Partition walls divide the interior space in a one-story building. They may be load-bearing or nonload-bearing walls.

Cavity

9-82. A *cavity* wall is a watertight wall that can be plastered without furring or lathing. It looks the same on the exterior as a solid wall without header courses (see Figure 9-38). Instead of headers, metal ties are installed every sixth course on a 24-inch center that holds the two tiers together. To prevent water penetration to the inner tier, angle the ties downward from the inner to outer tier. A 2-inch cavity or air space between the two brick wythes drains any water that penetrates the outer tier. The air space also provides good heat and sound insulation. The bottom of the cavity is above ground level. It is drained by weep holes in the vertical joints in the first course of the exterior tier. Make the weep holes simply by leaving the mortar out of the joint. Space them about a 24-inch interval.

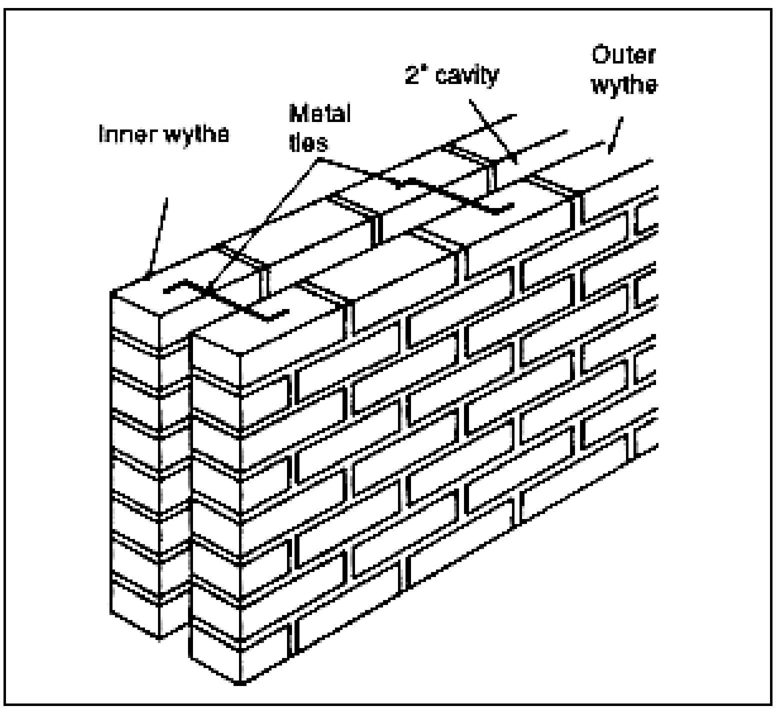


Figure 9-38. Construction details of a cavity wall

Rowlock

9-83. A *rowlock* is a header laid on its face or edge. A rowlock also has a 2-inch cavity between the wythes as shown in Figure 9-39. In this type of rowlock wall, the face tier is loose like a common-bond wall having a full header course every seventh course. However, the bricks in the inner or backing tier are laid on edge. A header course ties the outer and backing ties together. For an all-rowlock wall, lay the brick on edge in both the inner and outer tiers. Install a header course every fourth course (that is, three rowlock courses to every header course). The rowlock wall is not as watertight as the cavity wall, because water will follow along any crack in the header course and pass through to the interior surface.

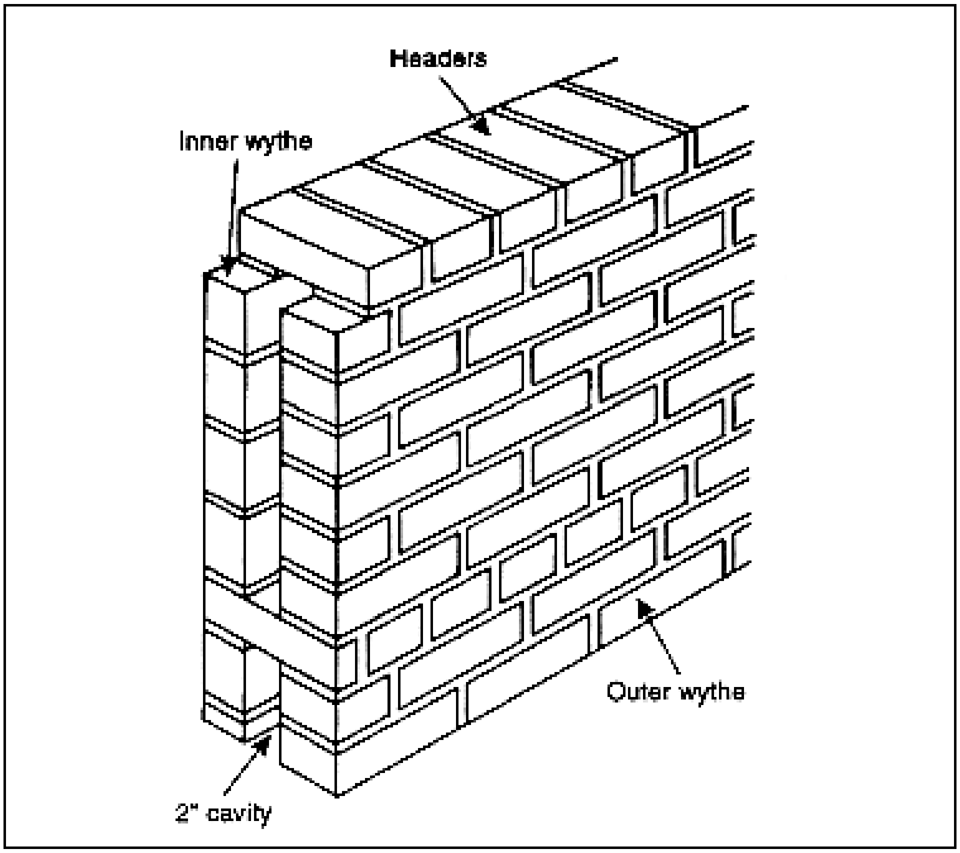


Figure 9-39. Construction details of a rowlock wall

PARTITION

9-84. A partition wall that carries very little load requires only one wythe producing a wall 4 inches thick. You can lay a wall of this thickness without headers.

LAYING HOLLOW AND PARTITION WALLS

9-85. Lay the brick for hollow and partition walls as described starting in paragraph 9-29 for making bed joints (f), head joints (h), cross joints (j), and closures (K and l). Use a line the same as for a common bond wall. Erect the corner leads first, and then build the wall between them.

MANHOLES

9-86. Sewer systems require man-holes (see Figure 9-40) for cleaning and inspection. The manhole size largely depends on the sewer size. Manholes are either circular or oval to reduce the stresses from both water and soil pressures. A 4-foot diameter manhole is satisfactory for small, straight-line sewers. Construction details of a typical manhole are shown in view 2 of Figure 9-40. Although both the bottom and walls of a manhole are sometimes made from brick, the bottom is normally made from concrete because it is easier to cast in the required shapes. However, you can construct the walls more economically from brick, because it requires no form work.

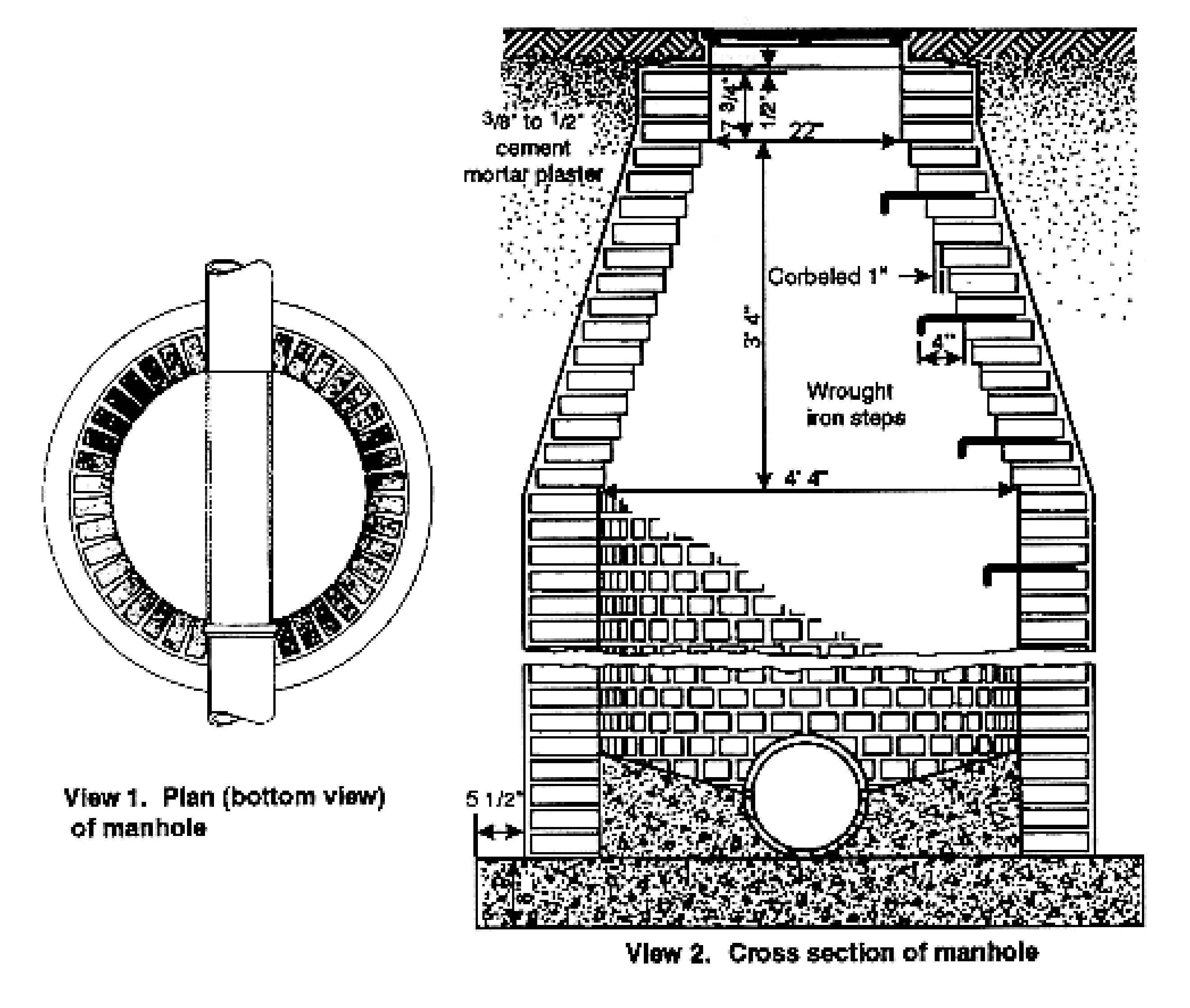


Figure 9-40. Construction details of a sewer manhole

WALL THICKNESS

9-87. The wall thickness of a manhole depends on its depth and diameter. You can use an 8-inch wall for manholes up to 8 feet in diameter and less than 15 feet deep. A qualified engineer should design any manholes over 15-feet deep.

