U. S. DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

RECOMMENDED MINIMUM REQUIREMENTS FOR SMALL DWELLING CONSTRUCTION

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RECOMMENDED MINIMUM REQUIREMENTS FOR SMALL DWELLING CONSTRUCTION

REPORT OF THE
DEPARTMENT OF COMMERCE
BUILDING CODE COMMITTEE

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LETTER OF SUBMITTAL

Washington, D. C., *March 31, 1932.*

Hon. R. P. Lamont,

Secretary of Commerce, Washington, D. C.

Sir: The report of the Building Code Committee, entitled "Recommended Minimum Requirements for Small Dwelling Construction," first issued in 1922, has been revised in accordance with present-day conditions and is herewith submitted with the recommendation that a new edition be printed for public distribution.

Since the publication of the first edition interest in safe and economical building construction has been intensified. Last year the President's Conference on Home Building and Home Ownership, under the leadership of Secretary Wilbur and yourself, met and called attention to the manifold problems associated with dwelling construction. Building regulations have been mentioned by several of its committees as deserving careful scrutiny. The Building Code Committee has been accumulating information bearing on the subject and welcomes the opportunity to cooperate by supplying revised suggested requirements. It has made a careful review of its earlier recommendations with special attention to construction developments that may be just over the horizon.

As before, an appendix useful to enforcing officials and to owners and builders of dwellings, generally, is included. This feature has proved of great value in the past, for better and more economical construction is to be hoped for not only through legal requirements but also through education.

Very truly yours,

Wm. K. Hatt,

Chairman, Building Code Committee.

LETTER OF ACCEPTANCE

Department of Commerce,
Office of the Secretary,
Washington, May 28, 1932.

Dr. William K. Hatt,
Chairman Building Code Committee,
Department of Commerce.

Dear Doctor Hatt: It is a great pleasure for me to receive the manuscript for the revised edition of the Building Code Committee's report on Recommended Minimum Requirements for Small Dwelling Construction, which the Building Code Committee has thoroughly revised and brought up to date.

There is a common tendency to forget the positive protection to safety and health which properly framed, well-administered building codes can effect through prohibiting faulty structures. This tendency has been due in large measure to the hampering effects of antiquated codes which unnecessarily restrict the development and use of many of the best improvements in materials and methods that have been made in recent years.

The prominent part played by the earlier edition of your committee's recommended small-dwelling requirements has already done much to bring about progressive changes. Your work has thereby helped to reduce costs and assure better quality of construction. These, your latest recommendations, should greatly assist local code committees in framing and revising codes and encourage uniformity in their requirements.

The report, as in the case of the earlier edition, should have an extensive circulation, and thus be of widespread use to commercial builders, designers, home owners, and other groups. By thus helping to lay the groundwork for a sound revival of small-home building, its timely value to the American people should be multiplied.

Your committee has established an enviable reputation for itself as a group of disinterested experts intent on producing rational suggested requirements that combine safety with economy. In accepting the present report I am again reminded of the public benefit that accrues through your labors.

Very sincerely,

R. P. Lamont.

RECOMMENDED MINIMUM REQUIREMENTS FOR SMALL DWELLING CONSTRUCTION

This report is a revision of another bearing the same title and issued in 1922. It is subdivided into three general headings, as follows:

Part 1.—Introduction: Covering a general description of the circumstances leading to formation of the committee and outlining its method of procedure and scope of operation.

Part 2.—Minimum Requirements for Safe and Economical Construction of Small Dwellings: Briefly stated, in a form suitable for incorporation in local ordinances.

Part 3.—Appendix: Containing material not suited to be incorporated in a building law but which is supplementary to the various requirements made in part 2.

PART 1.—INTRODUCTION

The circumstances at the time of issuance of the original report may be summed up in a statement appearing in a preliminary report of the Senate Committee on Reconstruction and Production appointed in 1920. This committee held extensive hearings and stated:

> The building codes of the country have not been developed upon scientific data but rather on compromise; they are not uniform in practice and in many instances involve an additional cost to construction without assuring more useful or more durable buildings.

The final report of this Senate committee gave wide publicity to the building code discrepancies long known by architects and building engineers but not fully comprehended by the general public. Secretary Hoover, of the Department of Commerce, recognizing the necessity for some central coordinating body to standardize, so far as possible, the building laws of the country, organized the Building Code Committee for that purpose. The committee is a part of the division of building and housing in the Bureau of Standards. This division has under way a broad program of investigation into problems of the building industry.

