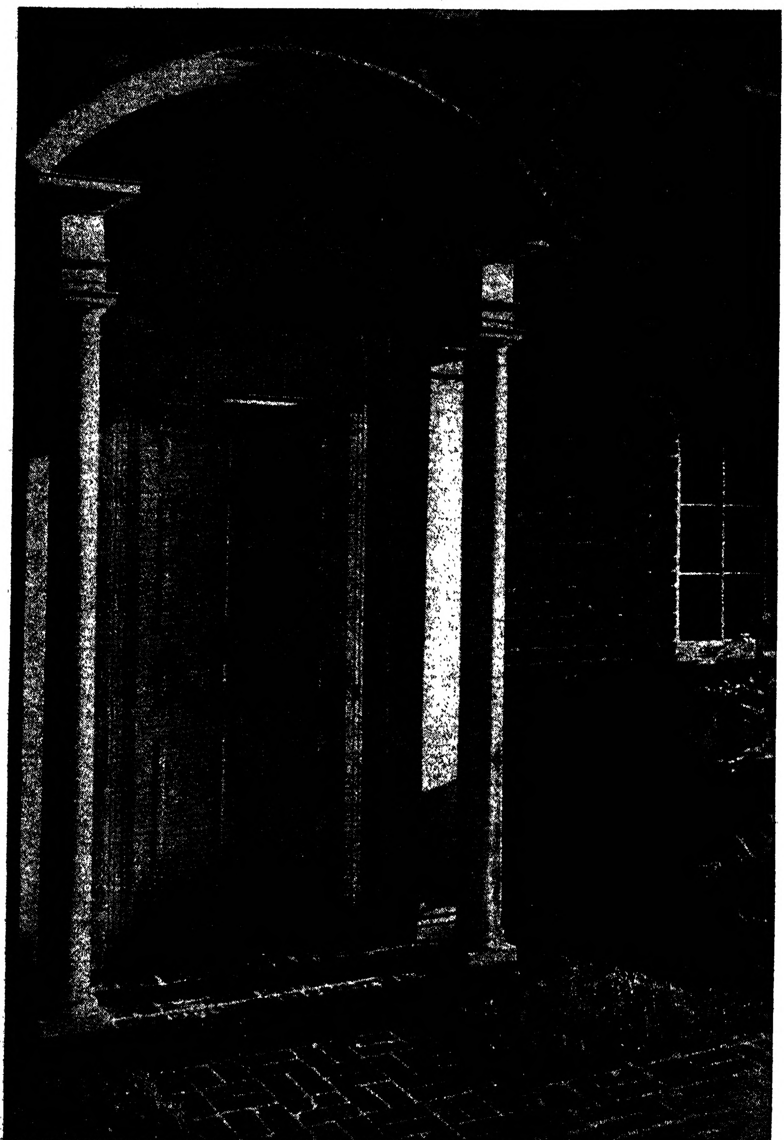
BRICK STRUCTURES

The quality of the materials used in the manufacture of this book is governed by continued postwar shortages.



(*Frontispiece*)

FIG. 1.—Brick combines structural and decorative qualities to an unusual degree. Brick facing, a strong and durable material, adapts itself to every type of architecture and offers unlimited design possibilities. Brick in this example are used in walls, steps, and walks. (*Courtesy of Dwight James Baum, Architect.*)

BRICK STRUCTURES

HOW TO BUILD THEM

Practical reference data on materials, design, and construction methods employed in brick construction; for contractors, builders, architects, engineers, and students. An authoritative manual on brick masonry, with particular reference to the structural uses of brick in residences and other small buildings

Revised and edited by

RALPH P. STODDARD

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BRICK STRUCTURES

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FOREWORD

This book, originally written by William Carver, architect, and reviewed by the late David Knickerbacker Boyd, F.A.I.A., was first published in 1920 by The Brick Manufacturers Association of America. Its original title was "Brick—How to Build and Estimate."

Nine editions of the book were published, and with each reprinting the text was revised and improved under competent authorship. With the tenth edition the text was extensively revised and brought up to date by the architects and engineers of Taylor, Rogers & Bliss, Inc., under the direction of Col. L. B. Lent, chief engineer of The Brick Manufacturers Association at that time.

This is the eleventh edition of the book, further revised and modernized for publication in permanent form by the McGraw-Hill Book Company.

PURPOSE OF THIS BOOK

The workmen who constructed the Pyramids of Egypt lived in houses built of secondhand brick taken from structures erected untold ages before. So write the investigators of the antiquity of building materials.

Brick has been used in all manner of structures throughout the known history of the world. Like stone, it is an eternal material, available and adaptable to many uses in construction today.

Brick possesses many qualities essential to a successful building material. A well-built wall of brick is highly fire resisting, each brick having been created in fire of great intensity. Brick is natural clay burned to practical inertia—unchangeable.

In the burning process chemicals contained in the clay give to the surface of the brick a pleasing color and texture. The color varies with the clay used, the position in the kiln in which it is burned, the fuel used in burning, and other variables in the manufacturing process. Such natural coloring is of course permanent. It often is said that the beauty of the brick wall is enhanced by exposure to the elements and aging.

The small size of the standard brick makes it a flexible material. It may be used to produce any desired practical thickness of wall and is adaptable to architectural design. These small, self-decorated units are to the architect what modeling clay is to the sculptor, or pigments to the painter. They stimulate the artistry of the architect because with brick he can express something more than form.

The engineer whose first consideration is strength and stability finds brickwork, plain or reinforced as needed, meeting his requirements and at the same time giving everlasting good appearance.

Brickwork may be easily altered when changes become necessary so that structures may be extended with perfect matching of exterior appearances.

Availability is another advantage of brick, because it is made practically everywhere in the United States. This convenience results in low cost, because it eliminates heavy transportation charges.

Although this book is devoted largely to the proper use of brick in residential and other small structures employing the load-bearing wall, the material is equally adaptable to large buildings as the facing material of steel or concrete structures. As a load-bearing wall, brick is particularly advantageous for schools, hospitals, institutions, and all kinds of industrial construction. It also is widely used in public works, sewers, bridges, tunnels, subways, retaining walls, walks, and pavements.

Brick is especially desirable for farm and other rural buildings where fire protection is inadequate.

The information in this book, although especially prepared for use by the builder of homes and all ordinary jobs not in the engineering field; applies to load-bearing walls suitable for houses, small apartments, and other multiple dwellings, garages, small office and industrial buildings, all farm structures, garden walls, walks, outdoor fireplaces, and many ornamental uses.

Preceding editions of the book have been widely used in colleges and schools in connection with the study of architecture and engineering. It is a reference work for the architect and engineer since it deals with the collateral materials used with brick to complete the masonry. It includes tables useful in estimating brickwork quantities, costs, and weights.

Construction details are given for both solid and hollow walls.

In compiling this book the author has attempted to avoid technical terms and reports and to make the information understandable to the average contractor, home builder, realtor, student, and even the layman who, as a prospective building owner, may be interested in the subject.

RALPH P. STODDARD.

CLEVELAND, OHIO,
January, 1946.

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BRICK STRUCTURES

CHAPTER I

STRUCTURAL PROPERTIES OF BRICK AND BRICKWORK

BRICK

Basic facts about brick and brick masonry are presented in this chapter, as a foundation for the practical design and construction information that follows in the subsequent sections.

For thousands of years the term "brick" has been used to designate a building unit of clay or shale. This is in accordance with the definitions of common and architectural dictionaries and with those of authoritative bodies.

When other materials are used to produce a building unit of the approximate shape and size of brick, the term "brick" should be suitably qualified.

Composition of Brick.—The *raw materials* from which brick are made are the clays and shales found in many localities all over the world.

Clays and shales are derived from the decomposition of rocks, such as granite, pegmatite, etc., and those used in the manufacture of brick are usually in alluvial (water-borne) deposits.

The combined processes of rock disintegration, erosion, and alluvial deposit, which have occupied thousands of years of time, result in a material that is chemically very stable and highly inert.

Clays and shales are chemically composed of a mixture of aluminosilicic acid (pure clay), free silica (quartz), and small parts of original decomposed rock.

It is the presence of these rock contents which makes clays and shales burn into bricks of varying colors and appearances.

The important properties of clays and shales (which are essentially compacted clays), that make them highly desirable as brick materials are (1) the development of plasticity when mixed with water and (2) the hardening under the influence of fire, which drives off the water content.

Manufacturing methods are largely controlled by the physical nature of the raw materials.

Whatever the particular methods or equipment used, the process consists essentially of screening, grinding, washing, and working the clay to the proper consistency for molding into bricks, whether done by hand or machine. After drying, the green bricks are then fired in kilns for several hours at high temperatures, approximating 2000°F. The result is a finished brick.

Types of Brick.—Trade names distinguishing the various types of brick are derived principally from the manufacturing process employed.

Three principal methods of forming bricks are (1) putting the prepared clay into molds—the *soft-mud* process; (2) forcing the clay from the orifice of an auger or extrusion machine in a continuous column and then cutting bricks off the column—the *stiff-mud* process; and (3) molding relatively dry clay under high pressure—the *dry-press* process.

In the molding process, the inner surface of the mold may be coated with sand—*sand-molded*—to facilitate getting the brick out of the mold; or it may be wetted with water—*water-struck*.

In the extrusion machine, the column or ribbon of clay is cut off with wires revolving in a suitable frame. When the machine produces the smaller 2¼- by 3¾-in. ribbon and it is cut off to form the 8-in. dimension, the brick is called "end-cut"; when the machine produces the wider (8-in.) ribbon and it is cut to form the 2¼- by 3¾-in. dimension, the brick is known to the trade as "side-cut."

The low moisture content in the dry-press process does not ordinarily require drying before burning.

Common brick, so called, made in various parts of the country and even from different parts of the same kiln, may have different colors and surface textures. Some clays and shales burn to a red color (the more common), but others may burn to darker or lighter colors and shades, so that an almost endless variety of colors and textures comprises the production of this country.

Strictly speaking, any brick used in the exposed (outer) face of brick masonry is a *facing brick*; but demands and usage have led to the controlled production of specific surface appearances.

Brick so specially processed goes by the trade name of *face brick.*

Properties of Bricks.—The principal properties of brick which make them superior as building units are (1) strength, (2) fire resistance, (3) durability, (4) beauty, and (5) satisfactory bond and performance with mortar. All bricks are quite alike in all

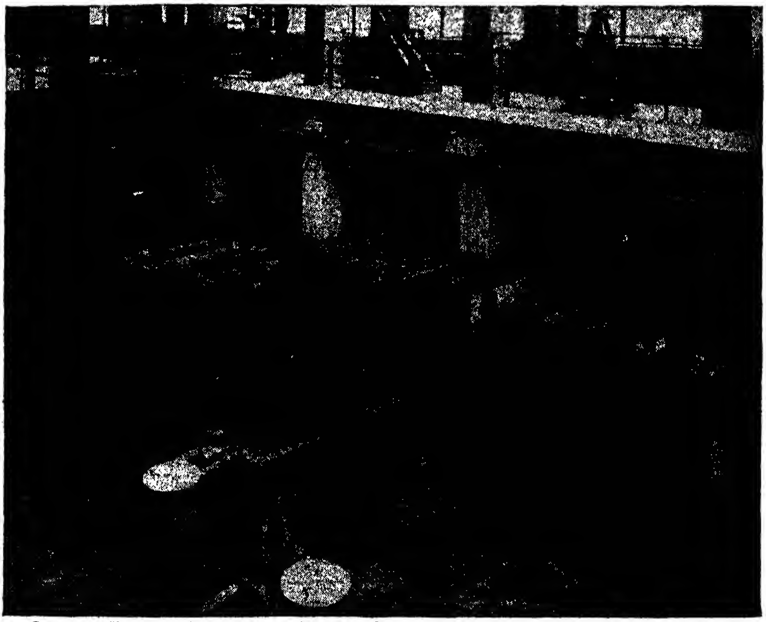


FIG. 2.—Part of the 186 full-sized wall panels of brick ready for test at National Bureau of Standards, Washington, D. C. Testing machine capable of crushing these panels is in rear center, with one tested panel in place. These walls represent different grades of brick, different types of walls, and varying grades of mortar and workmanship. Results of these tests are basis of recommendation made in this book regarding workmanship in brick masonry.

these properties, except in the first—strength. However, while the strengths of brick vary over a wide range, they are, on the average, much higher than other masonry materials.

The Strength of Bricks.—Since brickwork is more commonly laid to resist compressive stresses (vertical loads), the important strength of individual bricks is compressive strength.

The usual method of measuring this strength (American Society for Testing Materials Standard Method) is to test the brick on its flat side.

When so tested, the *compressive strengths* of individual bricks may run from about 1,600 lb. per sq. in. (for the underburned or "salmon" bricks) to well over 20,000 lb. per sq. in. (for the strongest bricks). Individual samples have tested over 28,000 lb. per sq. in.

The significance of these values may be best appreciated by comparison. A good grade of concrete (tested as 6- by 12-in. *cylinders) runs from 2,000 to 3,000 lb. per sq. in. (better grades are stronger, up to about 7,000 lb. per sq. in.)*; hollow concrete blocks, with various aggregates, usually are not much stronger than will meet building code requirements (700 to 800 lb. per sq. in. of gross area), the best ones rarely going above 1,200 lb. per sq. in.; hollow tile may run from 1,400 lb. per sq. in. (the code requirement—tested on end) to nearly 4,000 lb. per sq. in. The average compressive strength of commercial sand-lime brick is rarely above 3,000 lb. and the strength of commercial concrete brick is about 2,000 lb.

It is easily apparent that bricks are much stronger than other masonry materials, except natural stones, and this holds for the major part of the brick production of this country. Almost all bricks are stronger than 3,000 lb. per sq. in.; a large part of our production is stronger than 5,000 lb., and much of it is better than 10,000 lb. per sq. in. in compressive strength.

Of less importance or significance in the production or performance of brick masonry are other brick strengths, such as tensile, shearing, or flexural (bending) strengths.

After all, in brick masonry, the more important consideration is the result of combining three important factors: (1) bricks, (2) mortar, and (3) workmanship.

Absorption Unimportant.—It is unnecessary, therefore, to describe further or to discuss other structural properties of individual bricks, except to point out that the effect of *absorption* of brick, no matter how measured, has in the past been erroneously interpreted. It is not a measure of the ability of brick to resist water penetration, nor to resist the action of the elements (weathering), nor any other desirable property of brick masonry, so far as we now know.

Authority for this statement is found in the 1928 annual report of the brick committee (C-3) to the A.S.T.M., quoted as follows:

There appears to be a widespread belief that the percentage of absorption of individual bricks is a governing factor in the ability of brick masonry to resist moisture penetration. It has been conclusively shown that such belief is erroneous. On the contrary, a certain amount of absorption in the brick assists in obtaining a better bond between brick and mortar and, therefore, a more watertight joint. Any water penetration in brick masonry undoubtedly passes through the mortar joint and not through the brick.

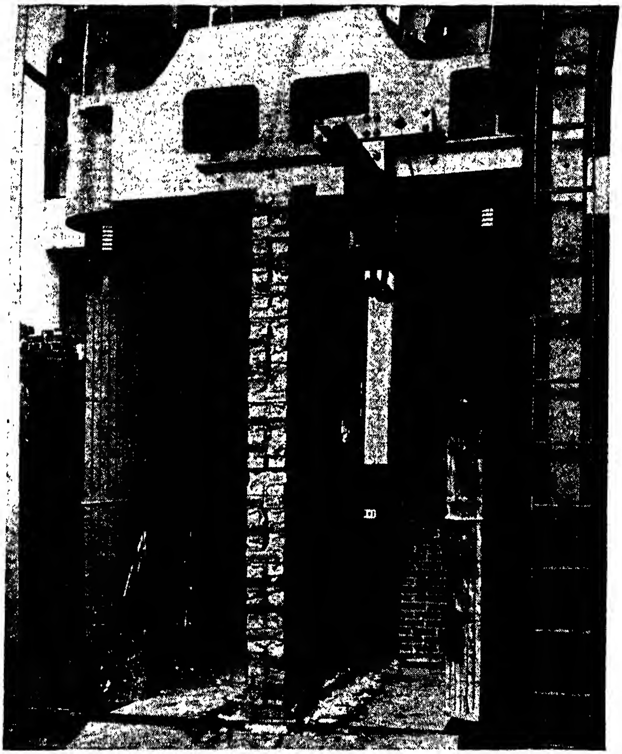


Fig. 3.—Testing an 8-in. solid brick wall for load-bearing capacity at National Bureau of Standards, Washington, D. C. Interior joints in this wall are unfilled.

If the absorption characteristics of brick from a particular district are known, then the harder burned bricks from that district usually have the lower absorption percentages.

The specifications under which bricks are sometimes purchased are (1) A.S.T.M. Standard Specification for "Building Brick—made from Clay or Shale," Serial Designation C62-44, and (2) U. S. Government Master Specification, No. 504, Common (clay) Brick.

BRICK MASONRY

Strength of Brick Masonry.—In plain brick masonry (not reinforced), compressive strength is the more important strength property. Hundreds of tests of walls, wallettes, and piers, both of solid and hollow construction, have furnished ample evidence of the high strengths of many types of brick masonry structures.

Brickwork is usually amply strong for the purpose, and for meeting with safety all provisions of the building code, when built with lime mortar. It is stronger when built with cement-lime mortar and strongest when built with Portland cement mortar.

A better grade of workmanship will increase the strength of any brick masonry, in favorable cases as much as 100 per cent. Better workmanship consists essentially of filling all joints with mortar and laying full flat (not grooved) horizontal bed joints.

The following tables represent strength values for brickwork in walls or piers, under the conditions indicated.

TABLE 1.—BUREAU OF STANDARDS TESTS—1926–1928 BRICK-WALL STRENGTHS

C.S. = compressive strength, lb. per sq. in.
M.R. = modulus of rupture, lb. per sq. in.
1:3 mortar = 1 part cement and 3 parts sand
1:1:6 mortar = 1 part cement, 1 part lime, and 6 parts sand

Brick strengths	Kind of wall	Kind of mortar	Kind of workmanship	Wall strength
C.S., 3,280	Solid	1:3	Uninspected	660
M.R., 1,225	Solid	1:1:6	Uninspected	579
C.S., 3,540	Solid	1:3	Inspected	1,133
M.R., 670	Solid	1:1:6	Inspected	947
C.S., 3,410	Solid	1:3	Inspected	1,510
M.R., 820	Solid	1:1:6	Inspected	1,232
	Hollow	1:3	Inspected	891*
	Hollow	1:1:6	Inspected	781*
C.S., 8,595	Solid	1:3	Inspected	2,712
M.R., 1,550	Solid	1:1:6	Inspected	1,840
	Hollow	1:3	Inspected	1,030*
	Hollow	1:1:6	Inspected	822*

* Average for all types of hollow walls.

Table 1 shows average values obtained in tests at the National Bureau of Standards on nearly 180 full-size wall panels, 9 ft. high, 6 ft. long, and 8 and 12 in. in thickness. These figures reflect quite accurately what may be expected in actual construction under similar conditions.

TABLE 2.—RELATIONS BETWEEN STRENGTH OF BRICK AND STRENGTH OF MASONRY

(Compiled from reports furnished by Department of Commerce Building Code Committee)

	Range of brick strengths, lb. per sq. in.	Average brick strength, lb. per sq. in.	Average masonry strength, lb. per sq. in.
1. Laid in portland cement mortar. Proportions from 1:1 to 1:6 (cement to sand) with not over 0.15 parts of lime.	1,000–1,500	1,155	407
	1,500–2,500	2,110	1,165
	2,500–3,500	3,120	1,010
	3,500–4,500	4,000	1,315
	4,500–5,500	5,020	1,390
	5,500–6,500	5,660	1,450
	6,500–7,500	6,814	1,715
	7,500–8,000	7,880	1,895
	8,000 or over	11,650	2,700
2. Laid in cement-lime or natural cement mortar (including all mortars having 0.25 or more parts of lime).	1,000–1,500	1,000	602
	1,500–2,500	none	none
	2,500–3,500	3,290	763
	3,500–4,500	4,050	1,720
	4,500–5,500	5,428*	1,523*
	5,500–6,500	5,808*	1,517*
	6,500–7,500	6,547	1,665
	7,500–8,000		
	over 8,000	13,300	2,075
3. Laid in lime mortar.	Under 1,500	1,110	307
	1,500–2,500	1,735	221
	2,500–3,500	3,130	408
	3,500–4,500	3,960	540
	4,500–5,500	5,240	577
	5,500–6,500	5,770	660
	6,500–7,500	6,620	925
	7,500–8,000	7,860	906
	over 8,000	12,450	1,460

* One test only.

That results obtained in the Bureau of Standards tests (reported in full in *Research Paper* 108) are not exceptional is proved by a study of the test results tabulated and reported by the Department of Commerce Building Code Committee. This tabulation shows the results of 706 tests on masonry, 454 of which were made in the United States, most of them on brick piers but a few on brick walls. They comprised tests on masonry of brick and sand-lime and concrete brick.

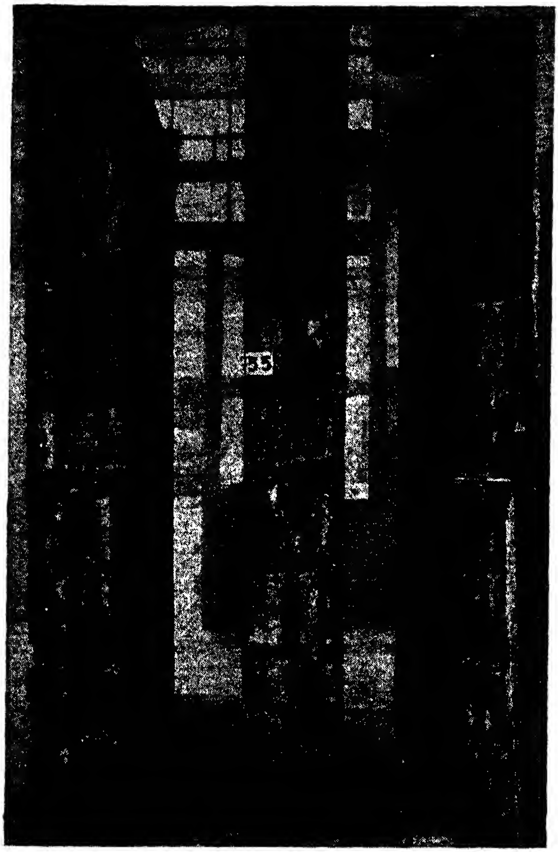


Fig. 4.—A series of test panels with all joints filled, ready for testing. This type of workmanship produces maximum strength.

For easy reference, the average results on masonry of brick (clay or shale) are tabulated (Table 2) in such form as to exhibit the resulting masonry strengths for a wide range of brick strengths, and for the use of the three more common kinds of mortar.

While all these test results are stated as averages, it is quite evident that a fairly uniform straight-line relation exists between the flat compressive strength of brick and the strength of the masonry, for each kind of mortar. The influence of inspected workmanship is to raise wall-strength values in every case.

Fire Resistance of Brick Masonry.—Years of experience have tested the fire resistance of brick masonry in all parts of the world, including several great conflagrations. No material has a better performance record than brickwork, either as walls, piers, or floor arches or as protection of other structural members. The testimony of trained investigators for the insurance bodies, which may be found in their reports and in the technical literature on the subject, completely substantiates this statement.

Methods of fire testing building construction and materials have been promulgated by the A.S.T.M. (serial designation C19-26T) in which results are stated as hourly ratings, during which the material or "assembly" (a brick wall, for example) will meet the provisions of the specification. These provisions briefly, measure the ability of the material to carry working loads and to prevent the transmission of temperature to a dangerous degree.

Brickwork Fire-resistance Ratings.—The specific fire resistance offered by brickwork, under a variety of types, thicknesses, and construction conditions, is given in National Bureau of Standards *Report of Fire Tests on Brick Masonry.*

Sufficient for our purpose are the ratings recommended by the National Board of Fire Underwriters. They are quoted as follows:

Classifications		Rating, Hr.
4-in.	Interior partitions. Non-bearing	1
8-in.	Interior or exterior walls. Non-bearing with incombustible structural members, framed in	5
	Bearing, with combustible structural members, framed in	2
12-in.	Interior or exterior walls. Non-bearing or bearing. Not less than	9

Resistance to Weather.—This term more often refers to water penetration, or "leaky walls," as some call it. More often than not, it is erroneously assumed that any water coming into an outside brick wall comes through the brick. In most cases this would be impossible, even during severe storms. Careful examination of many structures and a considerable amount of laboratory research confirm this. Even the softer and under-

burned bricks do not absorb or pass water fast enough to account for some conditions observed.

Water may find its way through the mortar joints, but more often it gains entrance to the wall around improperly set window and door frames and into improperly built or coped parapet walls.

The methods of construction that will prevent water penetration are discussed in detail in Chapter II.

Suffice it to say that properly built brick masonry is practically impervious to the severest storms, as is evidenced by the hundreds of examples of all kinds of buildings in all kinds of climates all over the world.

Durability or Permanence.—There are no accepted laboratory tests by which we can measure or predict the probable life of any masonry material. Long-time exposure in actual structures is the only reliable test; by such a measure, brickwork has no superior. Repeated freezing and thawing tests are thought to be a fair measure of weather resistance.

Bricks taken from the uncovered ruins of the ancient city of Ur in Chaldea are in perfect condition, and these bricks are known to have been made and put in place more than 5,000 years ago. The brickwork in many buildings abroad, which are several hundred years old, is practically as good as the day it was built; even in this country in many of our older structures the brickwork has long withstood the ravages of time and the elements and has preserved our historical buildings to their present state of perfection.

The very nature of the raw material from which bricks are made and the processes of manufacture produce an inherent quality of permanence.

Brick in sewers and other underground structures must withstand the most severe exposures, including the forces of erosion and corrosion, and no material has a better record than brick for durability under these severe conditions.

Thermal Resistance.—In considering the thermal or heat resistance of building or wall materials, one should have a fundamental knowledge of this somewhat complex subject.

The transmission of heat through any material depends on four principal factors, *viz.*, the character of the material, its thickness, the character of the surface (smooth or rough) and the velocity of the air across the outer surfaces.

Some tables show only the internal conductivity of a 1-in. thickness, omitting the surface conductivity; some tables show both internal and surface conductivity; some tables show both internal and surface conductivity, but for only a standard 1-in. thickness and some show the total conductivity (air to air) for the material or a combination of materials, such as a brick wall or a brick and tile wall.

Heat transmission at high temperatures (as in a fire) is quite different than at ordinary temperatures; one cannot be deduced from the other.

The only tables with which we need be concerned are those showing total conductivity of the material; or combination of materials (the assembly) for the commercial thickness or the actual thickness of the particular construction or material as sold for ordinary use.

Some advertisements say that a certain insulating material has eight times the resistance of brick, but this means 1 in. of the material as compared to 1 in. of brick. And even this is not always true. The material ordinarily used for residential insulation is often less than ½-in. thick.

Therefore, a comparison of actual constructions is the only fair one. An 8-in. brick wall should be compared to an 8-in. block, for instance, or an 8-in. brick wall to the usual wood wall construction.

But masonry walls and wood walls are not all alike, nor are their respective heat resistances all alike. Figures given in most tables are derived chiefly from tests of particular constructions, but the variation in specific heat resistance is not as great as variations in strength.

The infiltration or leakage of air through walls is sometimes a source of heat loss. Tests show that the infiltration of air through a plastered brick wall is negligible (see *A.S.H.V.E. Guide*, 1931, for comparative values).

Additions are constantly being made to our knowledge of specific conductances or resistances, so that the present tables reflect only the present state of knowledge.

Conductance is scientifically stated as the number of British thermal units (B.t.u.) which will pass through one square foot of exposed wall surface in one hour for each one degree difference in Fahrenheit temperature between the air adjacent to the two opposite wall surfaces. The short expression is: B.t.u. per sq. ft. per hr. per degree difference.

The *resistance* is the reciprocal of the conductance, or 1 divided by the conductance. Therefore, the lower the conductance and the higher the resistance figures, the better the wall.

FIG. 5.—Practical and economical use of brick in this house, with walls, entrance posts, steps, and walks all of brick. Brick laid in Flemish bond gives delightfully uniform texture. (*Courtesy of Dwight James Baum, Architect.*)

When Brick Walls Should Be Insulated.—It is a well-established fact that, in all kinds of buildings, especially in dwellings, much greater amounts of heat pass out through window and door openings and through the roof than through the walls. The real situation is well stated in the *Bureau of Standards Circular* 151, as follows:

> It is probably true that unless special precautions are taken most of the heat lost from our buildings passes out through windows and doors, so that no marked economy could be expected from increasing the thermal resistance of the walls.

It would, therefore, appear that adding special insulation to increase further the high thermal resistance of brick walls is justified only when (1) necessary measures to prevent loss through the roof, windows, and doors have been taken, and (2) when careful analysis shows that the cost of installed wall insulation results in a sufficient reduction in the cost of the heating plant and in subsequent fuel saving to make the cost of insulation a profitable investment.

There is wide variation in the results of experiments made by different investigators on the thermal conductivity of similar constructions. This is to be expected, for it is most difficult to build test wall panels of either brick, wood, concrete, stone, etc., which are exactly alike. And such new test panels may be quite different in thermal resistance from older similar construction in actual buildings.

For purposes of determining heating-plant capacities, radiator sizes, etc., the American Society of Heating and Ventilating Engineers annual *Guide* gives values for the conductance of many materials and types of construction. These values are derived by calculation, using the standard formula, and exhibit a fair approach to accuracy. The *Guide* may be consulted for specific values for the thermal resistance of insulating materials and types of building construction.

Resistance to Sound Transmission.—The transmission of sound through brickwork is occasionally important as it applies to interior partitions, party walls, and similar structures.

Elaborate laboratory apparatus and technique have produced quite accurate data regarding the resistance to sound transmission through many structures, but it is not easy to present the technical and physical results in terms easily understood by the layman or by those not familiar with the testing methods.

The results of laboratory tests are usually reported in what are known as "reduction factors," in units which are termed "sensation units" and which closely represent the effect on the ear.

For masonry walls, the resistance to sound transmission is quite closely related to the actual mass or weight of the wall per square foot of area. Even a thin brick partition, 2¼ in. thick with plaster on both sides, is highly resistant to sound. Thicker walls of brick are sufficiently resistant to reduce sounds of fairly high intensity to complete inaudibility.

It should be remembered that sound is more often transmitted through floors and through the framing of buildings than it is through the walls themselves. Moreover, even sounds of mild intensity in the room will completely mask sounds of greater intensity coming from an adjacent room.

CHAPTER II

BUILDING BRICK MASONRY

MATERIALS USED IN BRICK MASONRY

The essential considerations in the production of good brick masonry are treated in this chapter. Details of design and construction are presented in Chapter III.

Qualities Desired in Brickwork.—The properties of individual bricks do not accurately measure but only indicate the quality of brick masonry. Two other important factors influence brick masonry quality, namely, the kind of mortar and the character of workmanship. The character and desired performance of the structure, or of the structural part, should always be kept in mind in designing and building brick masonry. The strongest bricks and the strongest mortars are not always necessary to produce a desired performance; in fact, the use of the strongest bricks and mortars may often result in an inferior performance, as will later be described.

Those qualities, some or all of which may be desirable in a structure or structural part, are (1) strength, (2) fire resistance, (3) resistance to water penetration, (4) durability or permanence, (5) resistance to heat transmission, (6) resistance to sound transmission, and (7) pleasing appearance.

As will later be seen, the prevention of efflorescence is very largely ensured by so building brick masonry as to prevent water penetration.

Selecting the Brick.—Mortar and workmanship being the same, stronger bricks produce greater compressive strengths in masonry, so that if high compressive strength is most desired, then stronger bricks should be selected.

High strength is, however, very seldom the thing most desired, for watertightness and beauty are frequently the more important considerations. In any case, the weakest bricks produce masonry of ample strength, having a high factor of safety over the requirements of most building codes.

Ample *strength* is often accomplished by the use of relatively soft bricks (salmon) as backup for well-burned and harder bricks used in the exposed face of the masonry. For interior walls, especially non-bearing walls and partitions, the softer grades of brick are usually satisfactory and produce other desirable qualities such as resistance to heat and sound transmission.

A simple *test for a well-burned brick* is sometimes called the "ring" test. When two well-burned bricks are struck together lightly, or when a single brick is struck with a trowel, a metallic resonant sound (or ring) is produced. There are, however, some exceptions, for some very hard well-burned brick do not ring when struck.

To determine whether or not the bricks for a job may, in themselves, contain soluble salts which may *cause efflorescence,* stand a few samples on end in about an inch of distilled water. If harmful salts are present, at least a trace of efflorescence will appear just above the surface of the water within 48 hr. A 5-day test is quite certain to show the presence or absence of soluble salts in any harmful amounts. If no appreciable deposit appears, the bricks alone cannot cause efflorescence in the wall.

The common cause of this trouble is, of course, the mortar or other masonry materials.

For obtaining high *fire resistance* in brick masonry, the use of any well-burned brick is satisfactory. The very nature of bricks and their method of manufacture make individual bricks highly resistant to severe fires.

It is important, however, that brickwork in exposed walls and in fire walls and fire division walls be well laid in cement mortar or cement-lime mortar (see the following section on mortars).

For obtaining *durability,* exposed brickwork should be built of well-burned bricks. This applies particularly to parapet walls and all walls exposed on both sides. High compressive strength is not always necessary, for many structures that have withstood the weather for several hundred years are known to be built of bricks of moderate strength.

Resistance to heat transmission can be obtained with well-burned or underburned bricks. It is probably true that brick of a porous nature with minute air cells are slightly more resistant to heat transmission than the more dense ones. Here again, the character of the masonry, especially surface coating, such as plaster, greatly influences the transmission of heat through masonry walls or partitions.

Resistance to sound transmission is likewise obtained by the use of almost any kind of bricks, but extensive experiments show that resistance to sound transmission is roughly proportional to the density of the construction.

A common mistake of the past has been to assume that the strength of masonry of all kinds was the important consideration, and that other desirable qualities very largely fell in line with strength. We now know that this is not so. As previously stated, the selection of bricks should be made with these things in mind. It is not always necessary, although sometimes desirable, to choose the strongest bricks for a particular job.

Selecting and Mixing Mortar.—The selecting and mixing of mortar for use in brick masonry is an important factor in performance. The function of mortar is to (1) bind the bricks into a masonry mass, (2) carry its part of the loads and distribute these throughout the mass of masonry, (3) produce tight joints between the individual bricks (adhesion to bricks), and (4) become part of the pattern or architectural appearance of the exposed brickwork.

Brick masonry mortars are today very largely composed of four principal ingredients: portland or natural cement, lime (slaked or hydrated), sand, and water.

Portland cement mortar sets rather rapidly, produces high masonry strength, and is (in itself) relatively impervious to water, but, when alternately wet and dried suffers volume changes which may destroy the bond between mortar and brick. Portland cement for mortar may be of any reputable brand. It is sometimes required to meet the standard specifications of the A.S.T.M. (C150-42).

Lime for mortar usually comes in two forms: (1) lump lime, which must be slaked before using, after which it is usually called "lime putty," and (2) hydrated lime, which comes in the form of a powder (previously air-slaked) and is used as delivered. Slaked lime should be allowed to stand for at least 48 hr. before using, and preferably longer. It is likewise best to mix hydrated lime with water and let it stand for a short time before using. A.S.T.M. standard specification for lime is recommended.

Sand used for mortar should preferably be clean, sharp, and well graded; that is, be a mixture of fine, medium, and coarse particles. Bank sand is usually preferred to other kinds, although sand from the shores of fresh-water lakes and rivers is acceptable. Sand from salt-water shores should not be used, for it is almost always impregnated with salts which later will produce efflorescence on the face of the masonry.

Sand should also be free from loam, organic matter, and other harmful ingredients.

Water should be clean and free from acids or other impurities. Masonry mortar may consist of any proportions of cement and sand, lime and sand, or cement, lime, and sand. Sufficient water is always added to make a plastic mixture. When an excess of water is used, so that the mixture runs, it is commonly called "grout." Various mixtures of cement, lime, and sand produce mortars having various qualities, as more completely described hereinafter. The more common mixtures specified for use in brick masonry are, however, the following (all proportions are by volume):

Cement Mortar.—1 part portland cement, 3 parts sand. When not over 15 per cent of the cement quantity is added in the form of lime putty or hydrated lime, the mixture is still called cement mortar.

Lime Mortar.—1 part lime putty or hydrated lime and 3 parts sand.

Cement-lime Mortar.—1 part portland cement, 1 part lime putty or hydrated lime, and 6 parts sand.

Lime-cement Mortar.—2 parts lime, 1 part cement, 9 parts sand.

Mortar Colors. *Natural.*—Mortar may be colored by using colored sand, such as ground granite or other stone. When the desired shade can be thus obtained, these are preferable to artificial colors, for natural sands and stones usually have a permanent color and do not weaken the mortar.

White joints may be obtained with white sand, ground limestone, or marble, or by using white cement in cement mortars.

The color of the sand in the finished joint will, of course, be somewhat modified by uncolored cementing material.

Artificial Mortar Colors.—Care should be exercised in selecting the proper artificial color. Mortar is strongly alkaline and coloring matter should, therefore, be chemically inert or the color may fade or run when in the wall. Mineral colors are preferable.

For cement or cement-lime mortars, *cement* colors should be used, not mortar colors.

The common practice of mixing cement, sand, and color in a mortar box with a hoe is not recommended, for uniform batches *are difficult to produce.* Wherever possible, it is better to weigh *all the ingredients and to measure the water. If the measured ingredients can be mixed in a batch mixer, better results will be* had.

In any case, the manufacturer's directions should be carefully followed.

Slaking Lime.—Quicklime (unslaked) as such can never be used for structural purposes. It must always be slaked. And since the method of slaking is an important factor in determining the quality of the finished product, the following directions are given as a guide to those who lack experience:

Directions for Slaking.—Different kinds of lime vary considerably in the way in which they behave with water. A little supervision over the operation of slaking will amply pay for itself by ensuring the production of the greatest possible quantity and the best possible quality of putty. To find out how to slake a new lot of lime, it is safest to try a little of it and see how it works. Since different lots of the same brand of lime vary somewhat and since the weather conditions at the time have a decided influence, it is wise to try a sample from each lot used, whether familiar with the brand or not.

In a bucket, put two or three lumps of lime about the size of one's fist, or, in the case of granular lime, an equivalent amount. Add just enough water barely to cover the lime, and note how long it takes for slaking to begin. Slaking has begun when pieces split off from the lumps or when the lumps crumble. Water of about the same temperature should be used for test and field practice.

If slaking begins in less than 5 min., the lime is quick slaking; from 5 to 30 min., medium slaking; over 30 min., slow.

For quick-slaking lime, always add the lime to the water, not the water to the lime. Have enough water at first to cover all the lime completely. Have a plentiful supply of water available for immediate use—a hose throwing a good stream, if possible. Watch the lime constantly. At the slightest appearance of escaping steam, hoe thoroughly and quickly, and add enough water to stop the steaming. Do not be afraid of using too much water with this kind of lime.

For medium-slaking lime, add the water to the lime. Add enough water so that the lime is about half submerged. Hoe occasionally if steam starts to escape. Add a little water now and then if necessary to prevent the putty from becoming dry and crumbly. Be careful not to add more water than required, and not too much at a time.

For slow-slaking lime, add enough water to the lime to moisten it thoroughly. Let it stand until the reaction has started. Cautiously add more water, a little at a time, taking care that the mass is not cooled by the fresh water. Do not hoe until the slaking is practically complete. If the weather is very cold, it is preferable to use hot water, but if this is not available, the mortar box may be covered in some way to keep the heat in.

Making Mortar.—After quicklime is slaked into lime putty, a small quantity of sand is usually added and the mixture put aside in a pile until used. It should stand at least 24 hr. before use; a week is better. When required for mortar, the sanded putty is shoveled into the mortar box and *tempered* by adding water and more sand and working to a proper consistency. This is attained when the mortar slides easily off the trowel. Aging lime paste enables it to carry more sand.

Mortar with Hydrated Lime.—Hydrated lime is essentially slaked lime, purchased and delivered in the form of a fine dry powder instead of a paste. It is sometimes used where space on the job is limited and there is no room to prepare and store a stock of lime putty, and also when the time and skill necessary to prepare lime putty are not available. It is more quickly and accurately proportioned than lump lime.

Hydrated lime does not require slaking. It is usually mixed with the sand and the water added. When so mixed it does not trowel so easily as mortar made from lime putty, but the working qualities may be improved by allowing the mortar or paste to soak overnight.

Cement Mortar.—Since portland cement is of fairly uniform quality, cement mortar can be mixed in any desired proportions. The proportions recommended and most frequently specified for maximum strength and other desirable qualities are 1 part portland cement and 3 parts sand, by volume, with sufficient *water for the proper consistency. A greater amount of sand weakens the mix. A common but dangerous practice is to use more sand than specified in order to lessen the cost.*

Portland cement mortar is not plastic; it works "short."

Laying brick with portland cement mortar is slower and more difficult and the bed joints are apt to be not so well filled as with a more plastic mortar.

Cement-lime Mortar.—To produce a more plastic or easily worked mortar, lime putty is added to the cement mortar. Any desired amount may be used, but a very good mixture for all-round work, which is strong and also economical, is 1 part cement, 1 part lime, and 6 parts sand. Such a mixture works smoothly and easily under the trowel and produces brickwork of high strength and other desirable properties. An even more plastic mortar is lime-cement mortar, 2:1:9.

Retempering Mortar.—Specifications usually require that cement mortars be *not* retempered, for if the mortar has taken any degree of initial set, the retempered mortar is weaker. The quick-setting mortars are most affected. In fact, the loss of strength is roughly in proportion to the speed of mortar setting.

With a slower setting portland cement, the loss of strength is probably not serious if the mortar is retempered immediately after the initial set. It might, in fact, be retempered several times without seriously affecting the tensile strength, but most codes do not permit retempering and it is a dangerous practice at best.

With the slower setting cement-lime or lime mortars, retempering is not so harmful. A safe guide is that no mortar should be used after it has passed beyond a state of slight initial set.

The process of retempering is to add enough water to restore the desired consistency.

Patent or Masonry Mortars.—A number of brick mortars and trade-marked brick cements are now on the market. Some consist of portland cement, lime, and sand mixed dry and sold in bags. Others consist of natural cement mixed with hydrated lime or portland cement; and some also contain water-repellent materials, such as oils or soaps.

If they are to be used, their actual properties and previous performance over a reasonable length of time should be investigated. If used, the manufacturer's directions should be carefully followed.

Conclusions Regarding Mortar.—Mortar is an important element in good masonry. Much technical information on masonry mortars is available, but for ordinary small structures built by reliable contractors employing experienced bricklayers, resort to such technical information is not necessary.

The most extended research on masonry mortars, still in progress, is by the Structural Clay Products Institute of Washington, D.C. For reinforced brickwork or other engineering jobs where high stresses are to be resisted, the architect or engineer will have access to all technical information available on the subject. Especially for masonry underground or in contact with earth, such as sewers, tunnels, and walks, a strong mortar is necessary.

In ordinary brickwork the strongest, most expensive mortar is not required. Adding to the strength of mortar usually adds to its cost since it means a larger proportion of the more expensive ingredients in the mixture.

For Ideal walls and all cavity walls of brick, described and illustrated in this book, especially where the wall is subjected to any lateral stress, such as wind pressure, strong and good bonding mortar is necessary. However, for interior partitions or other cavity walls bearing compression loads only, no special mortar requirement is recommended.