MANHOLE CONSTRUCTION

9-88. Use only headers for an 8-inch wall, but no line. Use a mason's level to make sure that all bricks in a particular course are level. Span the manhole with a straightedge or place a mason's level on a straight surfaced 2 by 4 across the manhole, to make sure the brick rises to the same level all around. Because the wall appearance is not important, some irregularities in both brick position and mortar joint thickness are permissible. All joints should be either full or closure joints.

- Laying the first course. Place a 1-inch mortar bed on the foundation. Lay the first course on the mortar bed, followed by the succeeding header courses.
- Corbeling. To reduce the manhole diameter to fit the frame and cover, corbel the brick inward as shown in view 2 of Figure 9-40 above. No brick should project more than 2 inches beyond the brick underneath it. Space the wrought-iron steps about every 15 inch vertically, and embed them in a cross mortar joint. When complete, plaster the wall on the outside at least 3/8-inch thick with the same mortar used in laying the brick.
- Placing. Spread a 1-inch mortar bed on top of the last course, and place the base of the manhole frame in the bed.

SUPPORTING BEAMS ON A BRICK WALL

9-89. The following beams are used on brick walls.

- Wood Beams. Figure 9-41 shows how to support a wood beam on a brick wall. Note the wall tie. Keep mortar away from the beam as much as possible, because wood can dry rot when completely encased in mortar. Protect the beam with a beam box (see Figure 9-41). Cut the end of the beam at an angle so that, in case of fire, it will fall without damaging the wall above the beam. For an 8- or 12-inch wall, let the beam bear on the full width of the inside tier.
- Steel Beams. When a brick wall must support a steel beam, insert a steel bearing plate set in mortar under the beam. A properly designed bearing plate prevents the beam from crushing the brick. The size of the bearing plate depends on the size of the beam and the load it carries.

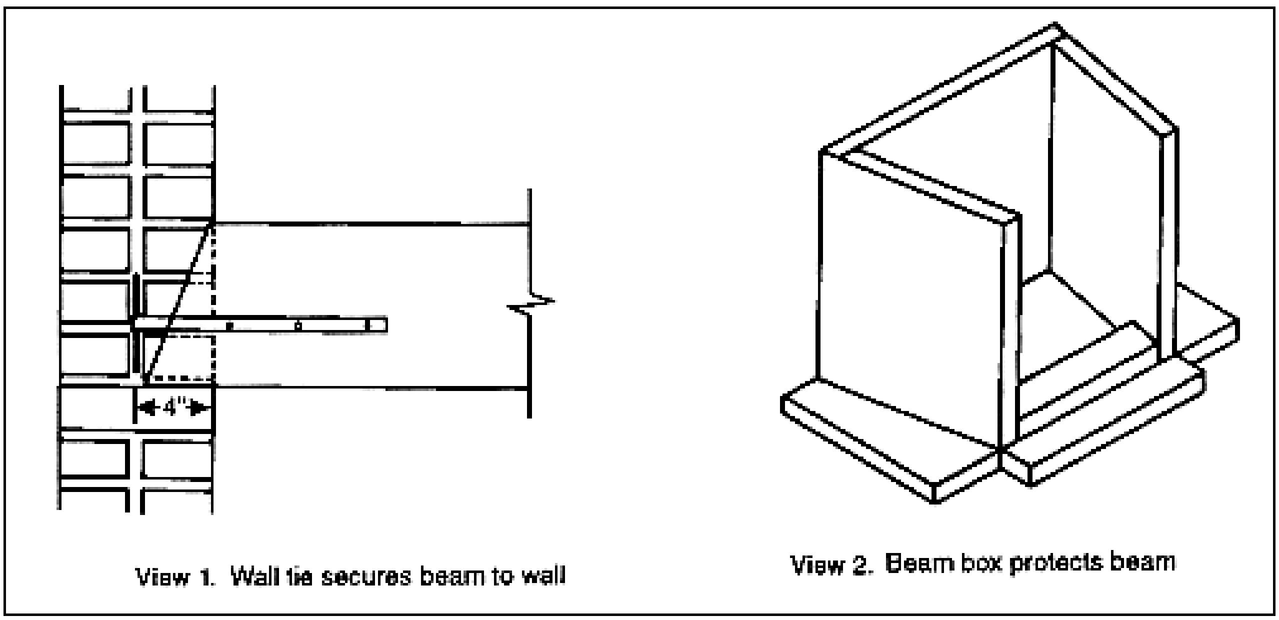


Figure 9-41. Supporting a wood beam on a brick wall

MAINTAINING AND REPAIRING BRICK WALLS

9-90. A well-constructed brick masonry wall requires little maintenance or repair. It can be more expensive to repair old masonry properly than to completely remove and replace just the disintegrated portion. Good mortar, proper joint finishing, and adequate flashing add little to the initial cost, but reduce maintenance cost throughout the life of the masonry.

TUCK-POINTING

9-91. Tuck-pointing during routine maintenance means to cut out all loose and disintegrated mortar to a depth of at least 1/2 inch and replace it with new mortar. Use a chisel having a cutting edge about 1/2 inch wide. To stop leakage, cut out all the mortar in the affected area, and replace it with new mortar.

PREPPING THE MORTAR JOINT

9-92. After cutting out the defective mortar, remove all dust and loose material with a brush or a water jet. If you use a water jet, no further joint wetting is required. If not, moisten the joint surfaces.

PREPARING MORTAR FOR TUCK-POINTING

9-93. Use portland--cement-lime prehydrated Type S mortar or prehydrated prepared mortar made from type II masonry cement. Prehydrating mortar greatly reduces the amount of shrinkage. Mix the dry ingredients with just enough water to produce a damp mass of a consistency that retains its form when you compress it into a ball with your hands. Allow the mortar to stand for at least 1 hour, but not more than 2 hours. Then mix the mortar with enough water to produce a stiff, but workable consistency.

FILLING THE JOINT

9-94. Filling a joint with mortar is called *repointing* and is done with a pointing trowel. Before filling the joint, allow the moisture used in preparing the joint to absorb. Then pack the prepared prehydrated mortar into the joint tightly in thin layers about 1/4 inch thick, and finish them to a smooth concave surface using a pointing tool. Push the mortar into the joint in one direction only from the starting point, using a forward motion to reduce the risk of forming air pockets.

CLEANING NEW BRICK AND REMOVING STAINS

9-95. A skilled bricklayer can build a masonry wall that is almost free from mortar stains. However, most new brick walls still need some cleaning.

Step 1. Remove large mortar particles adhering to brick with a putty knife or chisel. Remove mortar stains with an acid solution of one part commercial muriatic acid to nine parts water. Acid must be poured into the water, not the water into the acid. Before applying the acid, thoroughly soak the masonry surface with water to prevent the stain from being drawn into the brick pores.

Step 2. Apply the acid solution with a long-handled stiff-fiber brush. Take all precautions to prevent the acid from getting on your hands, arms, or clothing, and wear goggles to protect your eyes. Protect door and window frames. Scrub an area of 15 to 20 square feet with the acid solution, and then wash it down immediately with clear water. Make sure that you remove all acid before it can attack the mortar joints.

Step 3. Removing any efflorescence. *Efflorescence* is a white deposit that forms on the surface of brick walls. It consists of soluble salts leached from the brick by penetrating water that dissolves the salt in the brick. When the water evaporates, the salt remain. Because efflorescence requires the presence of both water and salts, proper brick selection and a dry wall will keep it to a minimum. However, if simply scrubbing the wall with water and a stiff brush does not remove the efflorescence, you can remove it with the acid solution described above for cleaning new masonry.

CLEANING OLD BRICK

9-96. The principal ways to clean old brick masonry are sandblasting, steam cleaning with water jets, or using cleaning compounds. The type of brick and the nature of the stain will determine which method you use. Many cleaning compounds that do not affect the brick will damage the mortar. Rough-textured brick is more difficult to clean than smooth-textured brick.

Sometimes you cannot clean rough-textured brick without removing part of the brick itself, which changes the appearance of the wall.

SANDBLASTING

9-97. Sandblasting consists of using compressed air to blow hard sand through a nozzle against a dirty surface, thereby removing enough of the surface to eliminate the stain. Place a canvas screen around the scaffold to salvage most of the sand. The disadvantage of sandblasting is that it leaves a rough-textured surface that collects soot and dust. Moreover, sandblasting usually cuts so deeply into the mortar joints that you may have to repoint them. After sandblasting, apply a transparent waterproofing paint to the surface to help prevent future soiling by soot and dust. Never sandblast glazed surfaces.

STEAM CLEANING WITH WATER JETS

9-98. Steam cleaning means to project a finely divided spray of steam and water at high velocity against a dirty surface. This removes grime effectively without changing the surface texture, which gives steam cleaning an advantage over sandblasting.

- Equipment. Use a portable, truck-mounted boiler to produce the steam at a pressure ranging from 140 to 150 psi. Each cleaning nozzle requires about a 12-horse-power boiler. The velocity of the steam and water spray as it strikes the surface is more important than the volume of the spray.
- Procedure. Use one garden hose to carry water to the cleaning nozzle and

another to supply rinse water. Experiment to determine the best angle and distance from the wall to hold the nozzle. Adjust the steam and water valves until you obtain the most effective spray. Pass the nozzle back and forth over no more than a 3-square-feet area at one time. Rinse it immediately with clean water before moving to the next area.

- Additives. To aid cleaning action, add sodium carbonate, sodium bi-carbonate, or trisodium phosphate to the water entering the nozzle. Reduce a lot of the salt or efflorescence remaining on the surface by washing it down with water before and after steam cleaning.
- Hand tools. Use steel scrapers or wire brushes to remove any hardened deposits that remain after steam cleaning. Be careful not to cut into the surface. After removing the deposits, wash down the surface with water and steam and clean it again.