The committee organized the last of May, 1921, and secured the appointment of a technical secretary and other clerical assistance; the task of gathering data on all phases of building regulations was at once begun, and has gone on as a continuous process since that time.

The general purposes of the committee are as follows:

1. To study existing building codes and determine the nature of their disagreement and the extent to which their requirements are oppressive to the building industry.

2. To gather information concerning minimum requirements considered essential by architects and engineers for safe and proper construction of buildings of different types and varying occupancy, in an effort to secure safe, economical construction, and eliminate waste in building.

3. To prepare and publish recommended building regulations based upon the consensus of reliable information obtained through various channels of inquiry throughout the country, such recommendations to represent minimum safe practice in all matters pertaining to engineering design and general building methods; these recommendations to be drafted in such form as to be easily adapted as amendments to existing building codes or adopted as ordinances by municipalities which at present have no building laws.

4. To investigate the merits of new building materials and methods of construction which promise economy and, so far as it can do so legitimately, to recommend such as appear to have special merit.

5. Supplemental to the foregoing, the committee may use its influence to further any measures promising improvement in present methods of building regulation or which encourage building industry.

6. The committee has under consideration the drafting of a complete building code. It believes the main objects desired can be most quickly and easily secured, however, by recommending standards of practice in those portions of building codes subject to the greatest general criticism.

The situation in 1921 was rendered especially acute by the great scarcity of dwellings throughout the country, especially the small 1 and 2 family type. While this situation is not so pressing at the time of issuance of this report, there is nevertheless an enhanced interest in sound and economical construction due to the growing conviction that home ownership is of deep significance to the welfare of the country. So strongly has this conviction been impressed upon responsible civic leaders that more than 3,000 of them came to Washington in December, 1931, for the purpose of evaluating available facts about home ownership and of stimulating greater opportunities for its fulfillment. This conference, known as the President's Conference on Home Building and Home Ownership, while recognizing substantial improvement in the building-code situation, has again emphasized the importance of sound building regulations.

The first edition of this report contained a rather extended appendix in which information on good construction going beyond the limits imposed by minimum safe standards was presented. This was done because investigation showed that many of the buildings erected where there were no building regulations or no means to enforce existing regulations were of such low-grade construction that much of the money invested in new homes was wasted. The committee felt it could render valuable service by spreading reliable information concerning sound building practice throughout the country so that poor building, which is usually the most wasteful, may be reduced. Elimination of this most insidious form of loss is believed to be fully as important as the modification of code requirements. Experience having justified this offering of supplementary information as a means of combating low-grade construction, it is continued in the present edition.

The committee has been fortunate in having continuity of service in dealing with the subject. Four of the seven original members have participated in the preparation of the revised edition after an interval of some 10 years. Death has removed Ira H. Woolson, the first chairman, and Edwin H. Brown. The committee wishes to pay tribute to the untiring interest and enthusiasm which was manifested by these members and which has left its imprint in the report as it now stands.

The report deals only with construction of dwellings intended for the occupancy of one and two families between exterior or party walls. No recommendations are made as to portion of lot that buildings may cover, the distances between buildings or between buildings and lot lines, or the effect upon construction imposed by such considerations. Lack of reference to these features is not due to their unimportance, but merely because the committee has considered them beyond the scope of the present report.

It is recognized that the requirements recommended in part 2 constitute, in some particulars, relaxations from those considered advisable for construction of large buildings. The committee believes, however, that for the simple types of buildings specified, and because of the need of eliminating all possible waste, the minimum standards advised are compatible with a due measure of utility and durability in the structures affected. The objects which the committee had in view in recommending these regulations were (1) to secure safe and yet economical construction, (2) to help eliminate waste in home building, and (3) to reconcile inharmonious and frequently too restrictive provisions in existing codes.

The recommendations are predicated on the assumption that good materials and workmanship will be used and all necessary care taken in assembling the various parts of the structures. The committee feels that thorough building inspection is often lacking and that many unnecessarily rigid code requirements have been adopted to offset possible laxity in enforcement. In modifying such provisions to reduce cost, therefore, local authorities should insist upon supervision of construction by an adequate, competent personnel.

It has been called to the committee's attention that some misunderstanding exists with regard to the legal status of its recommendations. It should be recognized that the committee's functions are purely advisory. The recommendations can not be considered in any sense as obligatory, but are issued to make available to those locally responsible for exercise of the police power the latest and most reliable information on building regulation for the class of buildings considered.