Of equal importance with strength is plasticity of mortar and its ability to retain water. If the water goes out of the mortar and into the brick too rapidly, the joint will be weak. Even the hardest burned bricks, if not vitrified, still have a degree of porosity; this is important in securing a good bond between the brick and the mortar.

Dry Walls.—Moisture penetration of brick walls, if through the surface of the wall, almost invariably results from separation of the mortar from the brick in the perpendicular joints. In the horizontal or bed joints in the brickwork the mortar is compressed by the weight of the brick. If a good job of bricklaying has been done and all joints well filled with plastic, water-retaining mortar, there should be no separation of brick and mortar at any point. Unless the mortar itself is porous, a perfectly dry wall, as far as surface penetration is concerned, will result.

It is not uncommon in investigating leaky walls to find perpendicular or end joints in the brickwork into which the blade of a pocket knife may be easily inserted between brick and mortar. It must be expected that rain, driven by wind, will penetrate such openings.

Ground Clay in Mortar.—In addition to the use of lime to give plasticity to mortar, it has been found that ground clay, in small quantity, also is a safe plasticizing agent. In brickwork on brick plants, such as kilns, sheds, and other structures, clay often is used in the mortar with satisfactory results.

National Bureau of Standards Tests.—The National Bureau of Standards at Washington, D.C., where many tests of brick masonry have been made, has issued a report on "Durability and Strength of Bond between Mortar and Brick" by L. A. Palmer and J. V. Hall, which gives much information of value to the brick mason. The authors of this report find that bricks varying widely in absorption show no great difference in the life of the bond between brick and mortar where the proper mortar is used.

BONDS IN BRICK MASONRY

The full strength of brickwork cannot be attained without good bond. The word bond means "to bind." Bond is the method of arranging the brick units so that by their overlapping the entire wall is thoroughly tied together throughout its length and breadth and will act as a unit in resisting stresses.

Stretchers, or bricks laid lengthwise of the wall, develop its longitudinal strength.

Headers, or bricks laid across the wall, develop its transverse strength.

Every type of brick wall is amply strong when properly built, so that for structures not carrying heavy loads, the relative strength of the various types of bond is unimportant.

Headers in Solid Walls.—The brick walls in an ordinary building are rarely called upon to support more than a small part of the load they will safely bear. If the foundation settles unevenly, however, some stress may be caused in the direction of the length of the wall. The brick wall can adjust itself to slight movements such as this without cracking or other damage, by reason of its small units and numerous joints.

It would appear logical, therefore, to build a solid wall mostly of stretchers, with just enough headers to tie it together thoroughly and securely.

In a solid wall built entirely of common brick, all the headers which appear on the face of the wall are real or "through" headers. Where other facing brick are used, it is more economical to use "bat" headers for all headers not actually required for ties, so that the face brick will go further. Face brick should be

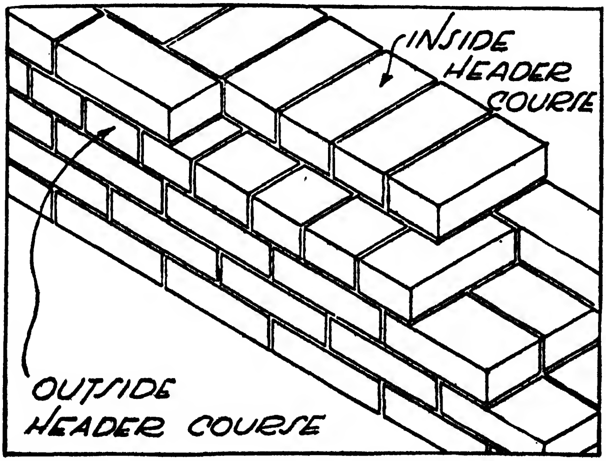


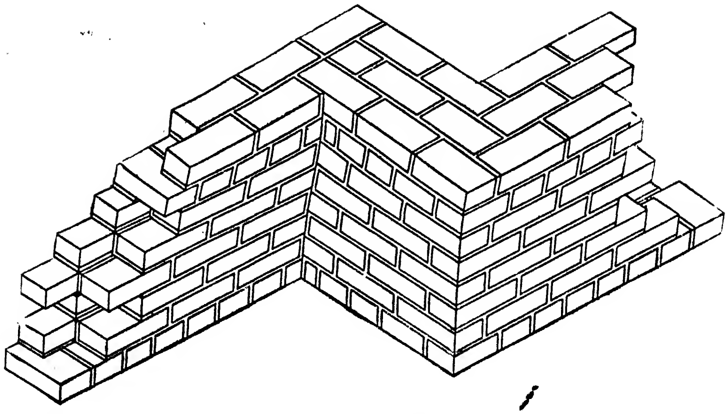
Fig. 6.—Method of lapping inside and outside header courses in 12-in. solid brick walls, common bond.

cut at the middle so that each half of the brick can be used for this purpose and waste avoided.

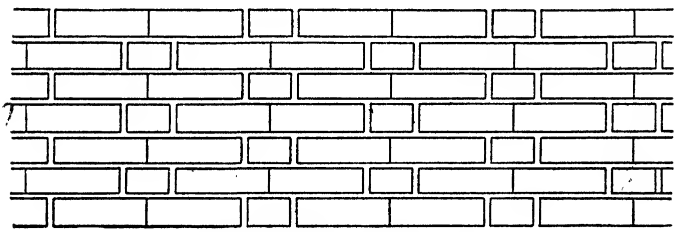
The number of through header courses is generally defined by building ordinances. Placing a header course at every sixth course, with all joints well filled, is a safe rule, except where the backing brick only is laid on a full bed of mortar, in which case through headers should preferably be placed every fifth course.

Header courses may consist of a full course of headers, or of headers and stretchers placed alternately (Flemish header course).

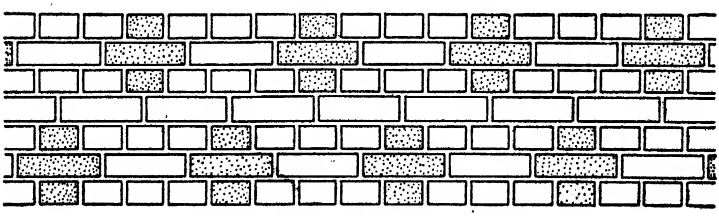
Appearance of Bonds.—In exposed work, the bond fulfills another purpose, the mortar joints forming attractive geometrical patterns on the surface of the wall. This is an important factor in the beauty of brickwork.



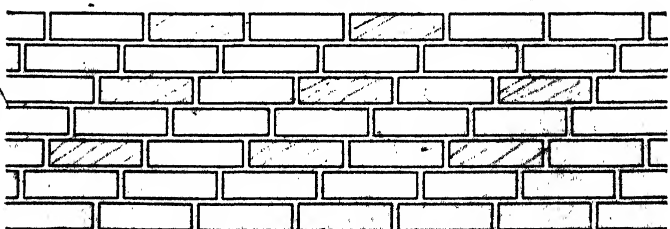
Common bond



Double stretcher Flemish bond

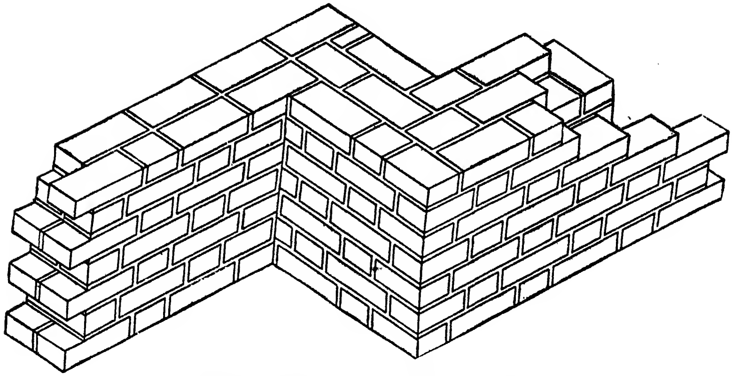


One pattern in English cross bond

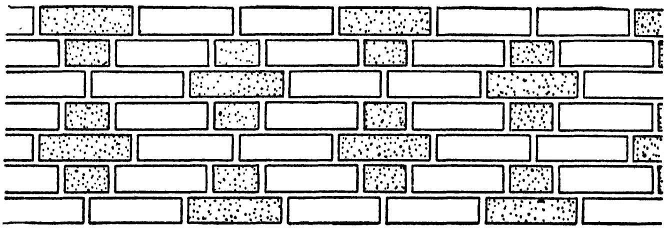


Variation of stretcher bond

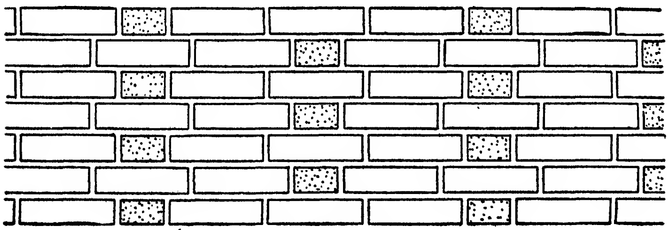
FIG. 7.—Various bonds used in brickwork, showing arrangement of stretchers and headers in outer surface.



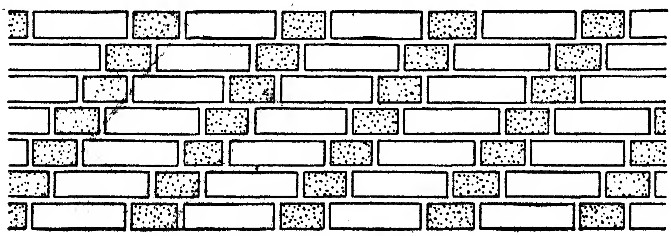
Single Flemish bond; Dutch corner



Flemish cross bond



Garden wall bond



Flemish spiral bond

FIG. 8.—Various bonds used in brickwork, showing arrangement of stretchers and headers in outer surface.

Selection of Bond.—Cost and appearance should be chiefly considered except for extremely heavy loads. For exposed work, the most suitable bond will be determined by the architectural design. For unexposed work and exposed low-cost work, common bond is generally employed, costing least because it is easily and quickly laid and in practice is probably the strongest of the bonds. Many charming buildings are, however, faced with brick in common bond.

Flemish bond is practical for Ideal all-Rolok walls where such walls are exposed. Any bond may be employed for facing Ideal Rolok-Bak walls. Economy walls are naturally built in common bond, with headers here and there for tying in the pilasters and for corbeling at floor and roof lines.

Types of Bond.—There are three basic types of bond and a multitude of variations of each: running bond, Flemish bond, and English bond.

Running or Stretcher Bond.—The surface of the wall is made up of stretchers which break joint at the center. At the corner, a header appears at each alternate course. Because of lack of headers, the bond is weak transversely. Only full headers have sufficient rigidity and bonding area to distribute the load. In a solid wall, 12 or more inches thick, sometimes the brick in the center is laid diagonally every few courses, the triangular portion of the brick projecting beyond the backing, forming a tie sufficient only to attach the face brick to the backing (clipped bond, Fig. 12). Metal ties are sometimes used (Fig. 13), but with each of these methods only the backing can be calculated to support the load. Metal ties are unsatisfactory also because they are liable to rust, and their use is not recommended.

Double headers are sometimes used, with a "buttered" joint between at every sixth or seventh course, the pair of headers appearing as a stretcher. This forms a thoroughly good bond, in reality a form of common bond.

Common Bond.—This is a variety of running bond, but with every fifth, sixth, or seventh course a header course, either full or Flemish, the former being all headers, the latter with headers and stretchers alternately. More bricks are laid in this bond than in all the other bonds combined. It is used for exposed and unexposed work and is the lowest in cost for solid walls or for facing Ideal Rolok-Bak walls.

A "three-quarter" brick starts each header course at the corner of the wall; bricks in other courses need not be cut at the corners to make them break joint. In a 12-in. wall, two header courses are used, one on each side of the wall in adjoining courses, overlapping in the center of the wall (Fig. 6).

For exposed work, the joints are kept perpendicular, but for unexposed work the brick does not require such careful placing. The end of a stretcher can be placed anywhere within the center 4 inches of the stretcher below and still produce a good bond (Fig. 14). This flexibility makes for rapid work.

Corners in Flemish and English Bond.—Before describing these bonds, attention is called to two distinct methods of starting corners with each of these types of bond. To correctly locate the vertical joints, it is necessary to introduce at the corner a unit half a header in width. In English brickwork, a header split in half or closure is used, but in Dutch brickwork the closure is eliminated, and the same effect is obtained by using a three-quarter brick in the stretcher courses (Fig. 9).

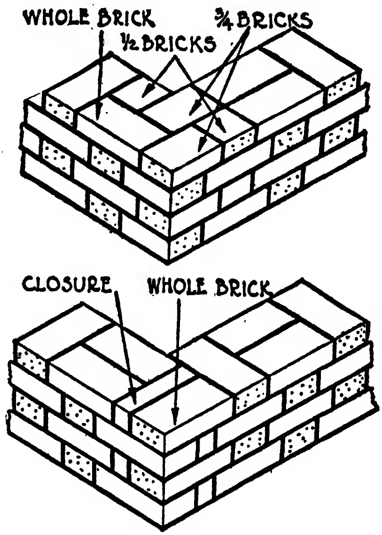


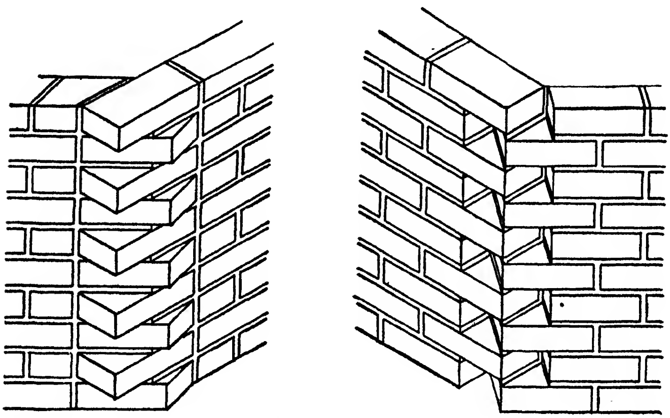
Fig. 9.—(Upper) Dutch corner. (Lower) English corner.

If a closure is used, never place it directly at the corner. Start with a full header, followed by the closure.

Flemish Bond.—This bond is a favorite among builders, being easy to lay and producing an artistic and pleasing wall surface. It may cost more to lay than common bond, because of the greater care required in the workmanship, but it is more attractive in appearance.

Double Stretcher Flemish Bond.—Garden Wall Bond.—A variety of Flemish, with two stretchers followed by a header in each course, the header centered on the pair of stretchers.

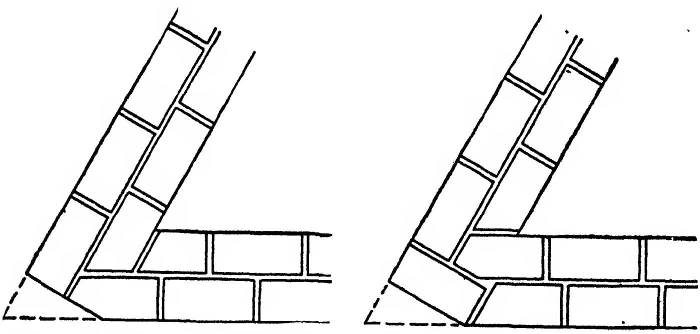
In double stretcher Flemish bond the joint between the pair of headers is a blind or invisible joint, constituting the sole difference between double stretcher Flemish and double stretcher garden wall bond; in the latter all the joints have the usual appearance. *Ordinary garden wall bond has three stretchers*



OBTUSE SQUINT QUOIN WITH UNCUT BRICK. THE PROJECTING BRICK ENDS MAY BE CUT OR RUBBED FLUSH WITH WALL SURFACES

OBTUSE SQUINT QUOIN WITH UNCUT BRICK LAID TO FORM PIGEONHOLES WHICH REDUCE EFFECTIVE WALL THICKNESS, TEND TO CONDUCT WATER TO INTERIOR OF WALL AND GATHER DIRT

Fig. 10.



ACUTE SQUINT QUOINS SHOWING ALTERNATE COURSES

Fig. 11.

between headers but may have from two to five stretchers between headers.

English Bond.—Composed of alternate courses of headers and stretchers, headers centering on stretchers or joints between them. Joints between stretchers are vertically over each other

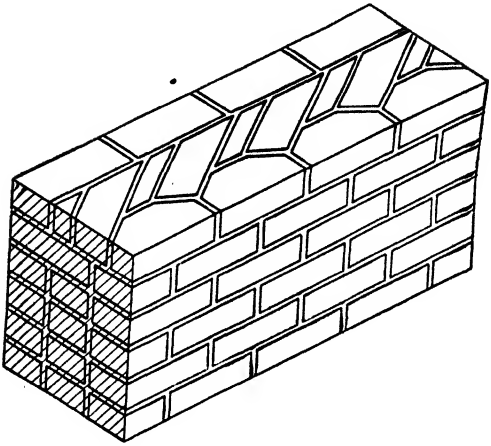


FIG. 12.—Stretcher bond tied to backing with clipped bond.

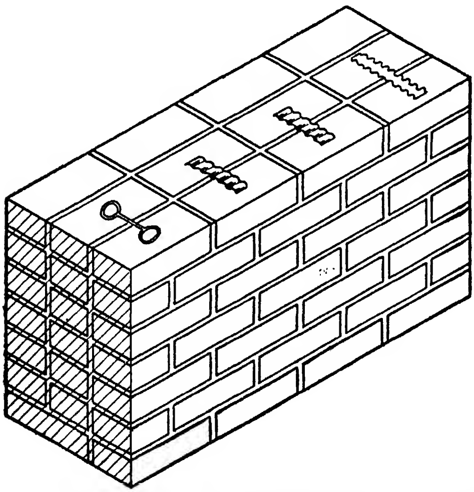


FIG. 13.—Running bond with various types of metal ties.

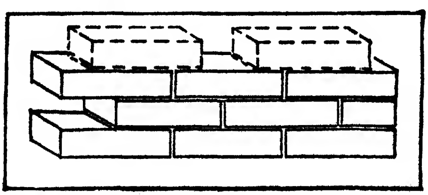


FIG. 14.—Greatest permissible shifting of stretchers to assume good bond in unexposed work.

in all stretcher courses. Note alternate methods of forming corners. In the lower cut, Fig. 9, the external corner closures are used; in the upper cut three-quarter brick, avoiding closures.

English Cross and Dutch Cross Bond.—Similar to English bond, but an interlacing pattern of Greek crosses, this bond is produced by breaking joints in the stretcher courses, the ends of stretchers in each stretcher course centering on stretchers in the courses above and below. The note with the illustration explains the difference between English cross bond and Dutch cross or Dutch bond.

Bond in Backing.—Regardless of the bond used on the face, unexposed backing is usually laid in common bond.

Brick Patterns.—Large-scale patterns formed by the geometrical arrangement of various-colored bricks and joints are very effective, if the designs are appropriate and in scale with the elevation. For large wall surfaces, such patterns may be used to splendid advantage, but for the ordinary residence or small building they should be employed with caution, to scale with the building. More bricklayers' time is required to form patterns than to lay the ordinary bonds.

JOINTS IN BRICKWORK

The space between adjacent bricks—whether filled with mortar or left open or "dry"—constitutes a joint. Upon the manner in which joints are treated depends much of the appearance, weather tightness, durability, strength, and cost of the finished wall.

Types of Joints.—There are four types of joints in brickwork (1) shoved joints, (2) grouted joints, (3) open joints, and (4) dry joints. Their formation and uses are as follows:

Shoved Joints.—On a bed of mortar, a little thicker than the finished joint will be, the brick is pressed downward and sidewise, the soft mortar rising between and filling the vertical joints. Such joints tend to produce strong and watertight masonry.

Grouted Joints.—The bricks are bedded on a full bed of mortar, vertical joints being filled with grout composed of similar mortar materials with more water added.

To grout a wall quickly and conveniently, provide each bricklayer with a bucket of water and a long-handled dipper. After placing a course of brick (laid the thickness of a joint apart) and taking the dipper with his left hand, trowel with his right, he picks up a trowel of mortar and a dipper of water with one motion. Spreading the mortar with one hand, he adds water from the dipper with the other, meanwhile working the mixture between the joints with his trowel until they are completely filled.

Fig. 15.—Full flat bed of mortar develops maximum wall strength and weather tightness.

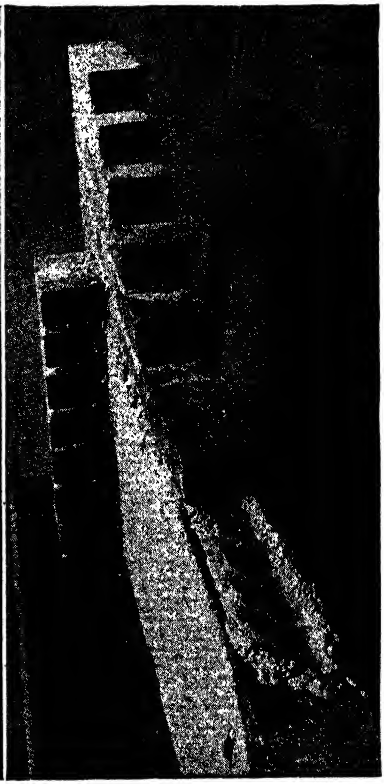


Fig. 16.—Grooved mortar joints should not be used, as they do not develop full strength or insure dry walls.

Grout is used in solid walls 12 in. or more thick, the outer and inner courses being shoved with mortar of ordinary stiffness to retain the grout. Grouted brickwork is less expensive than shoved brickwork and accomplishes the same purpose. However, it should not be employed where the face is to be left exposed on account of occasional trickling of the mortar over the face.

Where Filled Joints Are Required.—The strongest and most fire-resistive brickwork is laid solid with all joints full of mortar. *For fire, party, and division walls, and for construction in which piers or walls carry heavy loads and resist considerable stresses, all joints should be filled. Chimneys should have all joints* well filled, including the space between brickwork and the flue linings, to ensure a good draft.

Fig. 17.—Inferior masonry workmanship, showing unfilled vertical joint as result of deep grooving of horizontal joint.

Basement walls should have all joints filled.

In all walls exposed to the weather, the outside 4-in. course should have all joints well filled.

Specifications Should Not Always Require "All Joints Filled."—It is a mistake to specify "all joints filled with mortar" for all work. It is difficult for a mason to shove all the brick he lays, because a man's hand will be raw and tender after shoving brick all day. Requiring all brick to be shoved generally adds unnecessarily to the expense. In some respects not filling the joints is an advantage since its creates an air space in the walls.

Where Open Joints Are Allowed.—For solid construction above grade in common bond in a residence, a wall can be constructed by laying all the brick on a full bed of mortar, with joints in the outside course exposed to the weather shoved full, the brick in the backing (or in the full thickness of an interior partition) touching end to end and the vertical space between each 4-in. thickness left open. Every fifth course should be a header course with full joints and the mortar mixed softer than usual.

In the walls described, the partial interruption in the contact of material through the wall is considered to make the latter more weather resistive. Such a wall is also cheaper to lay, appears to dry out more quickly, and is amply strong for ordinary loads.

Basement walls in fairly dry soils may be laid with the outer joints shoved full, the brick in the remaining thickness laid on a full course with brick touching end to end and the vertical space between each 4-in. course filled with mortar.

Dry Joints.—Sometimes in low-cost work every sixth course on the interior face of a wall is laid directly on the brick below, omitting the bed of mortar. Dry horizontal joints provide secure nailing for grounds, frames, etc., but weaken the wall and are not recommended.

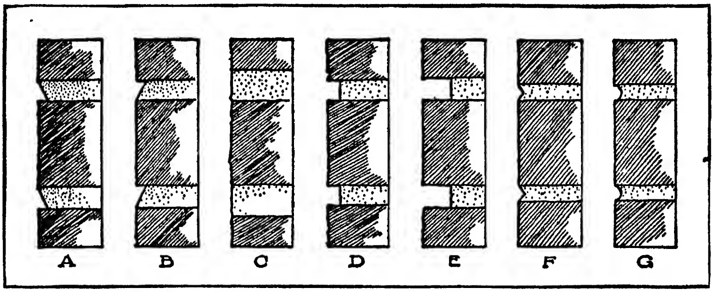


FIG. 18.—Common types of joints: (*A*) struck, (*B*) weathered, (*C*) flush or plain, (*D*) raked, (*E*) stripped (*F*) "V," (*G*) concave.

Joints in Ideal Walls.—The facing and backing in all Ideal walls should have full joints. The end joints of brick on edge are filled by buttering the bricks before they are placed.

Exposed Joints.—The mortar joint constitutes a considerable portion of the area of the finished wall and hence should be considered as to (1) width, (2) color, (3) section, and (4) texture.

Width.—With a standard brick, two headers require a ½-in. joint to coincide with the length of a stretcher. In forming bonds and patterns, the ½-in. joint is thus most practical. Joints ⅝ and ¾ in. wide are used extensively and are very effective, the difference between the unit length of a stretcher and two headers plus a joint being taken up by slightly varying the width of the vertical joints. Joints 1 in. and even wider have been used. A joint of ¾ in. and over slows down the work, a thick bed of soft mortar under each brick being more difficult to manipulate. Special mortar should be used for wide joints.

Color of Joints.—The richness of tone in the individual brick may be brought out and displayed to the best advantage by the proper selection of contrasting effects, which may or may not require the use of color in the joints. No matter what bricks are used, the effect may be spoiled and the wall have a "muddy" appearance if the color or tone of the joints is too near that of the bricks. The joints should be plainly visible, even at a distance. The importance of this cannot be overstated if appearance is essential.

Although the slight gradations in the shading of the brick add greatly to the beauty and interest of the finished wall, the color of the mortar joint must be kept even to produce the best effect. Very often natural uncolored mortar will produce excellent results, particularly with a red or darker brick. Strong sunlight may cause any artificial mortar color to fade.

Section and Texture of Joints.—For exposed work, the joints are made flush or recessed. With the former, the individual bricks are visible according to the contrast in color and texture between brick and joint. With the latter, the brick outlines are also marked by their shadows.

Some designers think that the texture of the mortar joint should resemble that of the brick, but it is unsafe to lay down hard and fast rules, for charming effects are often produced by a contrast in the texture of brick and joint.

A steel jointer or trowel produces a smooth texture, while a wood surface is generally used for a rough texture. Coarse sand or even fine gravel in the mix, if the joint is wide enough, also assists in forming a rough surface.

Types of Exposed Joints. *Plain Cut Joints.*—These joints are used for concealed surfaces and for joints in fire and party walls. Plain cut joints may be used on a basement wall to receive damp-proofing. They are formed by simply cutting off excess mortar with the edge of the trowel.

Struck Joints.—The cheapest and most easily formed joint for exterior surfaces. When well done, it makes a neat wall. Sometimes objection is made that this joint is not as weather resistive as the weathered joint. However, raked joints, which expose much more of the upper surface of the brick, have proved successful and this objection would seem more theoretical than otherwise.

This joint is widely used for exterior exposed work and for the inside exposed surface of basement walls and other unplastered brick surfaces. It should be used on a basement wall on which asphalt or similar damp-proofing is to be mopped.

It is formed as a plain cut joint and finished with the trowel as the mortar becomes stiffer.

Weathered Joints.—Similar to a struck joint but formed from above. Each course of brick throws a slight shadow. It is difficult to preserve exactly the same slope on the face of the joint.

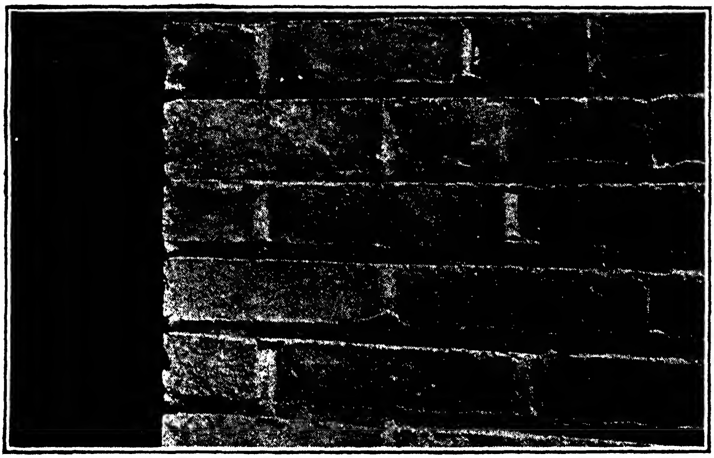


FIG. 19.—Struck joint in common bond.

Flush Joints.—Almost always finished with a rough texture. When used with rough textured brick it is difficult to keep the mortar from the face of the brick.

This joint is formed by cutting off mortar squeezed beyond the face of the wall. The joint must not be manipulated afterwards with the trowel, lest the cement be drawn to the surface and the rough texture spoiled. If further treatment is needed, the surface may be gently tapped with the end of a piece of wood having an extremely rough end grain.

Raked Joints.—The joint is first plain cut and afterwards raked out to the depth desired, a steel jointer being employed to obtain a smooth texture, a wood stick for a rough texture. Corners should be formed square and all excess mortar removed to produce a neat effect. A cheaper method is to rake the joint quickly and roughly with a stick as the wall is built, brooming *out the excess mortar the following day, no attempt being made to produce square corners.* This joint should not be attempted with rough-textured brick.

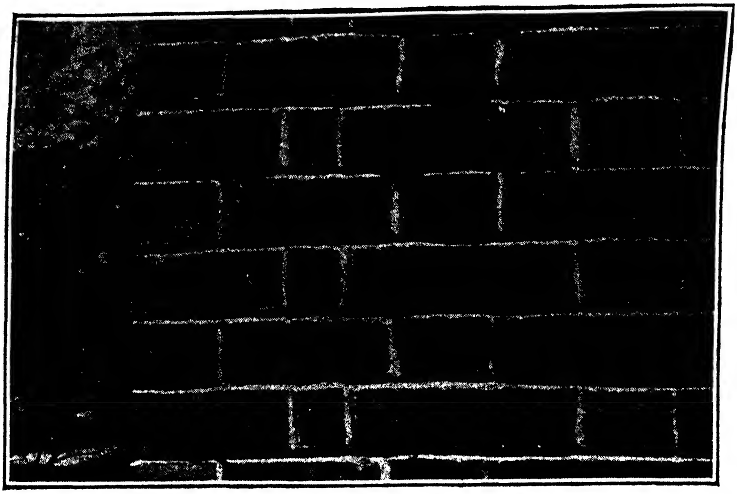


Fig. 20.—Concave joint in Flemish bond.

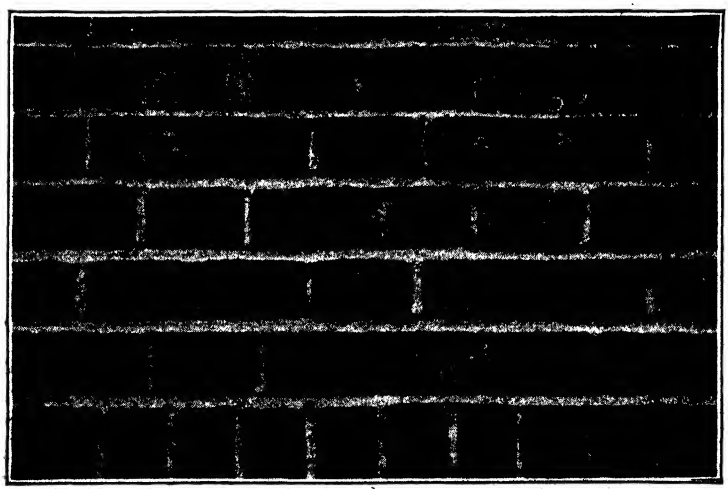


Fig. 21.—Weathered joint sheds water from the joint.

Ideal all-Rolok walls may be constructed with raked joints, if the rake is not cut too deeply. A brick on edge has a 2¼-in. bearing surface. A ½-in. rake, therefore, will leave 1¾ in. of bearing surface.

Stripped Joints.—These joints produce the neatest and cleanest raked joint and are specially useful with rough-textured brick, as they keep the mortar from the face of the wall. This is a slower and more expensive process than raking the joint.

A wood strip the thickness of the mortar joint is laid at the front of the wall, set in any depth desired. The bed of mortar is placed behind and flush with the top of the strip and the next course laid, the strip being removed when the mortar has set sufficiently.

V Joints and Concave Joints.—These joints are comparatively inexpensive to form and are weather resistive. Both are best formed with special tools made for the purpose. A V joint may be roughly formed, however, with a square-edged board held at an angle and rubbed along the joint; a concave joint may be similarly formed with a board having a rounded edge, or a bent iron rod.

Homewood Joints.—A special tooled joint developed in Baltimore that has come to be known as the Homewood joint is made with a tool that forms a fine indented line in the center of the mortar joint. This tool is run along the joints against the straight edge after the manner of marking false tile work in hard plaster walls.

Essentials of Good Workmanship.—To secure the desired performance of brick masonry, good workmanship is essential. It should never be sacrificed to speed of production. A skilled artisan will, however, produce good workmanship at relatively high speed, for his knowledge of the essentials automatically guides his technique.

The essence of good workmanship is joint filling. And joint filling is aided by the use of a workable mortar (see section on mortars). In certain types and certain parts of masonry, joint filling is not so essential, but these cases are exceptions to the rule, as mentioned specifically in preceding paragraphs.

Assuming that proper selections of bricks and mortar are at hand, the trained bricklayer needs but little guidance or supervision. When dominated by an ignorant or unscrupulous contractor, brick-mason production may well be supervised and inspected. The more important points that should command attention are discussed in the reference pages in Chapter III with respect to specific types of brickwork. The broader problems of *brick masonry construction, largely applying to houses and minor buildings, are touched upon in the following sections.*

PREVENTING WET WALLS AND EFFLORESCENCE

Discoloration.—The discoloration of brick masonry may result from three causes, namely, *efflorescence, staining,* or "scumming."

"*Scumming*" is a term used to describe the discoloration of brick during the process of manufacture. It is usually caused by the presence of gaseous combustion products of sulphur in dryers or kilns. Such bricks are rarely sold for use in facing, however and need be given little consideration here.

Staining is caused by the deposit of foreign materials such as iron rust, soot, etc., over exterior surfaces, usually by the action of rain or melted snow. While, in general, staining does not originate in the masonry materials themselves, certain types of limestone and sandstone contain organic material which, if such stone is used in structures, may be leached out by water and deposited on the surface, resulting in yellow, brown, or red stains.

Efflorescence, the more prevalent source of discoloration, is the deposit of soluble salts on the surface of masonry. This phenomenon is of such importance as to merit careful consideration. Efflorescence occurs only when water-soluble salts are present in masonry materials and water gains access to these materials and carries them, in solution, to the surface. Its occurrence might, therefore, be altogether avoided if it were possible to do either of two things—use only materials entirely free from soluble salts, or build waterproof masonry. In practice, while it is desirable to select materials as free as possible from deleterious salts, the remedy is found in the practical elimination of water by proper methods of design and construction and effective maintenance of the completed structure.

Selection of Materials.—No material used in brick masonry can be depended upon to be entirely free from soluble salts. Since materials from the same sources may vary greatly at frequent intervals, their chemical properties may well be checked by tests.

Brick.—While the process of burning brick tends to reduce the amount of soluble salts to a negligible minimum, sulphate of lime and, more rarely, the sulphates of iron, potassium, sodium, and magnesium may be present in harmful quantities, especially in underburned or porous brick.

A simple and effective test of brick to determine its tendency to develop efflorescence is the following: Select a number of bricks, representative of the manufacturer's product, and stand them on end in a pan containing distilled water, 1 in. in depth. Replenish water as necessary to take care of loss by evaporation. If soluble salts are present in harmful quantities, noticeable efflorescence will appear on the surfaces of the bricks, usually within 48 hr., though the test should be continued for at least 2 weeks before final conclusions are reached.

Portland Cement.—Although portland cement may or may not cause efflorescence, it usually contains soluble salts. Gypsum, which is added to cements to retard the rate of set, is itself soluble and small quantities of soluble alkali sulphates are often present. Chemical analysis is the most satisfactory method of determining the quality of cements and their tendency to cause efflorescence.

Lime.—Most limes contain soluble salts in small quantity, although an excessive amount of water is required to bring them to the surface of the masonry. As in the case of cements, chemical tests are necessary to determine quality.

Sand.—Sea sand or dirty sand which has not been thoroughly washed may contain soluble salts.

Water, particularly that which is strongly alkali, may contribute to efflorescence when used in mortar.

Admixtures, such as calcium or sodium chloride, used in mortar to prevent freezing, are almost certain to cause efflorescence and are therefore not recommended.

Details of Design.—After materials normally free from soluble salts have been selected, it is still essential that details of design be such as to prevent water from penetrating the interior of the masonry. The importance of careful design cannot be exaggerated, for efflorescence, objectionable in itself, is usually also a danger signal, indicating basic defects in construction. The circumstances favorable to the formation of efflorescence are those which are also favorable to the disintegration of mortar joints by the leaching, freezing, and thawing action of admitted water, and the masonry may be damaged or disintegrated unless such conditions are corrected. A sound principle of design is to allow only vertical surfaces of brick to be exposed to rain, unless proper flashing or waterproofing be interposed to prevent the travel of moisture.

Recommended Practices.—More specifically, the following practices are recommended:

Copings should be made of impervious materials and all joints should be thoroughly filled and watertight. Roof flashing should be carried completely through parapet walls, or within 1 in. of the face, to prevent water travel in the interior of the wall. If overhanging, the overhang of the coping should be ample and drip grooves should be provided.

Caps of stone or other material at the tops of buttresses, piers, chimneys, and elsewhere should project and be provided with drip grooves.

Parapet walls should be made of the best brick, mortar, and workmanship, because of their extreme importance in preventing wet walls and efflorescence. It is unfortunately customary for masons to use "tailings" of brick and mortar, brickbats, and imperfect brick in the parapet walls simply because these are the last to be finished. This is extremely bad practice and should never be tolerated.

Window sills, if made of a single piece of stone or other material, should project at least 2 in. and be provided with drips. If made of brick, suitable metal flashing or waterproofing should be placed under the sill.

Projecting courses of brick or exterior corbels should be used only when ample provision is made to prevent water penetration.

Recessed panels may be a source of trouble and require careful treatment.

Gutters and downspouts should be designed to avoid wash on the face of the wall.

Ground moisture at the grade line may be a source of efflorescence. Bituminous waterproofing should be interposed between the masonry and the soil or a damp-proofing course of slate, mastic, etc., be used at grade.

Foundation walls and retaining walls should have bituminous waterproofing applied on faces in contact with soil. Retaining walls should be capped so as to exclude water from the interior.

Integrally waterproofed mortars appear to be capable of stopping capillary travel of water, the most effective materials probably being the insoluble metal soaps. Their limitations have not yet been fully determined.

Transparent "Waterproofers."—No surface waterproofing is capable of filling holes in masonry or correcting structural defects. Surfaces requiring treatment should, therefore, be put in good repair. The transparent waterproofers in common use are (1) paraffin or very heavy mineral oils in solution in light mineral spirits; (2) metallic soaps (aluminum, zinc, etc., salts of fatty acids); (3) varnishes, usually mixtures of organic oils and gums; and (4) materials in water solution, intended to penetrate the pores of brick, stone, and mortar and form seals, as, for example, water glass (sodium silicate), fluosilicate, etc.

The use of transparent waterproofing materials is probably justified only when defects in construction have been made good and when it is then evident that the only moisture entering a wall is entering through the vertical face and is due to the porosity of the bricks or mortar, or both, and not to defective joints, and when this moisture is sufficient to cause and continue to cause efflorescence.

The choice of a suitable waterproofer can probably best be made on the basis of selecting that brand or type which actual experience in a given locality has shown to be the most permanently effective in withstanding local climatic conditions. Current opinion concerning this question is varied and often conflicting. Laboratory investigation does not thus far justify positive conclusions.

Selection of Mortar.—While more research is necessary before positive conclusions can be reached, the opinion is growing that the use of a mortar containing a fair proportion of lime is likely to produce more watertight masonry. A lime-cement mortar 2:1:9, for example, has sufficient compressive strength for all ordinary requirements. It is workable, a factor which makes for more completely filled joints. It is possible that such a mortar possesses a certain toughness or elasticity that tends to prevent the opening of cracks between brick and mortar joints which are likely to admit water. And finally, it is probably more immune to volume changes from variation in moisture content than richer mortars.

Joints.—All mortar joints in exposed masonry should be completely filled and finished in such a manner as to prevent horizontal ledges that may retain water that may subsequently find its way into the masonry.

Hollow Walls.—Hollow walls, discussed in detail in Chapter

III, are effective in preventing wet interiors. The air spaces which they provide, especially if proper provision is made for the circulation of air through them, may be depended upon to evaporate such moisture as may penetrate through the outer faces.

Care during construction is essential. Materials should be so stored as to avoid the absorption of excessive moisture. Unfinished walls should be covered at night with canvas or tar paper. Reinforced brickwork or concrete floors, when built simultaneously with walls, should be so constructed that the wash from their surfaces does not come in contact with the wall faces.

Maintenance.—The proper maintenance of brick masonry is important in the prevention of efflorescence. Downspouts and gutters should be kept in repair. Cracks due to settlement or other cause should be promptly pointed up. The appearance of efflorescence at any point may be an indication of faulty workmanship, which, if found, should be corrected.

Removal of Efflorescence.—Rain often washes efflorescence away and should be given a chance. If it still persists, it may be removed by scrubbing the affected surface with a solution of 19 parts water and 1 part muriatic (hydrochloric) acid, thereafter washing thoroughly with clear water. If considered necessary, the surface may be washed again with water to which a small amount of household ammonia has been added. Should efflorescence reappear, it may be necessary to treat the wall surface further. But, should transparent waterproofing be decided upon, this application should be made only during warm, dry weather.

PRACTICAL CONSTRUCTION EQUIPMENT

The following deals chiefly with equipment required for an ordinary house job.

Shed.—A small storage shed should be built on the job to keep cement and lime dry. On a small job, one corner of this shed near the door can be fitted with a window and a rough desk to serve as an office. Toward the completion of the job the shed may be taken down and the boards used for cellar shelving. The cost of the shed should be added to the cost of the job.

Safe Scaffolding.—Scaffolding can be used many times over on a number of jobs, and its first cost should be charged to equipment.

Great care should be used to make scaffolding safe. Scaffold accidents are by no means uncommon and are due in most cases to carelessness. "Blind traps," or boards that tip up when walked upon, should be avoided by not allowing the ends of the boards to project more than 6 in. over their support.

Where Scaffolding Is Required.—In building the lower part of the basement wall the mason stands in the excavation, the

FIG. 22.—Foot scaffold.

upper part being built from the grade. Scaffold plank on trestles is required in the basement only for independent chimneys and piers.

Walls above the first floor line are built from inside the house. In all but the cheapest construction a rough underfloor is used and this floor is laid as soon as the joists are placed. The mason builds the lower 4 to 4½ ft. of each story from the subfloor, scaffold planks on trestles being placed when the wall reaches this height. Where the finished floor is only of one thickness, rough plank flooring must be laid temporarily on the joists, this plank being moved up to the next story when the lower story wall is finished.

Walls can be cleaned down from a ladder or a painter's scaffold. On higher buildings, scaffold brackets may be used to support plank for this purpose if brickwork is cleaned down before the plasterer starts; otherwise, exterior scaffolding must be used.

The carpenter will need an exterior scaffold of some kind to work on the overhanging eaves or cornice.