CLEANING COMPOUNDS

9-99. You can use one of several cleaning compounds, depending on the nature of the stain. Most cleaning compounds contain salts that will cause efflorescence if the cleaning solution penetrates the surface. You can prevent this by thoroughly wetting the surface before applying the solution. You can remove white-wash, calcimine, or paint coatings with a solution of one part acid to five parts water. Use fiber brushes to scrub the surface with the solution while it is still foaming. After removing the coating, wash down the wall with clean water until you remove the acid completely.

PAINT REMOVERS

9-100. Apply paint remover with a brush to remove oil paint, enamels, varnishes, shellacs, or glue sizing. Leave the remover on until the coating is soft enough to scrape off with a putty knife. The following are effective paint removers:

- Commercial. When using commercial paint removers, the manufacturer's in-structions should be followed.
- Chemical. Use a solution of 2 pounds of trisodium phosphate in 1 gallon of hot water. Another solution is 1 1/2 pounds of caustic soda in 1 gallon of hot water.
- Blasting and torching. Sandblasting or burning off with a blowtorch will also remove paint.

REMOVING MISCELLANEOUS STAINS

9-101. The following are procedures for removing different types of stains:

- Iron stains. Mix seven parts lime-free glycerin into a solution of one part sodium citrate in six parts lukewarm water. Add whiting or kieselguhr to make a thick paste and apply it to the stain with a trowel. Scrape off the paste when it dries. Repeat the procedure until the stain disappears; then, wash down the surface with water.
- Tobacco stains. Dissolve 2 pounds of trisodium phosphate in 5 quarts of water. Next, in an enameled pan, mix 12 ounces of chloride of lime in enough water

to make a smooth thick paste. Then mix the trisodium phosphate with the lime paste in a 2-gallon stoneware jar. When the lime settles, draw off the clear liquid and dilute it with an equal amount of water. Make a stiff paste by mixing the clear liquid with powdered talc, and apply it to the stain with a trowel followed by washing the surface.

- Smoke stains. Apply a smooth, stiff paste made from trichlorethylene and powdered talc. Cover the container when you are finished to prevent evaporation. If a slight stain still remains after several applications, wash down the surface and then follow the procedure described above for removing tobacco stains. Use the paste only in a well-ventilated space because its fumes are harmful.
- Copper and bronze stains. Mix one part ammonium chloride (salammoniac) in dry form to four parts powdered talc. Add ammonia water and stir the solution to obtain a thick paste. Apply the paste to the stain with a trowel, and allow it to dry. Several applications may be necessary. Then wash down the surface with clear water.
- Oil stains. Make a solution of 1 gallon trisodium phosphate to 1 gallon of water, adding enough whiting to form a paste. Trowel the paste over the stain in a layer 1 1/2 inch thick, and allow it to dry for 24 hours. Remove the paste and wash down the surface with clean water.

FLASHING

9-102. Flashing is an impermeable membrane placed in brick masonry at certain locations to exclude water or to collect any moisture that penetrates the masonry and direct it to the wall exterior. Flashing can be made from copper, lead, aluminum, or bituminous roofing paper. Copper is best, although it stains the masonry as it weathers. Use lead-coated copper if such staining is unacceptable. Bituminous roofing papers are cheapest, but not as durable. They will probably require periodic replacement in permanent construction, and their replacement cost is greater than the initial cost of installing high-quality flashing. Corrugated copper flashing sheets produce a good bond with the mortar. They also make interlocking watertight joints at points of overlap.

PLACEMENT

9-103. Install flashing at both the head and sill of window openings and at the intersection between a wall and roof. The flashing edges should turn upward as shown in Figure 9-42 to prevent drainage into the wall. Always install flashing in mortar joints. You can provide drainage for the wall above the flashing either by placing 1/4-inch cotton-rope drainage wicks at 18-inch spacings in the mortar joint just above the flashing or placing dowels in the proper mortar joint as you lay the brick and then remove them to make drainage holes. Where chimneys pass through the roof, the flashing should extend completely through the chimney wall and turn upwards 1 inch against the flue lining.

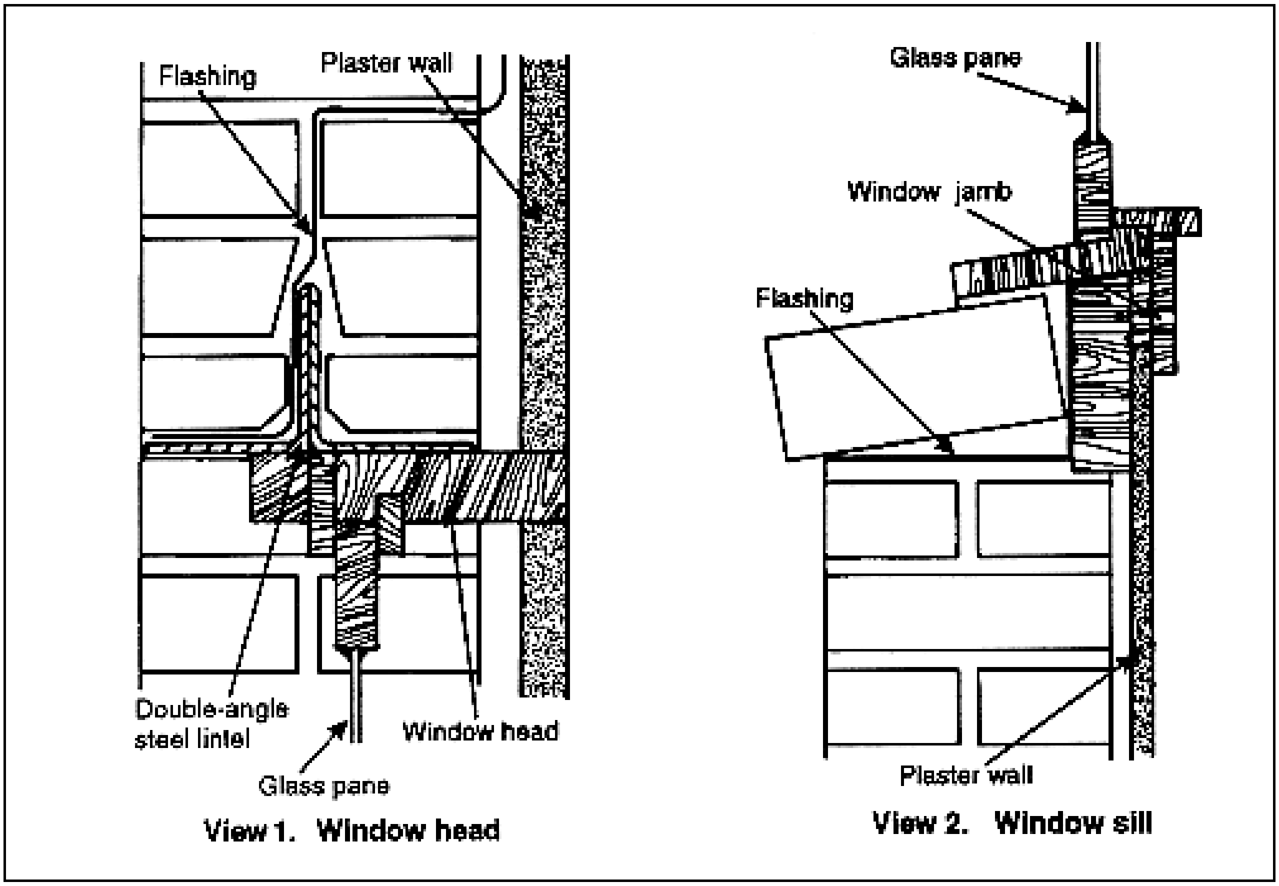


Figure 9-42. Installing flashing at window opening

INSTALLATION

9-104. Using the following steps to install flashing:

Step 1. Spread a 1/2-inch mortar bed on top of the brick, and then push the flashing sheet down firmly into the mortar. Spread a 1/2-inch mortar bed on the flashing, and then force the brick or sill onto the top of the flashing.

Step 2. Figure 9-42 above shows the proper flashing installations at both the head and the sill of a window. Note that the flashing fits under the face tier of brick at the steel lintel, then bends behind the face tier and over the top of the lintel.

Step 3. Figure 9-43 shows how to install flashing between the roof and the wall to prevent leakage at the intersection. Fit and caulk the upper end of the flashing into the groove of the raggle block as shown in Figure 9-43.

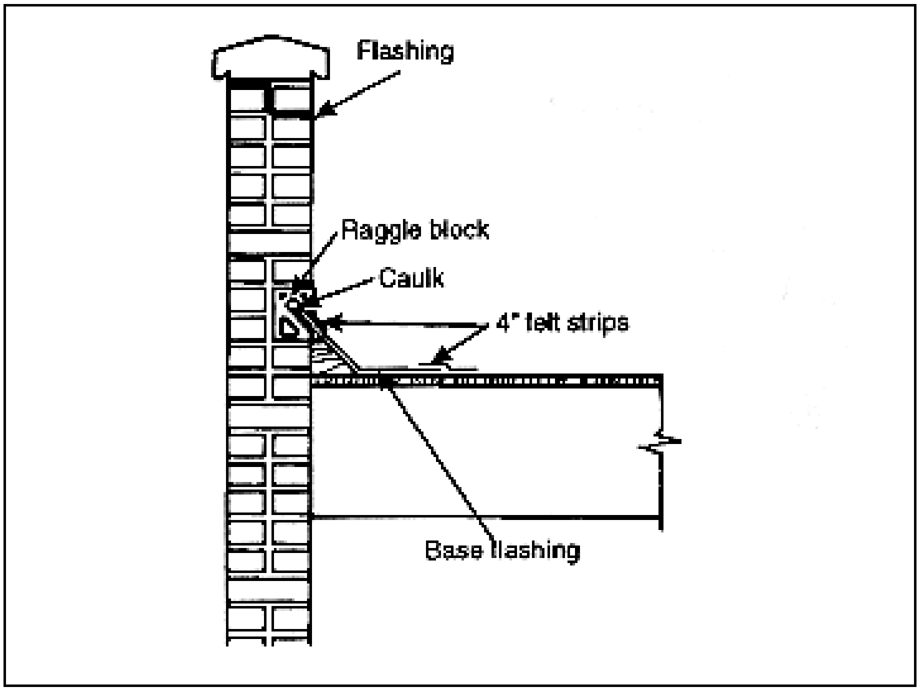


Figure 9-43. Flashing installation at intersection of roof and walls

FREEZE PROTECTION DURING CONSTRUCTION

9-105. Masonry walls built during cold weather may leak, because either the mortar froze before it set or the materials and walls were not adequately protected against freezing temperatures. During cold weather, prevent future wall leakage by--

- Storing materials properly.
- Heating mortar ingredients.
- Heating masonry units.
- Taking special precautions during placement.
- Protecting completed work.