In the preparation of the revised report the committee has had the advantage of accumulated information supplied through many architects, engineers, contractors, local building officials, representatives of manufacturing organizations, and others during its period of existence. In particular, it acknowledges its indebtedness to experts of the Bureau of Standards. H. B. Houghton, associate engineer in this bureau, has been of especial assistance in compiling necessary information and drafting proposed requirements. The committee

has reviewed available data and has endeavored to see not only that the present report is up to date, but that it does not discourage the introduction of new materials at present just over the horizon.

The committee also desires to acknowledge the courtesy of the following organizations in furnishing cuts with which the appendix of the report is illustrated: 1 and 2 of Figure 2 were furnished by the American Face Brick Association; 3 of Figure 2 by the Structural Clay Tile Association; Figure 3 by the Common Brick Manufacturers' Association of America; Figure 20 by the Gypsum Association; Figures 1, 6, 13, 14, 15, 16, 17, 18, and 19 by the Weyerhaeuser Forest Products; and Figures 21, 22, 24, 26, 27, 28, 29, 30, 31, 32, 33, and 34 by the National Board of Fire Underwriters.

PART 2.—MINIMUM REQUIREMENTS FOR SAFE AND ECONOMICAL CONSTRUCTION OF SMALL DWELLINGS RECOMMENDED BY THE BUILDING CODE COMMITTEE OF THE DEPARTMENT OF COMMERCE

SECTION 1. GENERAL REQUIREMENTS

Section 1–1. Definitions.

Approved.—As applied to a material, device, mode of construction, or testing agency, means approved by the building official under the provisions of this code, or by other authority designated by law to give approval in the matter in question.

Bearing wall.—A wall which supports any vertical load in addition to its weight.

Dead loads.—The weight of walls, floors, roofs, partitions, and other permanent portions of the structure.

Dwelling.—A building occupied exclusively as a residence for one or two families, or as a boarding or rooming house serving not more than 15 persons with meals or sleeping accomodations, or both.

Faced wall.—A masonry wall, the facing and backing of which are so bonded that they act together in sustaining the load.

Fire door.—A door construction consisting of door, frame, and sill, which under approved fire-test conditions meets the requirements for the location in which it is to be used.

Grade.—For buildings, adjoining one street only, the elevation of the sidewalk at the center of that wall adjoining the street.

For buildings adjoining more than one street, the average of the elevations of the sidewalk at centers of all walls adjoining streets.

For buildings having no wall adjoining the street, the average level of the ground (finished surface) adjacent to the exterior walls of the building. All walls approximately parallel to and not more than 5 feet from a street line are to be considered as adjoining a street.

Height.—The height of a wall is the vertical distance measured from the highest point of the wall to the top of the foundation wall; the height of a building is the vertical distance from the grade line to the highest point of the building.

Lintel.—A structural member supporting masonry above an opening in a wall or partition.

Live loads.—All loads except dead loads.

Masonry.—Stone, brick, concrete, structural clay tile (hollow tile), concrete block or tile, gypsum block, or other similar building units or materials or a combination of same, bonded together with mortar to form a wall, pier, or buttress.

Metal frame.—Metal frame construction is that in which structural parts are of metal or dependent on a metal frame for support, and in which the structural members are not required to meet ordinary standards for fire-resistive protection.

Nonbearing wall.—A wall which supports no load in addition to its own weight.

Party wall.—A wall used or adapted for joint service between two buildings.

Pier.—A bearing wall having a horizontal cross section not exceeding 4 square feet and not bonded at the sides into adjoining masonry.

Plain concrete.—Concrete containing not more than two-tenths of 1 per cent of reinforcement.

Private garage.—A building or a portion thereof in which motor vehicles are stored or kept, and whose area does not exceed 500 square feet.

Reinforced concrete.—Concrete containing more than two-tenths of 1 per cent of reinforcement and in which the reinforcement is so embedded that the two materials act together in sustaining the load.

Veneered wall.—A wall having a facing which is not attached and bonded to the backing, so that they act together in sustaining the load.

Wood frame.—Wood frame construction is that in which structural parts and materials are of wood or are dependent upon a wood frame for support, including construction having an incombustible exterior veneer.

Sec. 1–2. Limitations.