Material Runs.—Brick and mortar are generally handled in wheelbarrows for walls up to the height of the second-story joists, and a sloping 2- by 10-in. plank wheelbarrow run should be laid from grade through a convenient door opening to the first-floor line.

Above the line of the second-floor joists, materials are most conveniently handled in hods. An inexperienced man will at first have difficulty in carrying a full hod up a ladder, and some contractors prefer to use cleated runs of 2- by 10-in. plank instead. An experienced man much prefers a ladder.

Line.—In some localities it is customary for the contractor to provide the bricklayers with line; in others the masons furnish their own. The line in the average mason's kit bag, however, leaves much to be desired and, regardless of custom, it will generally pay the contractor to furnish the line. Line rotted by lime or cement breaks easily and soon becomes full of knots, the loose ends getting into the joints and cutting down the efficiency of the bricklayer. Moreover, when the line breaks, the bricklayers must stop until it can be tied and reset. Line costs only a few cents, and it is real economy for the contractor to furnish it.

PRACTICAL NOTES ON PROCEDURE

Dividing Work.—Always divide off the wall so that each bricklayer will have about the same amount of work to do. This will enable the contractor to pick out the best men. On a wall with few openings bricklayers are placed about 6 ft. apart.

Wetting the Brick Before Laying.—It is important that all brick, except impervious brick, be wet before being laid, except in freezing weather. The hotter and drier the weather, the more water should be used. If the bricks are not wet, they will absorb the moisture from the mortar, which will interfere with its setting and adhesion to the bricks. On the other hand, the bricks must not be soaked, as they can be made so wet that they will slide on a bed of mortar and this may so thin the mortar that it will run down the face of the wall, making good work difficult. No hard and fast rules for wetting brick can be given, even though we may know the absorption properties of the brick being used. Experience is the best guide.

Handling Brick.—Do not allow the brick tenders to throw down the bricks on the scaffold so that they scatter or chip.

Care on the part of tenders will save the more valuable time of the bricklayers.

Keeping the Scaffold Clean.—The bricklayer's working space on the scaffold can be kept clean and tidy just as well as not, and by ensuring a good foothold it will add to the efficiency of the masons.

Every bat or broken brick can and should be used in the wall as the work goes along. No brick should be wasted.

Protecting the Work at Night.—It is important that the walls be protected every night by being covered with boards or other substantial protection to keep off the rain and weather. Boards should have bricks piled on them loosely to prevent the wind blowing them off.

Building the Wall.—The bricklayers build the walls from the inside, pointing the face as they go. The most experienced bricklayers are placed at the corners to run up the leads and raise the line. Leads consist of a few courses of brick run up at the corners to which the "trig" and line are attached. The line is generally raised course by course.

Joist Support.—In brickwork, the courses can easily be laid out and adjusted so that the courses supporting joists will be at the exact height required. No "shims" or blocking under the joists are needed or should be allowed.

Joists and timbers should be set directly on the brick, unless their bearing surface is so small that they transmit a load greater than the safe bearing capacity of the wall. When this occurs, bearing plates are required.

Never use wood bonding timbers. They will shrink and seriously weaken any wall.

Floor and Roof Anchors.—In the better class of residence work floor joists and roof plates are anchored to the walls. Some cities require this by ordinance. In the great majority of speculative residence work outside such cities, however, anchors are not used. Anchors are spaced approximately 6 ft. apart both for floor joists and roof plate. Where joists run parallel to the wall the anchor straps (made long) are attached to about three joists, into which they are mortised on top.

When the joists are at right angles to the wall, anchors should be placed near the bottom of the joist, to lessen the strain on the wall in case the joist burns away in a fire and drops out.

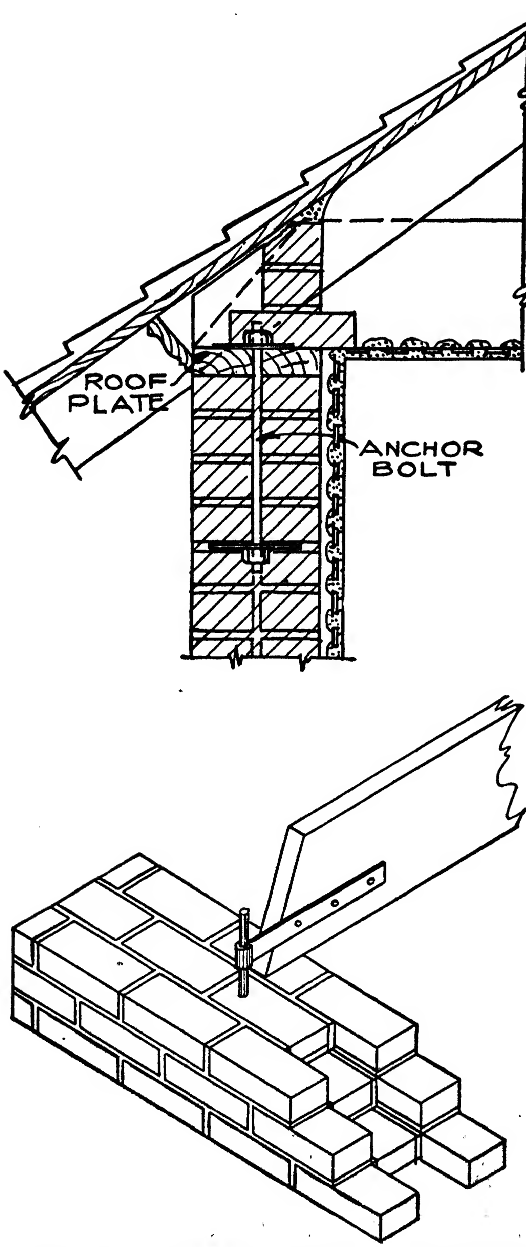


FIG. 23.—Roof-plate anchor and commonly used type of joist anchor.

Roof-plate anchors are built in as the wall nears that level. They are generally ½-in. bolts with a washer at the bottom and a nut and washer at the top.

Joists.—Joists with square ends should not be placed in a masonry wall. The ends should be splayed or fire cut as shown in Fig. 23. This enables the joist to drop out easily in case of fire without damaging the masonry.

A narrow space should be left on each side and at the end of every joist to allow the air to circulate around it to prevent dry rot.

Cleaning Brickwork.—The brick mason's job is not finished until his work is cleaned or washed down, if necessary with a dilute acid bath (usually a 5 per cent solution of muriatic acid, 1 pt. to 3 gal.), followed by a copious flushing with water.

Care in building the exposed tiers of brickwork will, more often than not, be well repaid in the smaller amount of cleaning necessary. It takes time to clean mortar stains from brickwork.

BRICK CONSTRUCTION IN FREEZING WEATHER

Cold Weather No Obstacle to Good Work.—Good brickwork can be produced in freezing weather and operations successfully carried on during winter weather, as was evidenced in demolishing old brick walls constructed in Winnipeg, Canada, during the coldest portion of intensely cold winters. It is the custom today at important summer resorts to do all construction work throughout the winter. Brick masonry may be built in cold weather at no great additional cost if a few simple precautions are taken.

Mortar.—Portland cement or cement-lime mortar should be used in freezing weather. Freezing temperatures may injure natural cements, and lime mortar sets too slowly.

It is better not to mix lime with the cement mortar, but in the event that it is used, only just enough lime to make the mortar workable should be added, for lime delays the initial set of the cement mortar.

Brick.—Impervious bricks are laid with more difficulty in freezing weather than are nonimpervious brick.

Bricks laid in freezing weather should not be wet. Bricks should be thoroughly dry and free of ice when laid in the wall. Much money will be saved in bricklayers' time if the brick piles are kept covered with tarpaulins.

Heating Materials.—On a small job in a moderate climate it may be possible to avoid the expense of special equipment. Manure may be spread on the soil around footings to prevent

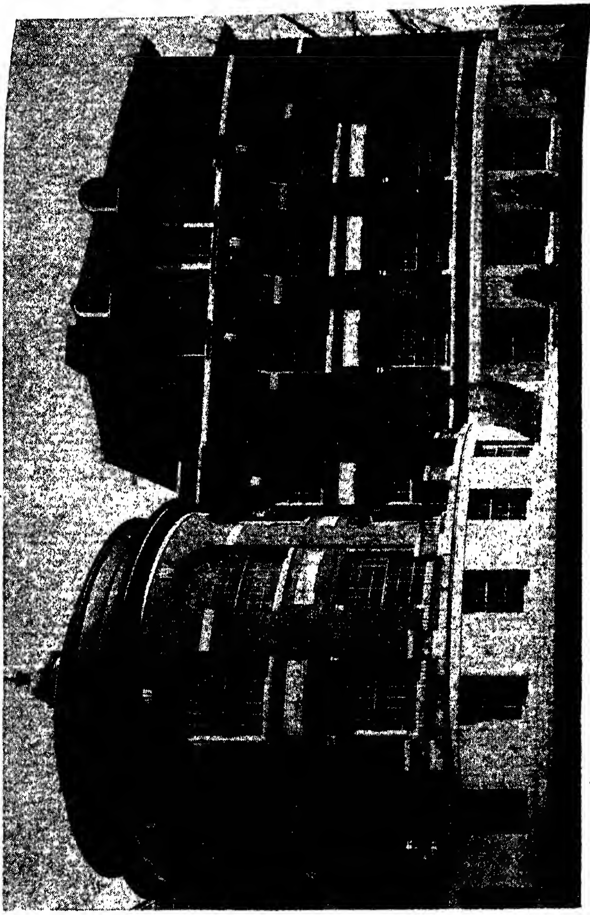


Fig. 24.—Gilman Hall at Johns Hopkins University at Baltimore illustrates adapatability of brick to straight or circular surfaces. These Homewood colonial brick are laid in Flemish bond with the Homewood joint referred to in text, which consists of a fine line drawn through the center of the mortar joint by a pointed tool. (*Courtesy of Parker, Thomas & Rice, Architects.*)

penetration of frost beneath them. Sand may be piled in a long high heap. The top and sides of the heap will freeze and sand for use can be tunneled from the ends. The openings at the ends should be kept closed. Frozen sand must not, of course, be used for making mortar. Mortar should have attained its initial set before it freezes, although some contractors who have successfully carried on operations in freezing weather are satisfied if the mortar can be kept from freezing until placed in the wall. A salamander or fire kept going near the box will help in preventing the mortar from freezing.

In severely cold weather, however, and on larger work the following methods may be followed advantageously:

All materials, including brick, water, cement, and sand, should be heated so that the mortar will be about 60°F. when bricks are laid. Sand may be heated most conveniently by running horizontally through the material pile a corrugated sheet-metal culvert about 20 in. in diameter and 10 ft. long, or an old steel chimney stack or any other circular iron section, keeping a fire going at one end. Water may be heated in a coil attached to the water main with a fire in the center, or in an iron can placed over a fire. Water should not be allowed to get much hotter than 165°F. or it will injure the mortar.

Lowering the Freezing Point of Mortar.—Salt or calcium chloride is sometimes added to the mortar to lower its freezing point, but these substances may cause efflorescence on the face of the wall and should not be used where appearance is a factor.

Screens for Bricklayers.—It is possible, where the cold is not too intense, to run a small job in winter without special equipment or protection. This applies also to protection for bricklayers, although bricklayers are, of course, more comfortable in an enclosed space heated with salamanders.

A screen may be constructed of canvas or tarpaulins on light wooden supports, forming an enclosure over the wall being built, with openings for material, etc. Salamanders fired with coke will keep the enclosure comfortable and help the mortar to set. Coal should not be used, as its gas affects the workers.

Keeping the Walls Even.—If a wall is carried up several feet in a day on one side of the house only, there may be some danger of throwing it out of plumb if the warm rays of the sun strike it. It is better practice to build less height per day and keep the walls at an even height all around the house. Clipped bond and metal wall ties should be avoided in freezing weather, and headers should be placed at least every sixth course.

Closing Up Each Story.—Each story should be closed up as soon as the floor joists are laid. Rough flooring above should be placed and openings boarded up, using building paper to cover the cracks. Salamanders should be used to raise the temperature and dry out the wall for the plasterer.

Keeping Going in Winter Weather.—It is not necessary to shut down in winter. Many operations, small and large, have been successfully put through in cold weather. There is no profit when the work is closed down.

CHAPTER III

STRUCTURAL USES OF BRICK MASONRY

PRACTICAL REFERENCE DATA ON DESIGN AND WORKMANSHIP IN TYPICAL STRUCTURAL APPLICATIONS OF BRICK IN BUILDINGS

Reference data pages, which constitute this chapter, present practical information on design, materials, and construction methods relating to the use of brick masonry in typical buildings.

To simplify reference to the subjects covered, the problems of brick construction are arranged as closely as possible in the order of their consideration when designing or erecting a brick masonry building. Thus the first section is devoted to footings, foundations, and basement construction; the next to different types of walls, and so through to a series of special problems which cannot be arranged in any structural or design sequence.

Except where necessary for eliminating too-frequent cross reference, the general information contained in Chapter II which relates to the broader problems of brick masonry construction is not repeated in the individual reference sections. For this reason, the reader may benefit by becoming thoroughly familiar with the contents of Chapter II before attempting to use the more specific information that follows.

Technical Design Data.—It should be noted that this book makes no attempt to incorporate technical details regarding structural design of the elements of brick masonry.

Estimating Data.—While general methods of estimating the quantities of materials required in any typical construction are given wherever possible in these reference pages, the reader should become familiar with the condensed reference tables which constitute Chapter V of this book.

FOOTINGS, FOUNDATIONS AND BASEMENT DETAILS

Advantages of Brick Construction in Basements.—Brick masonry constitutes excellent construction for basement walls, footings, piers, and floors. Among its advantages are the following:

1. Brick walls have great stability, easily resisting abnormal thrusts and stresses of considerable magnitude.

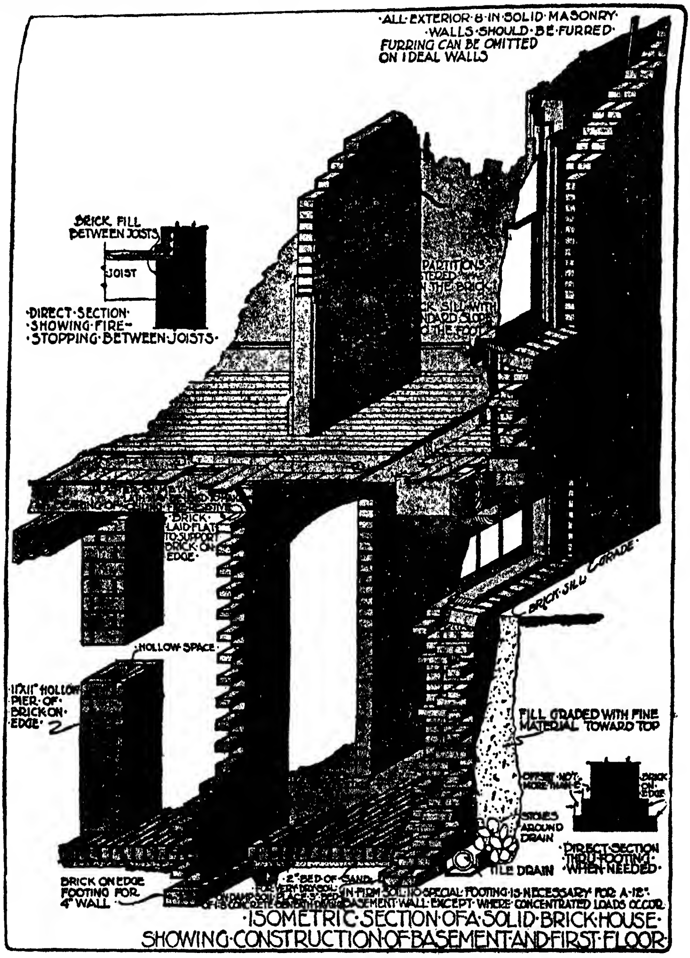


Fig. 25.

2. Brick basements require less excavation, less equipment, fewer materials, less supervision, and less overhead. They are quickly completed immediately after excavation is finished.

3. Brick basement walls are moisture resistive when properly built and may easily be waterproofed in wet soils.

4. Brick is unaffected by soil alkalies and should always be used in strongly alkaline soils, to the exclusion of other materials.

5. Brick basement walls are attractive in appearance and facilitate the use of basement space for playrooms, secondary living rooms, etc. They form excellent backgrounds for pictures, rugs, wrought-iron ornament, and other decoration. By laying the inner face of the wall in a selected bond or simple pattern, a recreation room may be made an architectural feature of extraordinary interest. Brick partitions should enclose the other sides of the basement room.

6. Brick piers are economical, permanent, and more highly fire resistive than metal stanchions or columns. The latter, filled with plain concrete, are given only a 25-min. fire rating; filled and reinforced, they have a 45-min. fire rating. Brick piers enjoy maximum fire ratings.

Workmanship.—In *footings* for both walls and piers, all joints should be completely filled by shoving the bricks into a full mortar bed or by grouting. Every other course, from the bottom upward, and the last outside course in each layer should be of headers, so that the corbeled overhang will be but a minor fraction of the total brick length (not over 2 in. in any case). The lowest course should rest on a full bed of mortar so as to spread the load uniformly.

A drain should be properly laid around the entire footing (in water-bearing soils) and connected to the sewer or other discharge.

Foundation walls should have all joints filled, be properly bonded, and be plumb with all courses horizontal. Maximum strength is thus developed. This also aids to ensure watertightness. The outside of foundation walls below grade should be plastered, as the work proceeds, with a coat of cement mortar, not less than ½ in. thick, well troweled on to an even smooth surface. In damp or wet soils, it may be well to add also a coating of bituminous waterproofing.

The construction of *piers* is governed by the same precautions as foundations, except for those affecting damp-proofing. Joints should be filled, the work well bonded and built plumb with courses horizontal. No chases or other openings of sufficient size to decrease the necessary bearing area should be built into piers.

Design and Construction Data.—Footings or walls without footings must always be taken below the frost line. The frost *should be given no chance to heave up walls or footings, porch* walls included.

No part of the building is more important than the foundation. If there is the least doubt regarding the firmness of the soil, the excavation should be carried down to firmer ground, and the footing made wider by stepping off with more courses. Never place a wall on filled ground or spongy, springy soil.

If stone of suitable character for footings or foundation walls is encountered during excavation, it may be economical to use it instead of brick below ground.

Footings.—A residence foundation wall 12 in. thick built upon firm ground will not require a footing in the majority of cases, except where concentrated loads occur. Where a footing is deemed necessary it may either be composed of concrete poured into a trench or be built expeditiously of hard-burned brick in cement mortar. The footing for a 4-in. interior partition may be 8 in. wide, consisting of a header course on edge.

Projections are formed by stepping off each course or every other course about 2 in., the projections being formed of a continuous course of headers. Projections should be equal on both sides of the wall. It is recommended that projecting courses be formed of brick on edge, these being capable of resisting a greater transverse stress than flat courses.

The excavation should be carefully leveled and the first course laid on cement mortar spread upon the ground.

Drain at Footings.—It is advisable in almost all cases to place a porous tile drain at the bottom of the wall or at the footings to carry off any water that may accumulate. This drain should be laid with an even slope, the high point not above the floor level and the low point not below the bottom of the wall or footing.

The best way to avoid dips and traps in the drain is to lay it on a board with a strip nailed at the side to hold it in place laterally. The fill over the tile should be of dry material such as large stones or broken brick placed carefully on the tile—not dumped from a wheelbarrow—and the finer fill graded toward the top. The tile should be connected with the cellar floor or surface-water-drainage system.

Basement Piers.—If local ordinances permit, basement piers may economically be built hollow with brick on edge, as shown in Fig. 25.

Basement Paving.—If the soil is firm and dry, basement paving may consist of brick on edge or flat laid upon a bed of sand not less than 2 in. thick. The sand is tamped or rolled level and the joints afterward carefully poured full of cement grout, the brick being wiped clean before the grout has set. Another

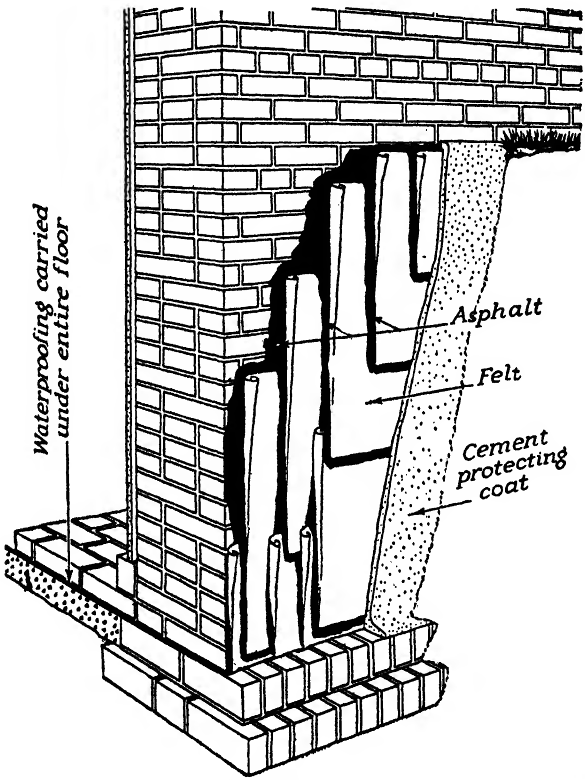


FIG 26.—Method of applying membrane waterproofing to walls and floors subjected to severe hydrostatic pressure.

method is to sweep the joints full of cement grout with a broom. Methods of laying brick walks and steps apply also in general to basement paving. A cheaper method even than this is to sweep the joints full of sand, as described for garden walks. Salt should be mixed generously with the sand to eliminate all danger of vegetation appearing between the joints. If the soil is not firm, however, the floor laid by either of the foregoing methods *may become irregular in time.* If there is any doubt about the *firmness of the soil or if it is not quite dry, place a 3-in. bed of lean 1:8 concrete under the floor with the brick wearing surface on top.*

Number of Bricks in Basement Paving.—Figure the area of the paving in square feet. If the bricks are on edge, read the number of bricks required from Table 9, page 165. If laid flat, figure 4½ bricks per sq. ft.

Allow 1½ cu. ft. sand to every square yard of paving for a cushion 2 in. thick.

Grout for Basement Paving.—Grout should be mixed in the proportion of 1 part portland cement to 3 parts sand, made thin so it will run down and fill the entire joint. Approximately 3 bags cement and ⅓ cu. yd. sand are required for every 1,000 brick laid with joints 3⁄16 to ¼ in. wide.

Damp-proofing Basement Walls.—Except in extremely dry soils, it is much safer to damp-proof the basement walls. This should always be placed on the outside of the wall.

To resist ordinary dampness, the best damp-proofing is considered by many to consist of asphalt thoroughly well mopped boiling hot directly on the brick wall, which should be laid with struck joints. A mixture of 3 parts tar and 1 part pitch is sometimes used; this forms an excellent low-cost damp-proofing. Tar alone is sometimes employed, but it soon becomes brittle and flakes off. A ½-in. coat of cement plaster is sometimes used, but it is probably not as effective or reliable as mopping the wall as described above.

If the soil is actually wet, the wall may be waterproofed by first mopping it thoroughly with boiling hot asphalt, and then applying one or two thicknesses of felt, with asphalt mopped between each ply and over the last ply. This treatment is expensive and need only be applied where water conditions are severe.

In very wet soils it is also advisable in some cases to waterproof the top of the footing to prevent moisture rising in the wall by capillary attraction. Two courses of slate, laid to break joint, or a strip of composition roofing will answer this purpose. As a further protection, a similar course may also be laid about 6 in. above the grade line.

Coating 1,000 sq. ft. of brick wall with asphalt requires 200 lb.

hot asphalt, 4 hr. attending fire, and 4 hr. mopping the wall. A boiler will be required for heating the asphalt.

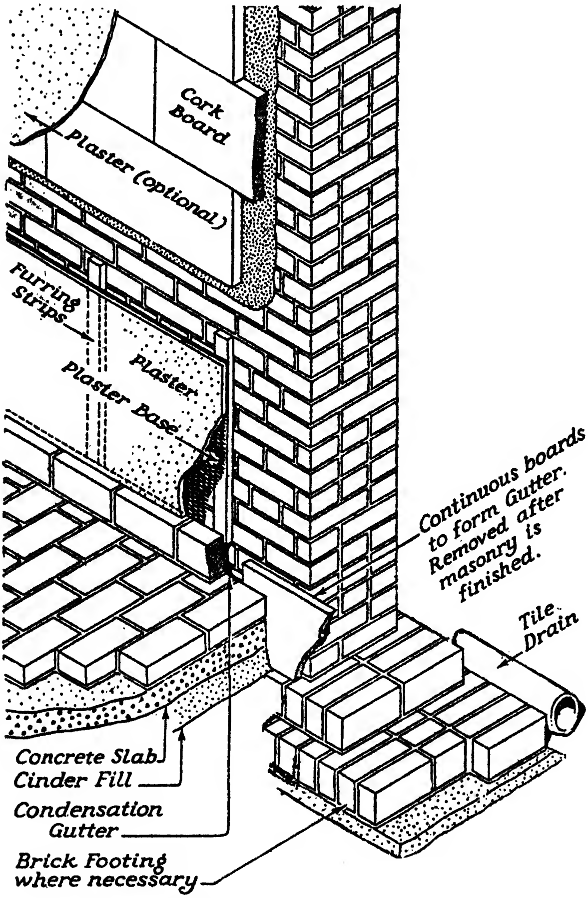


Fig. 27.—Alternate method of eliminating condensation on basement walls. Note formation of condensation gutter and use of insulating board and plaster. Open joints should be left at intervals in the brick base trim to allow water to reach condensation gutter.

Cement plaster for damp-proofing the outside of basement walls below grade should be composed of 7 part portland cement to 2 parts very coarse sand. The finish should be compactly troweled fairly smooth but need not be floated. The following quantity of material is necessary to cover 100 sq. ft. of brick with plaster

½-in. thick: 2 bags portland cement, 4 cu. ft. sand, ½ hr. laborer's time mixing plaster.

Eliminating Condensation in Basements.—Much of the dampness found in basements of any construction is due to condensation rather than to leakage through walls or floors. Masonry walls in contact with earth are not responsive to temperature changes within and frequently remain colder than the air in the

Fig. 28.—Building a basement wall 12 in. in thickness. With brick no forms are necessary.

basement after the heating plant has been turned off in the spring and summer. Moisture-laden air, entering the basement at these times, is cooled by the walls and condenses its moisture thereon, causing a condition of apparent dampness that is frequently blamed upon leakage.

Condensation Gutters.—If solid brick or other masonry walls below grade are left exposed, they are inevitably subject to condensation when there is no artificial heat to keep the air relatively dry. When the basement is not used for recreational or living purposes, this condensation does no damage and may be relieved by keeping the basement well ventilated when the heater is not in operation. Condensation that forms upon the walls may be prevented from spreading over the floor by constructing a condensation gutter in the manner illustrated in Fig. 27.

This gutter is formed by laying a 1-in. board against the inner face of the foundation wall from the top of the footing to a point above the grade of the finished floor. If a concrete subfloor or basement floor is laid, it should be poured against this board and not be permitted to bond with the footings. The finished brick floor surface, if used, should also be laid up against this board and the entire floor area should be pitched to drain from the center toward the surrounding walls. After the floor is completed, the board should be removed, leaving a gutter which will carry the condensation into the earth.

This construction is only recommended when the footings are drained with a tile drain carried to some outfall. If soil conditions are very wet and no drain is provided, this type of gutter should be omitted and, as a substitute, a shallow cement or brick gutter should be run around the foundation walls and pitched to drain at one corner into a sewer connection.

Insulating Basement Walls.—Where basement areas are to be used in summer for living or recreational purposes, condensation can be minimized or entirely eliminated by applying an insulating material to the inner face of the foundation wall which will prevent the contact of moisture-laden air with a colder surface. This material may be corkboard ($1\frac{1}{2}$ or $2\frac{1}{4}$ in. thick) or any fibrous insulating board of related character. These insulating materials can be applied to the inner surface of the brick wall, either by embedding them in a plaster coat of cement mortar or by the use of hot pitch or asphalt mastic.

Precaution should be taken at the same time to wrap all cold-water lines with an insulating material, as a great deal of condensation forms on such pipes and drips on the floors.

Furring Basement Walls.—Another method of eliminating condensation in livable basement areas is to fur the walls and apply a plaster base and plaster finish in the customary manner employed in the upper parts of the house. This will tend to prevent condensation entirely, but if any does develop behind the plaster, it will drip to the condensation gutter above described and be carried away without causing dampness in the living areas.

TYPES OF BEARING AND NON-BEARING BRICK WALLS

Solid and Hollow Walls

The following sections present basic data concerning types of wall construction and standards of workmanship. They should be referred to in connection with all subsequent data on wall construction of any type.

Solid Brick Walls.—Solid brick walls are to be preferred over any other form of unit masonry construction for almost every condition of service. They offer maximum stability, strength, durability, weather resistance, fire resistance, soundproofness, and adaptability to future alterations. All other types of brick wall construction must be considered as substitutes for solid walls; their use is justified by economic considerations (including enforced competition with inferior constructions) or by conditions of service that do not require the superior merits of solid walls.

Hollow Walls.—The Ideal wall is the general name used to describe all types of hollow walls built with standard solid brick—the universal and reliable burned-clay product—by placing some or all the brick on edge. There are three types of Ideal walls, all detailed in this publication, as follows:

Ideal Rolok-Bak walls.
Ideal all-Rolok walls.
Ideal all-Rolok walls in Flemish bond.

Only in the all-Rolok types does the exterior appearance of the Ideal wall differ from the standard and traditional brickwork with which all are familiar. In the other type—the Rolok-Bak wall—the face of the wall may be worked out in any bond and joint to suit the builder's taste, and the complete wall has the same appearance as a wall of solid brickwork.

Uses of the Ideal Wall.—Ideal walls are recommended for all purposes where walls of hollow units of other materials than brick are permitted under building-code regulations or by local custom. These purposes include basement wall construction, load-bearing exterior and interior walls, isolated piers, and curtain and interior partition walls.

Economy Wall.—The Economy wall is a brick wall 4 in. thick, blanketed with back mortaring, strengthened at intervals with vertical pilasters, having brick corbeling for the support of floors and roof, providing a 4-in. outside reveal for doors and windows, and with every window and door frame bricked in.

This wall makes a scientific and highly efficient use of the minimum amount of material that can properly be used in wall construction. The cost is therefore kept down to the minimum. That this wall is the lowest cost masonry wall is only natural, for brick is the cheapest manufactured material on the market.

Uses of the Economy Wall.—The Economy wall is a type of brick construction designed primarily for one- and two-story-and-attic houses, for garages, filling stations, and many other minor buildings. It is also excellent for garden walls, for

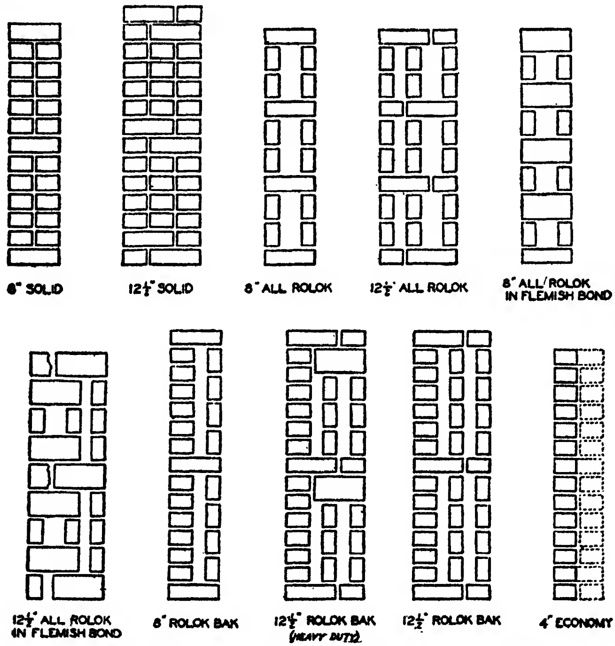


Fig. 29.—Various types of solid and hollow walls.

property line walls around large estates, or wherever a fence might be required.

Vaulted Wall Construction.—A type of hollow wall construction much used in some localities on this continent and very frequently in Europe consists of two walls of brick laid flat, separated by a 2-in. air space and connected with metal ties. In this country the wall is generally constructed with a total thickness of 10 in. A 14-in. thickness is sometimes employed. This wall is an excellent type of construction for residences but costs more than the 8-in. Ideal or solid wall and cannot be as strong as either of these types.

This wall is built upon the same basic principle of the ventilated air space as the Ideal wall, and its established and continued use is but another proof of the soundness of this principle.

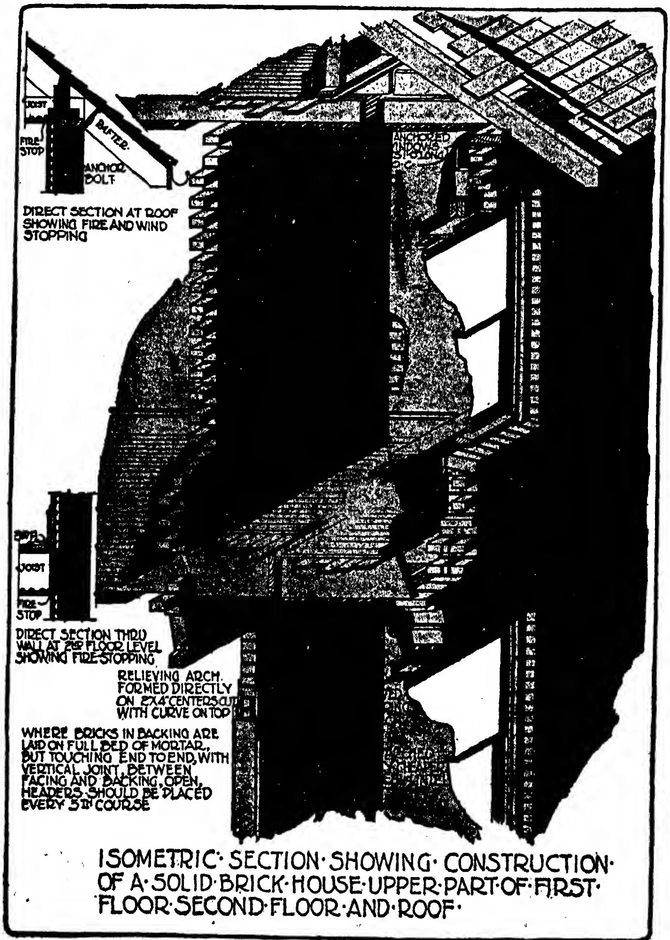


Fig. 30.

Furring is not required with a 10-in. wall of this construction, except under the same limitations for intensely cold climates as described for the Ideal wall.

BUILDING CODES SHOULD PERMIT 8-IN. WALLS FOR RESIDENCES

That a thickness of 8 in. for the brick walls of the usual home, above the basement, is ample, both for the first and second stories, is proved by recommendation of government authorities, by endless examples in practice, and by theory.

Government Advises 8-in. Thickness.—The Building-code Committee of the U.S. Department of Commerce recommends that 8-in. brick walls be allowed for the upper 30 ft. of exterior walls of residences, with an additional allowance of 5 ft. for gables. Foundation walls 12 in. thick are recommended for the excavated portions and 8 in. thick for unexcavated portions of the basement.

Nevertheless, an 8-in. solid brick foundation wall for dwellings is amply strong and amply stable (as a retaining wall) when the weight resting upon it is the equivalent of at least 12 ft. of vertical solid 8-in. wall. The greater the superimposed weight, the greater the stability.

The 8-in. brick wall is enormously strong; it is unquestionably firesafe; it now forms warm and dry walls for the homes of multitudes of people and gives a man of small or average means free choice of his building material without taxing his preference for good construction. Building codes not already permitting this thickness of brick wall should be amended so that both inside and outside the fire zones the 8-in. solid or Ideal wall will be allowed.

STANDARDS OF WORKMANSHIP

Bearing Walls.—The strength requirements of bearing walls are well ensured by full, flat (not grooved) bed joints, plumb walls, and horizontal courses. When laid in common bond, headers should be used in at least every sixth course. When maximum strength is not required, headers every seventh course may be used. It is not necessary to fill all vertical joints completely, especially those between vertical tiers or withes of brickwork, to obtain maximum compressive strength, but such vertical joint filling is required for high transverse and shearing strengths.

Toothing should not be permitted if it can be avoided. However, it may be used in joining new work to old. When used, all joints in the toothing should be filled, not just buttered or pointed on the outside. Careless work at such points may result in wall leaks.

Wall anchors and other ties are set by the brick mason and should be solidly bedded in mortar. It may be well also to

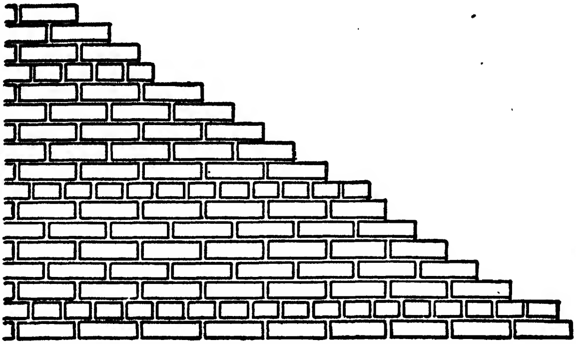


FIG. 31.—Incompleted wall sections should be stopped in manner shown here.

check their number and location and see that the plans and specifications, or the provisions of the local building code referring to their uses, are complied with.

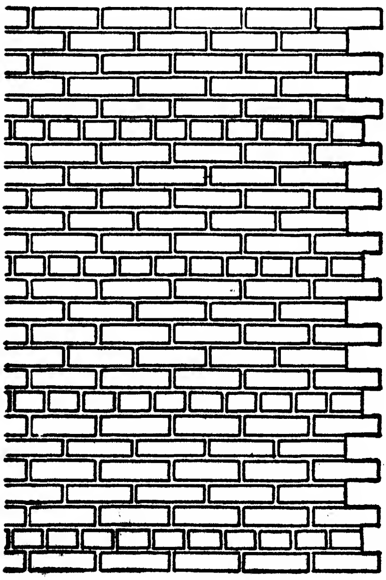


FIG. 32.—Toothing as shown here should be avoided except where necessary in bonding new work to old.

To prevent the penetration of water or dampness into a brick wall, all horizontal joints in the exterior tier and at least three-fourths of the thickness of all vertical joints must be filled with mortar. Lack of proper joint filling is the most common cause of leaking brick walls. Sufficient mortar must be used in bed joints (preferably spread flat) and each brick pushed into place so that bed joints are full. A common fault is that vertical exposed joints are only partly filled (by buttering the end of the brick); often the vertical joint is no more than pointed with a thin wedge of mortar.

Care should be used in placing closure bricks, either whole bricks or bats. See that they are cut small enough (when necessary) to permit a full vertical joint at each end. And see that a full end joint is laid, either by slushing or grouting.

The important thing in preventing leaking walls is to have all joints in the exposed tier or withe filled with mortar, not too rich. If this is done, the inner space, or spaces, between vertical withes may be unfilled or open, thus furnishing an air space across which the water will not travel, and also in some measure increasing the thermal resistance of the wall.

Hollow walls of brick, with outer exposed joints well filled, are highly resistive to water travel through the wall.

Curtain and Panel Walls.—The general provisions applying to outer walls apply equally well to panel and curtain walls. In addition, see that courses are properly laid out and the work is so executed that the periphery, or boundary, of all such walls is built solidly against the supporting framework. When the facing course projects beyond the framing proper, angle or other supports should be used, and the facing, in all cases, should be properly bonded to the backup.

It is usually necessary, and almost always desirable to build flashing or other water-diverting members into spandrel walls. The mason should see that this is not neglected.

Bonds and Patternwork.—A good workman will thoroughly understand the bond specified for use and will see that it is carried out with fidelity. He will lay out his work in advance so that both horizontal and vertical joints come flush with window and other wall openings with little or no cutting, and vertical joints plumb and in line. All joints should be properly struck with the trowel or pointer, as the case may require.

Brickwork courses should be laid out in advance, with proper joint thicknesses, so that the work will come to the right heights for the placing of window sills and lintels, doorheads and floor levels, all with a uniform thickness of bed joints. Lack of uniformity may spoil the beauty of the work. Special care is necessary in laying out the work when several workmen are building the same wall. In this case, see that the line is horizontal, using one or more trigs to prevent sagging of the line between distant supports. See that bricklayers do not "crowd" the line, thus causing the wall to look wavy.

Decorative Treatment.—In addition to carrying out bond work with fidelity, the mason should see that all decorative patterns and other ornamental masonry features are installed as specified or shown on the plans. All instructions applying to brickwork in general apply with equal or greater force to ornamental work.

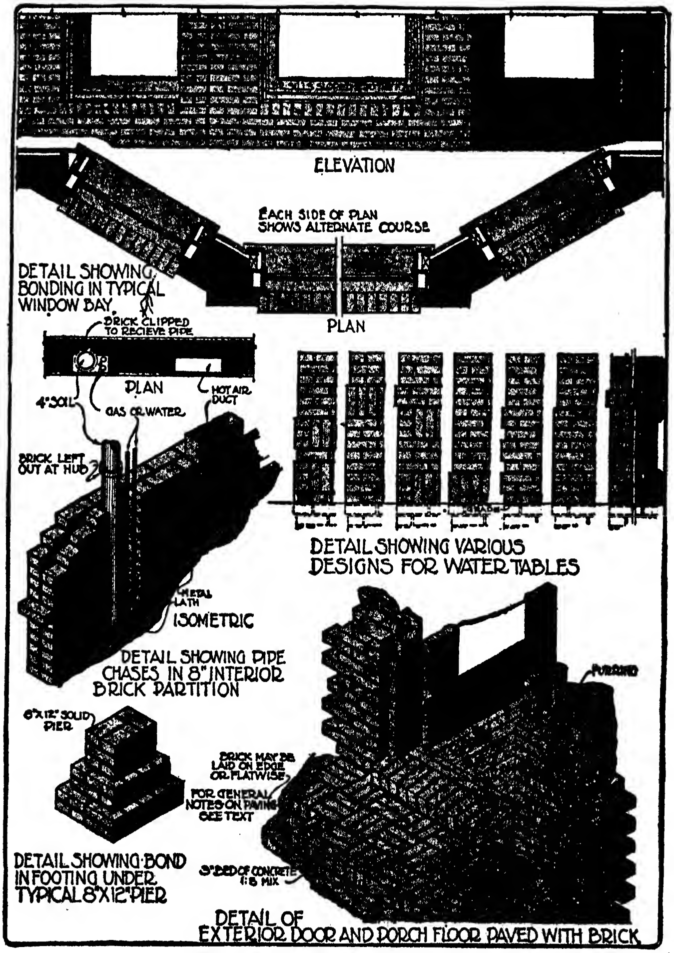


Fig. 33.

WORKING WITH OTHER TRADES

Bricklayers should, at all times, keep in mind the requirements of the other trades and so build into their work *all* the necessary chases, nailing strips, and blocks. The back of the wall should be smooth and plumb so as to facilitate furring, lathing, plastering, or other interior finish. Inattention to these points can be very costly.

Leaving Openings and Chases.—The location of chimneys, openings, and chases shown on the plans or otherwise necessary should be carefully noted and all such items taken care of as the wall goes up.

Pipes in Brick Walls.—Electric conduits, gas pipes, and small water pipes may be built within a solid wall as it goes up, and they can easily be placed in a sloping position in Ideal walls after the latter are built.

Four-inch soil pipes may be brought down and concealed in an 8-in. solid or Ideal interior brick wall. These pipes measure 6 in. over the hubs.