STORING MATERIALS

9-106. Careless materials storage can cause time delays and/or contribute to poor workmanship, because you must remove all ice and snow and thaw masonry units before construction can proceed. Instead, completely cover all masonry units and mortar materials with tarpaulins or building paper. Store them on plank platforms either thick enough or raised high enough to prevent moisture absorption from the ground.

HEATING MORTAR INGREDIENTS

9-107. Heat both water and sand to a temperature not exceeding 160°F. Make sure that the temperature of the mortar--when you use it--is at least 70°F but not more than 120°F. Use steel mortar boxes on small jobs, and raise them about 1 foot above the ground so that you can supply heat to keep the mortar warm after mixing. Never add salt water to mortar to lower its freezing point.

CONSIDERING TEMPERATURE VARIATIONS

9-108. If the outside air temperature is below 40ºF, the brick temperature when you lay it should be above 40ºF on both sides of the masonry for at least 48 hours for Type M or S mortar, or for at least 72 hours for Type N mortar. If you use high-early-strength cement, reduce these time periods to 24 and 48 hours, respectively. Note that the use of high-early-strength cement in a mortar does not alter the setting rate much, but it does increase the rate of strength gain, thereby providing greater resistance to further freeze damage.

HEATING MASONRY UNITS

9-109. To prevent the warm mortar from cooling suddenly as it contacts the cold bricks, preheat all masonry units to about 40ºF whenever the outside temperature is below 18ºF. This requires careful planning and timing. When heat is required, provide inside brick storage so that you can supply heat at minimum expense.

LAYING PRECAUTIONS

9-110. In below-freezing weather, sprinkle any high-suction brick with warm water just before you lay it. Never lay masonry units on snow- or ice-covered mortar beds, because little or no bond will exist between the mortar and units when the base thaws. Keep the tops of unfinished walls carefully covered whenever work stops. If the covering comes off and ice or snow collects on the wall top, remove it with live steam before continuing.

PROTECTING COMPLETED WORK

9-111. How you protect masonry from freezing varies with weather conditions and the individual job. Job layout, desired rate of construction, and the prevailing weather conditions all determine the amount of protection and the type of heat necessary to maintain above-freezing temperatures within the wall until the mortar sets properly.

MATERIAL QUANTITIES REQUIRED

9-112. See Table 9-6 for the quantities of brick and mortar required for various masonry wall thickness.

Table 9-6. Quantities of materials required for brick walls

Wall Area in, Square Feet	Wall Thickness, in Inches							
	4		8		12		16	
	Number of Bricks	Mortar, in Cubic Feet	Number of Bricks	Mortar, in Cubic Feet	Number of Bricks	Mortar, in Cubic Feet	Number of Bricks	Mortar, in Cubic Feet
1	6.17	.08	12.33	.2	18.49	.32	24.65	.44

10	61.7	.8	123.3	2	184.9	3.2	246.5	4.4
100	617	8	1,233	20	1,849	32	2,465	44
200	1,234	16	2,466	40	3,698	64	4,930	88
300	1,851	24	3,699	60	5,547	96	7,395	132
400	2,468	32	4,932	80	7,396	128	9,860	176
500	3,085	40	6,165	100	9,245	160	12,325	220
600	3,702	48	7,398	120	11,094	192	14,790	264
700	4,319	56	8,631	140	12,943	224	17,253	308
800	4,936	64	9,864	160	14,792	256	19,720	352
900	5,553	72	10,970	180	16,641	288	22,185	396
1,000	6,170	80	12,330	200	18,490	320	24,650	440
NOTE: Quantities are based on a 1/2-inch-thick mortar joint; a 3/8-inch-thick joint uses 80 percent of these quantities; a 5/8-inch-thick joint uses 120 percent of these quantities.								

SECTION IV. REINFORCED BRICK MASONRY

APPLICATIONS AND MATERIALS

9-113. When added strength is needed, brick walls, columns, beams, and foundations are reinforced the same as in concrete construction.

APPLICATIONS

9-114. Because brick masonry in tension has low strength compared with its compressive strength, it is reinforced with steel when subject to tensile stresses. Like concrete construction, the reinforcing steel is placed in either the horizontal or vertical mortar joints of beams, columns, walls, and footings. Reinforced brick structures can resist earthquakes that would severely damage nonreinforced brick structures. The design of such structures by qualified engineers is similar to that of reinforced concrete structures.

MATERIALS

9-115. Materials used for reinforced brick are--

- Brick. The same brick is used for reinforced brick masonry as for ordinary brick masonry. However, it should have a compressive strength of at least 2,500 pounds per square inch.

- Steel. The reinforcing steel is the same as that in reinforced concrete and is fabricated and stored the same way. Do not use high-grade steel except in emergencies, because masonry construction requires many sharp bends.
- Mortar. Use Type N mortar for its high strength.
- Wire. Use 18-gage, soft-annealed iron wire to tie the reinforcing steel.

CONSTRUCTION METHODS

9-116. Reinforcing steel can be placed in both horizontal and vertical mortar joints.

LAYING REINFORCED BRICK

9-117. Lay the brick the same way as ordinary brick masonry, with mortar joints 1/8 inch thicker than the diameter of the reinforcing bar. This provides 1/16 inch of mortar between the brick surface and the bar. Thus, large steel bars require mortar joints thicker than 1/2 inch.

PLACING THE STEEL

9-118. Embed all reinforcing steel firmly in mortar.

- Horizontal bars. Lay horizontal bars in the mortar bed, and then push them down into position. Spread more mortar on top of the bars, smooth it out until you produce a second bed joint of the proper thickness. Lay the next course in this mortar bed, following the same procedure as laying brick without reinforcing steel.
- Stirrups. Most stirrups are Z-shaped as shown in Figure 9-44 to fit the mortar joints. Insert the lower leg under--and contacting--the horizontal bars, which requires a thicker joint at that point.
- Vertical bars. Hold vertical bars in the vertical mortar joints with wood templets having holes drilled at the proper bar spacing, or by wiring them to horizontal bars. Then lay the brick up around the vertical bars.
- Spacing. The minimum center-to-center spacing between parallel bars is 1-1/2 times the bar diameter.

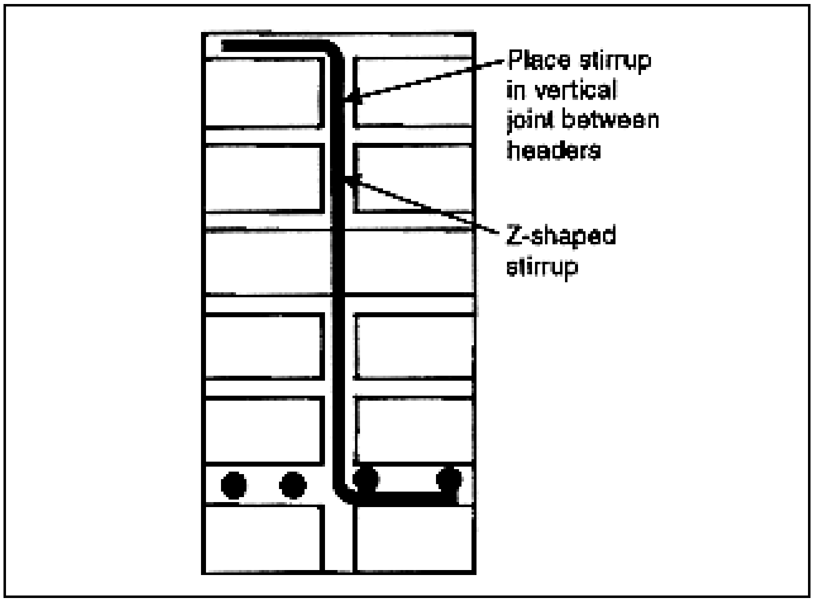


Figure 9-44. Reinforced brick-masonry beam construction

USING FORMWORK

9-119. Reinforced brick-masonry walls, columns, and footings need no formwork. However, reinforced brick beams and lintels--which act as beams--require formwork for the same reason that reinforced concrete beams do.

- The form consists only of support for the underside of the beam, no side formwork. The form for the beam underside is the same and is supported the same as that for concrete beams.
- When a beam joins a wall or another beam, cut the form short by 1/4 inch, and fill the gap with mortar. This allows the lumber to swell and makes form removal easy.
- Wait at least 10 days before removing the form from the beam underside.

BEAMS AND LINTEL CONSTRUCTION

9-120. Lintels are placed above the windows and doors to carry the weight of the wall above them. Lintels can be made of steel, precast reinforced concrete beams, or wood.

BEAM DIMENSIONS

9-121. Beam width and depth depend upon brick dimensions, mortar joint thickness, and the load that the beam will support. However, beam width usually equals the wall thickness, that is 4, 8, 12, or 16 inches. Beam depth should not exceed approximately three times its width.

BEAM CONSTRUCTION PROCEDURES

9-122. The following procedures will be used in beam construction:

Step 1. Lay the first course on the form using full head joints, but no bed joint (see

Figure 9-44).

Step 2. Spread a mortar bed about 1/8 inch thicker than the diameter of the horizontal reinforcing bars on the first course, and embed the bars.

Step 3. Slip the legs of any stirrups under the horizontal bars as shown in Figure 9-44. Be sure to center the stirrup in the vertical mortar joint.

Step 4. After properly positioning the stirrups and the horizontal bars, spread more mortar on the bed joints if necessary, and smooth its surface. Then lay the remaining courses in the normal way.

Step 5. Lay all bricks for one course before proceeding to the next course to ensure a continuous bond between the mortar and steel bars. Often, three or four bricklayers must work on one beam to spread the bed-joint mortar for the entire course, place the reinforcing steel, and lay the brick before the mortar sets.