These requirements shall apply only to buildings used as dwellings, either detached, semidetached, or in rows, and intended for the occupancy of not more than two families in each unit.

(The restrictions, limitations, and tabulations apply to small dwellings only, and are not to be considered as general for or applicable to other and larger types of construction. The recommendations are in no sense a housing code or tenement-house law in the ordinary acceptance of these terms; neither do they take into consideration regulations in regard to fire limits or congested mercantile districts or types of construction that should or should not be used because of exterior fire risks. See introduction, p. 3.)

Sec. 1–3. Heights.

The number of stories in dwellings shall be limited only by the permissible height of the walls, provided that for masonry wall and joist construction such height shall not exceed 45 feet and not more than three stories shall be allowed within this height, and provided further that for frame construction the height shall not exceed 40 feet and shall have not more than two and one-half stories. (See Appendix, par. 1.)

Sec. 1–4. Loads.

All parts of dwellings shall be designed to support safely their own weight and the portion of the live load on floor or roof which they carry. (See Appendix, par. 2.)

Sec. 1–5. Floor Loads.

1. Floors shall be designed to support their own weight, the dead loads they are to carry, and a live load of at least 40 pounds per square foot

2. Girders or other members supporting a floor area not exceeding 100 square feet shall be designed for a live load of not less than 40 pounds per square foot uniformly distributed over the floor area.

If the floor area exceeds 100 square feet but does not exceed 200 square feet, such members shall be designed for a live load of not less than 35 pounds per square foot uniformly distributed over the floor area. If the floor area exceeds 200 square feet, such members shall be designed for a live load of not less than 30 pounds per square foot.

Sec. 1–6. Roof Loads.

Roofs having a rise of 4 inches or less per foot shall be designed to support safely a vertical live load of 30 pounds per square foot of horizontal projection, applied to any or all slopes. With a rise of more than 4 inches and less than 12 inches per foot a vertical live load of 20 pounds on the horizontal projection shall be assumed. If the rise exceeds 12 inches per foot, provision shall be made for a wind force acting in a normal direction (on one slope at a time) of 20 pounds per sloping square foot. (See Appendix, par. 6.)

NOTE.—For roof coverings, see Appendix, paragraph 49.

Sec. 1–7. Roof Anchorage.

Roofs shall be securely attached to the construction on which they rest. (See sec. 7–3.)

SECTION 2. FOUNDATIONS

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Sec. 2–1. Footings.

Foundation walls shall extend below the frost level and the horizontal area at the bottom shall be such that the safe carrying capacity of the soil is not exceeded. (See Appendix, par. 9.)

Sec. 2–2. Foundation Walls.

1. Foundation walls shall be built of stone, brick, concrete (plain, rubble, or reinforced), solid or hollow masonry units, or hollow walls of brick. Materials and mortar for foundation walls shall be at least equal in quality in all respects to those required for exterior bearing walls.

2. Foundation walls shall be of sufficient strength and thickness to resist lateral pressures from adjacent earth and to support their vertical loads, provided that in no case shall their thickness be less than the walls immediately above them.

When built of brick, coursed stone, solid or hollow masonry units, or hollow walls of brick the thickness of foundation walls shall be not less than 12 inches, provided that when such walls do not extend more than 5 feet below the adjacent ground level the minimum thickness of solid brick, solid masonry units, or coursed stone walls may be 8 inches if included within the allowable height of 8-inch walls. When built of concrete cast in place, foundation walls shall be at least 8 inches in thickness. When built of rubble stone, they shall be at least 16 inches thick. Rough or random rubble without bonding or level bed shall not be used as foundations for walls exceeding 35 feet in height. (See Appendix, pars. 7 to 10, inclusive.)

3. Foundation walls for frame construction shall extend at least 8 inches above the adjoining ground surface. (See Appendix, par. 38.)

Sec. 2-3. Basement Columns.

Basement columns supporting the first floor or parts thereof shall meet the following requirements:

Wood columns shall rest on metal or masonry footings extending at least 3 inches above the basement or cellar floor.

Wrought-iron, cast-iron, or steel pipe columns shall have metal top and bottom bearing plates.

Sec. 2-4. Ventilation.

Cross ventilation shall be provided for the space inclosed by foundation walls, whether it be excavated or not. (See Appendix, par. 10.)

NOTE.—For information on rat proofing, see Appendix, paragraph 39.

SECTION 3. DWELLINGS HAVING SOLID BRICK WALLS

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 3-1. Quality of Brick and Mortar.