The method employed for a solid wall is to leave a chase 4½ in. deep where the soil pipe is to be placed. When the plumber is ready to "rough in" his work, a small section of brick about 2½ in. wide and 1 in. deep is chipped out from the back of the chase behind the exact location of the pipe unless the wall is to be furred or stripped, when no chipping is required. Where the hub of the pipe occurs one brick may be taken out entirely. Gas and water pipes may also be run in these chases. The open side of the chase is covered with wire lath and plastered with the rest of the wall. The holes on the other side of the wall, where brick were removed at the pipe hubs, should also be covered with wire lath. (Fig. 33.)

In an Ideal all-Rolok wall the 4-in. soil pipe will fit the hollow space with a little chipping, a brick being left out at the hubs.

Soil and water pipes should always be placed within interior partitions to lessen the liability of freezing.

Duct Chases.—Hot-air ducts may also be set in 8-in. solid or Ideal walls. Leave a chase slightly wider than the width of the tin ducts, and after the duct is set cover with wire lath. (Fig. 33.) Ducts run in brick walls do not need to be covered with asbestos. As with plumbing pipes, heat ducts should never be run in outside walls.

Building in Nailing Blocks and Grounds.—When building Ideal walls, build in nailing blocks for the carpenters to attach base and trim. These blocks can be small pieces of 2 by 4.

For attaching furring strips to solid walls, build in plasterers' lath in the joints about every seventh course, well backed with mortar and slightly projecting; break joints of lath.

Furring.—Under favorable conditions in some localities plaster may be applied directly to the inside of 8-in. solid and hollow brick walls. Generally speaking, however, it is safer to fur the inside of any ordinary exterior 8-in. masonry wall.

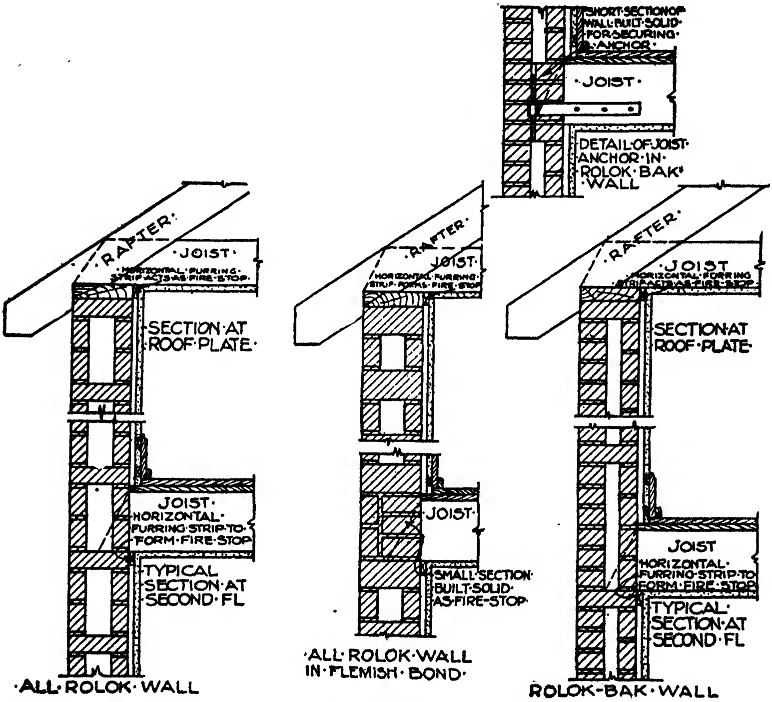


Fig. 34.—Details of hollow walls at floor and roof levels, showing typical joist and roof supports.

In hollow brick walls a few openings left in the inner withe of the wall below the first floor and also at the top of the wall, admitting circulation of air through the cavity of the wall, reduces the danger of moisture reaching the inner surface of the unfurred wall.

Furring may be of wood, metal, or hollow tile. Wood is ordinarily used, formed of 1- by 2-in. strips placed vertically, spaces 16 in. on center. In the cheapest work the strips are nailed into dry mortar joints; in better work, to lath placed by the masons in the joints, or the walls may be plugged with wood plugs left projecting and sawed off so that the strips will lie in an even plane, thus correcting any irregularities in the surface of the wall. Nailing to lath or to plugs also makes a more secure job than nailing into brick joints. The strips should be trued up where necessary by wedging behind them. Recent investigations show that furring strips placed horizontally will conserve heat in cold weather and also make effectual fire stops.

Split furring tile 3 or 4 in. thick, which are scored so that they can be split in half, are sometimes used. The tile is set without mortar and anchored at every second course by driving tenpenny nails into the mortar joints over every third tile. Tile provides a good surface upon which to plaster.

Metal furring is sometimes employed when metal lath is used. It may consist of small steel rods or stiffening members in the metal lath.

BUILDING CAVITY WALLS OF BRICK

Advantages of Hollow Walls

For certain kinds of structures and under some conditions the solid brick wall possesses an excess of strength and of fire resistance. This fact led to the development of hollow walls of standard solid brick, (known as Ideal walls), which reduce construction costs and at the same time give the remarkable advantages that always accompany the use of this ancient and dependable standard building unit.

Although thought to be new when introduced in 1924, it was found later that examples of this construction existed in nearly every part of the world where brick is used. Walls built in this fashion more than 200 years ago have been located and examined.

Ideal Walls Always Economical.—The only advantage that applies always to any type of hollow wall as compared to a solid brick wall is that the hollow wall is lighter than the solid. The question of the economy of *hollow unit* walls is a local one, inasmuch as they actually cost more than solid brick construction in some localities. But with the Ideal wall the economy advantage applies everywhere because, although it is built of the same material as the solid wall, it requires a smaller quantity. The saving varies according to the type of Ideal wall decided upon.

Advantages of the Ideal Wall.—Experience has indicated that

Ideal hollow wall construction possesses the following advantages and characteristics:

1. Lowest cost masonry wall possible to build for construction 8 in. thick and over.
2. Strongest hollow masonry wall.
3. Most highly fire-resistive hollow wall—not damaged by long exposure to high temperatures or water used in extinguishing fires.
4. The driest hollow masonry wall.
5. Contains thickest withes and has a large percentage of solids to voids.
6. Lighter in weight than the average hollow unit wall of brick substitutes.
7. Built of standard brick—no special sizes or shapes.
8. Bonds perfectly with any facing material.

GENERAL CONSTRUCTION DATA ON HOLLOW WALLS

Supporting Floors and Roofs.—Floor joists and roof construction should rest directly upon a header course. In most cases the header course can be made to come at the exact height required. If not, the header course can simply be brought up as nearly as possible to that height, the remaining height to the bottom of the joists being filled in with the necessary number of courses of solid brickwork to give the joists a firm bearing.

Setting the joists upon a header course also provides an effective fire stop.

Anchors.—While the necessity for using anchors to form a positive tie between floor and roof timbers and the masonry is no greater with the Ideal wall than with any other type of masonry construction, the use of such anchors is emphatically recommended by many experienced brick contractors. It is realized that the practice of using such anchors is more honored in the breach than in the observance; but when some natural calamity such as a tornado visits a community, it has been repeatedly shown that buildings in which anchors and other features of good construction have been conscientiously used come through practically unscathed. Small portions of the Ideal wall in which anchors are to be embedded can easily be made solid. In addition to anchoring floors and roofs, it is recommended that parapet walls be also substantially anchored to the construction.

Earthquake Construction.—It should be pointed out that in earthquake zones anchors are vital to the safety of the building. Girders, joists, and roof timbers should be anchored securely to the brick walls. Buildings so constructed will withstand earth-

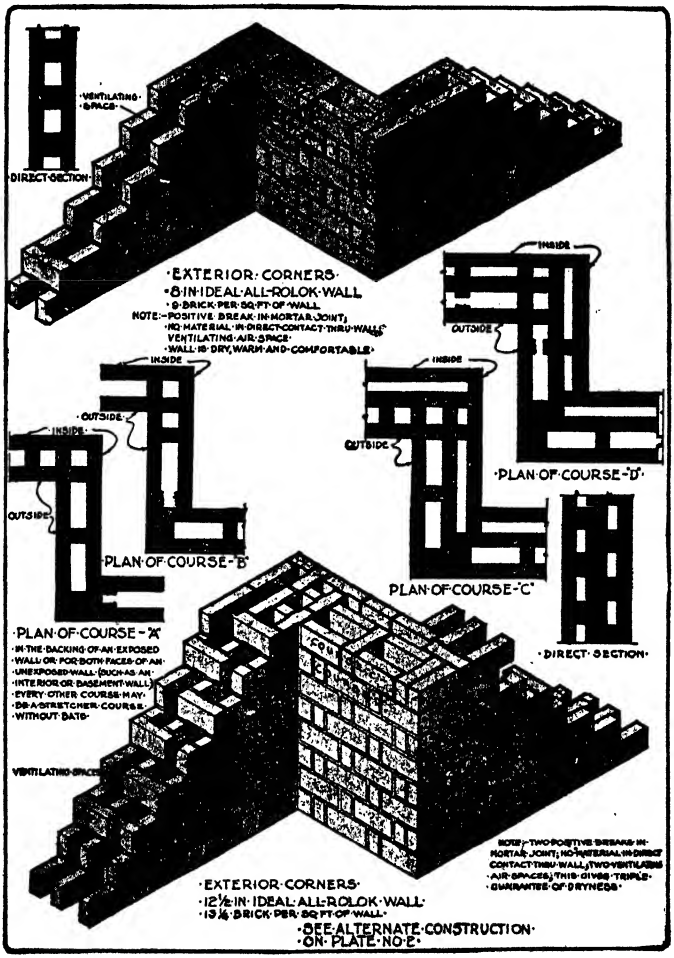


Fig. 35.

quake shocks without serious structural damage, as attested by numerous studies.

Window and Door Sills and Jambs.—Window and door sills (brick on edge or stone) are placed, and the frames set, plumbed, and braced upon them in the ordinary way, exactly as with the solid wall.

The frames are bricked in at the jambs also, exactly as with the solid wall.

Although not necessary for strength, it is recommended that the portion of the hollow space or spaces adjacent to the frame

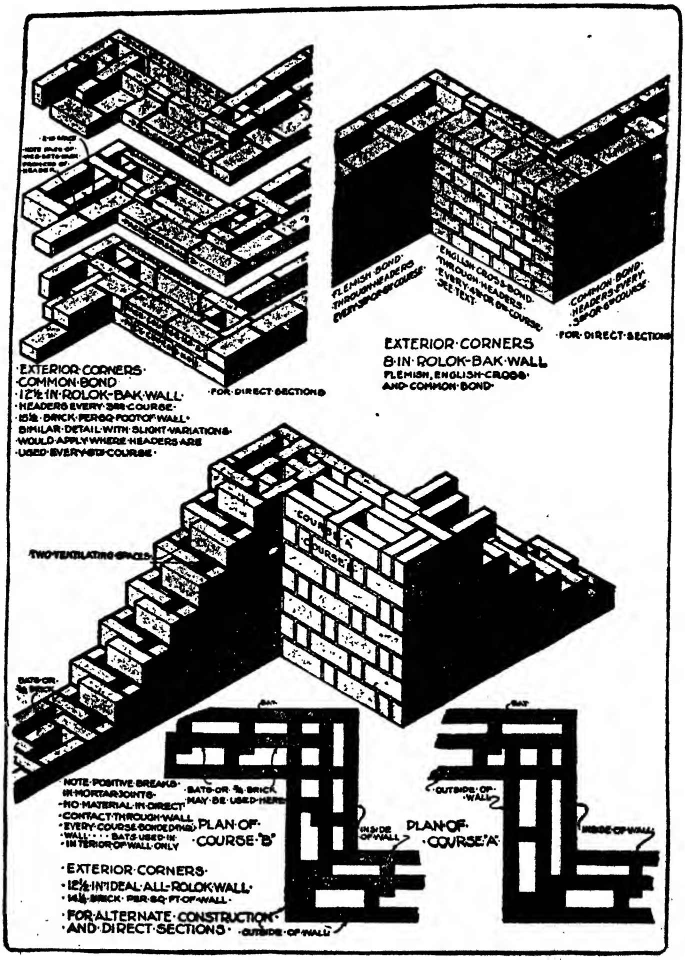


Fig. 36.

be filled for a width of 3 or 4 in. with brickbats to provide fire and draft stopping.

Exposed brick may be supported over openings by either of the usual methods of using lintels or arches.

For openings not exceeding the usual window or door widths, follow the same method employed in solid brick construction—that of placing 4- by 4-in. or 4- by 6-in. wood lintels to support the backing. The lintels have a 4-in. bearing on the brickwork

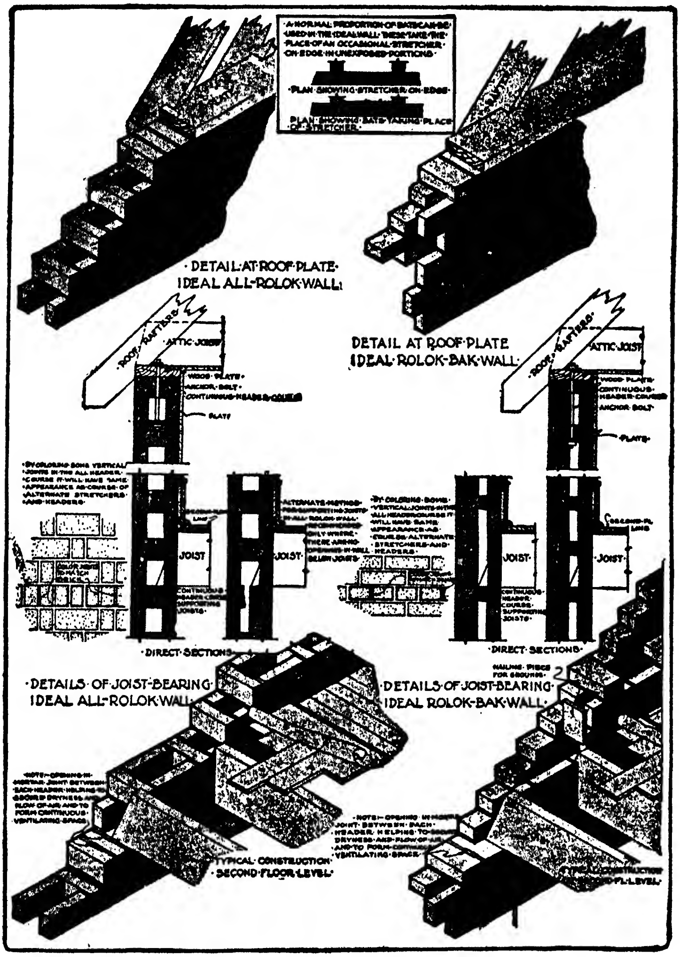


FIG. 37.

at each end. Brickwork either flat or on edge will arch itself over such an opening even after the wood lintel shrinks or is entirely destroyed by fire.

For wider openings the backing may rest on a steel lintel of proper size to support the load; or a wood lintel may be employed with a relieving arch over. A small portion of the brickwork at the spring line can be made solid to take the thrust, or the arch can spring from a header course. The space between the top

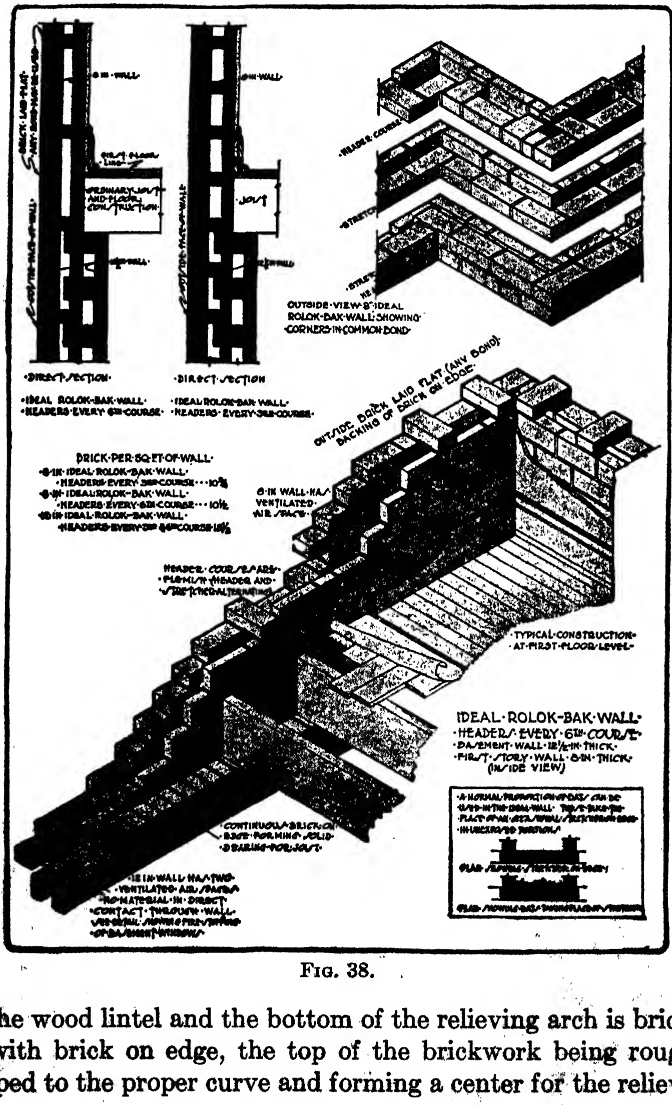


FIG. 38.

of the wood lintel and the bottom of the relieving arch is bricked in with brick on edge, the top of the brickwork being roughly shaped to the proper curve and forming a center for the relieving arch.

It should be emphasized that the foregoing methods are the traditional and ordinary methods of carrying brickwork over openings; the Ideal wall introduces nothing new or unusual in this portion of the construction.

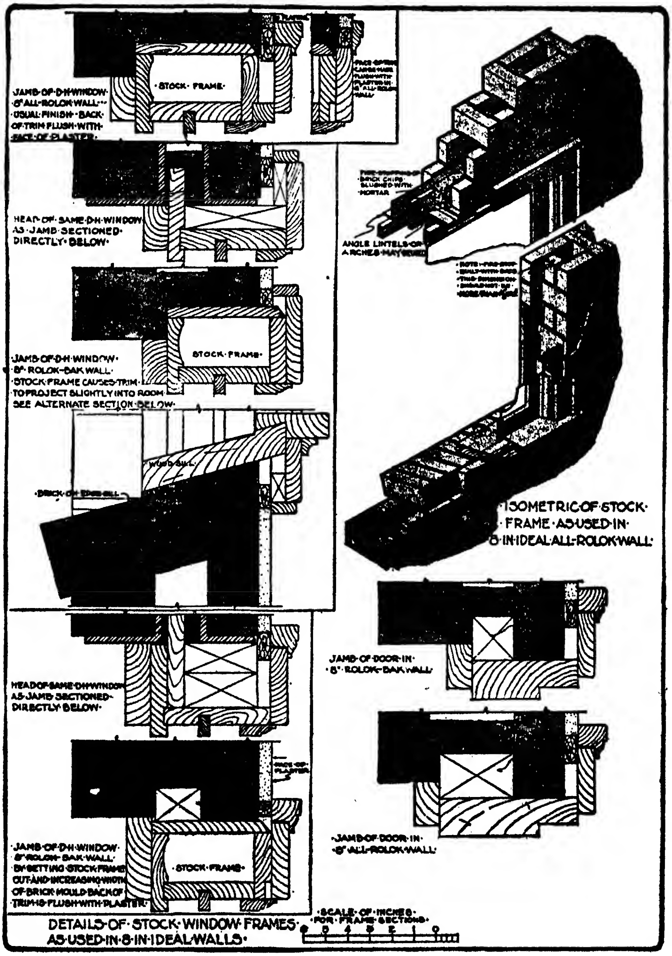


Fig. 39.

Steel reinforcing rods ($\frac{1}{4}$ in. in diameter) laid in the lower mortar joints develop ample beam strength for carrying the masonry loads above wall openings.

Mortar should be slushed over the top of wood window and door frames within the hollow space for the same purpose that the space is filled at the jambs—to provide fire and draft stopping.

Window and Door Frames.—Stock window and door frames in Rolok-Bak walls can have the same outside reveal and relation to the inside plaster line as in the ordinary wall.

In the case of 8-in. all-Rolok walls, the outside reveal can be made 2¼ in. wide—the width of a brick on edge. A piece of finish wood is placed between the inside face of the frame and the back of the trim at jamb and head as shown.

Mortar.—It is recommended that mortar of no less strength than 1:1:6 cement-lime mortar be used in constructing Ideal walls.

Thickness of Walls.—In the absence of code regulation, the following minimum thicknesses are recommended. Basement walls for masonry houses, 12 in. thick (or 8-in. solid walls). First-, second-, and third-floor walls for masonry houses, 8 in. thick. Basement walls for frame houses, 8 in. thick.

CONSTRUCTION OF ROLOK-BAK WALLS

General Description.—The *Rolok-Bak* wall is a general utility wall and may be employed not only for exposed walls but for unexposed walls and for basement construction. It forms a superior base for stucco where that finish is particularly desired, and for plaster in interior walls.

The exterior 4-in. thickness is laid with brick placed flat and the backing is laid of brick on edge. On the exterior, therefore, the brickwork has the usual appearance of brickwork laid in the traditional way and may be faced in any bond. The wall may be 8 in. thick or in multiples of additional 4 in. thicknesses.

In the 12-in. thickness, there are two types of the Rolok-Bak wall—the *standard* and the *heavy duty*.

In the standard Rolok-Bak wall, the flat header course is arranged in basket-weave bond so that it ties the whole wall together, as shown clearly in the illustrations. This allows the greatest saving in cost both in labor and material. A flat header course is laid with less labor than a solid header course on edge, and the wall requires fewer brick and less mortar per square foot.

The standard Rolok-Bak wall is designed for bearing walls of buildings in the multiple residential and other classes where a 12-in. thickness of wall is required and floor loads are moderate, such as apartment buildings, hospitals, clubs, office occupancies, etc.

The heavy-duty Rolok-Bak wall is designed for situations where heavy floor loads are to be carried.

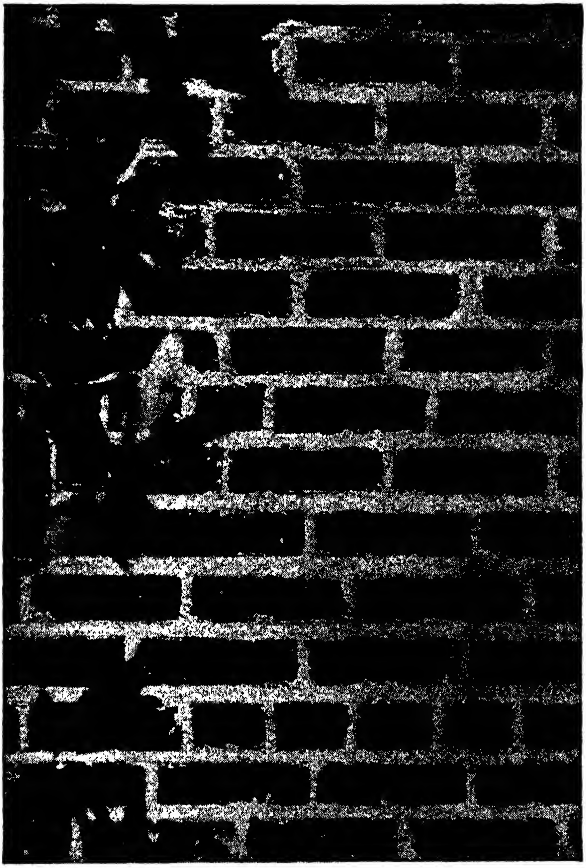


Fig. 40.—The Rolok-Bak wall does not reveal its construction on the exterior, its surface appearance being identical with that of the solid wall.

The heavy-duty wall is constructed by building the withes of the backing of three courses of stretchers on edge, the fourth course being a continuous course of headers on edge. On this course is laid a continuous course of flat headers, to tie the facing to the backing, with a flat stretcher fill behind it.

Appearance.—The Ideal Rolok-Bak wall has exactly the same exterior appearance as ordinary brickwork.

While the illustrations show this type of construction in common bond, any of the other bonds may be used instead. Even with the solid brick wall, when the more elaborate bonds such as Flemish, English, English cross, etc., are used, all headers not

Fig. 41.—The 12-in. all-Rolok wall is a sturdy structure with two air spaces inside the wall.

necessary for strength are bats not extending through into the backing. The bricklayer can save much time by building the outside 4-in. thickness "header high," afterward backing up. The same method of forming these more elaborate bonds by using bats is followed when building the Rolok-Bak wall.

The Flat Header Course.—Every seventh course of brick laid flat is a header course, to bond the facing to the backing.

Most building codes require this course to consist entirely of headers, a "continuous header course." Other codes permit

FIG. 42.—House at Dobbs Ferry, N. Y., with all-Rolok walls, Flemish bond. (*Courtesy of Theodore Meyer, Architect.*)

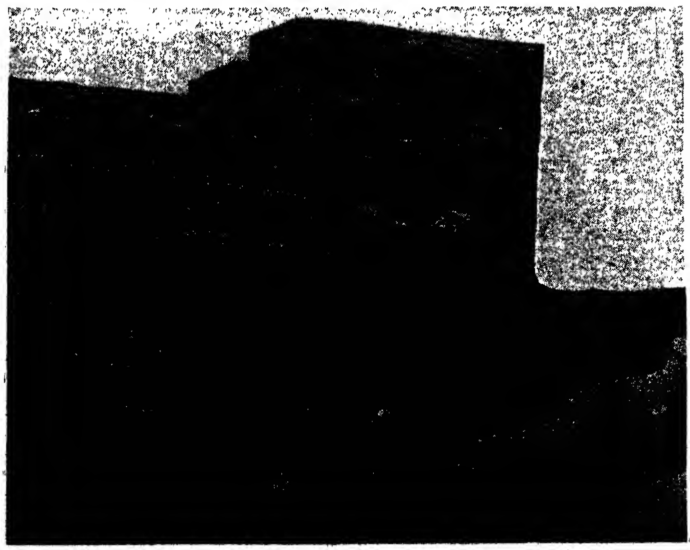


FIG. 43.—The sturdy 8-in. all-Rolok wall consists of alternate headers and stretchers on edge.

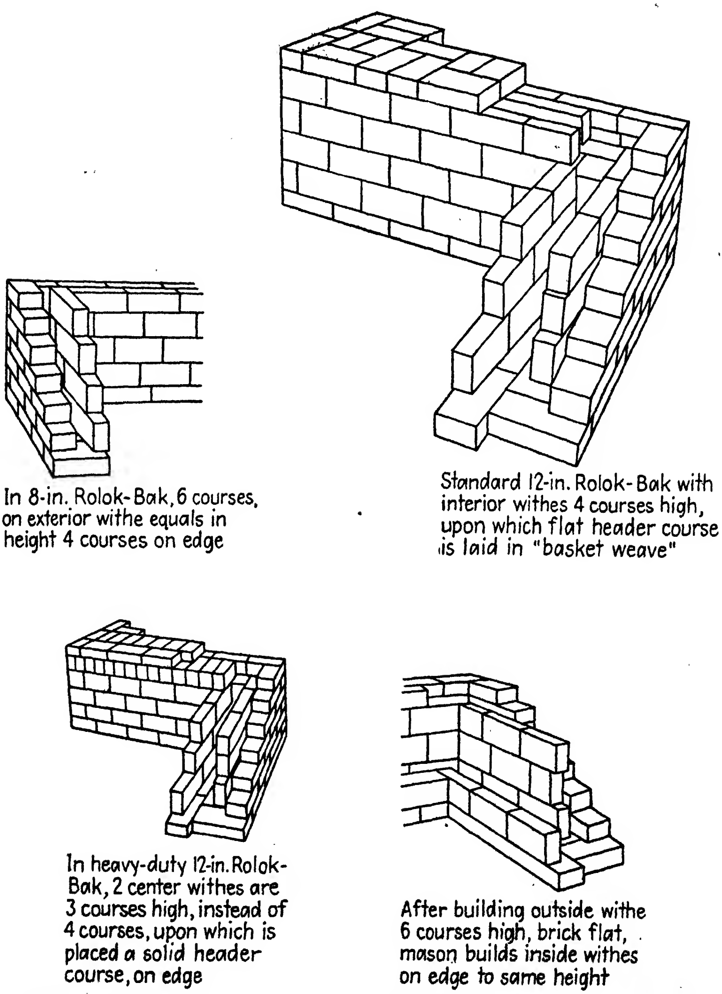


FIG. 44.—Details of construction of Rolok-Bak wall in 8-in., 12-in., standard and 12-in. heavy-duty types.

this course to consist of headers and stretchers placed alternately —a "Flemish header course."

The continuous header course is shown in these illustrations, except in the standard 12-in. wall.

The header course tying the two withes of the backing together in the 12-in. heavy-duty wall is shown as a continuous header course on edge, as this provides maximum strength.

Constructing the 8-in. Wall.—The bricklayer first lays six flat courses on the outside face of the wall. He then lays four courses on edge to form the inside withe. Six flat courses equal four courses on edge in height. He then places the header course.

Material Required, 8-in. Wall.—This wall requires 7 exposed bricks and 3½ backing bricks per sq. ft.

Constructing the 12-in. Standard Wall.—The six flat courses outside are first placed as for the 8-in. wall.

The center and inside withes are then built together according to the ordinary practice in the backing of brickwork, each four courses high.

The bricks for the center withe are placed against the back of the outside 4-in. withe, which thus forms a guide for the center withe. No mortar is placed in the vertical joint between the outside and the center withes.

Then the flat header course is placed, to tie the wall together. It is suggested that this course be backed up as each 8-in. length is placed. The headers are laid basket-weave fashion, one pair of headers being placed at the face of the wall, backed up by a stretcher; then a stretcher is placed at the face of the wall, backed by a pair of headers.

It is important to stagger the position of the pairs of exposed headers with respect to their position in the header course below.

Occasionally a bat should be used in place of a whole brick in the header course to permit slight circulation of air within the wall, as a means of drying out internal condensation or moisture.

This wall requires 6.6 exposed bricks and 8.4 backing bricks per sq. ft.

Building the 12-in. Heavy-duty Wall.—This wall has somewhat greater load-bearing capacity. It is constructed exactly like the standard wall except that the center and inside withes are built only three courses high.

Next the header course tying these two withes together is placed. This is a continuous course of Rolok headers. The bricks in this header course need not have the vertical joints between them filled with mortar.

Then the flat header course is placed, consisting of a continuous header course on the outside face with a course of stretchers behind it.

This wall requires 7 exposed bricks and 8.8 backing bricks per sq. ft

CONSTRUCTION OF ALL-ROLOK WALLS

In Common Bond

General Description.—The all-Rolok wall is a general utility wall; it may be employed for exposed and unexposed walls, both bearing and non-bearing, and for basement construction. It forms a perfect base for stucco, where a stucco finish is particularly desired, and for plaster where used as an interior wall.

The attention of architects and structural engineers is especially drawn to this wall on account of its low cost and light weight, and the opportunity it affords (in common with the Rolok-Bak wall) for impressive savings in the amount of steel required to support the exterior or interior walls of a skeleton frame building.

The wall is built with two courses entirely of stretchers on edge, alternating with one course of flat headers. To the architectural designer it offers opportunities for new and interesting effects.

No other form of masonry construction 8 in. or more in thickness can compete with this wall in low cost, not only for exposed walls but also for basement and unexposed walls, such as enclosing walls around stairways, etc.

This wall also has the great advantage of exposing to the weather not only a minimum thickness of 2¼ in. of solid brick units in its outside withe, but in addition both horizontal and perpendicular exposed mortar joints have the same solid thickness.

Position of the Header Course.—Placing the headers every third course as shown in the illustrations gives an interesting effect to an exposed wall, develops maximum strength, and expedites the construction in cold or wet weather or where an impervious type of brick is used.

When light loads only are to be supported, and when a brick with average absorption is used, one or two additional courses on edge may be placed safely between header courses.

Constructing the 8-in. Wall.—The bricklayers first lays two courses of continuous stretchers to form the outside withe and then two courses of continuous stretchers to form the inside withe. He then places the flat header course.

Material Required, 8-in. Wall.—This wall requires 9 bricks per sq. ft. of which 6 bricks are exposed in outside walls.

Constructing the 12-in. Wall.—The three withes are constructed, each two courses high. The header course consists of pairs of headers laid flat, basket-weave bond, with a stretcher placed alternately on the inside and outside of the wall.

The center withe is not placed in the center of the wall, but at the end of the headers which show on the outside face of the wall.

The same suggestions are made as to the building of the center withe and the placing of the header course as in the case of the 12-in. standard Rolok-Bak wall.

Material Required, 12-in. Wall.—This wall requires 13½ bricks per sq. ft. of which 6 bricks are exposed per sq. ft. in outside walls.

In Flemish Bond

General Description.—This wall is primarily intended for exposed walls. It is very strong construction, however, and is much used for basement work and for interior walls.

It is constructed entirely of brick on edge laid in Flemish bond for the outside 8-in. thickness. For thicker walls a withe of stretchers on edge is added for each additional 4-in. thickness.

The all-Rolok wall previously described corresponds roughly to traditional brickwork laid in common bond, and the all-Rolok wall in Flemish bond here described corresponds to traditional brickwork in Flemish bond. With Flemish bond, whether flat or on edge, the labor cost is higher than with the simpler bonds, such as common bond or the all-Rolok wall, because the latter can be built more rapidly.

Appearance.—The exposed face of the Flemish bond all-Rolok wall has a surprisingly distinctive appearance. Where the rough or wire-cut surface of the stretchers is exposed in combination with the smooth end of the headers this produces an effective and charming appearance.

Building the 8-in. Wall.—The wall is built by laying headers and stretchers alternately and backing up at every course.

The headers in each course are placed over the center of the stretchers of the course below.

The 8-in. thickness of this wall must be laid "pick and dip" fashion; hence, it is slower to lay than the other types of Ideal wall.

Material Required, 8-in. Wall.—This wall requires 9 bricks per sq. ft., of which 6 bricks are exposed in outside walls.

Building the 12-in. Wall.—The outside 8-in. thickness is built as above, three courses high.

One course is then placed on the outside withe. This consists of stretchers and bats alternately, the bats being used to preserve the bond.

The inside withe is then built three courses high entirely of stretchers.

A solid header course of brick on edge is then placed to tie the inside withe to the outside 8-in. thickness.

When building the outside 8-in. thickness, a 4-in. shelf is left inside on which the mason can store up brick. This partly eliminates the pick and dip method which is necessary when the completed wall is to be 8 in. thick and consequently allows the mason to lay more brick per day.

The same suggestions are made as to the mortar joints in the solid header course as in the case of the solid header course in the heavy-duty Rolok-Bak wall.

Material Required, 12-in. Wall.—This wall requires 13.75 bricks per sq. ft., of which 6 bricks are exposed in outside walls.

ECONOMY WALLS: 4-IN. PIER AND PANEL TYPE

General Description.—The Economy or "pier and panel" wall is a 4-in. wall built of brick laid flat in common bond supported at suitable intervals by pilasters 8 in. thick or by piers 8 or 12 in. square. It is designed primarily for one-story cottages, garages, filling stations, and other minor buildings but may also be used for two-story-and-attic structures where building codes permit, or where the least expensive type of masonry construction is demanded. It makes an excellent garden or boundary wall.

Economy Wall in Buildings.—When the Economy wall is used for building purposes, the 4-in. panels are supported by pilasters on the inner side of the wall, giving to its exterior surface the appearance of solid-brick construction in common bond (except that the bond is interrupted by headers at the pilaster points). The pilasters are spaced face to face at lengths of 4½ brick

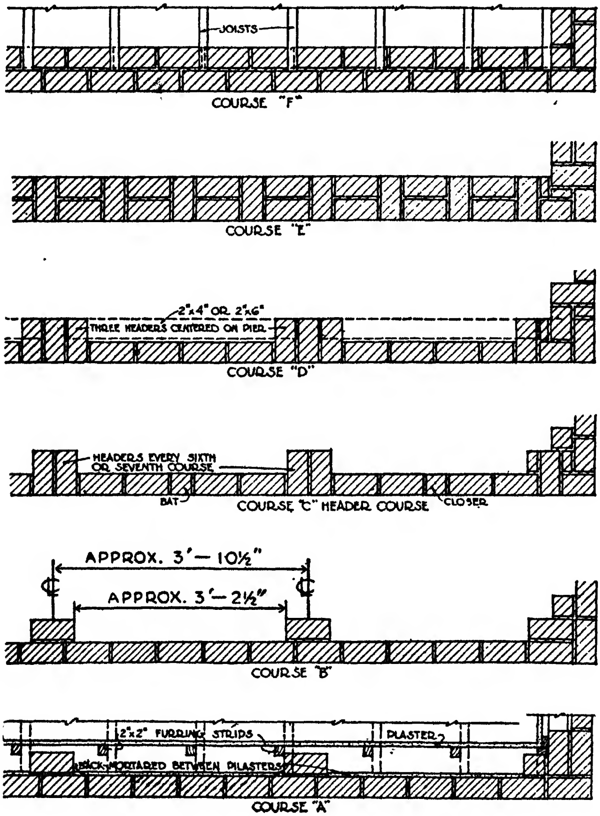


FIG. 45.—Plan showing construction of Economy wall by courses. Pilasters should be spaced to give 8-in. solid construction around all windows and doors.

stretchers and are made 8 in. in total thickness and 8 in. in width. The pilasters are bonded to the piers by through headers every sixth course.

The back of wall panels between pilasters should normally be back mortared to increase their weather tightness and insulating value.

Construction Details.—The illustrations on these pages indicate the essential features of construction of the Economy wall.

(1) Solid 8-in. construction around the jambs of windows and doors, and at sills, girts, and plates.

(2) Use of 2- by 2-in. furring strips between pilasters and ⅞- by 1½-in. furring strips over pilasters and other solid brick parts to carry the plaster base and interior finish.

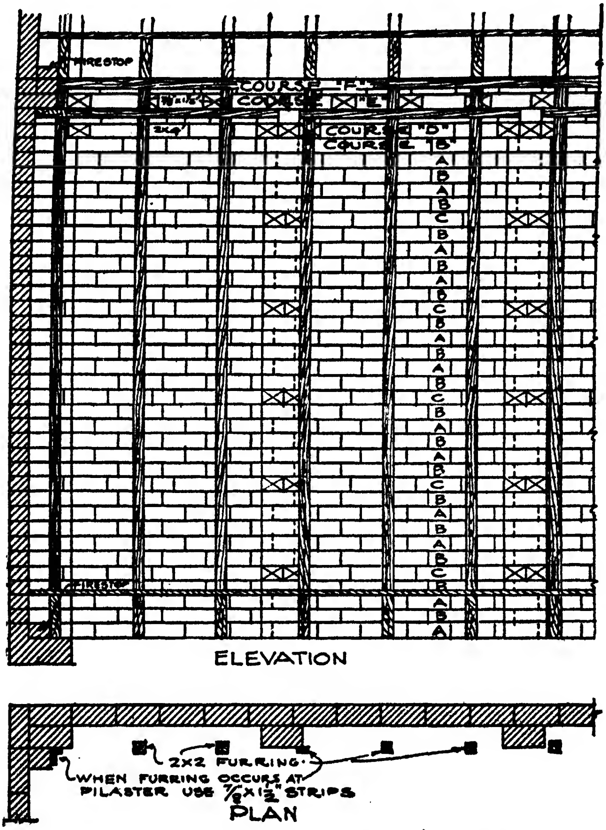


Fig. 46.—Typical elevation of Economy wall (with back mortar omitted), showing application of furring strips and key to courses, Fig. 45.

(3) A special method of bonding for maximum strength and minimum use of brick.

Pier and Panel Walls.—A similar construction employing piers instead of pilasters, or piers in combination with pilasters, makes an ideal property fence or garden wall. In many sections of the country, a wall of this type can be built as cheaply as fencing the property with a woven steel wire fence, with the added advantage of far greater beauty, durability, and seclusion. It can be built in serpentine design.

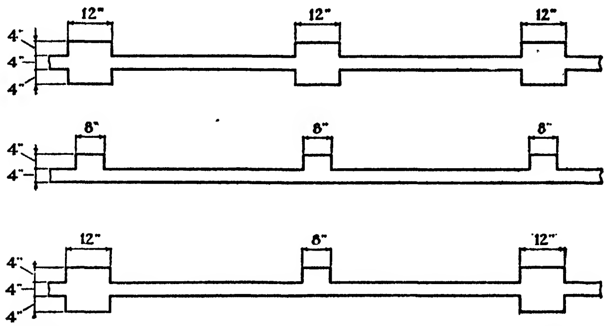


FIG. 47.—Three types of pier and panel 4-in. wall. The middle type is standard Economy wall.

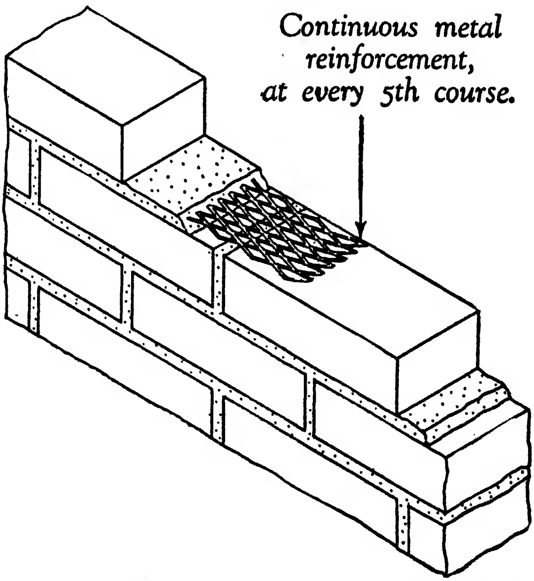


FIG. 48.—Method of reinforcing 4-in. wall construction for lateral strength, using welded wire mesh, strips of metal lath or light rods.

Free-standing walls of this type may be built in two ways—plain construction or reinforced. In the former, a 4-in. panel is built up of brick laid flat in common bond between piers 8 or 12 in. wide and 12 in. thick. The distance between piers depends upon the height of the wall and the required degree of lateral strength or stiffness. If, for design purposes, the piers are to be spaced at wide intervals, the back of the wall may be reinforced at intermediate points with the 8-in. pilasters, which do not show upon the outer face.

Reinforced Pier and Panel Walls.—For greater lateral strength, permitting wider spacing of piers and panels and the use of somewhat fewer brick, these walls may be reinforced by embedding in the horizontal mortar beds strips of welded wire mesh or expanded metal 3 in. wide. This wire reinforcement should be as continuous as possible, extending through the piers or pilasters. It is seldom necessary to use reinforcement in every course, adequate strength being added to the wall by reinforcing every fourth to sixth course.

REINFORCED BRICKWORK FOR STRUCTURAL PURPOSES

Nature of Reinforced Brickwork.—Whereas brickwork has heretofore been designed and used for carrying compressive loads only, the use of reinforcement permits it to develop very great flexural strength and so to resist lateral loads.

Reinforced brickwork is in all essential respects the same as reinforced concrete. Steel reinforcing rods are placed in the structure in the proper position to resist tensile stresses, the brickwork taking the compressive stress.

It might appear that the mortar joints in brick would constitute planes of weakness, but in practice and in laboratory experiments, this has been found not to be so. There is ample bond strength between steel and mortar and between bricks and mortar to enable the structure to function according to our present accepted theories.

Since brickwork is just as strong in compression as other masonry materials and since the tensile strength of steel is the same in any case, the transverse or bending strength of reinforced brickwork is the same as other kinds of similar design and size. The use of reinforced brickwork should be widely extended, especially where appearance is a factor.