LINTEL CONSTRUCTION

9-123. The steel bars should be 3/8 inch in diameter, or less if you must maintain a 1/2-inch mortar joint. Place the bars in the first and fourth mortar joints above the opening (see Figure 9-45). They should extend 15 inches into the brick wall on each side of the opening. Table 9-7 below gives the number and diameter of bars required for different width wall openings. See paragraph 9-56 for how to place the wall above a window or door opening.

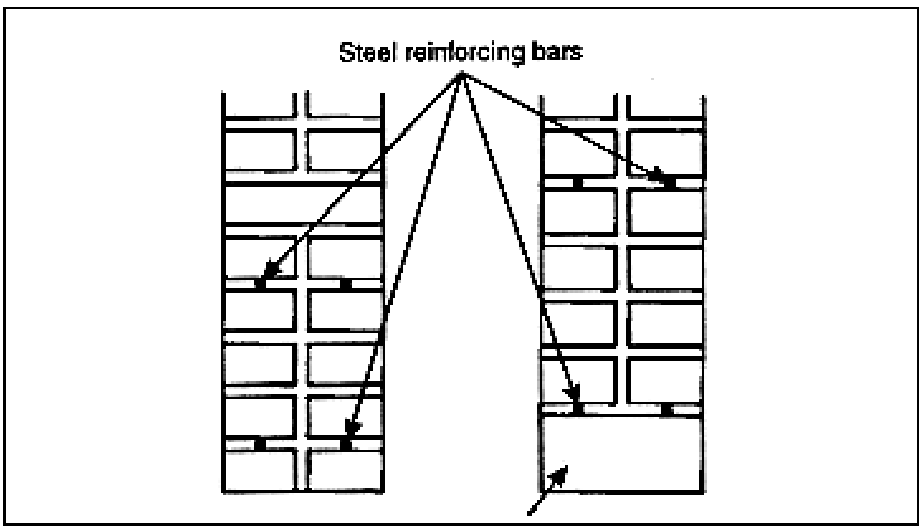


Figure 9-45. Reinforced brick-masonry lintel construction

Table 9-7. Quantities of bars required for lintels

Width of Wall Opening, in Feet	Bar Quantity	Bar Diameter, in Inches
6	2	1/4
9	3	1/4

12	3	3/8

FOUNDATION FOOTINGS

9-124. Footings are the enlargements at the lower end of a foundation wall, pier, or column and are required to distribute the load equally.

9-125. Large footings usually require reinforcing steel because they develop tensile stresses. As in all brick foundations, lay the first course in a mortar bed about 1 inch thick, spread on the subgrade.

WALL FOOTING

9-126. Figure 9-46 shows a typical wall footing with steel dowels extending above it to tie the footing and wall together. The number 3 bars running parallel to the wall prevent perpendicular cracks from forming.

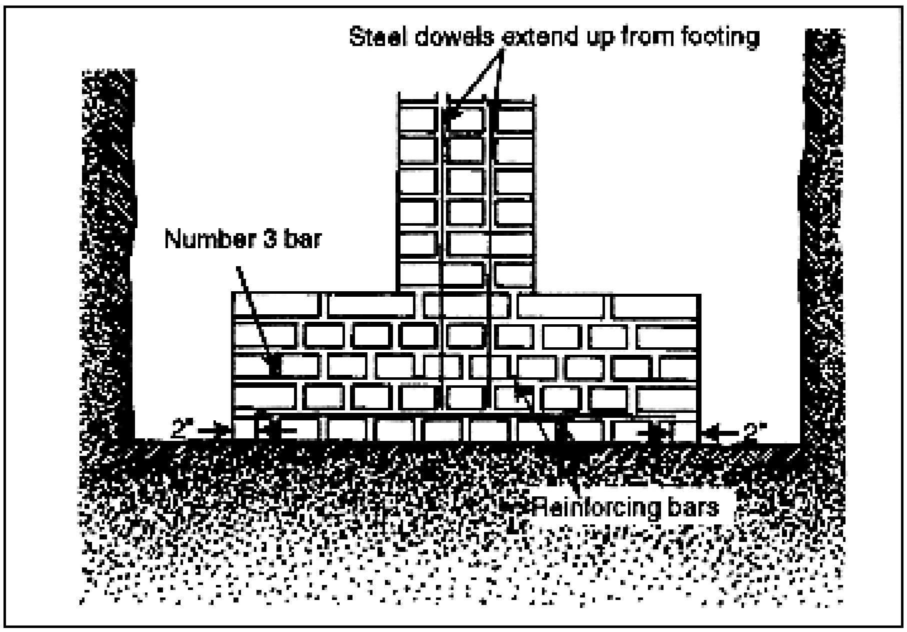


Figure 9-46. Reinforced brick-masonry-wall footing construction

COLUMN FOOTING

9-127. Reinforced brick-column footings are usually square or rectangular as shown in Figure 9-47. The dowels not only anchor the column to the footing, but transfer stress from one to the other. Note that both layers of horizontal steel are in the first mortar joint, which is accepted practice for small bars. When using large bars, place one layer in the second mortar joint, and reduce the bar spacing in this joint.

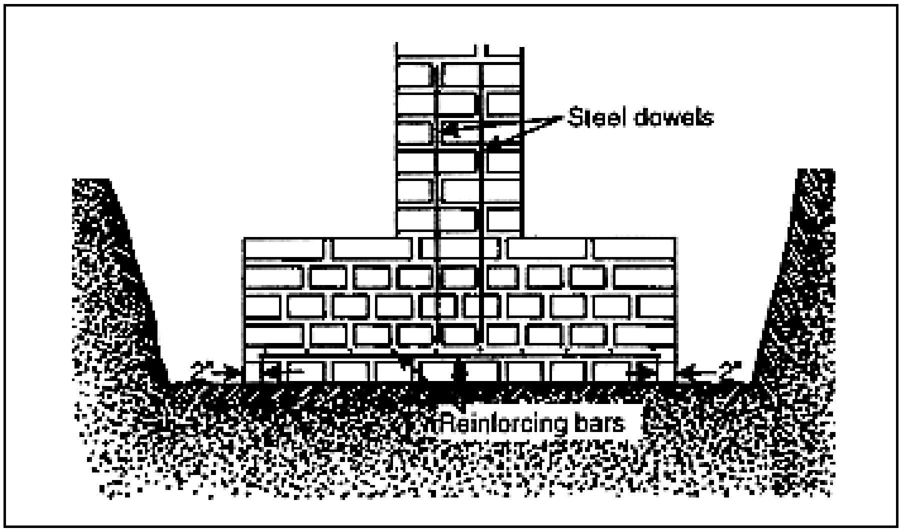


Figure 9-47. Reinforced brick-masonry-column footing construction

COLUMNS AND WALLS

9-128. Load-carrying capacity increases when brick columns and walls have steel reinforcement.

9-129. At least 1 1/2 inches of mortar or brick should cover the reinforcing bars. Install 3/8-inch diameter steel hoops or ties at every course (see Figure 9-48) to bold bars in place. Use circular hoops whenever possible. Lap-weld their ends, or bend them around the reinforcing bars as shown in Figure 9-48.

- Holding steel in place. When the column footing is complete, tie the reinforcing steel to the dowels projecting from the footing. Slip the necessary number of hoops over the dowels and fasten them temporarily some distance above the course being laid, but within your reach. You do not need to wire the hoops to the dowels. Hold the tops of the dowels in position either with a wood templet or by tying them securely to a hoop near the top of the column.
- Laying the brick. Lay the brick as described in paragraph 9-20. Place the hoops in a full mortar bed, and smooth it out before laying the next course. You can use brick bats in the column core or wherever it is inconvenient or impossible to use full-size bricks. After laying each course, fill the core and any space around the reinforcing bars with mortar. Then push any necessary bats into the mortar until they are completely embedded. Now spread the next mortar bed and repeat the procedure.

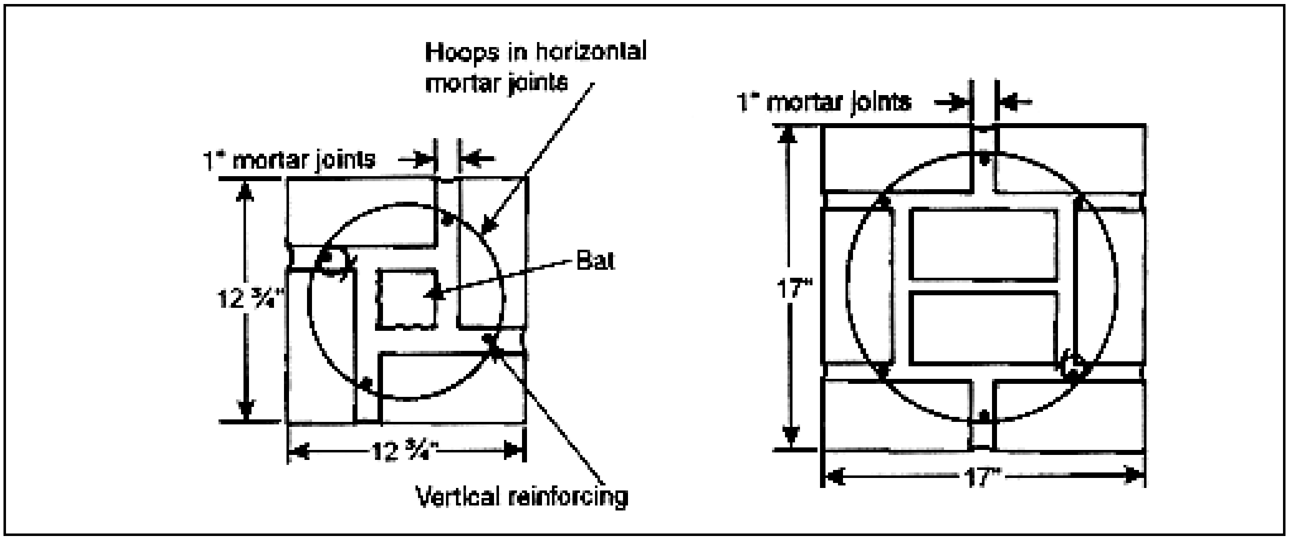


Figure 9-48. Reinforced brick-masonry-column construction

9-130. Reinforce brick masonry walls with both horizontal and vertical bars. Place the bars as described in paragraph 9-117. Then wire the vertical stirrups to the dowels projecting out of the wall footing.