Brick, whether of clay or other materials, shall have an average compressive strength tested flat of at least 1,500 pounds per square inch, provided that no brick having a strength of less than 2,500 pounds per square inch shall be used where exposed to the weather. (See Appendix, par. 12.)

Portland cement, natural cement, and lime used as cementing materials in mortars shall comply with the standard specifications of the American Society for Testing Materials with A. S. T. M. designations as follows:

Standard Specifications for Portland Cement	C9-30
Standard Specifications for Natural Cement	C10-09
Standard Specification for Quicklime for Structural Purposes	C5-26
Standard Specifications for Hydrated Lime for Structural Purposes	C6-24

(See Appendix, par. 3.)

Mortar for foundation or exterior walls, chimneys, or piers shall contain at least 1 part of Portland cement or a mixture of Portland cement and lime to 3 parts of sand by loose damp volume, but shall not be leaner in cement than 1 part cement, 1 part lime to 6 parts of sand. (See Appendix, par. 13.)

Sec. 3-2. Thickness, Height, and Bonding of Exterior Walls.

1. The minimum thickness of exterior solid brick walls shall be 8 inches for a height not exceeding 35 feet. If walls of greater height are used, the thickness shall be at least 12 inches for the uppermost 35 feet and shall be increased 4 inches for each successive 35 feet or fraction thereof measured downward from the top of the wall. In brick walls, at least every sixth course shall be a header

course or there shall be at least one full header in every 72 square inches of wall surface. Walls shall be securely anchored or bonded at points where they intersect. Sawed stone shall be permitted for walls under the same circumstances and subject to the same restrictions as solid brick. (See Appendix, pars. 14 to 18, inclusive. Requirements governing construction of interior walls and partitions, sec. 9–4. Requirements for foundation walls, sec. 2–2.)

2. Changes in the thickness of masonry walls shall be made only at the floor line.

Sec. 3–3. Piers.

The unsupported height of isolated masonry piers shall not exceed ten times their least dimension. Stone posts that spall under fire shall not be used as supports for girders or walls in cellars or basements. (See Appendix, par. 11.)

Sec. 3–4. Chases.

Chases shall not be permitted in 8-inch brick walls. In thicker walls the backs of chases shall be not less than 8 inches thick.

Sec. 3–5. Arches and Lintels.

1. The masonry above openings shall be supported by well-buttressed arches, or lintels either of metal or masonry, plain or reinforced, which shall bear on the wall at each end for not less than 4 inches.

2. Timber centering for brick arches may be allowed to remain, provided the opening is not over 4 feet wide and that the timber at each end bears on the wall for a distance not exceeding 2 inches.

Sec. 3–6. Wood Inserts in Masonry Walls.

No timber except lintels, as prescribed in section 3–5, 2, and no nailing blocks longer than 8 inches horizontally or nearer together than 2 feet, shall be built into any masonry walls. (Furring. See Appendix, par. 45, for material on advisability of furring masonry structures. For framing details, see sec. 7.)

SECTION 4. DWELLINGS HAVING WALLS OF HOLLOW MASONRY UNITS, OR HOLLOW WALLS OF BRICK

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 4–1. Quality of Materials.

Brick for use in hollow walls shall be of quality at least equal to that for use in solid walls as specified in section 3–1.

The average compressive strength of structural clay tile laid with the cells vertical shall be at least 1,400 pounds per square inch of gross sectional area when tested with the cells parallel to the direction of the applied force.

The average compressive strength of structural clay tile with the cells horizontal, and which are tested with the cells in that position, shall be at least 700 pounds per square inch of gross sectional area. (See Appendix, par. 19.)

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The shells of concrete block or concrete tile shall be at least three-fourths inch thick. The average compressive strength of concrete block or tile used in exterior or party walls or piers shall be at least 700 pounds per square inch of gross sectional area when tested in the position as used in the wall, except that for use with cells vertical, units having shells less than 1¼ inches in thickness shall have an average compressive strength of at least 1,000 pounds per square inch of gross sectional area. Concrete block or concrete tile units which will be exposed to the weather or soil in the finished building shall not absorb more than 15 pounds of water per cubic foot of net volume. This requirement for absorption shall be waived when the units will not be exposed to soil or weather or will be protected by a facing of 3 inches or more of stone, terra cotta, brick, or other veneer. (See Appendix, par. 19.)