Types of Construction and Common Applications.—The types of construction that have been most used are slabs (one or more bricks in thickness), rectangular and T beams, and various combinations of these elemental types.

Reinforced brickwork has been used in a wide variety of structures for the following purposes: Floor slabs (either plain or combined with reinforced brickwork beams), roof slabs, porch and balcony floors (including overhanging cantilevers), stairways both plain and spiral, porch floors and steps, walls and columns, and especially in structures of circular plan, such as silos and storage bins.

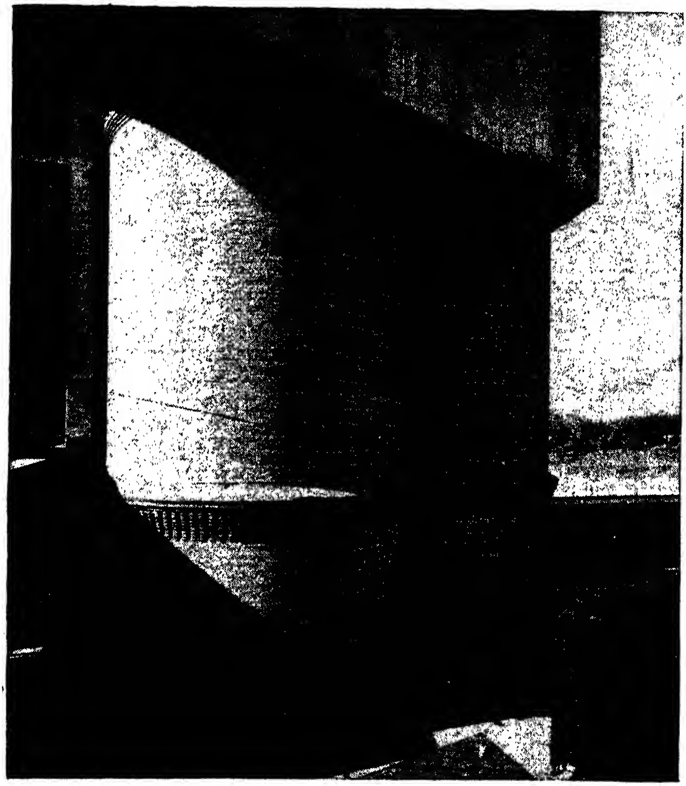


FIG. 49.—Storage bins, silos, and all circular structures can be simply and economically built with reinforced brickwork. These bins were built by Wedron Silica Company, Wedron, Ill.

Materials and Construction.—Obviously the necessary materials are bricks, mortar (either cement or cement lime), steel reinforcement (rods or mesh), and supporting centering.

Reinforced brickwork possesses the distinct advantage over reinforced concrete that all brickwork built in a vertical plane requires no forms, the reinforcement being placed as the work proceeds.

For construction in a horizontal or inclined plane, watertight forms are not necessary, simple centering for supporting the brickwork being all that is needed.

It is essential that the brickwork be well done, with all joints filled, and that the centering remain in place until the mortar

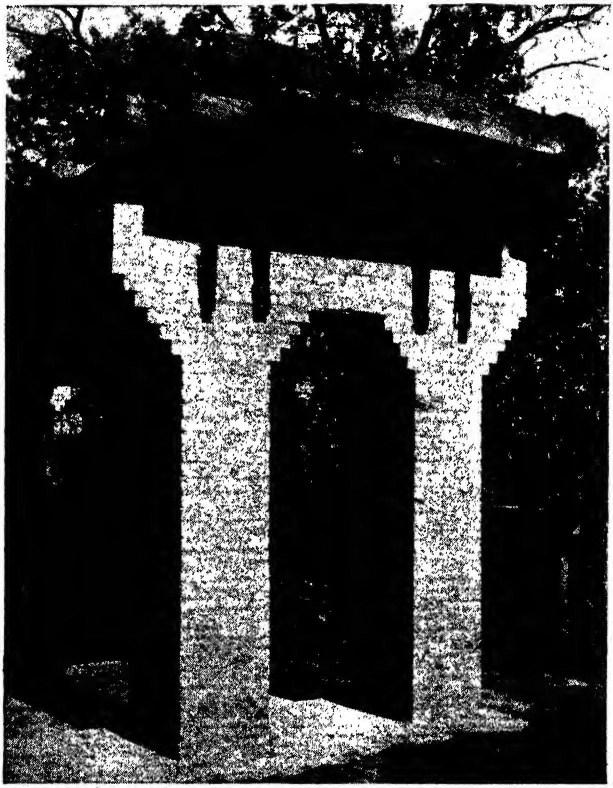


Fig. 50.—Railroad trestle supported by reinforced brickwork, built without forms.

has set, in order that the structure may give satisfactory performance.

Design of Reinforced Brickwork.—More complete information, including methods of design and illustrations of typical constructions, together with the results of field and laboratory tests, will be found in "Brick Engineering: Handbook of Design," by Harry C. Plummer and Leslie J. Reardon.

Brick Arch Construction.—An older and more common type of reinforced structural brickwork is to be found in the brick arch construction of floors and vaults.

Fireproof Brick Floors.—The use of brick arch construction is worthy of the serious attention of architects and engineers for general floor construction and for vaults. The brick arch floor is about the strongest type of floor arch for the span it occupies; the type shown in (*A*) Fig. 51, is probably the most fire resistive of any system that can be employed.

In this type of floor, the flanges of the beams are protected by terra cotta skewbacks. Similar construction, but with exposed tie rods, is employed for the floors of the principal stories of the Government Printing Office at Washington, D.C.

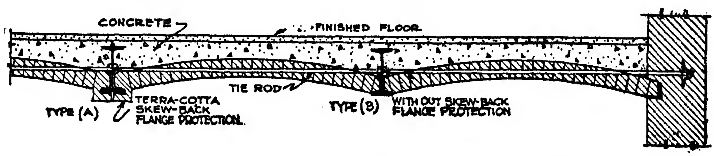


Fig. 51.—Fireproof brick floor-arch construction.

Experiments show that brick arches will stand very severe pounding and a great deal of stress without failure.

Arches need not be more than 4 in. thick for spans up to between 6 and 8 ft. (the most desirable span), if the haunches are filled with concrete level with the top of the arch. Tie rods should always be employed.

A 4-in. brick arch, 6-ft. span, well grouted and leveled off with concrete, should safely carry 300 to 400 lb. per sq. ft. The weight of this floor without the concrete fill is about 40 lb. per sq. ft.

To lay this floor in the most economical way, the brick may be laid upon the centering touching each other at the soffit, the wedge-shaped joints being filled with grout.

Size and Spacing of Tie Rods.—Tie rods are employed to prevent the beams being pushed apart, especially in the outer bays. They should run from beam to beam from one end of the floor to the other. If the outer arches spring from an angle, as in Fig. 51, the tie rods in this bay should be anchored in the wall with large plate washers.

Rods should be located in the line of thrust, ordinarily below the half depth of the beams and in some cases near the bottom flanges. Arches should be designed, however, so that the rods will be protected from fire by keeping them above the soffit of the arches. This also gives a better appearance.

Rods are spaced generally in the proportion of eight times the depth of the supporting beams, but never more than 8 ft. on center. Their size should be proportioned to the horizontal thrust of the arches.

For more complete data on the strength of fireproof brick floors and for formulæ and tables for proportioning of tie rods, see "Kidder's Architects' and Builders' Handbook."

CHAPTER IV

CONSTRUCTION OTHER THAN EXTERIOR WALLS

FIREPROOFING STRUCTURAL-STEEL MEMBERS WITH BRICK MASONRY

To meet building-code requirements, structural steel requires the protection of a suitable fire- and heat-resistive material, of which the most common forms are brick, concrete, clay tile, and gypsum. The purpose of this protection is to retard or prevent the development of temperatures that will impair the structural strength of the steel members. Obviously the most important members requiring protection are columns, because their failure would bring down a large part of the structure; next in importance are girders, beams, and floor joists, in order.

Advantages of Brickwork.—Of the materials used to protect structural-steel members, "brick is by long odds the most efficient, when properly made and properly used" (Report on San Francisco Earthquake and Fire, by A. L. Himmelwright, C.E.).

Brick is particularly suitable for the fireproofing of steel *columns* because it eliminates the need for concrete forms, because the small units are readily adapted to enclosing any size column without procuring special shapes, and particularly because brick of good quality is given a very high fire-resistive rating for such uses.

Brickwork is not so well adapted to the fireproofing of horizontal members except when employed to form load-bearing floors in the form of segmental brick arches, as described on a preceding page under the heading Fireproof Brick Floors. Bonding or fastening brickwork to the underside of steel is not easily done.

Methods of Fireproofing Steel Columns.—A thoroughly satisfactory method of fireproofing a steel column is to enclose it with 4 in. of hard-burned common brick in a single withe around the column and to fill the space inside with mortar and broken bricks (bats) when necessary.

A common method is to brick in the webs of the column with bats or whole brick and mortar and to surround the exterior faces of the column with a withe of hard-burned brick all laid up together.

Where building codes require 2 in. or less of fireproofing, the outside withe can be laid rolok, forming a protection approximately $2\frac{1}{4}$ in. thick. In using brick for this purpose, effort should be made to secure good bonds at the corners by overlapping the brick as shown in the accompanying illustration. Very light reinforcing rods, bent to a right angle and laid in the horizontal bed joints around the corners, will add greatly to bond strength. These rods need be used only every other course or even less often. Fitting of the brick by cutting to length or by the use of bats should largely be confined to the center of each face of the column, but joints should be broken at intervals by the use of a whole brick across the center.

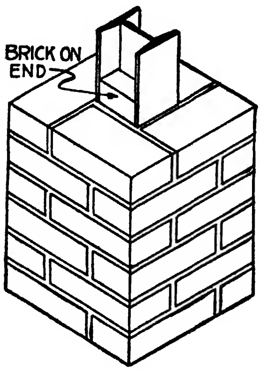


Fig. 52.—Brick-column protection. Some codes permit $2\frac{1}{2}$-in. protection by placing brick on edge.

Spandrel Beam Fireproofing.—Exterior horizontal beams between outside columns are frequently fireproofed on the outside by filling against the web with brick, while the inside face and soffit may be fireproofed with concrete cast with the floor slab. This permits effective anchorage and bonding of exterior masonry of stone or brick as the work is carried up on the outside. The use of brick for this purpose also facilitates the introduction of the all-important spandrel waterproofing.

FIRE WALLS AND PARTY WALLS

Definition of Party, Fire, and Division Walls.—A *party wall* separates two adjacent buildings and is adapted for joint service by adjoining buildings.

A *fire wall* subdivides a building so as to resist the spread of fire, by starting at the foundation and extending continuously through all stories to and above the roof.

Division walls subdivide a building or buildings, usually to resist the spread of fire, but are not necessarily continuous through all stories and the roof.

Authorities Recommend Solid Brick.—For walls of these classes, the solid brick wall is found in every building code of our cities, in the code recommended by the National Board of Fire Underwriters, and is recommended by all authorities on building construction and fire prevention.

Buildings of large area should be divided into separate sections by fire walls, thus reducing the liability to one fire and giving an opportunity to place hazardous goods in one section and less hazardous goods elsewhere.

Fire Walls.—Fire walls may be solid or hollow but, in any case, should be thick enough and so constructed as to meet the requirements of building codes.

These requirements are now more often stated in terms of hourly resistance periods.

Brickwork over openings in fire walls (for fire doors, etc.) must be properly supported by steel members or by reinforcement in the brickwork, to carry all superimposed loads. Solid brick walls are best.

Party Walls.—Party walls, when also acting as fire walls, must meet fire-wall code requirements. They must also satisfy the legal requirements of joint use. Legal authorities agree that solid brick walls best meet such requirements, for they can be altered to accommodate changes in one side without violating the rights of the adjacent joint owner of the walls.

Enclosures and Fire Towers.—Stairways, elevators, and other shafts or openings extending from one floor to another should be enclosed in brick walls extending above the roof.

Fire towers should either be placed so that one side is formed by an exterior wall and provided with an outside balcony, accessible from each story on both sides of the tower, or the tower may be constructed within the building, connecting with an outside vestibule open to the weather, the vestibule having openings at each story closed with fire doors.

FIRE STOPPING IN BRICK AND FRAME BUILDINGS

No one feature of frame construction will contribute more to its safety in case of fire than efficient, well-placed fire stops. Their purpose is to delay the spread of fire by preventing drafts through floors and walls and so assist in confining the fire to the story or room in which it starts.

Brick is a superior material for fire stopping in any type of construction. It may be used with brick masonry walls or frame walls, floors, and partitions. For this purpose almost any sort of bricks will serve, such as salmon brick, or chipped, broken, or other defective bricks, providing sufficient mortar is used to fill all joints and interstices.

As wood studs are only 3⅝ in. wide, the space between them will not permit ordinary brick to be laid flatwise. In such cases

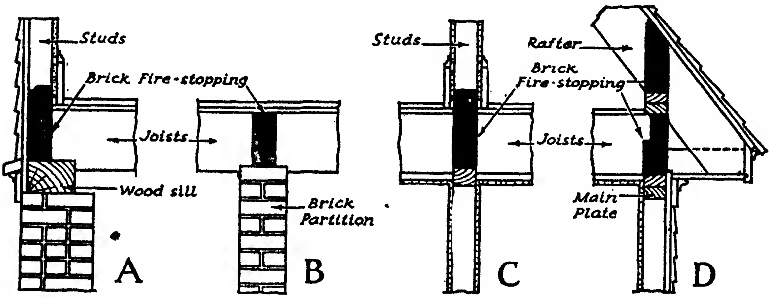


FIG. 53.—Typical method of using brick for fire stopping in frame construction. (*A*) at sill line; (*B*) between joists resting on brick partition; (*C*) between joists and studs in a typical interior partition; (*D*) at eaves.

the brick should be laid on edge on the inner line of fire stopping and the space between the brick and the sheathing filled with mortar. When fire stopping a partition resting on a girder or the cap of the partition below, the bricks can be laid flatwise nearly up to floor level and then be laid edgewise with sufficient mortar on the side or sides to fill the space in the partition.

Where to Use Fire Stopping.—Fire stopping should be arranged to cut off all concealed draft openings of combustible construction and form an effectual horizontal fire barrier between stories.

Furred Walls.—All brick walls furred with wood should be built with the brick between the ends of wooden beams projecting the thickness of the furring beyond the inner face of the wall for the full depth of the beams; or a double course of bricks above and below the beams should be laid to project beyond the face of the wall the full thickness of the furring. Where a furred wall is offset from a thicker to a thinner wall, beam filling of brick should be placed between the joists to the subfloor level.

Frame Walls.—In frame buildings, all stud walls should be completely fire stopped with brickwork at each floor level. The space between the studs should be filled to a height of 4 in. above the floor level.

Partitions.—Where stud partitions rest directly over each other and cross wooden floor beams at any angle, they should be run down between the floor beams and rest on the top plate of the partition below and should have the space between the studs filled in solid to at least 4 in. above each floor level with brick and mortar.

Roofs.—Brick filling formed in mortar should also be placed between the rafters above the roof plate and the slope of the roof sheathing. This also acts as a wind stop and makes the house more comfortable in winter.

In short, brick and mortar should be used to block every point in a masonry or frame building where drafts may circulate from one space to another, behind studding furring strips, or through the spaces between floor joists or rafters. Fire stops should also be placed where woodwork joins chimney construction, as indicated in chimney details.

PARAPET WALLS

Proper design, the use of hard-burned brick only, and careful workmanship on parapet walls are most important, for such

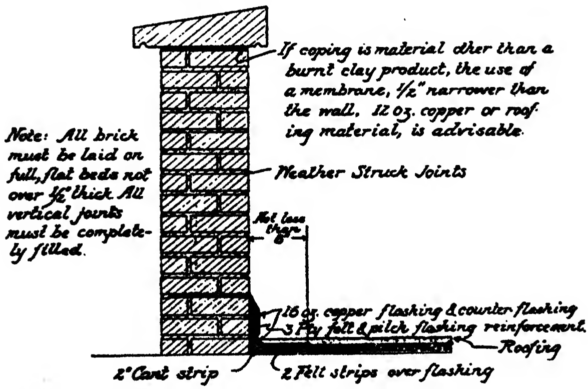


Fig. 54.—Weathertight construction of parapet walls is of utmost importance. Use only best materials and workmanship.

walls must presumably function as fire barriers and they also should form an impervious top of the walls beneath. In other words, they should be stable and watertight, especially at the top (be properly coped).

Height of Parapet Walls.—To be stable, such walls should be no higher than four times their thickness, unless given additional lateral support. Parapet walls rarely need be more than 4 ft. high; lower walls will often suffice.

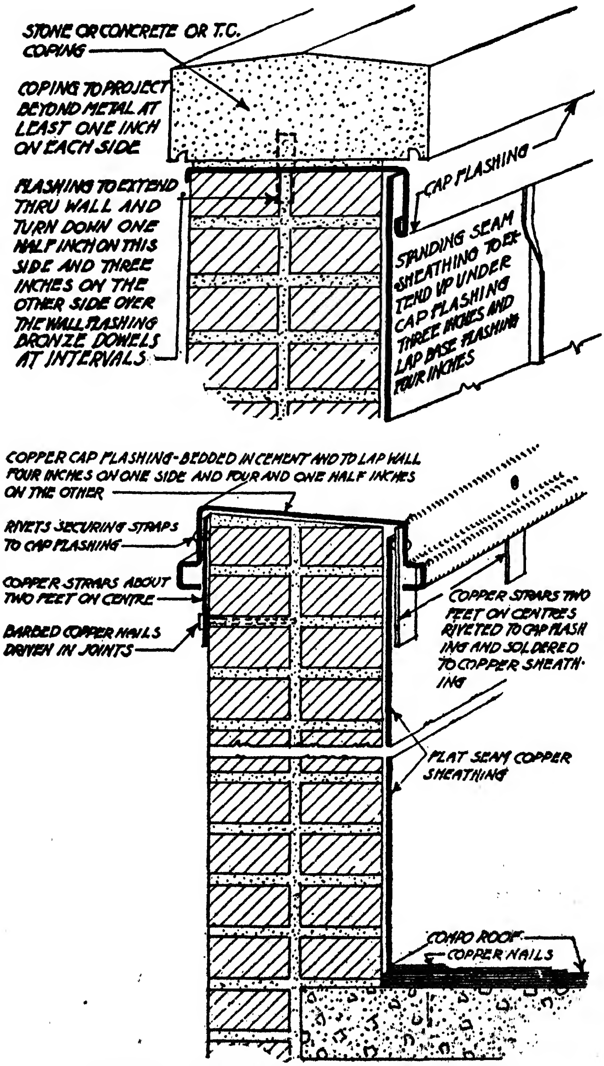


Fig. 55.—Detail of flashings for parapet walls.

Copings.—Precautions for making outer walls of brick resist water penetration apply equally to parapet walls, but special care should be used to make the coping tight. Burned-clay materials only, such as brick or coping tiles, or natural stone, are best, for they do not suffer from swelling and shrinking due to alternate wetting and drying.

Flashings.—Tightness at the top is best assured by a proper through flashing, such as tarred building paper, mastic, or sheet copper under the coping.

Roof flashing and counter flashing should be carried up and into the parapet wall at least three or four courses of brick above the roof line. This distance depends on the climate, or more properly, on the depth of snow which may accumulate on the roofs.

Importance of Sound, Weathertight Construction.—Under no considerations should the mason use tailings of brick or mortar left over from construction of lower walls as the materials for parapet wall. Sound brick with a minimum of bats even in the backing, fresh mortar (not reworked), and filled joints should be required. Bear in mind that both faces of parapet walls are exposed to weather, requiring filled joints on both sides, unless flashed to the coping.

CONSTRUCTION OF OPENINGS IN BRICK WALLS

Workmanship

It is the duty of the brick mason to see that all brickwork supports over wall openings are properly placed and on a proper bearing. Lintels, beams, and similar parts should have end bearings laid in a full bed of mortar and on solid brickwork (not hollow). If flashings or other waterproofing are called for, the brick mason should see that they are installed as specified.

The mason should exercise special care in setting window and door frames. See that they are set in a full bed of mortar all around, particularly at window sills. Frames should be provided with wind stops, or rabbets, which aid materially in stopping water travel around them and should be thoroughly calked.

Window sills should be set with a proper downward slope and preferably have a drip ledge cut in the projecting lower edge. If made of brick, they should have all joints well filled. Some even add a membrane of impervious flashing under them.

The building of arches requires careful workmanship. The skewbacks should be cut properly and solidly built first. Every brick used in the arch should be fully bedded in mortar on all sides by shoving all brick into place and *not* by buttering the ends or sides and attempting to fill joints by slushing. The key (of brick or other material) should be small enough to allow a full mortar bed all around. In cutting the brickwork over an arch (to fit the extrados), have all pieces so cut as to permit of a solid mortar joint of uniform thickness with the arch bricks.

In short, the arch should have solid supports and solid masonry (with no voids) in the arch itself and in the brickwork immediately above.

Methods of Construction

Window and Door Sills.—Brick, terra cotta, or stone window sills should be used in a brick building. Cement sills poured in place or wood sills are not well adapted for this purpose, nor are they sightly or permanent. Stone window or door sills should be of such thickness that they line with the courses of brick, with a lug at each end.

Brick sills are the least expensive. The brick are laid on edge and sloped forward, with the bottom edge projecting about an inch to form a drip. The standard slope is 2 in. to the foot.

To line the edge of the sill accurately, a plank should be fastened to the wall and the brick placed upon it, as shown in Fig. 56, which shows also the way each brick is buttered with mortar before being pressed into place. 1:3 or, preferably, 1:2 cement mortar should be used. While the illustration shows a brick sill being placed under a steel frame after the latter is set, it is better construction to set the sill first. This should always be done with a wood frame.

To obtain the best effect, brick sills should be "slip sills," not wider than the actual masonry opening. Brick sills laid horizontally with a pitch formed with mortar are not satisfactory, as the action of the weather may cause the mortar to loosen.

In general, brick is the most satisfactory material for either window or door sills, although it may be used to form charming combinations with other materials. Where brick is used throughout, however, no material has to be specially ordered.

Brick is beautiful and flexible. An appearance of great solidity may be gained by sloping the brick window sills very sharply, thus apparently increasing the depth of the reveal of the windows.

Brick for doorsills should be hard burned. The standard slope for brick doorsills is 3/8 in. to the foot.

Window and Door Frames.—The only difference between double-hung windows for frame and for brick walls is that the latter are boxed in at the jambs to provide a housing for the weights and that they have a staff bead outside. It is cheaper,

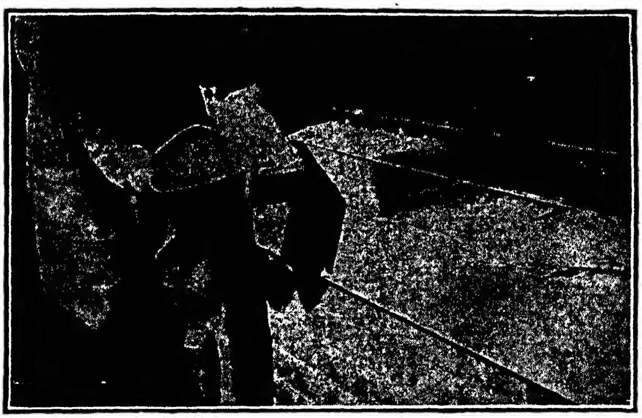


Fig. 56.—Laying brick sills, showing use of board and line and full-bedded mortar joint.

however, to buy stock frames for brick walls with the box in place than to have the carpenter on the job make the box.

Frames should always be constructed so that there is no straight joint at the back of the frame from front to back of the wall. A wind stop should be nailed on all such frames so that shrinkage of the frame will not allow drafts to blow through into the house.

Window and door frames for brick walls are made by all millwork companies. Contractors should use standard sizes wherever possible. Frames of any size can, of course, be used with brick walls, the small brick units and numerous courses allowing easy adjustment to any dimension.

Setting Window and Door Frames.—Window and door frames are set by the carpenter, window frames being placed on top of the sill of a thin bed of mortar. A much better job is made if they are set before the wall has risen above the sill level. They are leveled, plumbed, and braced so that the braces will not interfere with the placing of the scaffold.

First-floor frames are sometimes braced to stakes driven in the ground outside the house. The most convenient way, however, is to place an upright at about the center of a small house,

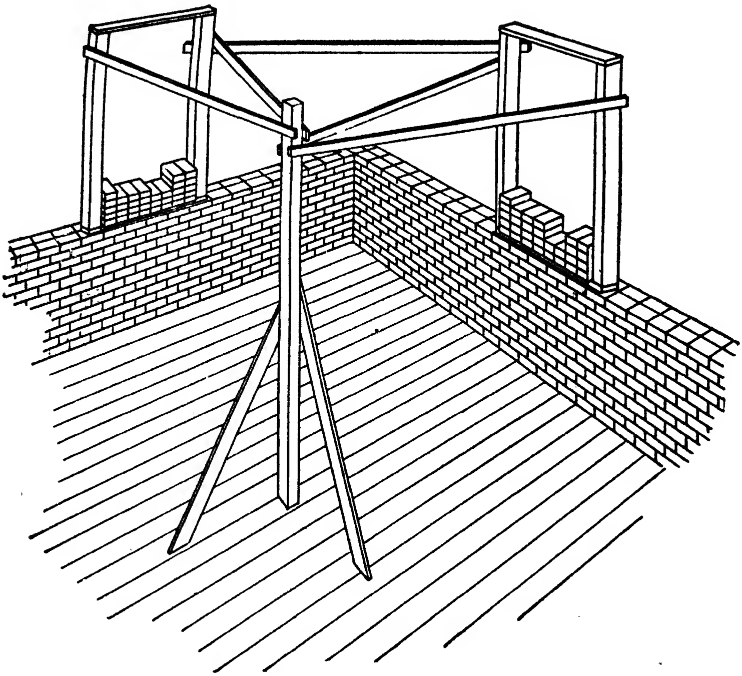


FIG. 57.—Convenient type of window bracing for small buildings.

braced in two directions near the bottom with short pieces of plank. All the window frames on the story are then braced to the upright with braces placed horizontally, near the top of the frame, sloping braces being entirely avoided. This provides clear working space under the braces, and scaffolding can be moved around at will (Fig. 57).

The carpenter should pile a few brick on the sill to assist in holding the frame steady. If he fails to do this, the bricklayer should place them himself before starting to brick the window in.

If a door frame or casement window frame is high, a crosspiece should be nailed on the frame to prevent the window being bowed in. The box stiffens a double-hung frame considerably. Especial care should be exercised in bricking around steel windows and doors, as the jambs must not be bowed in by the pressure of the masonry.

The openings for interior frames are generally formed in brick and the frames set afterwards.

Labor in Setting Window and Door Frames.—No more time is required to set window or door frames in a brick than in a frame house. The carpenter does the setting and bracing, the bricklayer simply bricks them in.

Supports over Openings.—Supporting the brickwork over wall openings may be done by arches of various types or by lintels. Over window and door frames, the brickwork the depth of the reveal is carried on the face arch or lintel, the backing carried on another lintel set higher than the face support, with or without a relieving arch above it. Where openings are arched, however, a less expensive and more general method is to run the arch the full thickness of the 8-in. wall, and this method is shown on the plates. It has the disadvantage, however, of not providing such a good windbreak as the method first described. In a small house, flat or practically flat lintels or arches over openings are to be preferred for the sake of appearance. The effect of a segmental arch is to increase the apparent size of the opening, and this may tend to throw it out of scale with the building.

A stone lintel should not be relied upon to sustain the load of the wall above. It is safer to support the stone with steel. Stone has uncertain transverse strength and may crack unless made too high for good proportion. A small mold of appropriate section over the top and at the sides of a stone lintel will produce a better effect than a flat lintel set flush with the brick wall, particularly where the lintel is three or more brick courses high.

Rough Support of Backing.—Over a door or window opening the brick backing may be carried on a wood lintel. This is all the support required for backing over openings 3 ft. wide and less, for, when the mortar is set, brickwork will support itself over spans of this width, even though the wood lintel should burn or decay. For openings wider than 3 ft., a brick relieving arch should be thrown over the lintel, bearing on the wall at the ends of the lintel and not on the lintel itself. The space between the lintel and relieving arch should be filled with brickwork. This is built upon the lintel and shaped at the top to form a center for the relieving arch.

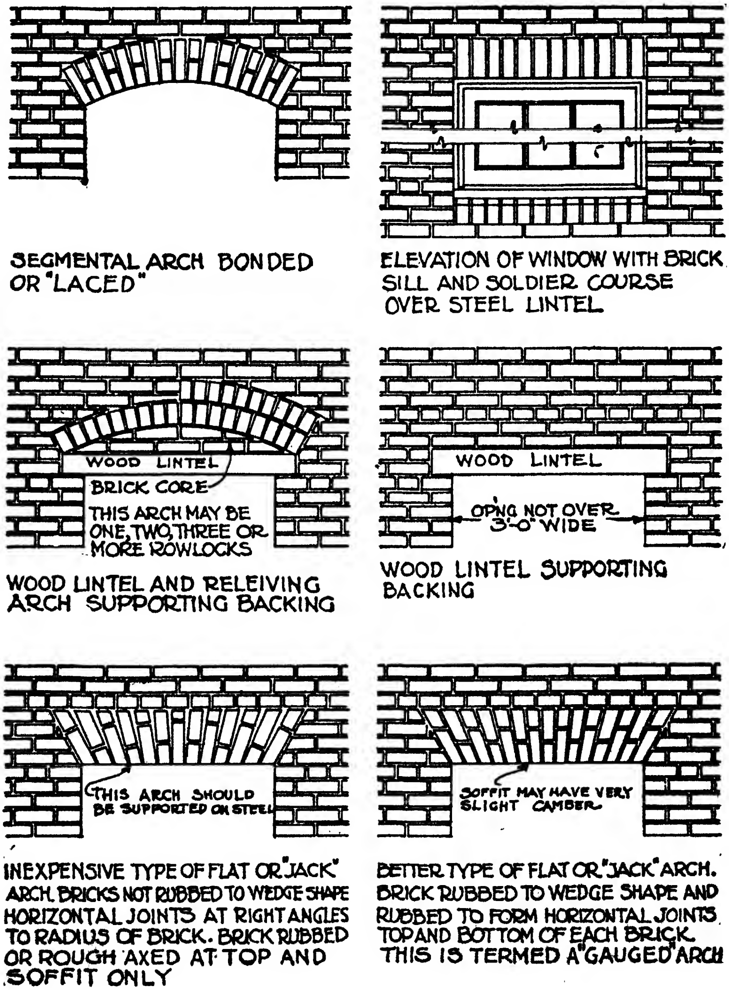


FIG. 58.

Steel Lintels.—Where a flat soffit is desired, a simple steel lintel may be used to support the outside thickness of brickwork over an opening with a 4-in. reveal. A 4- by 3-in. or even 3- by 3-in. steel angle is generally sufficient for openings up to 4 ft. wide; wider openings up to 5 ft. require a 3- by 5-in. angle. If the reveal is 8 in., two angles back to back should be used, preferably riveted together.

If both sides of the wall are exposed, the whole thickness should be carried upon the steel.

If the floor joists above are close to the top of the opening below, the lintels must be strong enough to carry them

Painting Steel Angles.—Before setting the angles, the surface and ends which will be buried and concealed in the masonry

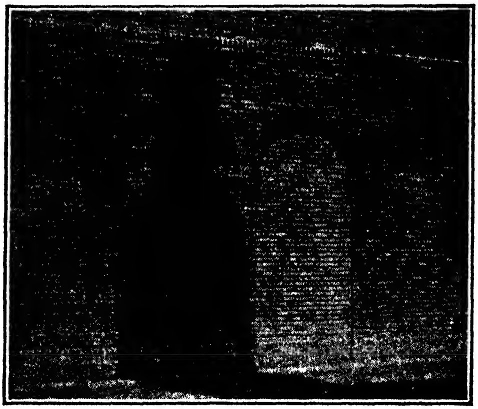


FIG. 59.—Semicircular arches used as a decorative feature to relieve an otherwise blank wall surface.

should first be thoroughly painted with graphite or red lead and oil.

Soldier Course over Angles.—A soldier course of brick on end is frequently placed over a steel lintel. Very often the mistake is made of making this course wider than the opening. A much better effect will be gained by making it no longer than the width of the opening, similar to the brick on edge "slip sill" already mentioned.

Bearing of Lintels.—Wood or steel lintels should generally be made 8 in. longer than the openings, giving a 4-in. bearing at each end.

Types of Brick Arches.—Flat, segmental, semicircular, and elliptical arches are commonly used. In the latter type a more pleasing outline may be obtained by laying out the curve freehand than by using a true ellipse constructed mechanically.

The Flat Arch.—Although, in theory, a flat or "jack" arch is a *true arch, capable of bearing a load, in practice it is weak and* should be supported on steel if the opening is over 2 ft. wide. The steel should of course be bent to the camber, if any, of the soffit.

If the very best effect is desired, jack arches should be constructed so that the radial joints are the same width for the whole length of the joint. To make a perfect job either special brick must be made or the bricks rubbed to a wedge shape. Either of these methods is, of course, expensive.

The brick should also be shaped so that the joints at the ends of the brick within the arch are horizontal, instead of at right angles to the radius of the arch.

Inasmuch as a perfectly horizontal soffit, especially a wide one, appears to the eye to sag in the middle, a slight camber may be formed in the soffit to correct this.

Segmental and Semicircular Arches.—The strongest type of arch is the segmental, where the abutment is ample to resist the thrust. With small abutments the semicircular arch is safer.

For openings over windows and doors in residences the segmental arch is the type almost always used. The rise of a segmental arch will, of course, depend on the architectural design. A good rule to follow, however, is to make the rise equal to one-eighth the width of the opening.

For relieving arches and for arches in basements the rise from springing line to soffit may be made 1 in. for every foot of opening.

In the very best work, the bricks in segmental arches where rowlocks are 9 in. wide are rubbed to wedge shape, but for ordinary residence work the curve is taken up in the joints, by making them wider at the top than at the bottom. Bricks are sometimes chipped to wedge shape by the bricklayer.

The strongest arches are bonded by headers, as in the case of a brick wall.

Centering.—Centering for arches is furnished, set, and struck by the carpenter.

Over windows and doors having a 4-in. reveal, the face arch may be constructed without centering, the window frames with the staff bead in place furnishing sufficient support.

Cost of Supports over Openings.—For ordinary residence work with 4-in. reveals to windows and doors the segmental arch is the lowest in cost. A flat steel lintel, with or without a soldier course on top, costs a little more than a segmental arch but may present a better appearance, depending on the design.

Segmental face and relieving arches set in 4-in. rowlocks, and soldier courses over steel lintels, take practically no more time to set than the brick in the rest of the wall, and nothing extra should be figured for them.

Where brick are roughly chipped to wedge shape the cost of the chipping only should be added. A bricklayer can chip about 40 brick per hr.

Brickwork Carried by Arch or Lintel.—It should not be assumed that a strip of brickwork to the top of the wall, the same width as the opening, is carried by the support. Brickwork tends to arch itself over. A section of brickwork forming an equilateral triangle, each side having the same length as the width of the opening, should be assumed to be carried by the support. The weight of any floor construction within or near the top of this area should, of course, be added.

BRICK AS FOUNDATION FOR STUCCO

Stucco.—Stucco is plaster in various surface textures applied to exterior walls. In its natural state, however, cement finish is dreary and lifeless compared to the rich sparkling effects produced by exposing the brick.

A house finished in stucco placed upon a base of any construction cannot compete in price with the Ideal wall, with its beautiful everlasting brick surface; and in many localities the solid wall furred compares very favorably in price with the stucco house. It should be noted, however, that the price of the latter varies considerably according to the nature of the construction behind the stucco; and the fire-resistiveness and permanence of the underlying construction should always be carefully considered.

Since the Economy wall and after that the Rolok-Bak types of walls, is the lowest in cost of any wall that can be constructed, it is suggested that, if stucco finish appears desirable, bids be obtained upon this finish placed upon the types of walls mentioned, built with low-cost brick.

If a stucco finish is specially desired, a brick surface with joints left rough is far superior to any other building material yet devised as a base upon which to place it. The surface of the brick itself is of a nature that enables the stucco to bond into it,

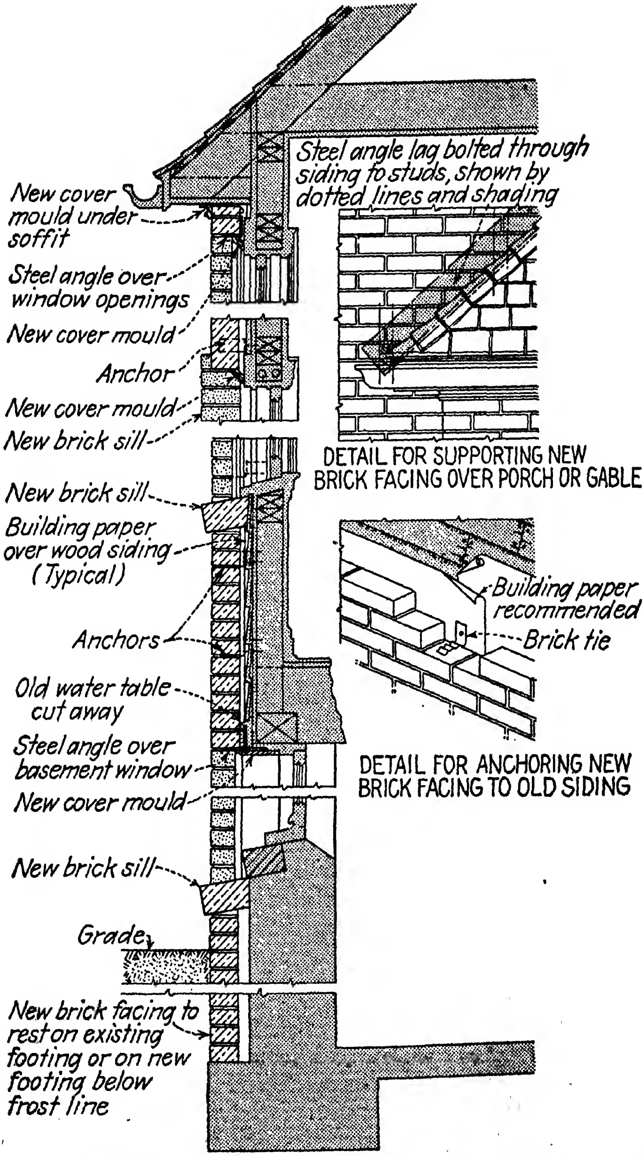


Fig. 60.—Application of brick veneer to existing frame construction, with details of method of anchoring brick to old siding and of supporting brick over gables and wide openings. Similar construction may be employed in new buildings over sheathing and building paper attached to studs.

if well wet when the latter is applied; if the joints are left rough a mechanical "key" is also provided. Brickwork, of course, has little or no shrinkage.

Stucco with Brick Trim.—Certain architectural styles employ stucco with exposed brick trim for lintels, sills, quoins, belt courses, cornices, and similar details. Under such circumstances, the only sound construction is to apply the stucco on a masonry load-bearing wall and, for this purpose, brick is the ideal material. The brick details to be left exposed are corbelled or projected beyond the plane of the areas to be coated with stucco, and then the latter is applied in the usual manner.

BRICK VENEER ON FRAME CONSTRUCTION

Characteristics of Brick Veneer on Frame.—The use of brick veneer as a facing material only, without utilizing its load-bearing properties, has found applications, principally to dwellings, in many parts of the country. Such veneering is usually applied over wood framing and sheathing in both old and new houses. It lacks many of the desired qualities of solid brick wall construction, or even of hollow walls of brick, but may be advantageously employed to rehabilitate an older wood wall or stucco surface. In appearance, a brick veneer wall may have almost any distinctive character and colorful beauty.

For new construction, brick veneer costs about the same as solid or hollow 8-in. brick walls.

A brick veneered job, however, possesses certain desirable qualities when well done, and certain precautions should, therefore, be observed in its construction.

Structural stability is obtained by (1) sufficiently strong and well-braced frame backing, (2) ample anchorage of the veneer to the backing, and (3) good construction of the brickwork.

The brick veneer should, obviously, not extend below grade and should rest on a substantial support, either on the foundation wall or on well-anchored steel shelf angles.

Veneered construction resists exterior fire exposures better than frame but has about the same internal resistance. However, when the space between the veneer and sheathing is poorly fire stopped or the sheathing is not of incombustible material, fires of internal origin may be difficult to extinguish.

Anchorage between veneer and sheathing should be frequent and anchors should be of noncorrodible metal and strong. Wall openings should be carefully flashed to prevent the entrance of water behind the facing, and the use of waterproof paper between veneer and sheathing is strongly recommended.

Adequate fire stops should be installed at floor lines and at intersections of partitions with external walls. With the above precautions, veneered structures may be dry, fairly durable, and easy to build.

New Construction.—In new work the foundation is extended outward beyond the sheathing line approximately 5 in. to allow a slight air space between the brick and the sheathing. The brick is carried up from the foundation as a single 4-in. withe in running bond or in any pattern that may be formed by the use of half brick as headers. The brick should be bonded to the framework by the use of noncorrodible metal ties, spaced not over 16 in. apart vertically and 24 in. horizontally.

Modernizing Existing Buildings with Brick Veneer.—All the advantages enumerated above apply with equal force to brick veneering over existing wall surfaces of wood or stucco.

Typical construction methods are indicated in the accompanying figure. Particular attention is called to methods of extending existing window sills and finishing off the existing wood trim against the new veneer.

Foundations may be extended to carry the veneered construction by trenching against the old foundation to below frost line and carrying a new foundation of brick up to grade line upon which the veneer above is supported. An alternate method is to bolt a heavy angle iron to the wood sills to carry the veneer, but this is not recommended, as rotting of the sills will endanger the veneer. When the original foundation has a stepped footing, it is advisable to carry the facing down to a solid bed as indicated.

Angle irons may be used to carry veneer over existing wood porches and above wide openings, as shown in the accompanying illustration. They should be firmly lag-bolted into the studs and should follow the slope of the roof. Angle irons used as lintels over openings should be lag-bolted and also carried about 4 in. into the brickwork on both sides.

Metal ties should be used in the manner described in the preceding paragraph headed New Construction.