- Constructing corner leads. Place the reinforcing bars in corner leads as shown in Figure 9-49 below. Use the same size bars as in the rest of the wall, and let them extend 15 inches. The horizontal bars in the remaining wall should overlap the corner bars by the same 15 inches. As for beams, you must lay all brick in one course between the corner leads before laying any other brick, because you must embed the entire bar in mortar at one time.
- Laying the remaining wall. As you lay the remaining brick, fill all spaces around the reinforcing bars with mortar.

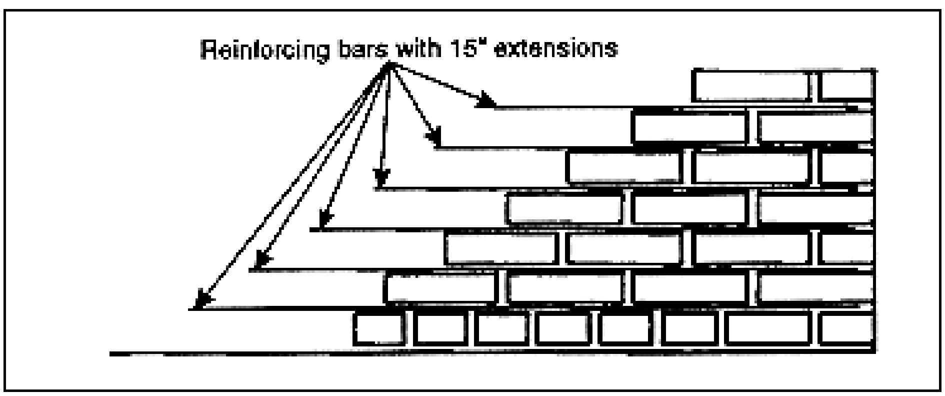


Figure 9-49. Corner lead for reinforced brick masonry wall

SECTION V. STRUCTURAL CLAY-TILE MASONRY

STRUCTURAL CLAY TILE

9-131. Structural clay tile is either a hollow or cored burned-clay masonry unit having cores that are parallel either in the vertical or horizontal direction. The manufacturing process and the type of clay used are the same as it is for brick.

9-132. Hollow masonry units made from burned clay or shale are usually called simply clay tile. Figure 9-50 shows several common types and sizes. These stretcher units are made by forcing a plastic clay through special dyes, then cutting the tiles to size and burning them the same way as brick. The amount of burning depends upon the tile grade.

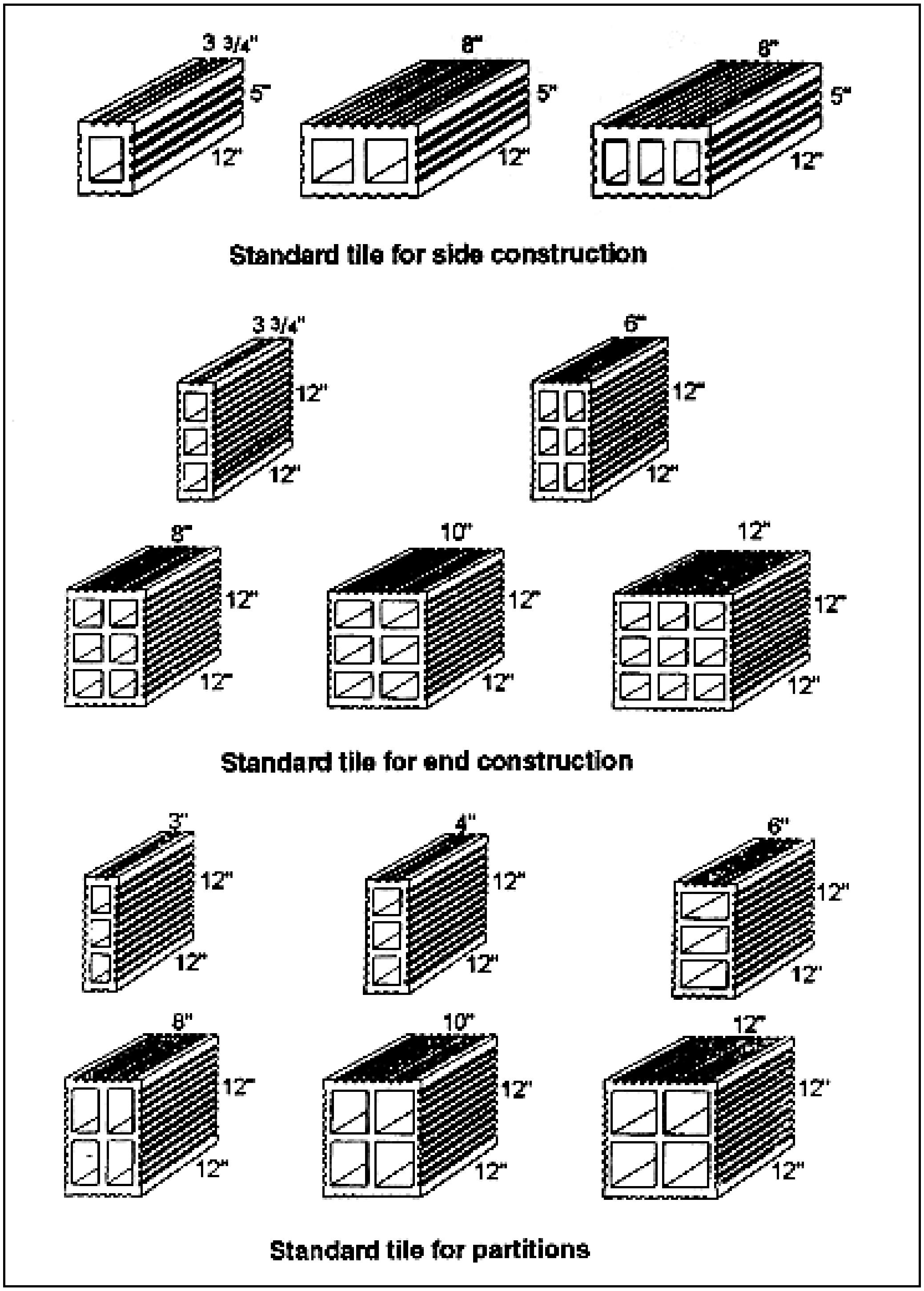


Figure 9-50. Corner lead for reinforced brick masonry wall

9-133. The hollow spaces in the tile are called *cells*, the external wall is called a *shell*, and the partitions between cells are called *webs*. The shell should be at least 3/4 inch thick and the web 1/2 inch thick.

9-134. Side-construction tile has horizontal cells, whereas end-construction tile has vertical cells. Neither is better than the other, and both are available in the types described below.

9-135. The two basic categories of structural clay tile--load-bearing and nonload-bearing--differ in their characteristics. Load-bearing structural clay tile further subdivides into three categories: load-bearing wall tile, structural facing tile, and ceramic glazed structural facing tile. Nonload-bearing structural clay tile further subdivides into three categories: nonload-bearing partition and furring tile, fireproofing tile, and screen tile.

LOAD BEARING

9-136. Load-bearing tile has three types, divided by use: wall, facing, and glazed facing. Load-bearing wall tile includes--

- Wall tile for constructing exposed or faced load-bearing walls. This tile carries the entire load, including the facing of stucco, plaster, stone, or other material.
- Back-up tile for backing up combination walls of brick or other masonry in which both the facing and the backing support the wall load. Headers bond the facing or outer tier to the backing tile. The inside face is scored so that you can plaster it without lath.

9-137. The ASTM covers two grades of wall and back-up tile based on weather resistance. Grade LB is suitable for general construction that is not exposed to weathering, or exposed to weathering but protected by at least 3 inches of facing. Grade LBX can be used in masonry exposed to weathering with no facing material.

- Structural facing tile is divided into two classes, based on the thickness of the face shell: standard and special duty. The ASTM grades each of these classes by factors affecting appearance.

  - Type FTX is suitable for both exterior and interior walls and partitions. It has an excellent appearance and is easy to clean.
  - Type FTS, although inferior in quality to Type FTX, is suitable for both exterior and interior walls where some surface finish defects are not objectionable.
- Ceramic glazed structural facing tile has an exposed surface of either a ceramic or salt glaze, or a clay coating. Use this tile where you need a stainproof, easily cleaned surface. It is available in many colors and produces a durable wall having a pleasing appearance. Ceramic glazed facing tile is divided into two types and two grades:

  - Type I is suitable for general use where only one finished face will be exposed.
  - Type II is suitable for use where the two opposite finished faces will be exposed.
  - Grade S (select) is suitable for use with comparatively narrow mortar joints.
  - Grade SS (select sized or ground edge) is suitable for uses requiring very small variations in face dimensions.

NONLOAD BEARING

9-138. Nonload-bearing tile include three types:

- Nonload-bearing partition and furring tile.

  - Partition tile is suitable for constructing nonload-bearing interior partitions or for backing nonload-bearing combination walls.
  - Furring tile is suitable for lining the wall interiors to provide both a plaster base and an air space between plaster and the wall.
- Fireproofing tile protects structural members including steel girders, columns, and beams.
- Screen tile is available in a large variety of patterns, sizes, and shapes, and in a limited number of colors. The surfaces may be smooth, scored, combed, or roughened. Screen tile is divided into two types and three grades:

  - Type STX has an excellent appearance and minimum size variation.
  - Type STA varies more in size.
  - Grade SE has high resistance to weathering, freezing, and thawing.
  - Grade ME has moderate resistance to weathering.
  - Grade NE is suitable for interior use only.

SPECIAL UNITS

9-139. Besides the standard units shown in Figure 9-50 above you can order special clay tile units to use at windows, door openings, and at corners. Consult a manufacturer's catalog for any special units you need.

QUANTITIES OF MATERIALS REQUIRED

9-140. Tables 9-8 and 9-9 below give the number of structural clay tiles--both side construction and end construction--and the amount of mortar required for walls of different thickness covering varying areas.