Mortar for walls of hollow unit construction or hollow walls of brick shall be at least equal to that required for solid wall construction as given in section 3–1.

Sec. 4–2. Thickness, Height, and Bonding of Exterior Walls.

Walls of hollow masonry units or hollow walls of brick shall not exceed 50 feet in height above the top of foundation walls. (See Appendix, par. 1.)

The minimum thickness of exterior walls built of hollow masonry units or hollow walls of brick shall be 8 inches for a height not exceeding 35 feet. If walls of greater height are used, the thickness shall be at least 12 inches for the uppermost 35 feet of their height and at least 16 inches for the remaining lower portion. (See Appendix, pars. 20 and 21.)

Where two or more hollow units are used to make up the thickness of a wall, the inner and outer courses shall be bonded at vertical intervals not exceeding three courses by lapping at least one cell completely over a cell of the unit below. Walls shall be securely anchored or bonded at points where they intersect.

Veneering for walls of hollow masonry units shall be tied into the backing either by a header for every 300 square inches of wall surface or by substantial, noncorrodible metal wall ties spaced not farther apart than 1 foot vertically and 2 feet horizontally.

Facing for walls of hollow masonry units shall be bonded into the backing with at least one header course in every six courses, or there shall be at least one full-length header in every 72 square inches of wall surface.

(See Appendix, par. 22. Requirements for foundation walls, sec. 2–2. Requirements for change in thickness of masonry walls, sec. 3–2, 2. Requirements covering construction of interior walls and partitions, sec. 9–4.)

Sec. 4–3. Piers.

The unsupported height of piers built of hollow masonry units shall not exceed eight times their least dimension.

Sec. 4–4. Bearing for Concentrated Loads.

Walls of hollow masonry units or hollow walls of brick on which beams, joists, or concentrated loads rest shall be provided with bearing plates or courses of solid tile, brick, or concrete. Such plates or courses when of tile or concrete shall be adapted to the service required.

Sec. 4–5. Chases.

Chases shall not be permitted in 8-inch walls. In thicker walls chases shall not be cut but may be built in, and the back of the chase shall be not less than 8 inches thick.

Sec. 4–6. Arches and Lintels.

The masonry above openings for walls built of hollow masonry units or hollow walls of brick shall be as required for solid wall construction given in section 3–5.

Sec. 4–7. Wood Inserts.

Wood inserts in walls of hollow masonry units or hollow walls of brick shall be as required for solid wall construction given in section 3–6.

SECTION 5. CONCRETE DWELLINGS OF MONOLITHIC, UNIT, OR STRUCTURAL FRAME TYPE

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 5–1. Quality of Materials.

Concrete for bearing walls and piers of plain concrete shall be not leaner in cement than a mixture of 1 part of cement, 2 parts of sand, and 4 parts of coarse aggregate, proportioned by volume, provided that any concrete having an ultimate strength of 2,000 pounds per square inch at 28 days may be used.

Cement for plain concrete shall comply with the standard specifications for Portland cement, A. S. T. M. designation C–9–30, of the American Society for Testing Materials. (See Appendix, par. 3.)

Concrete aggregates shall be well graded from fine to coarse and shall consist of natural sands and gravels, crushed rock, slag, burned shale or clay, or other approved inert materials having clean, uncoated grains of strong and durable minerals. They shall be free from harmful amounts of shale, clay, silt, crusher dust, soft fragments, and other deleterious materials.

Coarse aggregate shall have at least 95 per cent retained on a ¼-inch sieve. The maximum size shall not be larger than one-fifth the least distance between forms nor larger than three-quarters the minimum clear distance between reinforcing bars or between reinforcing bars and forms.

Fine aggregate shall all pass a ⅜-inch sieve, at least 85 per cent shall pass a ¼-inch sieve, at least 10 per cent shall pass a No. 50 sieve, and not more than 5 per cent shall pass a 100-mesh sieve. (See Appendix, par. 23.)

Water used in mixing concrete shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, or other harmful substances.

Sec. 5–2. Thickness, Height, and Bonding of Exterior Walls.

1. The minimum thickness of exterior concrete walls shall be 8 inches for a height not exceeding 35 feet. If walls of greater height are used, the thickness shall be at least 10 inches for the uppermost 35 feet of their height and shall be increased 3 inches for each successive 35 feet or fraction thereof measured downward from the top of the wall.