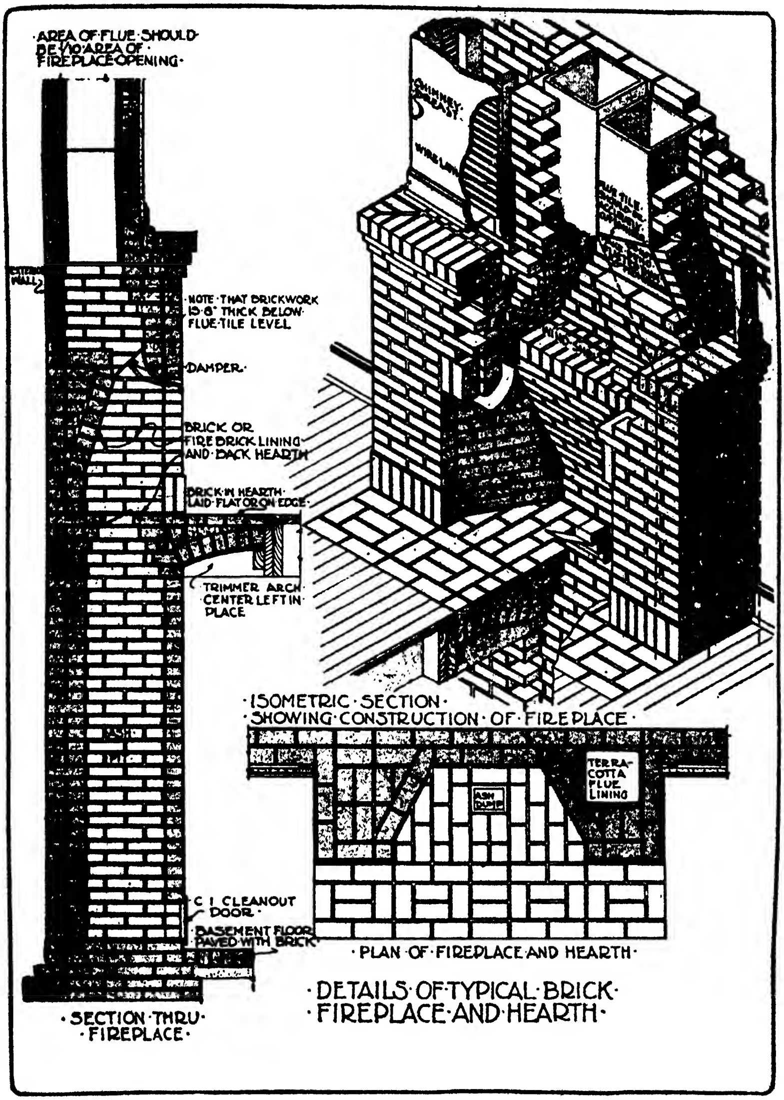

·AREA OF FLUE SHOULD BE 1/10 AREA OF FIREPLACE OPENING·
·NOTE THAT BRICKWORK IS 8" THICK BELOW FLUE TILE LEVEL
·DAMPER·
BRICK OR FIRE BRICK LINING AND BACK HEARTH
BRICK IN HEARTH LAID FLAT OR ON EDGE·
TRIMMER ARCH· CENTER LEFT IN PLACE
C I CLEANOUT DOOR·
BASEMENT FLOOR PAVED WITH BRICK
·SECTION THRU· ·FIREPLACE·
·ISOMETRIC·SECTION· ·SHOWING·CONSTRUCTION·OF·FIREPLACE·
TERRA COTTA FLUE LINING
ASH DUMP
·PLAN OF FIREPLACE AND HEARTH·
·DETAILS OF TYPICAL BRICK· ·FIREPLACE AND HEARTH·

Fig. 61.

Reinforced Brick Facing.—A method employed in residential steel frame construction that is also applicable to veneering over wood frame is to apply to the sheathing a fibrous-backed welded wire mesh of heavy gauge and to build up the brick facing approximately ½ to 1 in. away from this fabric. Mortar is slushed down behind the brick so that it becomes thoroughly embedded in the reinforcing fabric, which thus serves to bond the entire wall surface into a strong vertical slab. Metal ties are recommended, attached to the reinforcing fabric at suitable intervals.

DESIGN AND CONSTRUCTION OF CHIMNEYS AND FIREPLACES

Design

Brick Is Best for Chimneys and Fireplaces.—Solid brickwork is the safest and most satisfactoy material to use for chimneys and flues. If a chimney fire occurs considerable heat may be developed in the chimney, and the safety of the house will then depend upon the integrity of the flue wall. It is dangerous to use hollow units for this purpose, for these cannot stand high temperatures without danger of cracking and spalling. Salmon brick may be used for interior chimneys below the roof line, but this is not recommended.

The Brick Fireplace.—The comfort and pleasure of a home may be vastly increased by a fireplace in the living room, and the most appropriate and the safest material of which to build both the fireplace and mantel is brick.

The fireplace is very properly a part of the furnishing of a room —a built-in feature. It should conform to the dominant architectural style and period.

The natural surfaces of brick, the slight irregularities, and the wide variety of shadings makes this material particularly "flexible" and adaptable in the hands of the architect. And these same native textures and tones make brick most appropriate for interior decoration.

Successful Design Easily Attained.—The art of building a fireplace so that it will perform properly and satisfactorily is often more or less a mystery to the homeowner and even to many brick masons. Building a fireplace which does not deliver smoke into the room as well as up the chimney and which gives out a fair measure of heat in return for the fuel fed has been considered as much a matter of good luck as of good management.

This older prevailing impression is far from being a correct one, for there is nothing mysterious about the design or construction of a thoroughly satisfactory fireplace. On the contrary, the principles upon which good fireplace design are based are few, simple, and easily understood and, if applied in the construction of any fireplace, will ensure satisfactory results.

These few essentials of correct design have only to do with proper combustion and heat radiation, so that fireplaces need not be alike in exterior design or ornamentation. They may, indeed, be of almost any design and still function properly if combustion chambers and flues are of correct proportions.

Essential Requirements.—The essential objects to be attained are

1. Proper combustion of the fuel.
2. Delivery of all smoke and other products of combustion up the chimney.
3. Radiation of the maximum amount of heat to the room.
4. Simplicity and firesafeness in construction.

The first two essentials are closely related and depend mainly upon

1. Shape and relative dimensions of the combustion chamber.
2. Ratio of flue area to the fireplace opening.
3. Proper location of the fireplace throat and smoke shelf.

The amount of heat radiated also depends upon the shape and relative dimensions of the combustion chamber.

Size of Fireplace.—The first consideration is the choice of a size proportionate to the size of the room.

One may have been charmed by an immense fireplace in some quaint colonial home and be led into the error of building a fireplace entirely out of scale with one's own room. A fire that would fill such a fireplace would be entirely too hot for a moderate-sized room. Moreover, it would require a larger chimney and would induce an abnormal infiltration of air through doors, windows, crevices, etc., to supply the needs for combustion and thus waste fuel. With this in mind, select a size suitable to the room. A living room with 300 sq. ft. of floor space is well served by a fireplace opening 30 to 36 in. wide. Fireplaces of 42-, 48-, 54-, and 60-in. widths should only be used in rooms of correspondingly greater size.

Location of Fireplace.—The location of the fireplace in the room is also an important consideration. Since it is perhaps the most ornamental feature inside the house, it should be given a prominent position. But it should not, if avoidable, be in the line of travel through the room, nor near the entrance door, nor where a cross draft sweeps it. If placed in the longer side of the room, it should not be built out so far as to cut down the useful width of the room or cause a floor rug or other covering to overlay the hearth. If built into an outer wall, the same caution holds. Keep in mind also that when large windows flank the fireplace, people face too much light when the fireplace is used during the day. It is better to use small windows placed high in the side wall. An outside end wall is a favorite and well-chosen location. The full floor space of the room may be preserved by building the back of the fireplace and chimney projecting out from the side wall. This often improves the exterior appearance of the entire side of the house.

Proportions of Fireplace Openings.—Fireplace openings should not be too high. Regardless of the width, the height of the opening is usually made from 30 to 34 in. above the hearth, principally because of flame height and also with a view to proper mantel height. The table below gives a combination of openings, depths, and corresponding flue-lining sizes that are known to work well. The depth is often determined by wall depth or by the permissible projection into the room. A shallow opening throws out more heat. There is no particular advantage in a deep fireplace and there are often disadvantages.

Flue Areas Relative to Fireplace Opening.—Relatively high velocities through the throat and flue are desirable, for they induce the adjacent air and smoke into the stream and so prevent smoke from coming into the room.

Both the height of the chimney and the area of the flue affect the velocity. For the average two-story dwelling, the flue area should be about one-tenth the area of the fireplace opening; some authorities uses one-twelfth. For a chimney 30 ft. or more high, one-twelfth should be ample, but for chimneys of bungalows or where the chimney height is 20 ft. or less, one-tenth the area is safer. But the full area of *circular* flues only is effective. The corners of square and oblong flues are practically dead spaces. Therefore the *effective* areas are less than the geometric area, and effective areas should always be used in calculations. The effective areas of various-shaped flue linings of commercial sizes are given in the following table. Since the effective flue area may seldom equal exactly one-tenth or one-twelfth the fireplace opening, use the lining which in effective area is next above the calculated area. However, a few square inches less in area will make no essential difference.

TABLE 3.—FIREPLACE DIMENSIONS

Width of opening, in.	Approximate height, in.	Depth of opening, in.	Rectangular outside dimensions, in.	Effective area, sq. in.	Nominal flue sizes, circular, diameter, in.	Effective area, sq. in.
24	28	17–20	8½ by 8½	41	10	78
28	28	17–20	8½ by 13	70	10	78
30	30	17–21	8½ by 13	70	12	113
34	30	17–21	8½ by 13	70	12	113
36	30	21	8½ by 18	97	12	113
40	30	21–24	8½ by 18	97	15	177
42	30	21–25	8½ by 18	97	15	177
48	32	21–26	13 by 13	100	15	177

Proper Shape of Combustion Chamber.—The shape of the combustion chamber influences both the draft and the heat radiated to the room. For good draft the upper part on all sides should slope in gently to the size of the throat. This slope should preferably be not greater than about 30 deg. from the vertical, a ratio of approximately 3 in. horizontal to 5 in. vertical. The slope usually starts from a point a little less than halfway from the hearth to the throat. This slope of the sides and the back to the long, narrow throat throws the flame forward and leads the gases with increasing velocity through the throat.

For maximum heat radiation, the sides are not only sloped in toward the center, but they are also splayed toward the back. The amount of splay that gives maximum radiation has been, by years of experience, fixed at approximately 5 in. for each 12 in. of depth.

Importance and Location of Smoke Shelf.—A good draft *depends not only upon the proper relation of fireplace opening to the flue size, but upon the location of the throat, which in turn* determines the position of the smoke shelf. The slope of the back and sides terminates in the throat, which is usually formed of a combination metal throat and damper. It is best to place a damper in the throat in any case. The throat should be not less than 4 in. above the top of the fireplace opening; 8 in. is much better. The illustrations show this construction better than a verbal description.

The space above the throat and smoke shelf is the smoke chamber, and this is again gently sloped inward to the size of the flue lining, from which place the flue lining starts.

The smoke shelf has an important duty. The usual cause of smoke being discharged into the room is downdrafts in the chimney. The smoke shelf, located above the upper fireplace opening, deflects the downdraft upward into the rising column of gases and so prevents its escape into the room.

Metal Throats and Dampers.—As previously stated, a combined throat and damper of metal is used in most cases. It forms a smooth throat passage and simplifies the mason's work. Some metal throats are built with a broad flange at the base which becomes the supporting lintel for the brickwork above. In other cases, a steel angle forms the support, except where a brick arch is used. A damper for controlling the draft is essential and it further serves to close off the flue when the fireplace is not in use.

Design of Chimney.—The construction of the brickwork comprising the fireplace and chimney is usually one continuous operation. The same chimney often contains other than the fireplace flue and is an integral piece of brick masonry from the foundation footing to the chimney top.

Not more than two flues should be in the same chimney space. Where there are more than two flues, each third flue should be separated from the others by a withe, or 4-in. brick partition.

Chimneys constructed entirely within the house are more efficient than chimneys on the outside wall, the former allowing the flues to become hotter, giving a better draft.

The chimney should be carried up to a point at least 1 ft. above the highest point of the roof; 2 ft. is a better minimum clearance. Wind curling over the roof top will not then cause a downdraft in the chimney. The preferred finish is a slab of natural stone or of masonry, supported high enough above the chimney top to make each side opening equal to or greater than the total flue areas. Ornamental chimney pots are also much used. Their slightly contracted area helps to prevent downdrafts.

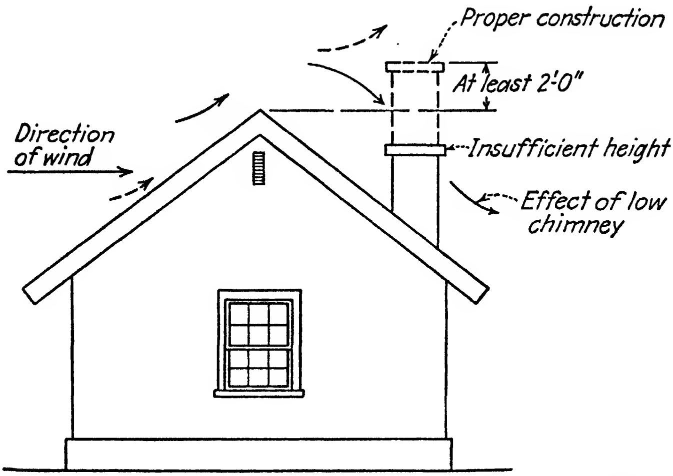


FIG. 62.—Top of chimney should be at least 2 ft. above the top of ridge in order that wind currents may not be deflected down the chimney.

Use Separate Flues.—Every fireplace and every other stove, furnace, or what not should have a separate flue carried to the top of the chimney, with no other connections.

The fireplace flue should start from the middle top of the smoke chamber and not from the side. If it is necessary to offset it, start the slope to the offset from the middle, as shown in the illustration. The sloped portion should not be inclined more than 30 deg. from the vertical (3 in. horizontal to 5 in. vertical); otherwise, soot may accumulate and decrease the draft.

The adjacent ends of both flue-lining sections must be mitered off to make the angle joint, if the full area of the flue is to be preserved at this point.

Ashpits Under Each Flue.—An ash trap door in the back hearth, with an ash chute and cleanout door at the bottom of each flue of the chimney in the basement, is preferred construction and almost always used.

Construction

Supports for Chimneys.—A wall to support the fireplace and adjacent flues should be built up from a footing in the basement. This wall may be hollow to form an ashpit. Small isolated chimneys may be supported on corbels built out from the wall, although it is better practice in every case to carry the support right down to a bearing below the basement floor.

According to the National Board of Fire Underwriters Chimney Ordinance, mortar for chimneys should be composed of 2 bags portland cement and 1 bag hydrated lime mixed together thoroughly while dry, added to three times its volume of clean sharp sand. One cubic foot of lump lime putty may be substituted for the hydrated lime.

Thickness of Flue Walls.—The least expensive way to build flue walls is to make them 4 in. thick, lined with burned-clay flue lining. With walls of this thickness the lining never should be omitted nor replaced with plaster. The expansion and contraction of the chimney would cause the plaster to crack and an opening from the interior of the flue through which flame could pass might eventually be formed. All joints should be completely filled with mortar.

If flue lining is not used, the walls should be not less than 8 in. thick, with joints in the flue carefully pointed. In Europe, a mixture of cow dung and lime plaster, used for plastering flues, is found to crack but little. The plaster is applied as the flue goes up. As the flue is built, a bag of shavings fitting the flue tightly may be drawn up by a rope attached to the top of the bag. This is used to catch the plaster droppings. It is also useful in a flue in which clay lining is used and in which there is an offset. It may save much trouble and cost to contractors in cleaning out flues after completion.

Setting Flue Linings.—The flue lining should extend the entire height of the chimney, projecting about 4 in. above the cap and a slope formed of cement to within 2 in. of the top of the lining. This helps to give an upward direction to the wind currents about the top of the flue and tends to prevent rain and snow from being blown in.

The flue space should not extend up from the foundation but only from about a foot below the first connection. The furnace flue should have a cleanout door. Be careful that there is no connection between the flues at the bottom or trouble may be experienced with the draft.

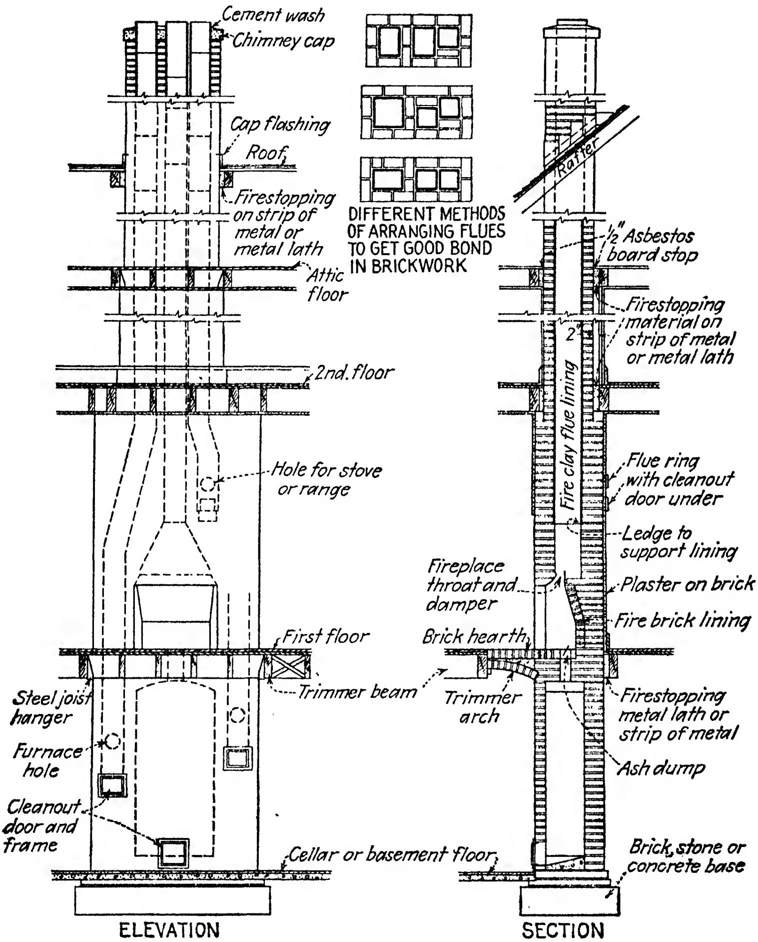


FIG. 63.—Elevation and section of interior independent chimney showing recommended construction. It is wise to build one extra flue. It may prove invaluable to accommodate later appliances. The extra cost when chimney is being constructed is small.

Fill all the joints of the flue lining and the space between the lining and the brickwork tightly with mortar.

The partitions between flues (called "withes") should be bonded as shown in Fig. 63.

Adjacent Woodwork.—Keep all woodwork—joists, furring strips, rafters, etc.—at least 2 in. away from all flues and brick chimney breasts. Above all, never rest any woodwork on the walls of flue.

Construction of Mantel.—To prevent the finished mantel from being spotted with plaster, the rough work only is installed first, the mantel and hearth being built after the plasterer has finished his work.

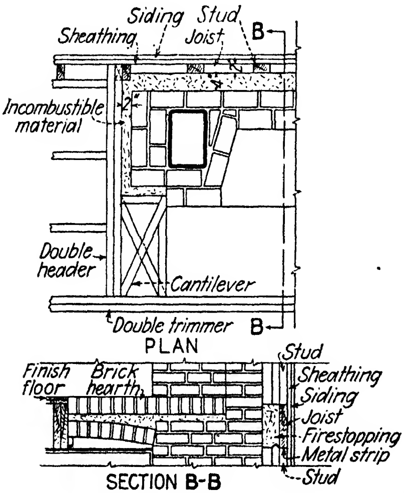


FIG. 64.—Protection around fireplace in outside frame wall and section showing trimmer arch and hearth.

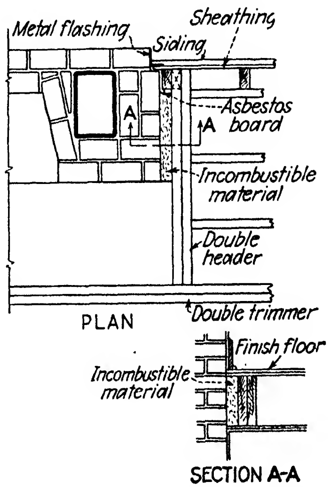


FIG. 65.—Protection around fireplace extending through outside wall.

Number of Bricks in Fireplaces.—To figure the number of bricks in a fireplace, multiply the width of the fireplace by the height from floor to floor and figure it as a solid wall. Then deduct an area equal to the brick displaced by the flues and fireplace from the total area given above. Find material quantities in Table 5 on page 161.

Hearth.—The front and back hearth are generally laid of the same brick as the mantel, either flat or on edge. Sometimes the back hearth is of firebrick. The portion projecting into the room rests upon a "trimmer arch," as shown in Fig. 64, thrown from the fireplace to the header joist, the filling between the trimmer and the hearth being either lean concrete or mortar.

Sides and Back.—These also may be formed of the same brick as used for the mantel. Firebrick is sometimes used. The back should be perpendicular for two or three courses, sloping or curving outward from this point.

Smoke Shelf.—Place the throat well forward to form a smoke shelf at the damper level, for the reasons given above.

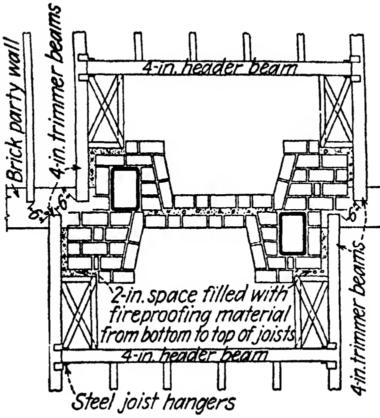


FIG. 66.—Method of building two fireplaces back to back in a brick party wall to secure proper spacing between ends of floor joists.

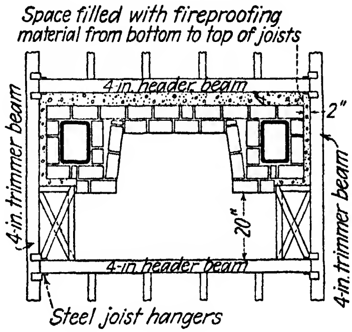


FIG. 67.—Floor framing around a single fireplace.

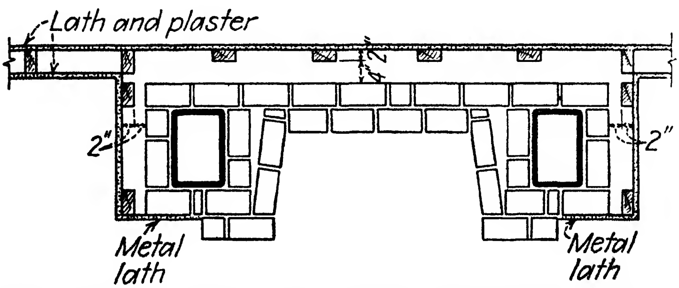


FIG. 68.—Stud partition across back of fireplace and around the ends of chimney breast, showing proper arrangement of studs.

The opening above the smoke shelf should be "gathered" or contracted to the size of the flu by corbeling, this being done within the least height practicable. Up to the level of the clay flue lining, the brickwork should not be less than 8 in. thick, for the space immediately above the damper is the hottest part of the chimney.

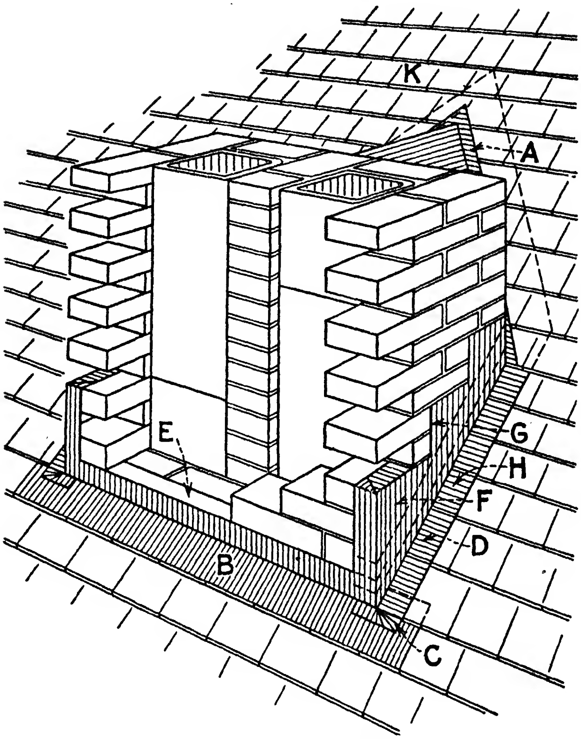


Fig. 69.—Chimney and roof connection. Sheet metal *A* should have roof units *K* lap over it at least 4 in. Apron *B* bent as at *E*, with base flashings *C*, *D*, and *H* and cap flashings *F* and *G* lapping over the base flashings, provide waterproof construction. When the chimney contains two flues, the joints and the linings should be separated as shown.

WHERE TO USE FLASHINGS AND CALKING

Weathertight construction of any type—whether masonry, wood, or steel—requires the use of flashings and calking at certain important points in the structure. The purpose of flashings is to prevent the entrance of water at vulnerable points in the exterior surfaces. Calking is employed to prevent the entrance of both wind and water around window and door frames, and at other places where there may be shrinkage or expansion of the joints between masonry and other materials that cannot be protected by flashings.

Construction of Flashings.—Typical methods for constructing and installing flashings are indicated in the accompanying diagrams. Flashings may be made of any durable and watertight material. Heavy waterproof building felt may be employed for concealed flashings or for some exposed flashings for maximum economy, but copper, zinc, lead, and sometimes aluminum flashings are to be preferred because of their greater durability. Galvanized iron, unless of copper-bearing or rust-resisting type, has about the durability of waterproof felts and should seldom be employed.

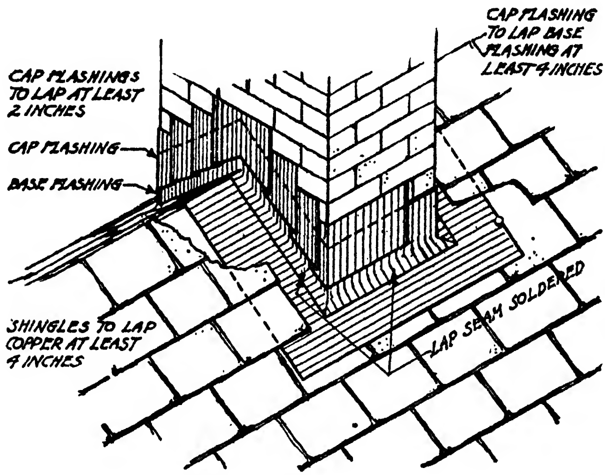


FIG. 70.—Recommended flashings of chimney extending through ridge of roof. (*Courtesy of Copper and Brass Research Association.*)

Through flashings in brickwork are those which are carried entirely through the masonry wall or, in the case of Ideal hollow wall construction, those which are carried through the outer withe. They are used to interrupt the passage of water within the mortar joints and to force it to the outer surface of the wall. They are usually employed where there is a change of material, as over lintels, under sills, and at spandrels.

Counter flashings should always be employed where two surfaces meet in different planes, as where a roof joins a parapet wall or where a low roof meets a higher exterior wall. They consist of two flashings, one applied to the lower horizontal or sloping surface and turned up against the vertical surface and the other a counter flashing built into the brickwork of the vertical surface and turned down over the top of the lower flashing, as illustrated in Fig. 71.

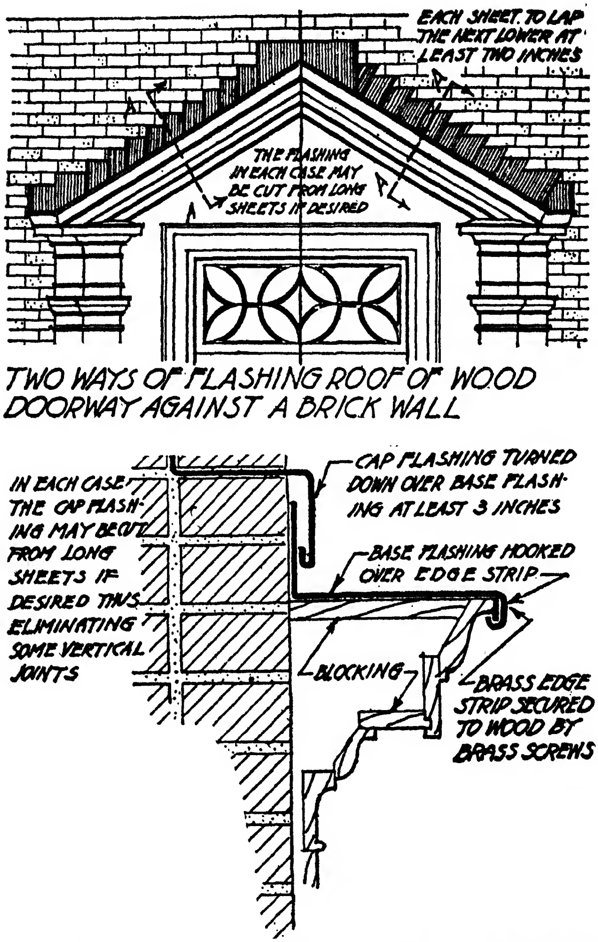


Fig. 71.—Flashings should be used where applied wood detail joins brickwork. Typical methods recommended over doorway.

Where to Use Through Flashings.—Through flashings should be employed at the following points:

1. Under the coping of parapet walls (see Figs. 54 and 55, pages 97 and 98).
2. Over spandrel beams (see Fig. 73).
3. Over lintels.
4. Under sills of windows and doors.
5. At the upper surface of half-timber work, through timbering, or wherever masonry joins a nonmasonry material. Also over

applied woodwork, such as pilasters and other wood trim, as shown in Fig. 71.

6. Above the grade line at the top of brick or other masonry foundations. This is for the purpose of preventing the capillary seepage of water upward from the ground into the structural wall to minimize the possibility of efflorescence. It may consist of a durable metal or a flat bed of slate or other impervious stone.

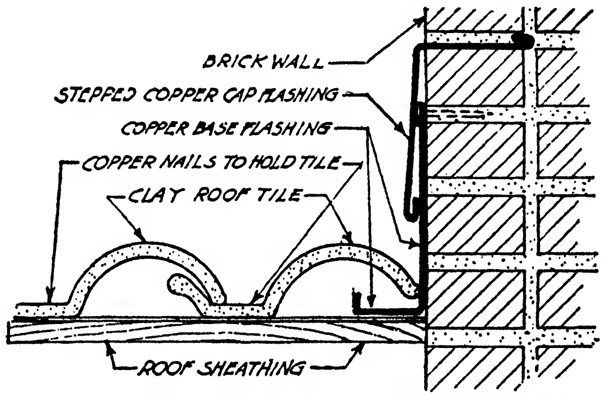


FIG. 72.—Flashing at the junction of a tile-covered sloping roof running down the side of a brick wall. Similar base and counter flashings are used where roof slopes away from wall.

Where to Use Counter Flashings.—Counter flashings should be employed at the following typical points in any masonry structure:

1. Where brick chimneys penetrate the roof surface (see Figs. 69 and 70).

2. At the junction of parapet walls and flat or sloping roofs. The flashing should be carried up the side of the wall to a height greater than that at which snow or ice may be expected to collect (Figs. 54 and 55).

3. Wherever low roofs adjoin higher side walls (Fig. 72).

4. Wherever two independent but adjacent structures meet at different levels, as in city construction where two adjoining buildings of different height are built against the same property line, in which case flashings and counter flashings should be used to prevent water or ice penetrating the joint separating the two independent walls.

The Importance of Calking.—Window and door frames, whether of metal or wood, should always be calked at their junction with masonry materials. For this purpose leave a space not less than ¼ nor more than ⅜ in. wide between the brick masonry and the face of the window or door frame. This permits the insertion of the nozzle of a pressure calking tool with

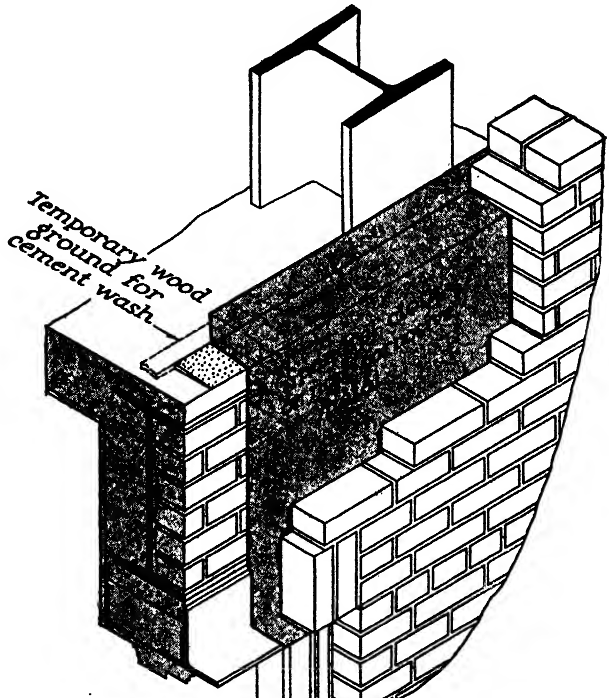


Fig. 73.—Flashing of spandrel in fireproof steel construction, showing 8 in. of brick over exterior of steel columns.

which suitable calking compounds can be forced into the space to make a weathertight joint. This construction allows for shrinkage of woodwork and for temperature changes in metal frames.

Where to Use Calking.—Always make provision for calking around window or door frames of any type and at all other points where masonry joins a nonmasonry material, unless the joint is covered by through flashings or counter flashings.

BEARING AND NON-BEARING SOUNDPROOF PARTITIONS

Brick masonry makes a superior soundproof partition wall of either bearing or non-bearing type. Load-bearing partitions are built like exterior load-bearing walls. They may be solid or hollow, as governed by the load and space limitations.

Non-bearing Partitions of Brick.—Two types of non-bearing partitions may be built of brick in addition to fire walls and party walls (which may be non-bearing.) They are the 4-in. solid brick partition and the 2¼-in. solid brick rolock partition. Both are exceptionally soundproof and the choice should be governed primarily by the permissible thickness and unsupported length or height. The 4-in. partition is built with the bricks laid flat in common bond and requires no description.

Soundproof Rolock Partition Wall.—This partition is built of common clay brick laid on edge (rolock) to form a core 2¼ in. thick. This is then plastered on both sides with ½ in. of old-fashioned lime plaster, making a total wall thickness of approximately 3¼ in.

Tests on this wall prove that it is remarkably soundproof, its resistance to sound being such as to nullify almost completely the sounds of singing, loud talking or laughter, phonograph records, radio receiving sets, and all other normal objectionable noises. Its weight is only about 20 lb. per sq. ft. and it can be constructed at very low cost.

Applications of Soundproof Rolock Partition.—This wall is particularly desirable for use in apartment buildings, office buildings, hotels, schools, and commercial structures of all sorts where it may be keyed to masonry floors and ceilings of normal height and to vertical structural columns at normal spacings. Its economy, light weight, soundproofness, and ease of construction strongly favor its use. It has adequate rigidity and thrust resistance after it is keyed or bonded in at the top, and even during construction it is as rigid or more rigid than walls of other materials of related character.

Construction of Soundproof Rolock Partition.—Mortar should not be too rich a mixture because of the absorption quality of common brick. If too rich a mixture is used, it may dry too rapidly and crack, which must be avoided.

Only old-fashioned lime plaster is recommended, because with a "hard wall" or other special types of plaster, a metallic sound is apt to develop, thus reducing to some degree the sound resistance of the wall. Old-fashioned lime plaster is very economical to use and bonds perfectly to the brick.

In computing quantities, allow 4½ bricks per sq. ft. of partition.

FURRING AND PLASTERING ON BRICK WALLS

In many cases the beautiful natural surface of the brickwork may be taken advantage of for interior finish, either for the whole

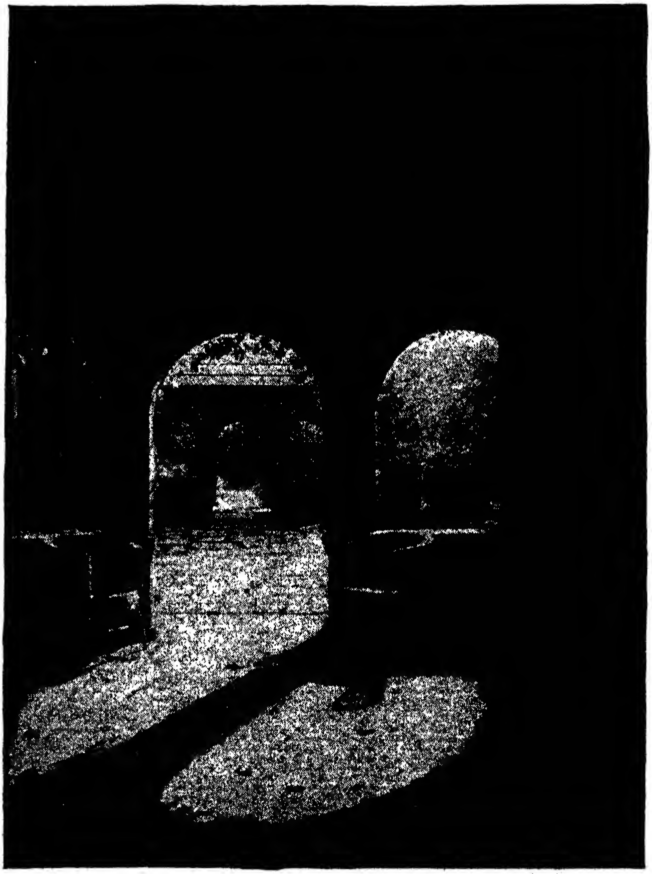


Fig. 74.—Brick loggia and open porch with brick floor. (*Courtesy of Butler and Corse, Architects.*)

interior of the building or for special rooms. The brick surface may be laid in a simple or elaborate bond or effective special designs may be worked out. In any case the advantage of a continuous surface of attractive brickwork for walls and engaged or independent column coverings is apparent. If fireproof brick floors are used the ceiling may also be formed of exposed brickwork.

Saving by Decorating Directly on the Brick.—In many buildings such as schools, and in much industrial work, it is possible to reduce the cost of the building by omitting the plaster and dull painting, enameling, or decorating the interior directly upon the brick.

Plastering Direct on Brick.—Plaster can be applied directly to a brick surface, without any chipping or other expensive preparation of surface and with no uncertainty as to whether the plaster will stay on.

Whether to apply plaster directly on brick or to a suitable lath furred out from the walls is a problem to be governed by individual circumstances. It is not merely a question of the capacity of brickwork to take and hold plaster successfully. The possibilities of either water penetration or condensation of atmospheric moisture on the interior surface of exterior brick walls must also be considered. Condensation appears on cold wall surfaces when the air in contact with the wall is warmer and heavily laden with moisture. Condensation is often mistaken for leakage through walls, as it frequently appears in rainy weather after a cold period has been followed by warm rains and when artificial heat is not applied within the building. Condensation does not trouble furred walls but may occasionally cause dampness on the interior surface of walls plastered directly on masonry. This danger is minimized by the use of Ideal hollow walls or other types of cavity wall.

It is almost impossible under practical conditions for a well-burned header to carry moisture along its entire length by capillary attraction. Moisture can, however, be conducted under severe conditions through a continuous mortar joint either of cement or lime mortar.

In most types of the Ideal wall there is no continuous mortar joint from front to back of the wall. (Where plaster is to be applied direct, such continuous through mortar joints must be avoided in case small sections of the wall are built solid for various purposes.)

In most types of the Ideal wall there is also an additional safeguard in the fact that a slight steady circulation of air within the cavities dries out any small amount of moisture that might reach the portion of the header in the hollow space.

The properly constructed Ideal all-Rolok wall in Flemish bond has established an enviable reputation for itself in many sections of the country as a wall which can be confidently relied upon to be thoroughly dry when plastered directly on the brick.

If in any locality it has been found by experience that walls of hollow units do not need to be furred and lathed, then the various types of Ideal walls used under the same conditions and with the same grade of workmanship can be depended upon with much greater confidence to be dry and furring can be omitted.

Waterproofed Walls in California Climate May Need No Furring.—Highly successful results have been accomplished in California and other parts of the country by waterproofing the inside face of solid walls, or by dipping about half the length of each header in Ideal walls in a waterproofing mixture of equal parts of asphaltum and distillate, the waterproofed end of the header being placed toward the inside of the wall. In that climate walls so treated do not need to be furred, and the plastering may be placed directly on the surface of the brickwork. This treatment is quite inexpensive.

Exterior Masonry Walls Should Generally Be Furred or Waterproofed.—As a general safe rule, all types of exterior masonry walls, of whatever material constructed, and whether solid or hollow, should be furred, lathed, and plastered on the inside surface to ensure nonpassage of moisture and to guard against condensation. Satisfactory results are also often obtained by waterproofing the inside surface.

This supercautious general recommendation is made to include all-Rolok construction in Flemish bond also, even though a multitude of structures have been built in that construction and plastered directly on the brickwork, and in all that number not more than half a dozen cases have been reported where traces of moisture appeared on the inside face of the wall; that result was found to be due in every instance to carelessness in construction.

Application of Heat-insulating Materials.—Where exceptional resistance to the passage of heat through walls is demanded, as may be the case in dwellings heated by gas, electricity, oil, or other expensive fuels, solid brick or Ideal hollow brick walls can be insulated in either of two ways:

Certain types of insulating materials, such as solid corkboard 1½ or 2 in. thick, may be cemented directly to the inner surface of the brick wall, using either a portland cement mortar, hot pitch, or special mastic compounds recommended by the material manufacturer. Plaster may then be applied directly to the corkboard or other insulating materials where the manufacturer so advises, or to a metal lath or welded wire reinforcing fabric applied over the insulation.

The more common method is to nail an insulating board or flexible insulating blanket over the furring strips before applying the plaster base and plaster.

PORCHES, WALKS, AND GARDEN STRUCTURES OF BRICK

Porches and Terraces.—Brick-paved porches and terraces are particularly charming with brick houses but are always appropriate with any type of building.

Porch floors of brick that are not laid on solid fill, like terraces, may be economically constructed of reinforced brickwork as described under Reinforced Brickwork for Structural Purposes, page 88. Only one thickness of brick is required for the panels between brick piers or deeper reinforced brick girders. The brick may be laid in running bond or basket-weave pattern as desired, by confining the reinforcing rod to the joints that run through the patternwork.

Brick-paved porches are most economically built on a solid fill of tamped earth or cinders brought to a suitable grade below the finished grade of the floor. Construction is identical with that described for walks.

Brick-paved Terraces.—Brick-paved terraces are laid on the natural grade or upon a soil or cinder fill brought up to the required level in the manner described below for the laying of brick walks. Terraces and porches that are to be extensively used for living purposes, as outdoor dining rooms, etc., should preferably be laid on a concrete subbase with the surface sloping away from the building at a grade of about ¼ in. per ft. to assure satisfactory drainage.

Terraces or porches requiring very smooth surfaces suitable for dancing can be attractively created by laying brick in full mortar joints on a concrete bed and subsequently grinding the surface to a smooth finish with a terrazzo grinding machine. The brick should preferably be laid in suitable patterns for heightened decorative value, and may be placed either on edge or flat as the

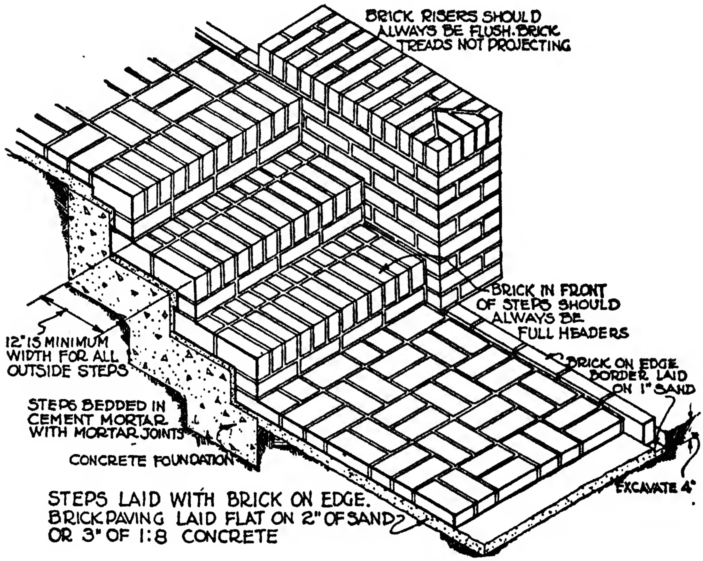


FIG. 75.—Steps laid with brick on edge, walk with flat brick.