Table 9-8. Quantities of materials required for side construction of hollow clay-tile walls

	4-inch thick wall and 4 x 5 x 12-inch tile		8-inch thick wall and 8 x 5 x 12-inch tile	
Wall Area, in Square Feet	**Number of Tiles**	**Mortar, in Cubic Feet**	**Number of Tiles**	**Mortar, in Cubic Feet**
1	2.1	.045	2.1	.09
10	21	.45	21	.9
100	210	4.5	210	9.0
200	420	9.0	420	18
300	630	13.5	630	27

400	840	18.0	840	36
500	1,050	22.5	1,050	45
600	1,260	27.0	1,260	54
700	1,470	31.5	1,470	63
800	1,680	36.0	1,680	72
900	1,890	40.5	1,890	81
1,000	2,100	45.0	2,100	90
NOTE: Quantities are based on 1/2-inch thick mortar joints.				

Table 9-9. Quantities of materials required for end construction of hollow clay-tile walls

	4-inch thick wall and 4 x 12 x 12-inch tile		**6-inch thick wall and 6 x 12 x 12-inch tile**		**8-inch thick wall and 8 x 12 x 12-inch tile**		**10-inch thick wall and 10 x 12 x 12-inch tile**	
Wall Area, in Square Feet	**Number of Tiles**	**Mortar, in Cubic Feet**	**Number of Tiles**	**Mortar, in Cubic Feet**	**Number of Tiles**	**Mortar, in Cubic Feet**	**Number of Tiles**	**Mortar, in Cubic Feet**
1	.93	.025	.93	.036	.93	.049	.93	.06
10	9.3	.25	9.3	.36	9.3	.49	9.3	.6
100	93	2.5	93	3.6	93	4.9	93	6
200	186	5.0	186	7.2	186	9.8	186	12
300	279	7.5	279	10.8	279	14.7	279	18
400	372	10.0	372	14.4	372	19.6	372	24
500	465	12.5	465	18.0	465	24.5	465	30
600	558	15.0	558	21.6	558	29.4	558	36
700	651	17.5	651	25.2	651	34.3	651	42
800	744	20.0	744	28.8	774	39.2	774	48
900	837	22.5	837	32.4	837	44.1	837	54
1,000	930	25.0	930	36.0	930	49.0	930	60

NOTE: Quantities are based on 1/2-inch thick mortar joints.

PHYSICAL CHARACTERISTICS OF STRUCTURAL CLAY TILE

STRENGTH

9-141. The compressive strength of an individual clay tile depends on its ingredients and the method of manufacture, plus the thickness of its shell and webs. You can predict that tile masonry will have a minimum compressive strength of 300 pounds per square inch based on the cross section. Tile masonry has low tensile strength--in most cases less than 10 percent of its compressive strength. Other physical properties are--

- Abrasion resistance. Like brick, the abrasion resistance of clay tile depends mainly on its compressive strength. The stronger the tile, the greater its resistance to wear, but abrasion resistance decreases as the amount of absorbed water increases.
- Weather resistance. Structural clay facing tile has excellent resistance to weathering. Freezing and thawing produces almost no deterioration. Tile absorbing up to 16 percent of its weight of water satisfactorily resists freezing and thawing effects. When masonry is exposed to weather, use only portland-cement-lime mortar or mortar prepared from masonry cement.
- Heat- and sound-insulating properties. Because of the dead air space in its cells, clay tile has better heat-insulating qualities than solid unit walls. Its sound penetration-resistance compares favorable with that of solid masonry walls, but is somewhat less.
- Fire resistance. Structural clay-tile walls have much less fire resistance than solid masonry walls. However, you can improve it by plastering the wall surface. Partition walls 6 inches thick will resist a fire for one hour, if the fire's temperature does not exceed 1,700^{o}FF within that hour.
- Weight. Structural clay-tile weighs about 125 pounds per cubic foot. However, because hollow cell size varies, actual tile weight depends on the manufacturer and the type. A 6-inch tile wall weighs approximately 30 pounds per square foot, whereas a 12-inch tile wall weighs approximately 45 pounds per square feet.

CONSTRUCTION DETAILS AND METHODS

9-142. Refer to the paragraphs listed to obtain specific information applicable to structural clay-tile construction:

- Tools and equipment (paragraphs 7-4 and 7-5).
- Finishing joints (paragraph 9-37).
- Bricklayer's duties (paragraph 9-38).
- Bricktender's duties (paragraph 9-39).
- Watertight walls (paragraph 9-67).

- Maintaining and repairing brick walls (paragraph 9-90)
- Cleaning new brick and removing efflorescence (paragraph 9-95).
- Cleaning old brick (paragraph 9-96).
- Freeze protection (paragraph 9-105).

APPLICATIONS

9-143. The three practical uses for structural tile are discussed below.

- Exterior walls. You can use structural clay tile for either load bearing or nonload-bearing exterior walls. It is suitable for both below-grade and above-grade construction.
- Partition walls. Nonload-bearing partition walls ranging from 4 to 12 inches thick are often built of structural clay tile. They are easy to construct, lightweight, and have good heat- and sound-insulating properties.
- Backing for brick walls. Structural clay tile can be used as a backing unit for a brick wall.

MORTAR JOINTS

9-144. The general procedure for making mortar joints for structural clay tile is the same as for brick. Mortar joints for end-construction units are described as follows:

- Bed joint. To make a bed joint, spread 1 inch of mortar on the bed tile shells, but not on the webs (see view 1 of Figure 9-51 below). Spread the mortar about 3 feet ahead of laying the tile. Because the head joints in clay-tile masonry are staggered, the position of a tile in one course does not match the tile underneath it. Therefore, the webs do not make contact, and any mortar you spread on them is useless.
- Head joint. Form the head joint by spreading plenty of mortar along each tile edge, as shown in view 2 of Figure 9-51. Because a clay tile unit is heavy, use both hands to push it into the mortar bed until it is properly positioned. The mortar joint should be about 1/2 inch thick, depending upon the type of construction. Use enough mortar that it squeezes out of the joints, and then cut the excess off with a trowel. The head joint need not be solid like a head joint in brick masonry, unless it is subject to weather.
- Closure joints. Use the procedure described in paragraph 9-33 for making closure joints in brick masonry.

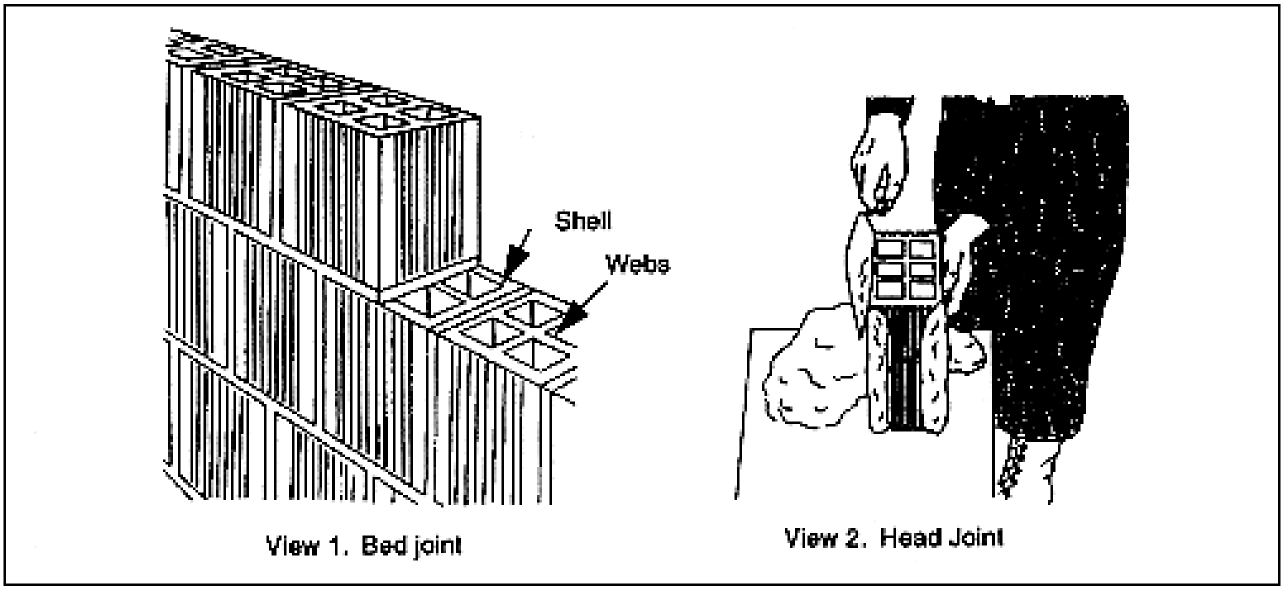


Figure 9-51. Laying end-construction clay tile

9-145. Mortar joints for side-construction units are described as follows:

- Bed joint. Spread the mortar about 1 inch thick, approximately 3 feet ahead of laying the tile. You need not make a furrow as you must for brick bed joints.
- Head joint. Use one of the two following methods:

  - Method A. Spread as much mortar on both edges of the tile as will adhere (see view 1 of Figure 9-52). Then push the tile into the mortar bed against the tile already laid until it is properly positioned. Cut off the excess mortar.
  - Method B. Spread as much mortar as will adhere on the interior shell of the bed tile and on the exterior shell of the unit you are placing (see view 2 or Figure 9-52). Then push the tile into place and cut off the excess mortar.

- Mortar joint thickness. Make the mortar joints about 1/2 inch thick, depending upon the type of construction.