2. Reinforcement, symmetrically disposed in the thickness of the wall, shall be placed not less than 1 inch above openings and extending not less than 9 inches each side of such opening, consisting of two ⅜-inch round rods for openings up to 4-foot spans, and two ¾-inch round rods for openings up to 8-foot spans, or their respective equivalents. For openings of greater span, reinforced concrete or rolled steel beams, designed in accordance with standard methods, shall be used.

At the corners of all openings two ⅜-inch round rods or their equivalent, symmetrically disposed in the wall, shall be placed at an angle of 45° with the horizontal, extending at least 12 inches each way from the corner of the opening.

At wall junctions or returns two ⅜-inch round rods or their equivalent, bent to the angle of the junction, not less than 12 inches long each side of the bend, shall be spaced not over 20 inches apart in the height of the wall, symmetrically disposed with at least 1 inch of concrete covering the steel.

3. Hollow monolithic walls shall have not less than 6 inches aggregate thickness of material. Wall openings and corners shall be reinforced in the same manner as solid monolithic walls. The inner and outer parts of such walls shall be securely braced and tied together with noncorrodible ties or other means to bring them into common action. Where floor and roof systems are carried by such walls, provision shall be made for the distribution of these loads to all parts of the wall. (See Appendix, pars. 24 and 25. Foundation wall requirements, sec. 2–2. Requirements for change in thickness of masonry walls, sec. 3–2, 2.)

Sec. 5–3. Piers.

The unsupported height of piers of plain concrete shall not exceed ten times their least dimension.

Sec. 5–4. Chases.

Chases shall not be permitted in 8-inch walls. In thicker walls the backs of chases shall be not less than 8 inches thick. In hollow monolithic walls the chases shall not be cut but may be built in, and the back of the chase shall be not less than 8 inches thick.

Sec. 5–5. Arches and Lintels.

The masonry above openings for solid or monolithic concrete walls shall be as required in sec. 3–5.

Sec. 5–6. Unit Construction.

Precast concrete units for construction of dwellings shall be of sufficient strength, and where necessary shall be reinforced to carry safely the loads imposed. Connections between the several parts of such structures shall be sufficiently strong and rigid to resist the vertical and horizontal forces which may be imposed. (See Appendix, par. 26.)

Sec. 5–7. Concrete Structural Frame with Inclosing Walls.

Dwellings constructed with monolithic reinforced-concrete frames cast in metal lath or other forms, and with inclosing walls of concrete plastered or shot on metal lath, or of precast units carried by such frames, or having reinforced-concrete bearing walls, shall be designed in accordance with standard methods of reinforced-concrete design to carry safely the dead weight of the structure and the live loads which may be imposed. Inclosure or panel walls shall be of sufficient strength and rigidity to resist lateral forces and transmit them to the framework. (See Appendix, par. 27.)

Sec. 5–8. Concrete Floors, Floor Beams, and Columns.

Concrete floors, floor beams, and columns shall be designed in accordance with standard methods to carry safely the loads imposed. (See requirements governing framing in masonry walled buildings, sec. 7.)

SECTION 6. WOOD FRAME CONSTRUCTION

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 6–1. Exterior Walls.

1. Where exterior walls or parts thereof more than one story high are sheathed, the sheathing boards shall be nailed to each stud with not less than two 8-penny nails. Where the sheathing is omitted or is not laid diagonally, all corners shall be diagonally braced and such other measures taken to secure rigidity as may be necessary.
2. Walls shall be constructed to develop a strength and rigidity equal to that of wood studding not less than 2 by 4 inches, spaced not to exceed 16 inches on centers and provided with sheathing or bracing as given in the paragraph immediately preceding. Wood sheathing may be omitted when other types of construction are used that have been proved of adequate strength and stability in tests conducted by recognized authorities. (See Appendix, pars. 30 and 35.)
3. Ledger or ribbon boards used to support joists shall be not less than 1 by 4 inches, shall be cut into the studs, and securely nailed with not less than two 10-penny nails to each stud. (See Appendix, par. 30.)

Sec. 6–2. Masonry Veneer on Wood Frame Construction.

1. Masonry veneer applied to the walls of frame structures shall rest directly upon the masonry foundation of the structure and shall be not less than 3¾ inches in thickness.
2. Noncorrodible flashing shall be installed where necessary to prevent moisture from penetrating behind the walls.
3. The masonry veneer shall be securely attached to the frame structure at intervals of not more than 16 inches vertically and 24 inches horizontally with noncorrodible nails or ties.