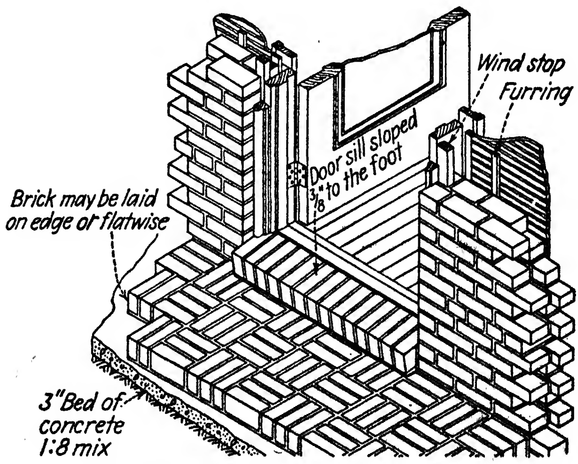


FIG. 76.—Steps laid with brick on edge.

requirements of the design indicate. Mortar joints of light or contrasting color increase the beauty of the effect. Grinding should be carried on only to a sufficient degree to take out the minor roughnesses of the brick surface and mortar joints. When finished, the floor may be filled with shellac and oiled or waxed, if used on a porch, or may be left without treatment if exposed. The resulting effect has the color and beauty of a rich Oriental rug.

Outside Steps.—Steps should be laid on a firm base. Treads should never be less than 12 in. wide, or they may be dangerous

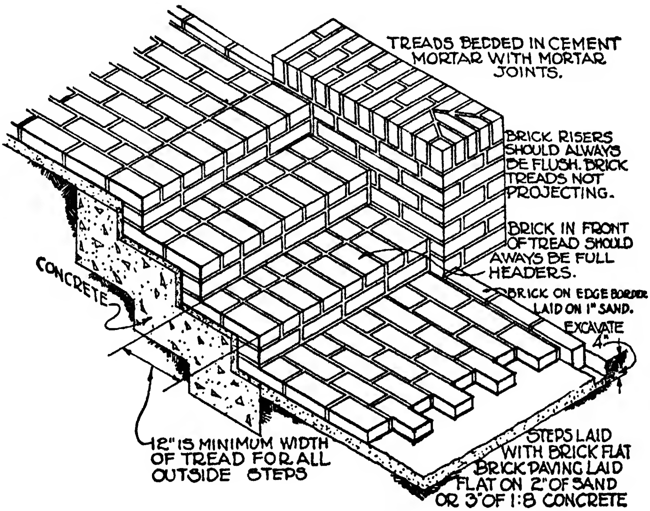


FIG. 77.—Door sill and step, brick flat.

when covered with ice and snow. Steps should pitch forward with a slope of about ¼ in. per ft. The under surface of the concrete base should never slope but be stepped off horizontally or the concrete is likely to slide out of place. The concrete should be thick enough to prevent it breaking. It may be reinforced if necessary (Fig. 77).

Where the subbase is not firm for any reason, reinforced brick construction may be employed economically.

Joints in steps should always be filled with cement mortar, and pointed with a "thumb" joint, which is a broad, slightly concave joint thoroughly rubbed with a steel jointing tool. The front of the treads should be laid of full-length headers. Half bricks should not be used in this position. It is good practice to give the face of the brick to be exposed a coat of raw linseed oil immediately before laying, as this prevents mortar sticking to the face of the brick.

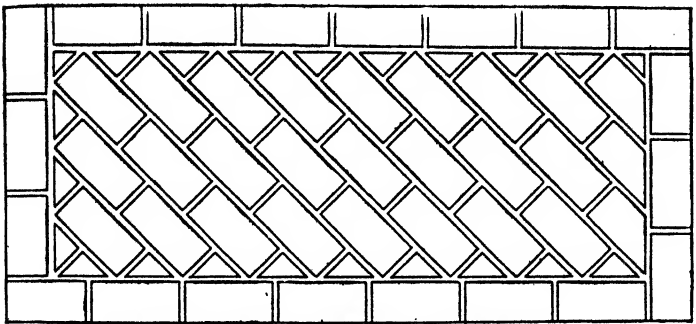
Brick Walks.—Brick for this purpose should be hard burned. Ask the manufacturer whether his bricks are suitable for this use. Walks may be laid in one of two ways, either on sand or cinders or on a concrete base, in the latter case with mortar or sand joints.

For those who prefer a walk to be a little irregular, perhaps with grass growing up in the joints, the first-mentioned method is recommended. Grass can easily be kept down if desired, however, by mixing salt with the sand. The bricks may be laid flat or on edge.

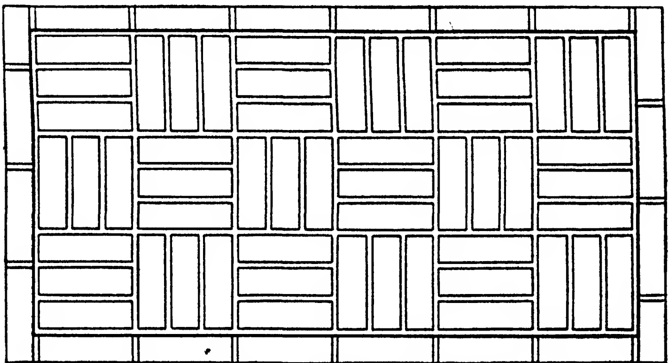
A method of laying walks in this manner is indicated above. First excavate the soil to the depth of about 4 in. Lay a 1-in. thickness of sand for the border bricks, which are placed on edge. Then lay and tamp or roll a 2-in. bed of sand or cinders for the rest of the walk, placing the bricks flat. It is important, especially in a clay soil, to drain the sand or cinder bed thoroughly. If bricks are on edge the excavation should be proportionately deeper. Leave about ½ in. space between the bricks. As soon as they are laid, fill the vertical joints by placing a layer of sand on the walk and sweeping it into the joints with a broom. Leave the sand on the walk for a few days, agitating it once or twice a day, so that the joints will be completely filled. Tight mortar joints may be used, however, as described below.

A concrete base will ensure the walk or terrace remaining rigid and even. A lean 1:8 concrete should be used, 3 in. thick, laid on a bed of cinders or sand, thoroughly drained. The brick may be laid on a ½-in. setting bed of cement mortar or upon a bed of sand just thick enough to straighten out the irregularities of the rough concrete. The curb may be formed of concrete or of brick on edge. The vertical joints may be sanded or filled with mortar.

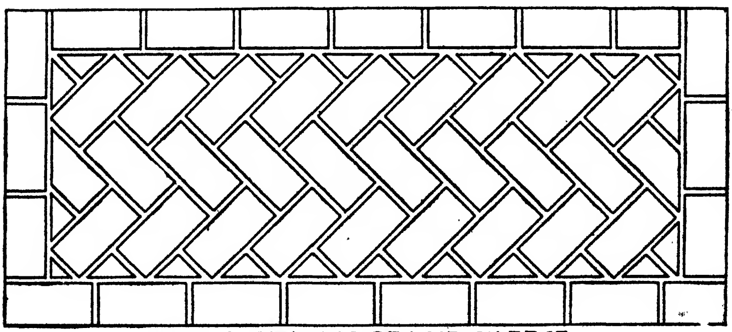
In the latter case the most satisfactory but most expensive method is to trowel the joints carefully. A cheaper way is to broom the joints full of a thin 1:3 cement grout, but this has the disadvantage of smearing the surface of the brick with mortar. This may, however, be removed by going over the surface while the mortar is soft with a scrubbing brush and water containing not more than 5 per cent muriatic acid, afterwards removing the acid by scrubbing again with clean water.



BRICK CAN ALSO BE LAID ON EDGE



THIS PATTERN MAY BE MADE BY LAYING BRICK FLAT



BRICK CAN ALSO BE LAID ON EDGE

FIG. 78.—Typical patterns for brick-paved walks and terraces.

Another and better method is to pour the grout carefully into the joints, wiping the brick clean before the mortar has set.

If bricks are laid with tight mortar joints, the walk should be slightly crowned for drainage if on flat ground. If laid with sand joints on concrete, the latter should have a slight crown.

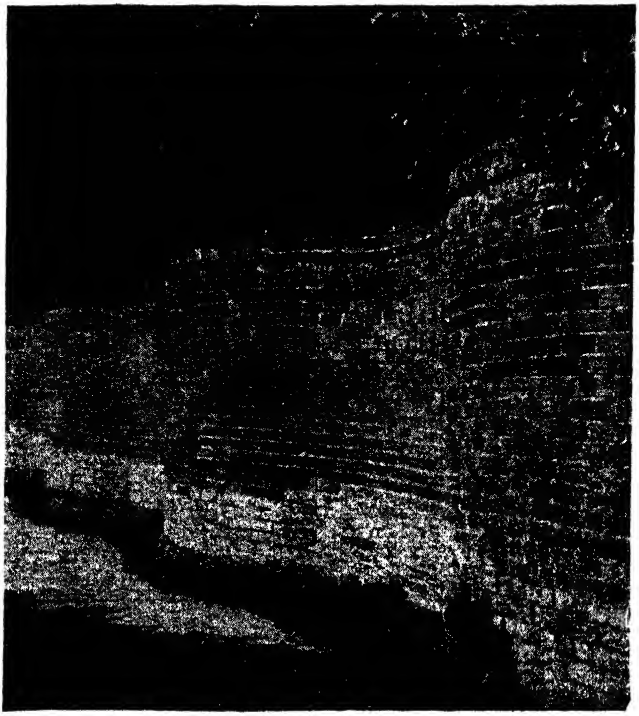


FIG. 79.—An old serpentine garden wall 4 in. thick.

Number of Bricks in Walks.—If the walks are to be laid with brick on edge, figure the number of bricks by finding the area and reading the number of bricks required for a 4-in. wall, table 9, page 165, about 6 bricks per sq. ft.

If the bricks are laid flat, about 4 bricks per sq. ft. will be ...ired. For a walk 3 bricks wide, allow ½ cu. ft. sand, 2 in. ... foot run of walk; 4 bricks wide, ⅝ cu. ft.; 5 bricks wide,

...s of Brick.—Brick posses the same qualities ... for outside uses as for the walls of the

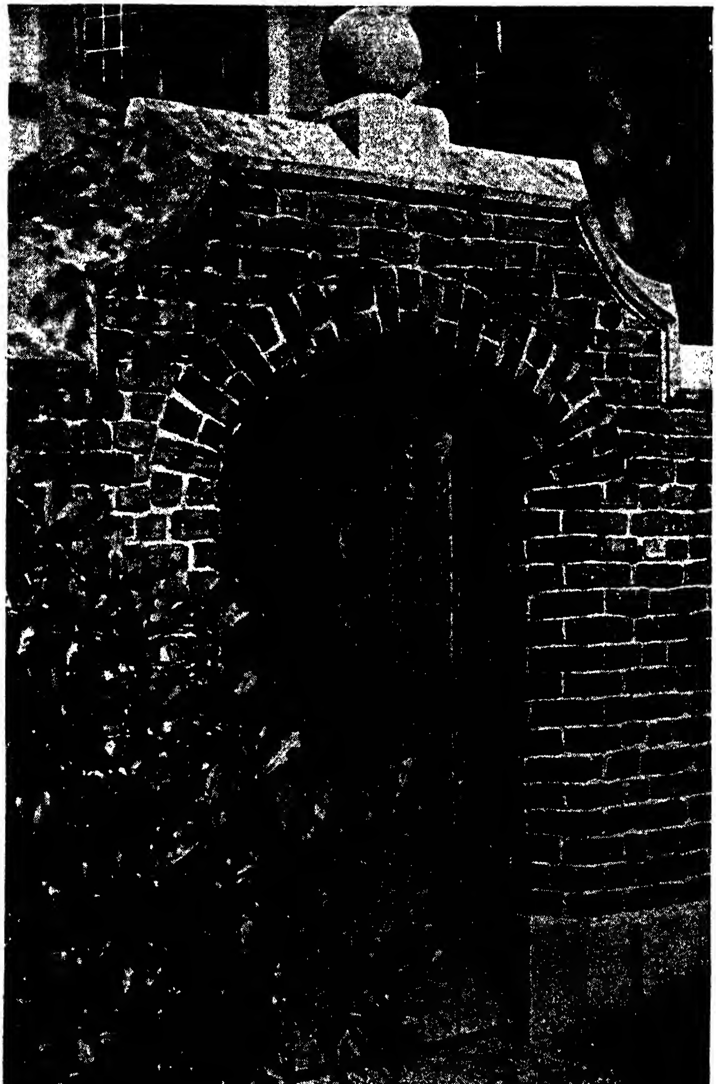


FIG. 80.—Wall and gate of antique brickwork. (*Courtesy of John Russell Pope, Architect.*)

home. Brick harmonizes well with any garden, formal or otherwise. Creepers and vines cling well to it and do not cause it to decay. Its beautiful colors and soft texture, forming a background for foliage and flowers look cool and inviting even in the hottest sun.

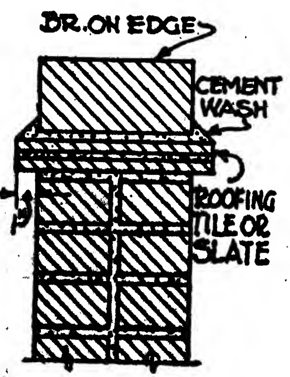
Summerhouses, garden walls, seats, steps, pergolas, gateposts, and walks form but a few of the instances where advantage may be taken of the unrivaled beauty, permanence, and ultimate economy of brickwork.

Garden Walls.—A brick wall is unexcelled either as a division wall or to shelter plants in certain exposures.

Solid walls or 8-in. Ideal all-Rolok walls make charming walls for the garden. A straight wall should be thickened to form 12- by 12- or 12- by 16-in. piers at intervals of about 10 to 12 ft., according to the height, to add stability to the wall. Offsets or irregularities in the plan answer the same purpose. The wall should extend below the frost line, but no footing is required. Portland cement mortar should be used.

For a wall dividing the same property into two or more parts, a wall 4 in. in thickness may be built in serpentine design (Fig. 79), the curves in the plan of the wall giving it the necessary stability. The wall shown, 4 in. thick and about 8 ft. high, has been standing over a century. It produces a variety of shady and sunny surfaces.

Pier and panel walls using 4-in. panels are ideal for property boundaries and garden walls where a sense of isolation or separation is desired. They are very economical to build, occupy but little space, and have all the rich beauty of heavier walls.



Capping Garden Walls.—The wall should be capped with a course of brick on edge in a 1:3 portland cement mortar. An artistic touch may be provided by placing two courses of slate or tile below the capping, projecting about 1 in. on each side of the wall.

Pergola Posts; Gateposts.—Hollow piers or posts, either of brick on edge or flat, make sightly and permanent supports for the pergola roof. The brick on edge posts should not be more than 11- by 11-in., the flat brick posts 12- by 12-in. The interior may be left hollow. Footings should extend below the frost line.

Gateposts and entrance posts may be built in the same manner, the gate being secured by bolts with anchor ends extending far enough into the post to take the strain, or passing entirely through the post with a plain or ornamental washer on the oppo-

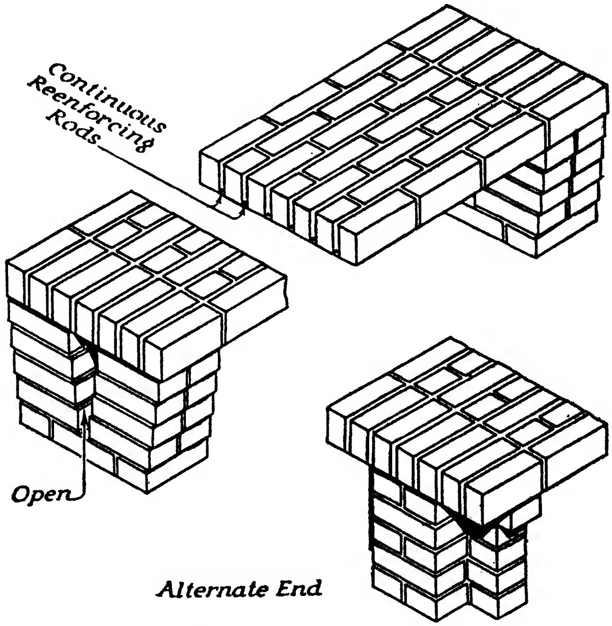


FIG. 81.—Modern and classic designs for garden seats employing a slab of reinforced brickwork.

site side. Brickwork should be made solid and the pier large enough to stand the lateral strain of the gate. A charming effect may be secured by building a brick semicircular arch over the gateway. There should be sufficient brickwork at the haunches to resist the thrust of the arch. Wrought-iron gates, lamps, strapwork, and other ornamental features are very effective when used in combination with brick.

Garden Seats.—A simple garden seat can be very cheaply and attractively built of reinforced brick in the following manner: Upon a board of suitable dimensions lay enough brick to form the top of a garden seat or bench, preferably about 16 in. wide and as long as desired, up to 6 or 8 ft. maximum. Place the brick lengthwise on the board, spacing the brick about ½ in. in each direction. Fill the joints partially with a 1:1:6 cement-lime mortar and then embed in each longitudinal mortar joint, about ½ in. below the upper edge of the brick, a ¼-in. reinforcing rod of steel. Finish filling the mortar joints over the rods flush with the brick surface. After 3 or 4 days, when the mortar has set, turn over the panel and mount it on two brick piers spaced to come under each end of the panel. The finished height of the top surface should be not over 15 in. from the ground. The top may be smooth finished by grinding and waxing, as described for porches.

Other garden structures requiring horizontal self-supporting members of this type, such as garden tables, small bridges over streams, exedras, etc., may be readily constructed of reinforced brickwork in the manner indicated.

Swimming Pools of Brick Construction.—Swimming pools, especially those located outdoors, are subject to the damaging influences of soil exposure, which may be acid or alkali, to alternate wetting and drying as the pool may be filled or drained, and to frost action in the cold season.

Brick has proved its ability to withstand these several influences without damage better than any other material.

Advantages of Brick Construction.—Building the bottom and side walls of the pool of brickwork is a simple performance and can easily be so supervised as to ensure a sound structure and subsequent satisfactory performance for an indefinite time.

Reinforcing rods may be built into the brickwork, if necessary, to give it greater lateral strength.

Form work is unnecessary with brick and the flexibility of the small units makes it easy to work out decorative panels, molds, or other architectural ornamentation.

Brick may be used merely for the structural backing of the walls and floor of swimming pools or may also be used for the inside facing, for copings, and for other decorative details.

Brick Pools Easily Made Watertight.—Shrinkage cracks seldom develop in solid brickwork embedded in the soil. The multiplicity of the units takes up ordinary strains without developing cracks that would impair the effectiveness of waterproofing. The recommended construction is to build the structural side walls of solid brick masonry with cement plaster or membrane waterproofing on the exterior (the latter being preferred unless a second membrane is used on the inner face). The waterproofing should be carried through the side walls at the level of the bottom of the pool and across the floor of the pool, which should also be of brick laid on edge on a bed of portland cement mortar. Floor brickwork may be reinforced with steel rods in the mortar joints if the soil beneath does not have uniform bearing power.

A second membrane waterproofing may be employed on the inner face of the side walls if the pool is to be lined with tile or another withe of brick, and this membrane should be joined to the floor membrane or carried completely across the subfloor, as the case may be.

Lining of Swimming Pools.—Smooth-faced brick may be employed to line the pool, or the inner membrane may receive ceramic tile set in mortar, whichever may be preferred.

SUGGESTIONS FOR DECORATIVE TREATMENT OF BRICKWORK

In the following pages are a selected group of illustrations chosen to suggest the infinite range of textures, colors, patterns, and design treatments that may be developed in brickwork.

There was developed in Chicago a type of brickwork called "skintled," that gave many new effects to brickwork surfaces. One type left the mortar joint uncut, with the joint extending beyond the surface of the wall. Other types were evolved by irregular placing of the exterior course of brick, which at a distance resembled stonework. The use of clinker brick, swollen and distorted by excessive heat in the kiln, producing a rustic effect, has been used in structures architecturally suited to that style.

The painting or whitewashing of brickwork has a considerable vogue, especially in the warmer climates where Spanish architecture is popular. Special paints are made for this purpose. A thin grout of white portland cement and water makes a satisfactory and quite permanent coating. Where whitewash is used it is expected that weathering will gradually wear away the coating, exposing the natural color of the brick in spots. This gives the effect of age. Examples of several of these types are shown.

BARBECUE FOR OUTDOOR LIVING

The barbecue and outdoor fireplace, having its initial popularity in the warmer climates, has extended to all parts of the country. It is an all-year convenience and joy on the Pacific Coast, while in the northern and eastern parts of the United States it is none the less popular during the warm months.

Not infrequently is the barbecue or outdoor fireplace built by the owner, without previous experience as a mason. While the building of a plumb and true wall is the job of an expert bricklayer, the smaller structures, where no important stresses are involved, may be done by a mechanically minded novice. However, it is recommended that a contractor be employed.

All the metal equipment necessary for these outdoor grills is available, ready to build into the masonry. It may usually be obtained through a building-supply dealer.

Two examples of these structures for outdoor living are shown with construction details. A simple fireplace, planned upon the same principle as the indoor fireplace, is largely ornamental for garden decoration. The open fire may be used for broiling meat and toasting. The barbecue is capable of cooking the usual outdoor feast.

TEXTURES IN SKINTLED BRICKWORK

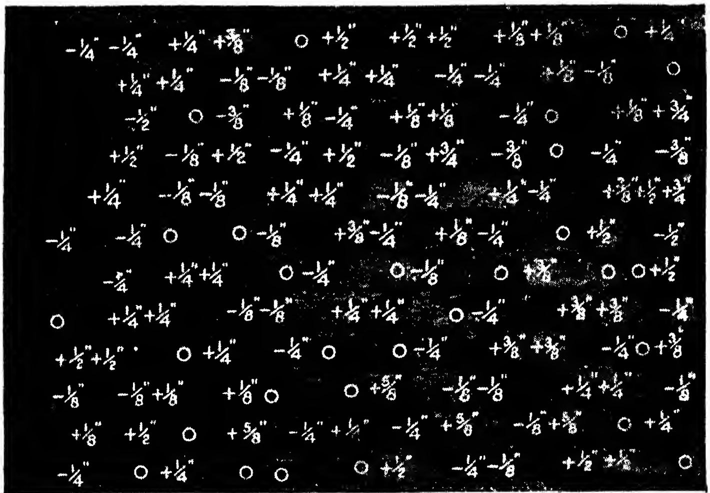


FIG. 82.—Detail of skintled brickwork. Plus dimensions indicate projection beyond wall line. Minus dimensions indicate set-back from wall line.

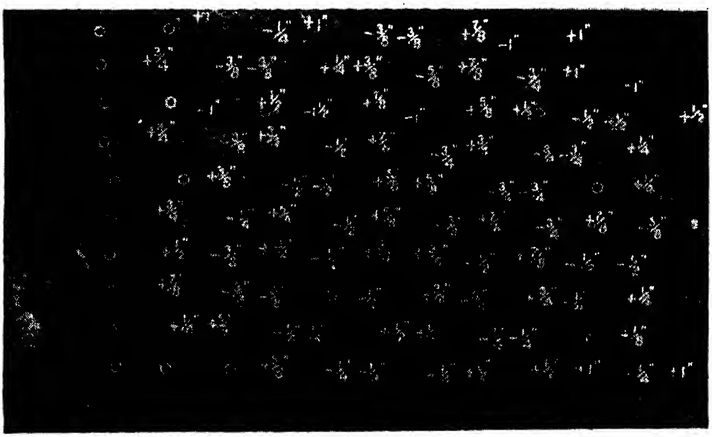


FIG. 83.—Unusually coarse design of skintled brickwork.

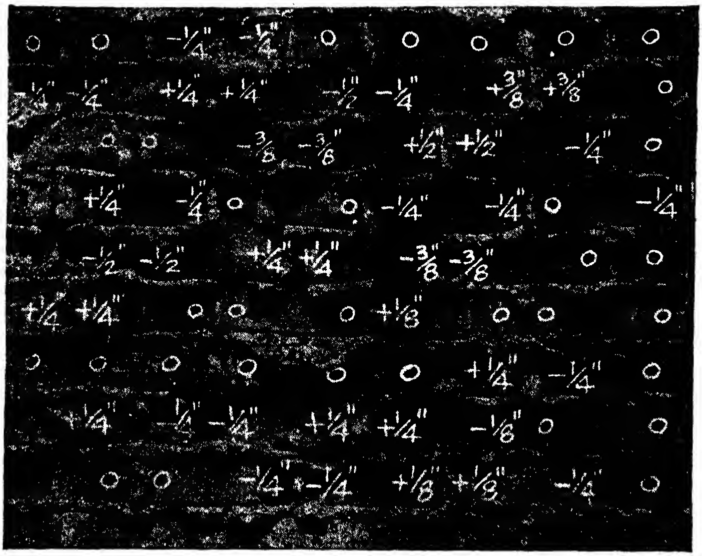


FIG. 84.—This effect is produced by irregular laying of brick and uncut mortar joint.

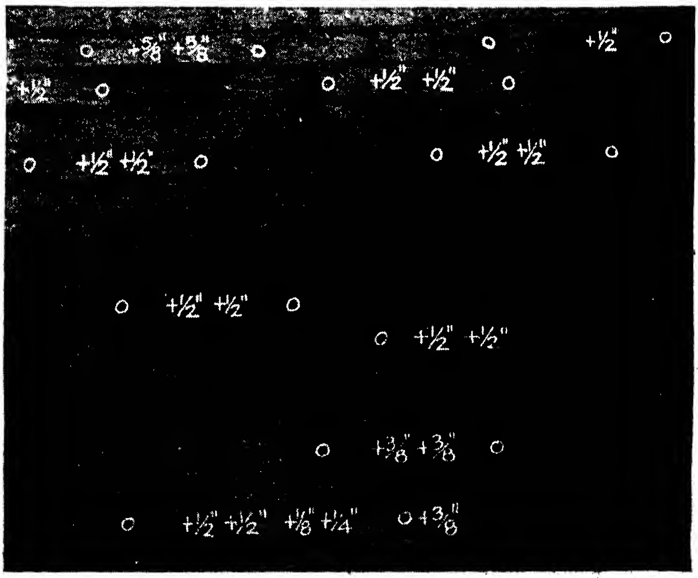


FIG. 85.—Moderate skintled pattern and one of most pleasing of this novel type of brickwork. Figure 86 shows section of wall built in this design.

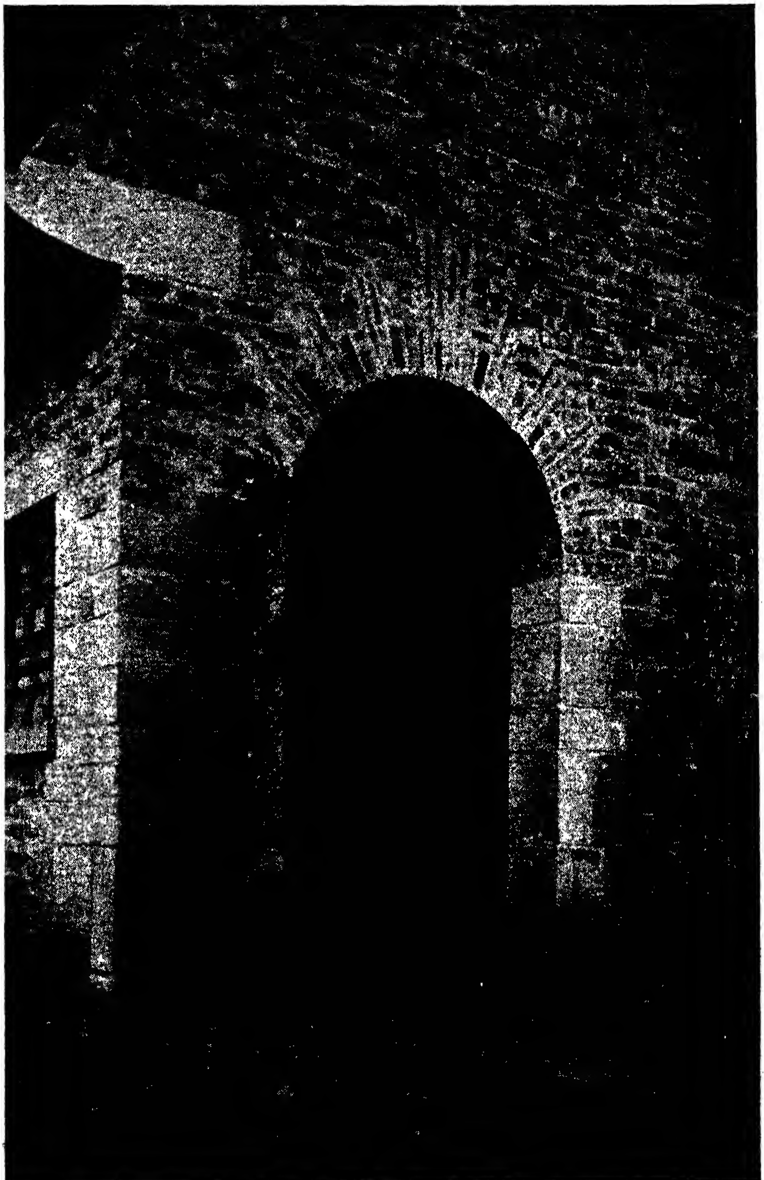


FIG. 86.—Here is a modified and one of the most attractive of the skintled-type surface. The bricks projecting slightly from the wall line produce shadows that add to the interest in the structure. (*Courtesy of Elmo C. Lowe, Designer.*)

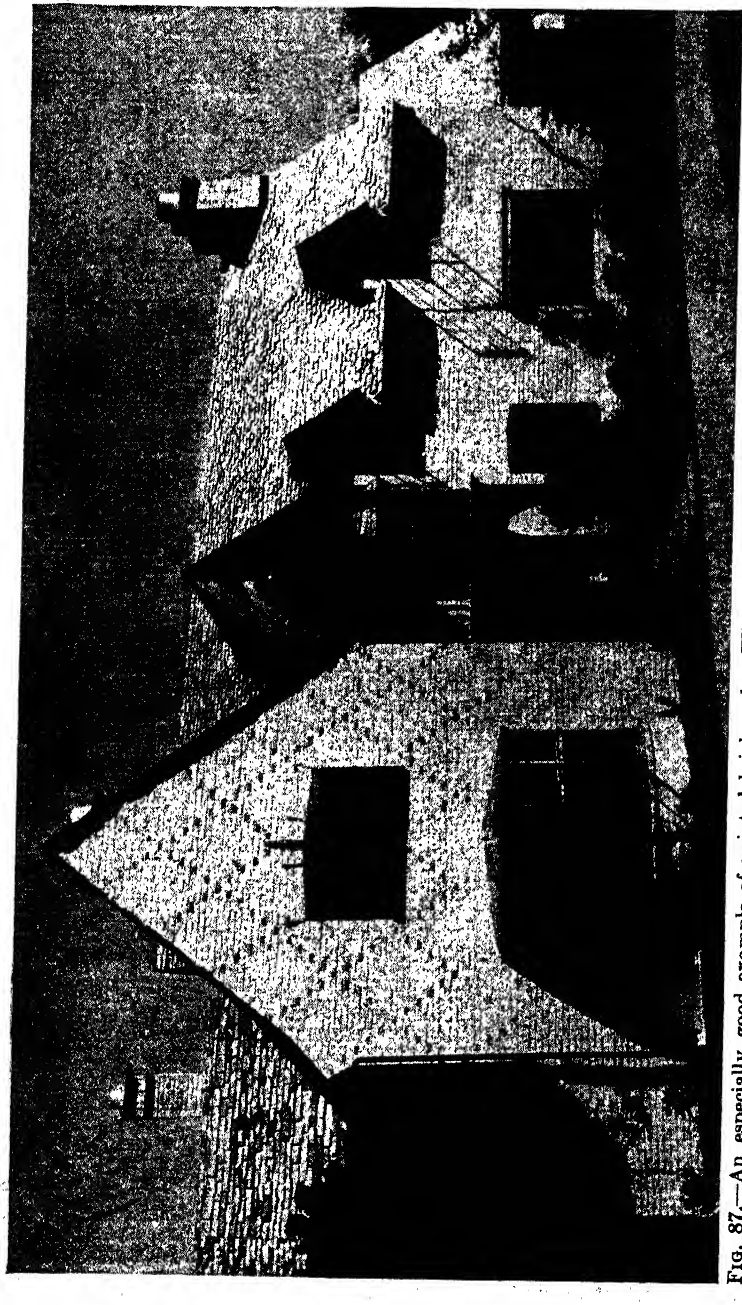


Fig. 87.—An especially good example of painted brickwork. With pattern in upper part of gable and brick outline showing through the white coating, an attractive texture is obtained. (*Courtesy of G. Forster, Architect.*)

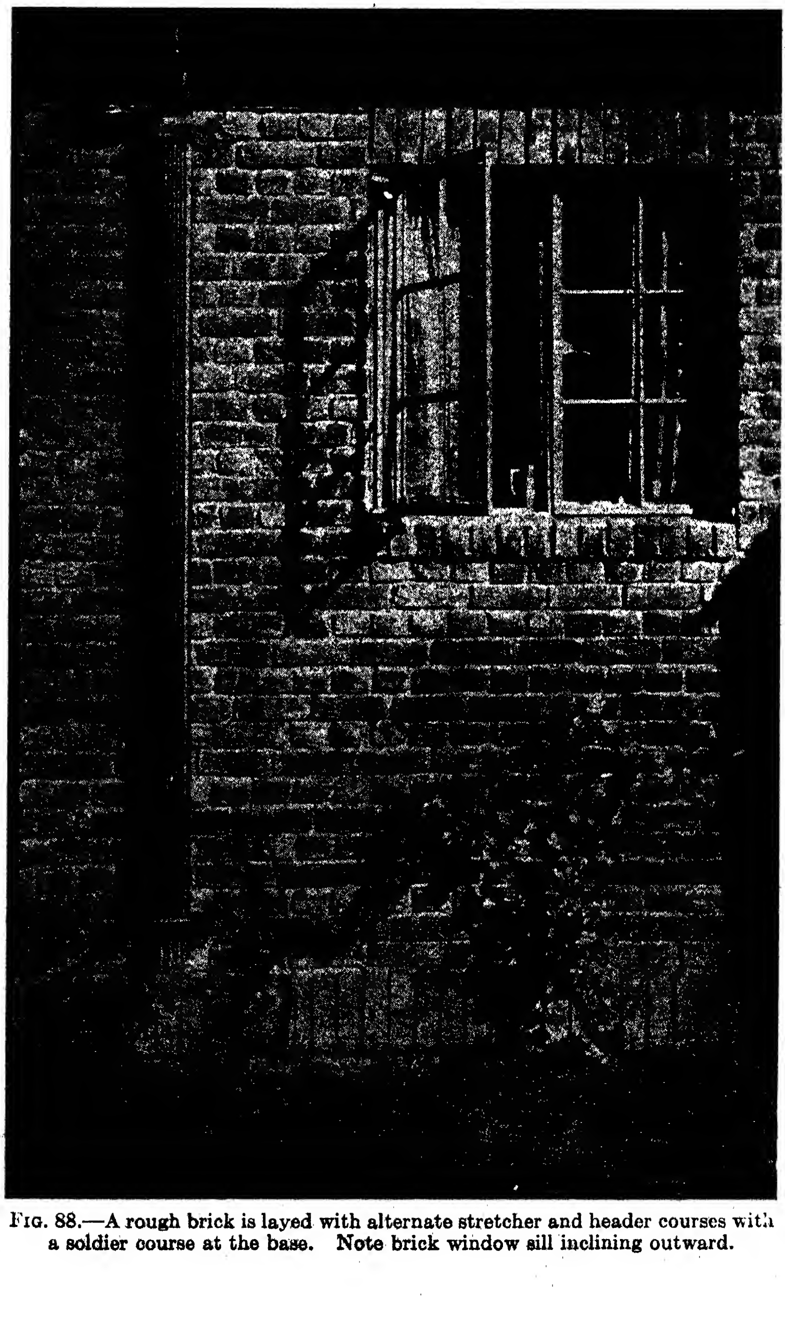


FIG. 88.—A rough brick is layed with alternate stretcher and header courses with a soldier course at the base. Note brick window sill inclining outward.

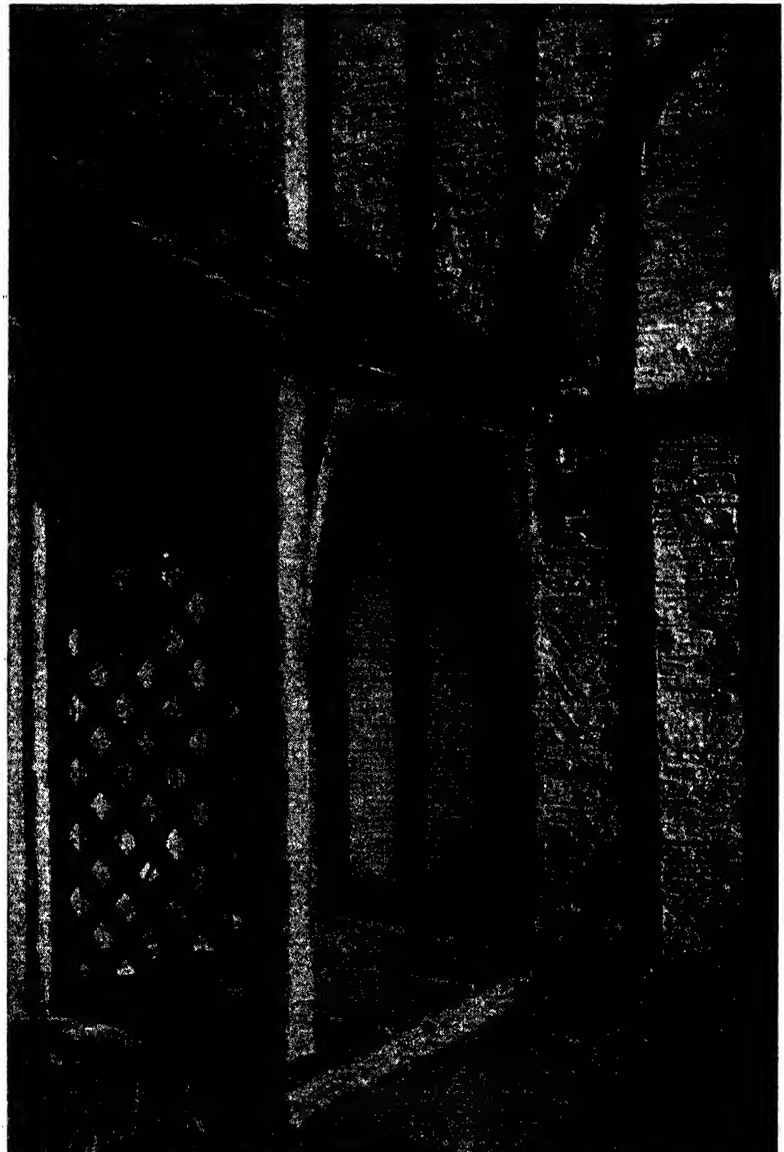


Fig. 89.—Brick nogging between timbers is painted white to produce an attractive effect.

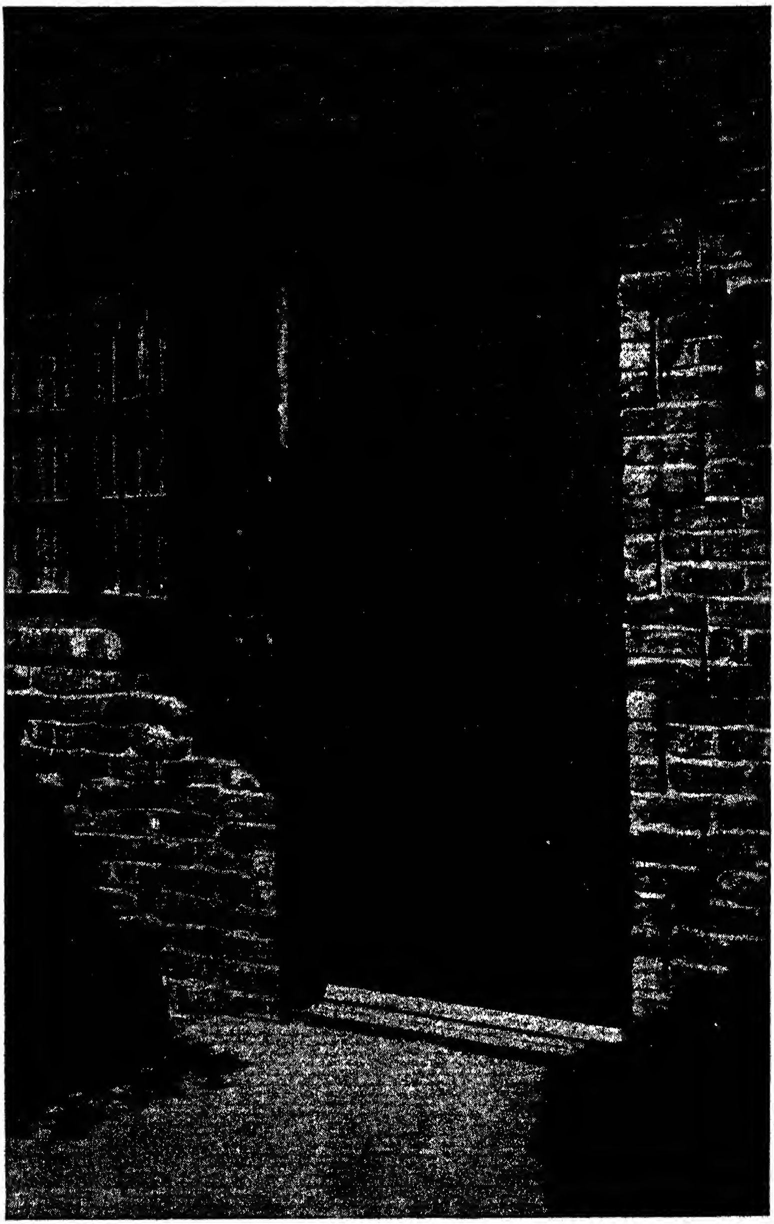


FIG. 90.—Clinker brick are used in this wall appropriately in connection with heavy timber lintels. (*Courtesy of Frank Forster, Architect.*)

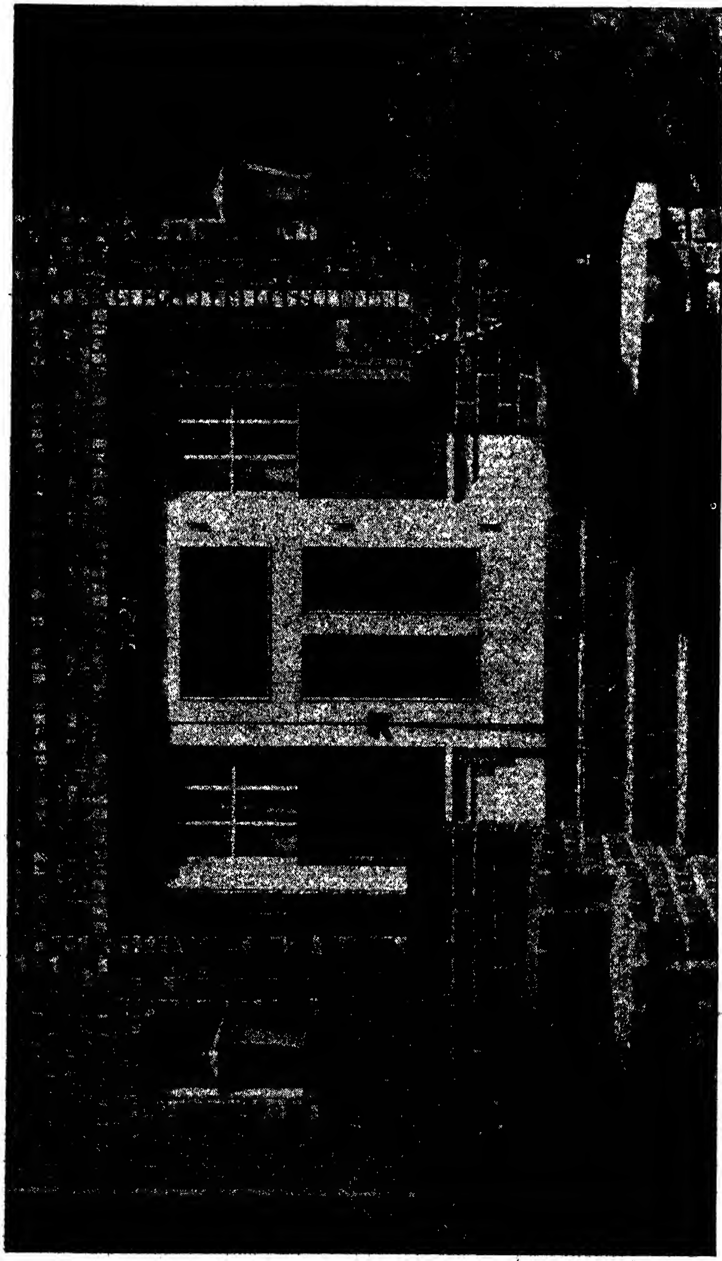


FIG. 91.—Deep-raked joints and unusual pattern of projecting headers combine to produce an interesting doorway, porch, and steps.