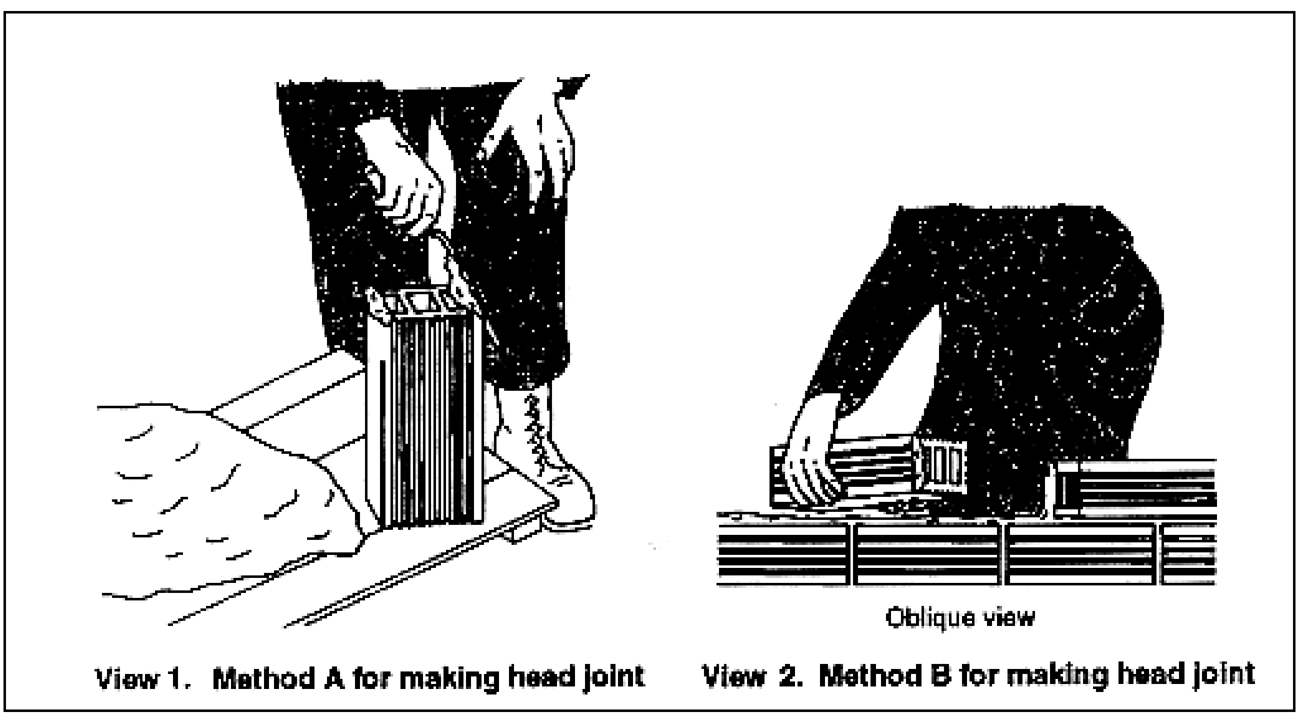


Figure 9-52. Laying side-construction clay

LAYING AN 8-INCH BRICK WALL WITH A 4-INCH HOLLOW-TILE BACKING

9-146. When laying an 8-inch brick wall with a 4-inch structural hollow-tile backing, the brick wall has six stretcher courses between the header courses. The side-construction backing tile is 4 by 5 by 12 inches in size. The 5-inch tile height equals the height of two brick courses plus a 1/2-inch mortar joint.

Lay the tile bed joint so that the top of the tile is level with every second brick course. Therefore, the thickness of the tile bed joint depends upon the thickness of the brick bed joint.

LAYING OUT THE WALL

9-147. Lay out the first brick course temporarily without mortar, as described in paragraph 9-44. This determines the number of bricks in one course.

LAYING THE CORNER LEADS

9-148. As shown in view 1 of Figure 9-53, the first brick course in the corner lead is the same as the first course of the corner lead for a solid 8-inch brick wall, except that you lay one more brick next to brick (p) as shown in step 5 of Figure 9-22. Lay all the bricks for the corner lead before laying any tile. Then lay the first tile course as shown in view 2 of Figure 9-53. Complete the corner lead as shown in view 3, Figure 9-53.

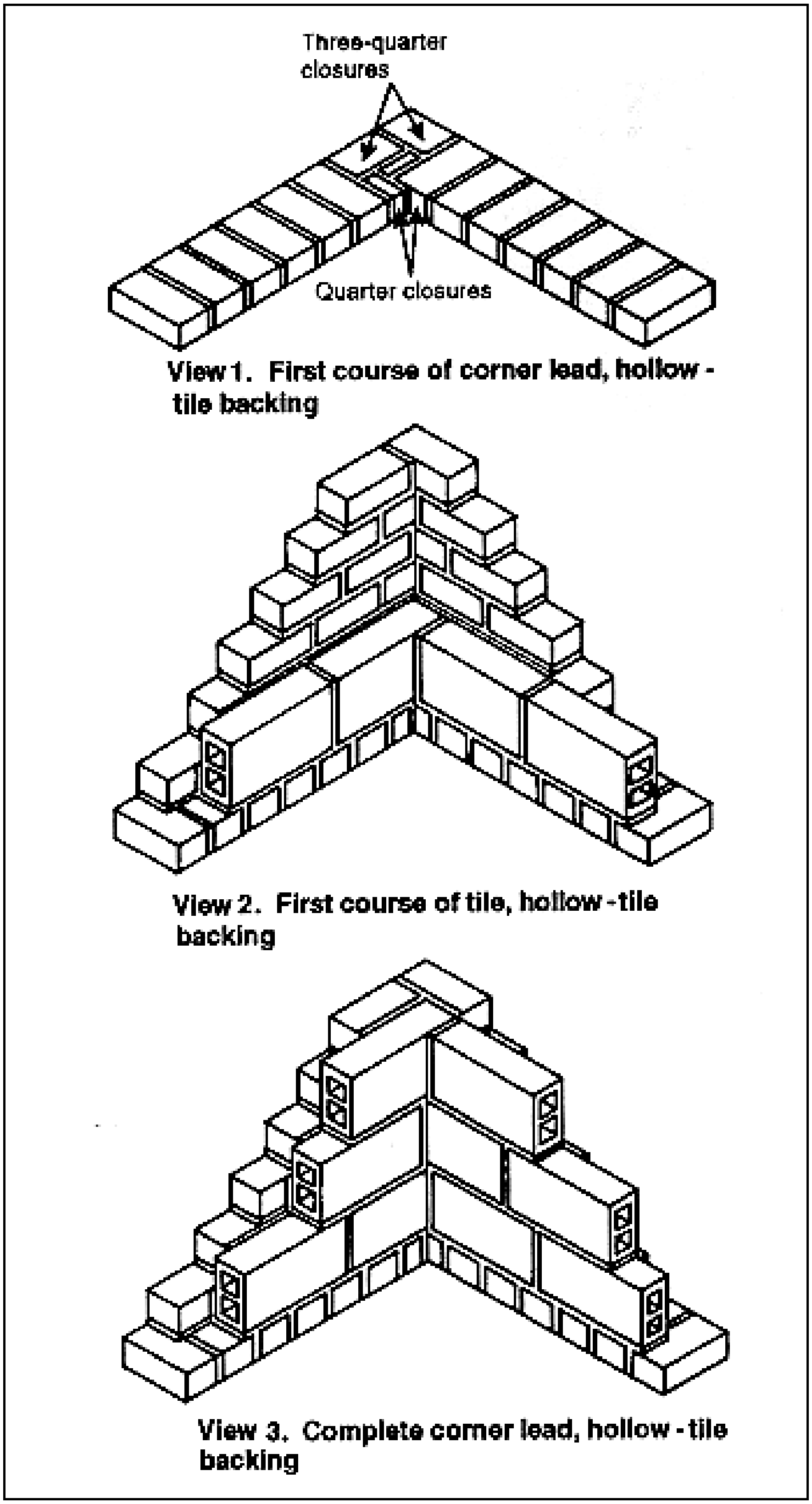


Figure 9-53. Laying a corner lead with hollow-tile backing

LAYING AN 8-INCH STRUCTURAL CLAY-TILE WALL

9-149. Use 8- by 5- by 12-inch side-construction tile in a half-lap bond to construct an 8-inch structural clay-tile wall. You can insert a 2- by 5- by 8-inch soap at the corners as shown in Figure 9-54 below. A *soap* is a thin end-construction tile.

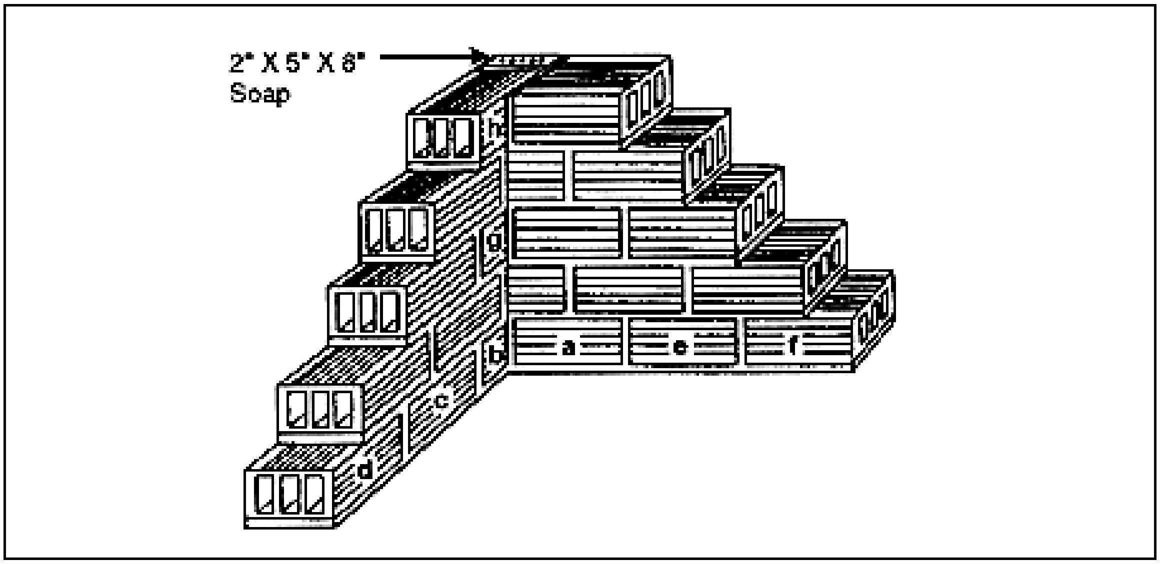


Figure 9-54. Constructing the corner lead of an 8-inch structural clat-tile wall

LAYING OUT THE WALL

9-150. Follow the procedure described inparagraph 9-43.

LAYING THE CORNER LEADS

9-151. Lay tiles a and b first (see Figure 9-54), and check their level as you lay them. To avoid exposing open cells on the wall face, use either end-construction tile for corner tiles b, g, and h, or a soap as shown in Figure 9-54. Lay tile b so that it projects 6 inch from the inside corner, as shown, to start the half-lap bond. Now lay tiles c and d, and check their level as you lay them. Next, lay tiles e and f, and check their level. Lay the remainder of the corner tile, and check the level of each as you lay it. After erecting the leads, lay the wall between them using a line.