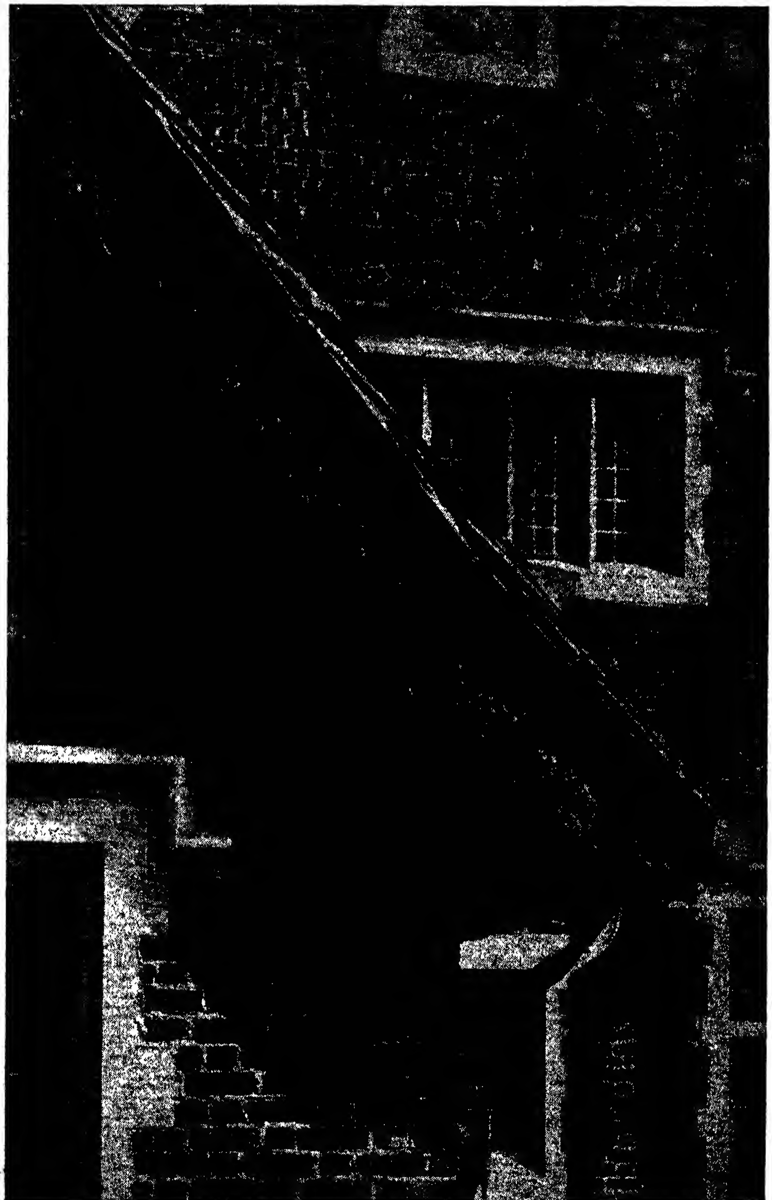


FIG. 92.—Dwight James Baum designed this house, with Flemish bond, hand-carved frieze, and unusual window arches.

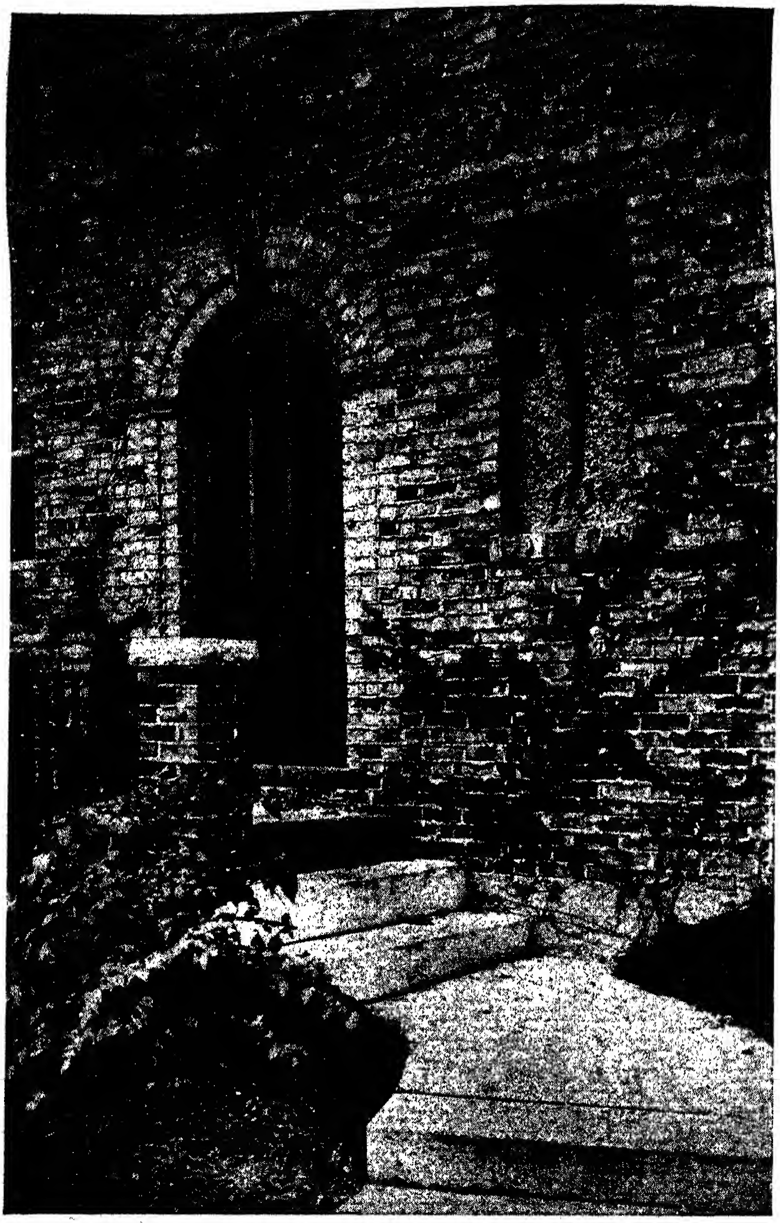


FIG. 93.—Skintled brickwork with uncut mortar joint is featured in this house. Note the thin tiles at the bases of the door arch.

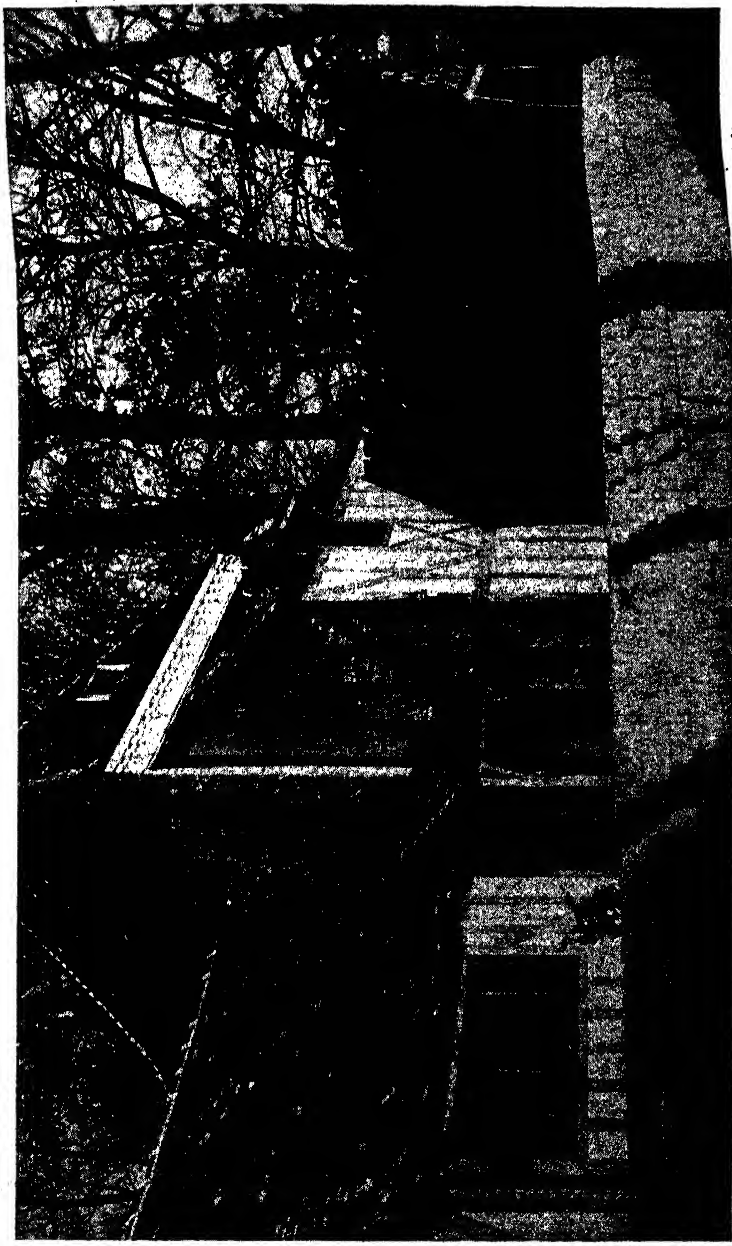


FIG. 94.—A brick garden wall, with lower part plastered and coping of pyramided brick painted white.

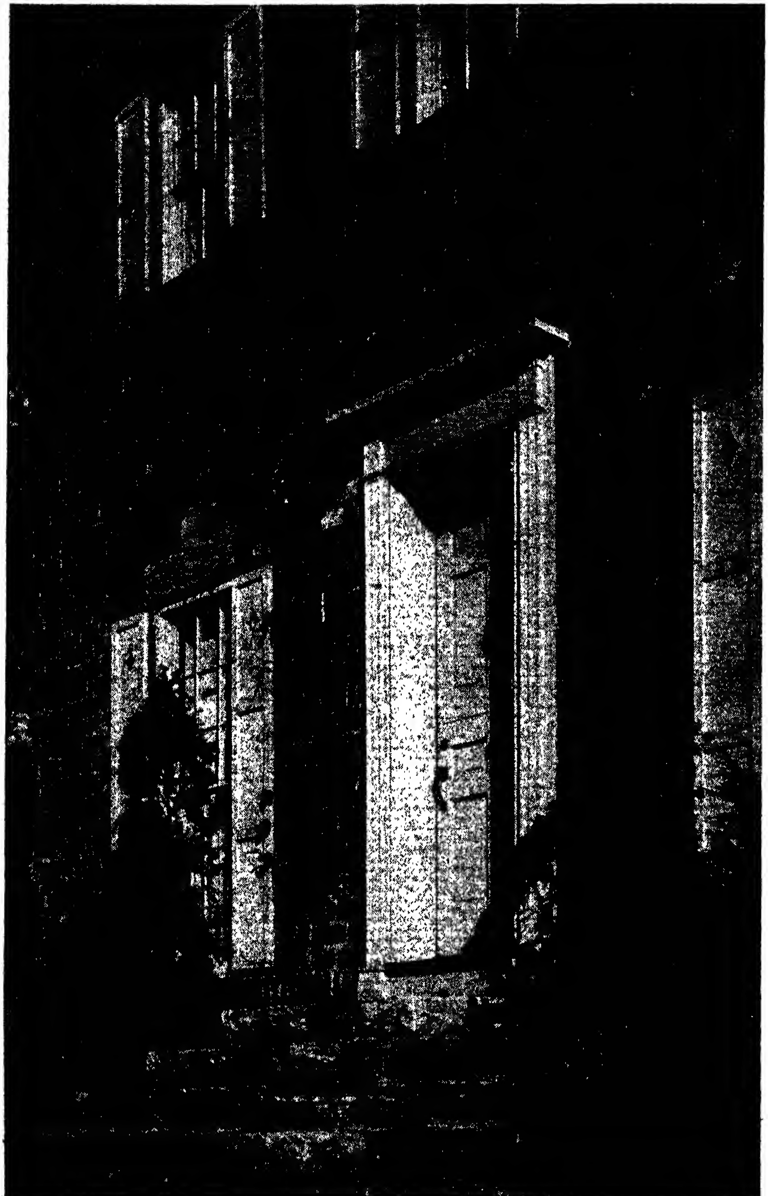


Fig. 95.—Here is a good example of all-Rolok Ideal wall. All brick laid on edge is in Flemish bond pattern.

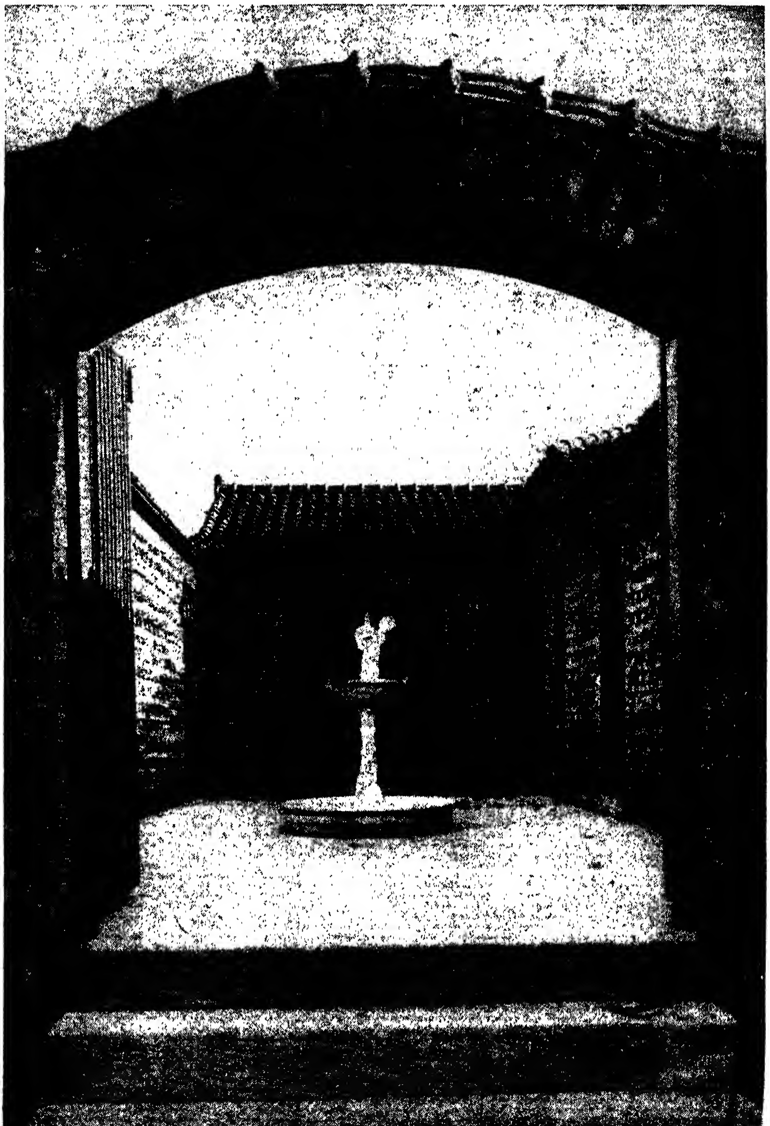


FIG. 96.—Gateway and patio with brick in skintled design. Alternating courses are laid "saw tooth," and header courses are of flush joints. (*Courtesy of W. Aitken, Architect.*)

FIG. 97.—Practical brick barbecue and range with Dutch oven and wood storage. The complete range, oven, and crane are obtainable as accessories, ready to install. (*Design and illustrations by courtesy of Donley Brothers Company, Cleveland, Ohio.*)

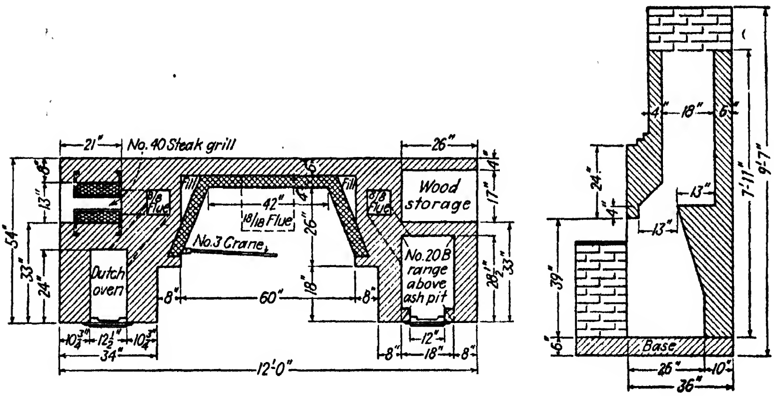


FIG. 98.—Plan of barbecue, illustrated in Fig. 97.

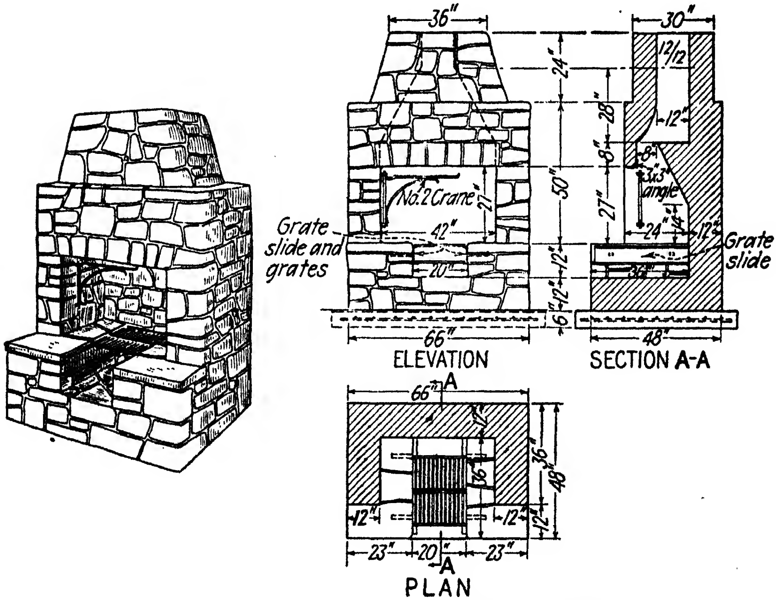


FIG. 99.—Brick or stone may be used to build this outdoor fireplace. For the novice, brickwork will be much simpler and will better withstand the heat. (*Design and illustrations by courtesy of Donley Brothers Company, Cleveland, Ohio.*)

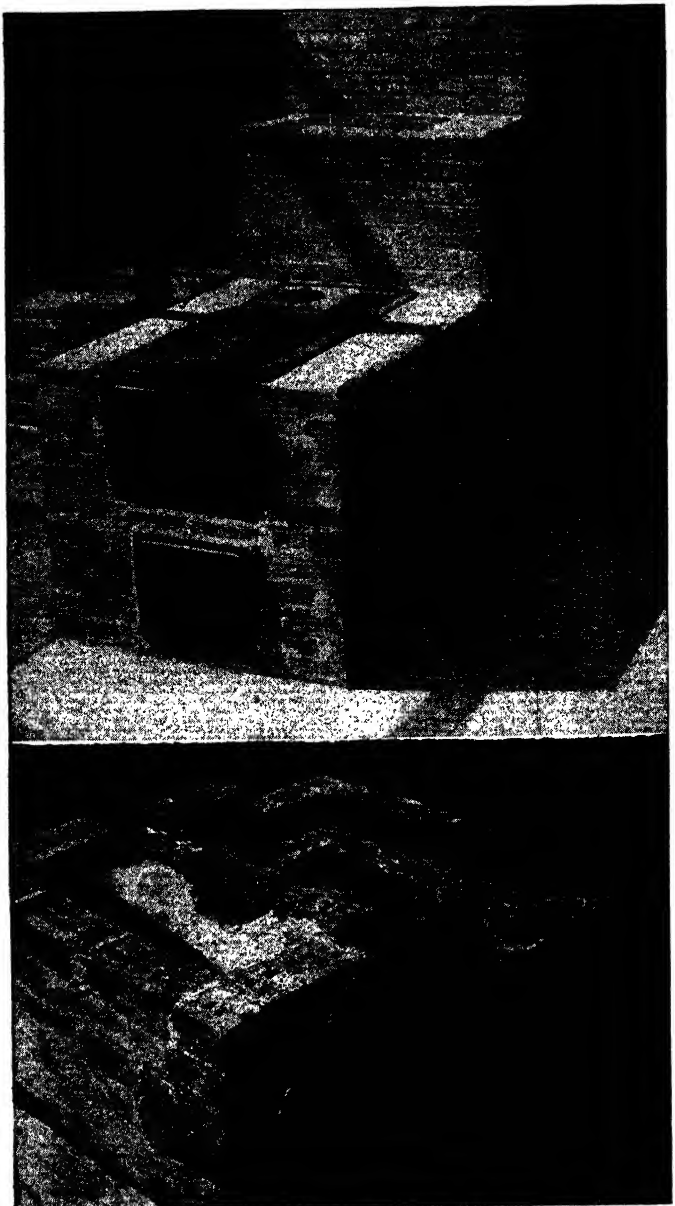


FIG. 100.—Small range and grill, easily constructed by use of ready-to-install accessories. A novel oven of sheet metal may be built into this assembly, as illustrated in smaller cut. (*Courtesy of Donley Brothers Company, Cleveland, Ohio.*)

CHAPTER V

REFERENCE TABLES FOR DESIGNING AND ESTIMATING BRICKWORK

When designing or estimating brickwork, the following reference tables will prove useful. Here will be found coursing tables, a table of weights of brick walls, and a series of tables showing the quantities of brick and mortar in typical forms of brick construction.

It will be noted that labor estimates are not included for the reason that such tables, even though conservatively developed and sometimes useful to the inexperienced estimator, are apt to be taken too literally without due allowance for varying conditions of labor, local customs, and the special requirements of the job at hand.

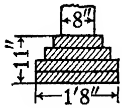
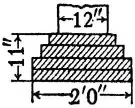
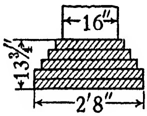
Experienced contractors make daily checks on the work of their masons and keep a constant record of bricklayers', helpers', and laborers' time on all types of work. Only upon such data should labor estimates be based.

TABLE 4.—HEIGHT OF SOLID AND IDEAL BRICKWORK BY COURSES
Based on Standard Brick 2¼ by 3¾ by 8 in.
Height from Bottom of Mortar Joint to Bottom of Mortar Joint

No. of courses	⅜-in. joints		½-in. joints		⅝-in. joints		¾-in. joints
	Brick flat	Brick on edge	Brick flat	Brick on edge	Brick flat	Brick on edge	Brick flat
1	2⅝″	4⅛″	2¾″	4¼″	2⅞″	4⅜″	3″
2	5¼″	8¼″	5½″	8½″	5¾″	8¾″	6″
3	7⅞″	1′ ⅜″	8¼″	1′ ¾″	8⅝″	1′ 1⅛″	9″
4	10½″	1′ 4½″	11″	1′ 5″	11½″	1′ 5½″	1′
5	1′ 1⅛″	1′ 8⅝″	1′ 1¾″	1′ 9¼″	1′ 2⅜″	1′ 9⅞″	1′ 3″
6	1′ 3¾″	2′ ¾″	1′ 4½″	2′ 1½″	1′ 5¼″	2′ 2¼″	1′ 6″
7	1′ 6⅜″	2′ 4⅞″	1′ 7¼″	2′ 5¾″	1′ 8⅛″	2′ 6⅝″	1′ 9″
8	1′ 9″	2′ 9″	1′ 10″	2′ 10″	1, 11″	2′ 11″	2′
9	1′ 11⅝″	3′ 1⅛″	2′ ¾″	3′ 2¼″	2′ 1⅞	3′ 3⅜″	2′ 3″
10	2′ 2¼″	3′ 5¼″	2′ 3½″	3′ 6½″	2′ 4¾″	3′ 7¾″	2′ 6″
11	2′ 4⅞″	3′ 9⅜″	2′ 6¼″	3′ 10¾″	2′ 7⅝″	4′ ⅛″	2′ 9″
12	2′ 7½″	4′ 1½″	2′ 9″	4′ 3″	2′ 10½″	4′ 4½″	3′
13	2′ 10⅛″	4′ 5⅝″	2′ 11¾″	4′ 7¼″	3′ 1⅜″	4′ 8⅞″	3′ 3″
14	3′ ¾″	4′ 9¾″	3′ 2½″	4′ 11½″	3′ 4¼″	5′ 1¼″	3′ 6″
15	3′ 3⅜″	5′ 1⅞″	3′ 5¼″	5′ 3¾″	3′ 7⅛″	5′ 5⅝″	3′ 9″
16	3′ 6″	5′ 6″	3′ 8″	5′ 8″	3′ 10″	5′ 10″	4′
17	3′ 8⅝″	5′ 10⅛″	3′ 10¾″	6′ ¼″	4′ ⅞″	6′ 2⅜″	4′ 3″
18	3′ 11¼″	6′ 2¼″	4′ 1½″	6′ 4½″	4′ 3¾″	6′ 6¾″	4′ 6″
19	4′ 1⅞″	6′ 6⅜″	4′ 4¼″	6′ 8¾″	4′ 6⅝″	6′ 11⅛″	4′ 9″
20	4′ 4½″	6′ 10½″	4′ 7″	7′ 1″	4′ 9½″	7′ 3½″	5′
21	4′ 7⅛″	7′ 2⅝″	4′ 9¾″	7′ 5¼″	5′ ⅜″	7′ 7⅞″	5′ 3″
22	4′ 9¾″	7′ 6¾″	5′ ½″	7′ 9½″	5′ 3¼″	8′ ¼″	5′ 6″
23	5′ ⅜″	7′ 10⅞″	5′ 3¼″	8′ 1¾″	5′ 6⅛″	8′ 4⅝″	5′ 9″
24	5′ 3″	8′ 3″	5′ 6″	8′ 6″	5′ 9″	8′ 9″	6′
25	5′ 5⅝″	8′ 7⅛″	5′ 8¾″	8′ 10¼″	5′ 11⅞″	9′ 1⅜″	6′ 3″
26	5′ 8¼″	8′ 11¼″	5′ 11½″	9′ 2½″	6′ 2¾″	9′ 5¾″	6′ 6″
27	5′ 10⅞″	9′ 3⅜″	6′ 2¼″	9′ 6¾″	6′ 5⅝″	9′ 10⅛″	6′ 9″
28	6′ 1½″	9′ 7½″	6′ 5″	9′ 11″	6′ 8½″	10′ 2½″	7′
29	6′ 4⅛″	9′ 11⅝″	6′ 7¾″	10′ 3¼″	6′ 11⅜″	10′ 6⅞″	7′ 3″
30	6′ 6¾″	10′ 3¾″	6′ 10½″	10′ 7½″	7′ 2¼″	10′ 11¼″	7′ 6″
31	6′ 9⅜″	10′ 7⅞″	7′ 1¼″	10′ 11¾″	7′ 5⅛″	11′ 3⅝″	7′ 9″
32	7′	11′	7′ 4″	11′ 4″	7′ 8″	11′ 8″	8′
33	7′ 2⅝″	11′ 4⅛″	7′ 6¾″	11′ 8¼″	7′ 10⅞″	12′ ⅜″	8′ 3″
34	7′ 5¼″	11′ 8¼″	7′ 9½″	12′ ½″	8′ 1¾″	12′ 4¾″	8′ 6″
35	7′ 7⅞″	12′ ⅜″	8′ ¼″	12′ 4¾″	8′ 4⅝″	12′ 9⅛″	8′ 9″
36	7′ 10½″	12′ 4½″	8′ 3″	12′ 9″	8′ 7½″	13′ 1½″	9′
37	8′ 1⅛″	12′ 8⅝″	8′ 5¾″	13′ 1¼″	8′ 10⅜″	13′ 5⅞″	9′ 3″
38	8′ 3¾″	13′ ¾″	8′ 8½″	13′ 5½″	9′ 1¼″	13′ 10¼″	9′ 6″
39	8′ 6⅜″	13′ 4⅞″	8′ 11¼″	13′ 9¾″	9′ 4⅛″	14′ 2⅝″	9′ 9″
40	8′ 9″	13′ 9″	9′ 2″	14′ 2″	9′ 7″	14′ 7″	10′
41	8′ 11⅝″	14′ 1⅛″	9′ 4¾″	14′ 6¼″	9′ 9⅞″	14′ 11⅜″	10′ 3″
42	9′ 2¼″	14′ 5¼″	9′ 7½″	14′ 10½″	10′ ¾″	15′ 3¾″	10′ 6″
43	9′ 4⅞″	14′ 9⅜″	9′ 10¼″	15′ 2¾″	10′ 3⅝″	15′ 8⅛″	10′ 9″
44	9′ 7½″	15′ 1½″	10′ 1″	15′ 7″	10′ 6½″	16′ ½″	11′
45	9′ 10⅛″	15′ 5⅝″	10′ 3¾″	15′ 11¼″	10′ 9⅜″	16′ 4⅞″	11′ 3″
46	10′ ¾″	15′ 9¾″	10′ 6½″	16′ 3½″	11′ ¼″	16′ 9¼″	11′ 6″
47	10′ 3⅜″	16′ 1⅞″	10′ 9¼″	16′ 7¾″	11′ 3⅛″	17′ 1⅝″	11′ 9″
48	10′ 6″	16′ 6″	11′	17′	11′ 6″	17′ 6″	12′
49	10′ 8⅝″	16′ 10⅛″	11′ 2¾″	17′ 4¼″	11′ 8⅞″	17′ 10⅜″	12′ 3″
50	10′ 11¼″	17′ 2¼″	11′ 5½″	17′ 8½″	11′ 11¾″	18′ 2¾″	12′ 6″
60	13′ 1½″	20′ 7½″	13′ 10″	21′ 3″	14′ 4½″	21′ 10½″	15′
70	15′ 3¾″	24′ ¾″	16′ ½″	24′ 9½″	16′ 9¼″	25′ 6¼″	17′ 6″
80	17′ 6″	27′ 6″	18′ 4″	28′ 4″	19′ 2″	29′ 2″	20′
90	19′ 8¼″	30′ 11¼″	20′ 7½″	31′ 10½″	21′ 6¾″	32′ 9¾″	22′ 6″
100	21′ 10½″	34′ 4½″	22′ 11″	35′ 5″	23′ 11½″	36′ 5½″	25′

TABLE 5.—QUANTITIES OF BRICK AND MORTAR IN FOOTINGS, PIERS, AND CHIMNEYS

Footings—Quantities for 100 Lin. Ft.

	Construction	Number of brick	Mortar, cu. ft.
	8-in. wall	2,272	39
	12-in. wall	2,812	48
	16-in. wall	4,592	78

Piers—Quantities for 10-ft. Height

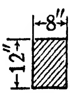
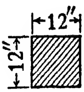
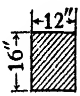
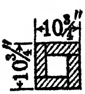
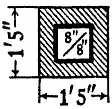
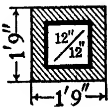
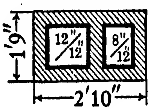
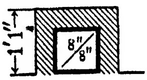
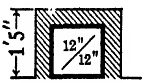
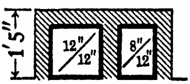
	Construction	Number of brick	Mortar, cu. ft.
	8- by 12-in. solid	124	2¼
	12- by 12-in. solid	185	3¼
	12- by 16-in. solid	247	4½
	10¾- by 10¾-in. hollow, brick laid on edge	113	1

TABLE 5.—QUANTITIES OF BRICK AND MORTAR IN FOOTINGS, PIERS, AND CHIMNEYS.—(*Continued*)

Chimneys—Quantities for 10-ft. Height

Construction		Number of brick	Mortar, cu. ft.
	8- by 8-in. flue	259	4½
	12- by 12-in. flue	345	6
	12- by 12- and 8- by 12-in. flues	539	8½
	8- by 8-in. flue	173	3
	12- by 12-in. flue	238	4
	12- by 12-in. and 8- by 12-in. flues	367	6½

NUMBER OF FACING BRICK IN SOLID WALLS

The first part of the table below gives the number of facing brick in straight running bond per square foot of wall for different joint thicknesses. It must be apparent that an additional number of facing brick will be required for various bonds, in proportion to the number of through headers used. The second part of the table, therefore, gives the percentages to be added to the number of facing brick in running bond.

TABLE 6.—NUMBER OF FACING BRICK IN RUNNING BOND PER SQUARE FOOT OF WALL

Joint, in.	1/8	1/4	3/8	1/2	5/8	3/4
No. of brick	7 1/2	7	6 1/2	6 1/8	5 3/4	5 1/2

Percentages Added to Number of Brick Given Above for Various Bonds

Common (full header course every 5th course)	20 % (1/5)
Common (full header course every 6th course)	16 2/3 % (1/6)
Common (full header course every 7th course)	14 1/3 % (1/7)
English or English cross (full headers every 6th course)	16 2/3 % (1/6)
Flemish (full headers every 6th course)	5 2/3 % (1/18)
Double header (two headers and a stretcher every 6th course)	8 1/3 % (1/12)
Double header (two headers and a stretcher every 5th course)	10 % (1/10)

TABLE 7.—AVERAGE WEIGHT OF SOLID BRICK WALLS
Brick Assumed to Weigh 4 1/2 lb. each. 1/2-in. Joints Filled with Mortar

Area, sq. ft.	4-in. wall, lb.	8-in. wall, lb.	12-in. wall, lb.
1	36.782	78.808	115.414
10	368	788	1,154
20	736	1,576	2,308
30	1,103	2,364	3,462
40	1,471	3,152	4,617
50	1,839	3,940	5,771
60	2,207	4,728	6,925
70	2,575	5,517	8,079
80	2,943	6,305	9,233
90	3,310	7,093	10,387
100	3,678	7,881	11,541
200	7,356	15,762	23,083
300	11,035	23,642	34,624
400	14,713	31,523	46,166
500	18,391	39,404	57,707
600	22,069	47,285	69,249
700	25,747	55,166	80,790
800	29,426	63,046	92,331
900	33,104	70,927	103,873
1,000	36,782	78,808	115,414

TABLE 8.—SOLID EXTERIOR WALLS IN FLEMISH, ENGLISH, AND ENGLISH CROSS BONDS—½-IN. JOINTS, PARTLY FILLED

Area of wall, sq. ft.	8-in. wall		12-in. wall		16-in. wall	
	No. of bricks	Mortar, cu. ft.	No. of bricks	Mortar, cu. ft.	No. of bricks	Mortar, cu. ft.
1	12.320	.195	18.866	.254	25.411	.313
10	124	2	189	3	255	3½
20	247	4	378	5½	509	6½
30	370	6	566	8	763	9½
40	493	8	755	10½	1,017	13
50	617	10	944	13	1,271	16
60	740	12	1,132	16	1,525	19
70	863	14	1,321	18	1,779	22
80	986	16	1,510	21	2,033	25
90	1,109	18	1,698	23	2,288	29
100	1,233	20	1,887	26	2,542	32
200	2,465	39	3,774	51	5,083	63
300	3,697	59	5,660	77	7,624	94
400	4,929	78	7,547	102	10,165	126
500	6,161	98	9,434	127	12,706	157
600	7,393	117	11,320	153	15,248	189
700	8,625	137	13,207	178	17,789	220
800	9,857	156	15,094	204	20,330	251
900	11,089	175	16,980	229	22,871	283
1,000	12,321	195	18,867	255	25,412	314
2,000	24,642	390	37,733	509	50,824	628
3,000	36,963	584	56,599	763	76,236	942
4,000	49,284	779	75,466	1,017	101,648	1,256
5,000	61,605	973	94,332	1,272	127,059	1,570
6,000	73,926	1,168	113,198	1,526	152,471	1,884
7,000	86,247	1,363	132,065	1,780	177,883	2,198
8,000	98,567	1,557	150,931	2,035	203,295	2,512
9,000	110,888	1,752	169,797	2,289	228,706	2,826
10,000	123,209	1,947	188,664	2,543	254,118	3,140

TABLE 9.—SOLID WALLS IN ALL BONDS—½-IN. JOINTS, ALL JOINTS FILLED WITH MORTAR

Area of wall, sq. ft.	4-in. wall		8-in. wall		12-in. wall		16-in. wall	
	No. of bricks	Mortar, cu. ft.	No. of bricks	Mortar, cu. ft.	No. of bricks	Mortar, cu. ft.	No. of bricks	Mortar, cu. ft.
1	6.160	.075	12.320	.195	18.481	.314	24.641	.433
10	62	1	124	2	185	3½	247	4½
20	124	2	247	4	370	6½	493	9
30	185	2½	370	6	555	9½	740	13
40	247	3½	493	8	740	13	986	17½
50	309	4	617	10	925	16	1,233	22
60	370	5	740	12	1,109	19	1,479	26
70	432	5½	863	14	1,294	22	1,725	31
80	493	6½	986	16	1,479	25	1,972	35
90	555	7	1,109	18	1,664	28	2,218	39
100	617	8	1,233	20	1,849	32	2,465	44
200	1,233	15	2,465	39	3,697	63	4,929	87
300	1,849	23	3,697	59	5,545	94	7,393	130
400	2,465	30	4,929	78	7,393	126	9,857	173
500	3,081	38	6,161	98	9,241	157	12,321	217
600	3,697	46	7,393	117	11,089	189	14,786	260
700	4,313	53	8,625	137	12,937	220	17,250	303
800	4,929	61	9,857	156	14,786	251	19,714	347
900	5,545	68	11,089	175	16,634	283	22,178	390
1,000	6,161	76	12,321	195	18,482	314	24,642	433
2,000	12,321	151	24,642	390	36,963	628	49,284	866
3,000	18,482	227	36,963	584	55,444	942	73,926	1,299
4,000	24,642	302	49,284	779	73,926	1,255	98,567	1,732
5,000	30,803	377	61,605	973	92,407	1,569	123,209	2,165
6,000	36,963	453	73,926	1,168	110,888	1,883	147,851	2,599
7,000	43,124	528	86,247	1,363	129,370	2,197	172,493	3,032
8,000	49,284	604	98,567	1,557	147,851	2,511	197,124	3,465
9,000	55,444	679	110,888	1,752	166,332	2,825	221,776	3,898
10,000	61,605	755	123,209	1,947	184,813	3,139	246,418	4,331

TABLE 10.—QUANTITIES OF MORTAR MATERIALS

Mortar, cu. ft.	1:0.25:3 mix						1:1:6 mix						1:2:9 mix					
	Weight			Volume			Weight			Volume			Weight			Volume		
	Cement, lb.	Hydrated lime, lb.	Sand, lb.	Cement, sack	Hydrated lime, sack	Sand, cu. ft.	Cement, lb.	Hydrated lime, lb.	Sand, lb.	Cement, sack	Hydrated lime, sack	Sand, cu. ft.	Cement, lb.	Hydrated lime, lb.	Sand, lb.	Cement, sack	Hydrated lime, sack	Sand, cu. ft.
1	28	3	74	0.3	0.06	0.92	15.3	6.5	78.4	0.16	0.13	1	10.3	8.75	79.2	0.11	0.18	1
2	56	6	147	0.6	0.12	1.8	31	13	157	0.3	0.3	2	21	18	158	0.2	0.4	2
3	85	9	221	0.9	0.18	2.8	46	20	235	0.5	0.4	3	31	26	238	0.3	0.5	3
4	113	12	294	1.2	0.24	3.7	61	26	314	0.7	0.5	3.9	41	35	317	0.4	0.7	4
5	141	15	368	1.5	0.30	4.6	76	33	392	0.8	0.7	4.9	52	44	396	0.6	0.9	5
6	169	18	442	1.8	0.36	5.5	92	39	470	1.0	0.8	5.9	62	53	475	0.7	1.1	5.9
7	197	21	515	2.1	0.42	6.4	107	46	549	1.1	0.9	6.9	72	61	554	0.8	1.2	6.9
8	226	24	589	2.4	0.48	7.4	122	52	627	1.3	1.0	7.9	83	70	634	0.9	1.4	7.9
9	254	27	662	2.7	0.54	8.3	138	59	706	1.5	1.2	8.8	93	79	713	1.0	1.6	8.9
10	282	30	736	3.0	0.6	9.2	153	65	784	1.63	1.3	9.8	103	87.5	792	1.1	1.75	9.9
20	564	60	1,472	6.0	1.2	18.4	306	130	1.568	3.3	2.6	19.7	207	175	1,584	2.2	3.5	19.8
27	761	81	1,987	8.1	1.6	24.8	413	176	2,117	4.4	3.5	26.5	279	236	2,138	3.0	4.7	26.7
30	846	90	2,208	9.0	1.8	27.6	459	195	2,352	4.9	3.9	29.5	310	263	2,376	3.3	5.3	29.7
40	1,128	120	2,944	12	2.4	36.8	611	260	3,136	6.5	5.2	39.3	414	350	3,168	4.4	7.0	39.6
50	1,410	150	3,680	15	3.0	46	764	325	3,920	8.2	6.5	49.2	517	438	3,960	5.5	8.8	49.5
60	1,692	180	4,416	18	3.6	55	917	390	4,704	9.8	7.8	59.0	620	525	4,752	6.6	10.5	59.4
70	1,974	210	5,152	21	4.2	64	1,070	455	5,488	11.4	9.1	68.8	724	613	5,544	7.7	12.3	69.3
80	2,256	240	5,888	24	4.8	74	1,223	520	6,272	13.0	10.4	78.6	827	700	6,336	8.8	14.0	79.2
90	2,538	270	6,624	27	5.4	83	1,375	585	7,056	14.7	11.7	88.5	931	788	7,128	9.9	15.8	89.1
100	2,820	300	7,360	30	6.0	92	1,528	650	7,840	16.3	13.0	98.3	1,034	875	7,920	11	17.5	99

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