4. A waterproof sheathing shall be securely attached to the framework of the structure back of the masonry veneer. (See Appendix, par. 28.)

Sec. 6–3. Stucco on Frame Construction.

1. Cement and lime for stucco shall conform to the requirements for these materials as given in section 3–1.

2. Noncorrodible flashing or other expedients which will prevent penetration of moisture behind the stucco shall be used where necessary.

3. Back plastering shall be required where sheathing is omitted. (See Appendix, par. 29.)

4. Where wood sheathing is used it shall be of not less than 6-inch boards securely nailed to the studding with at least two 8-penny nails to each stud.

5. Metal reinforcement shall be of expanded metal or wire fabric weighing not less than 1.8 pounds per square yard and having openings not less than three-fourths inch nor more than 2 inches in greatest dimension. Where sheathing is omitted, the weight of such metal reinforcement or mesh shall be not less than 3.4 pounds per square yard.

NOTE.—For information on insulation, see Appendix, paragraph 46.

6. If a wall is back plastered, the plaster shall be of sufficient thickness to extend back between the studs a distance not less than one-fourth inch. (See Appendix, par. 29.)

7. Metal reinforcement for stucco of any type shall be furred away from sheathing or building paper at least three-eighths of an inch at all points by the use of special furring nails or devices or by suitable metal strips unless self-furring metal lath is used.

8. The thickness of stucco when applied on metal lath or similar reinforcement shall be at least 1 inch and the metal reinforcement shall be covered at least five-eighths of an inch.

NOTE.—For information on plastering, see Appendix, paragraphs 40 to 44, inclusive.

SECTION 7. WOOD FRAMING

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 7–1. General Requirements.

Members shall be so framed, anchored, tied, and braced as to develop the maximum strength and rigidity consistent with the purpose for which they are used.

Sec. 7–2. Strength of Members.

1. Wood structural members shall be of sufficient size and strength to carry the load safely without exceeding the allowable working stress of the material. The strength of such members shall be determined from actual dimensions of the pieces and not from nominal dimensions. (See Appendix, pars. 30 and 36.)

2. Stress due to dead and live loads acting singly or in combination, without wind load, shall not exceed the allowable stress specified in Table 1. For stresses produced by wind loads or by a combination of wind loads and dead and live loads the working stresses

allowed in Table 1 may be increased by 50 per cent, provided the resulting sections are not less than those required for the combined dead and live loads. (See Appendix, par. 31.)

3. The stress in compression across the grain may be increased 50 per cent in the case of joists supported on a ribbon board and spiked to the studding. (See Appendix, par. 32, bearing values for joists; par. 33, sizes for girders and maximum permissible length of floor joists; and par. 35, for general information on use of lumber.)

TABLE 1.—*Allowable stresses permissible for structural timbers in small dwellings* [1]

Species	Grade [2]	Allowable stresses in— Bending: In extreme fiber	Bending: Horizontal shear	Compression: Parallel to grain "short columns"	Compression: Perpendicular to grain	Modulus of elasticity
		Lbs./in.²	*Lbs./in.²*	*Lbs./in.²*	*Lbs./in.²*	*1,000 lbs./in.²*
Cedar, western red	Select	900	80	700	200	1,000
	Common	720	64	560	200	
Cedar, northern white	Select	750	70	550	175	800
	Common	600	56	440	175	
Chestnut	Select	950	90	800	300	1,000
	Common	760	72	640	300	
Cypress	Select	1,300	100	1,100	300	1,400
	Common	1,040	80	880	300	
Douglas fir	Select	1,600	90	1,173	347	1,600
	Dense select	1,750	105	1,283	379	
	Common	1,200	72	880	325	
Douglas fir (Rocky Mountain region)	Select	1,100	85	800	275	1,200
	Common	880	68	640	275	
Fir, balsam	Select	900	70	700	150	1,000
	Common	720	56	560	150	
Gum, red	Select	1,100	100	800	300	1,200
	Common	880	80	640	300	
Hemlock, west coast	Select	1,300	75	900	300	1,400
	Common	1,040	60	720	300	
Hemlock, eastern	Select	1,000	70	700	300	1,100
	Common	800	56	560	300	
Larch, western	Select	1,200	100	1,100	325	1,300
	Common	960	80	880	325	
Maple, hard	Select	1,500	125	1,200	500	1,600
	Common	1,200	100	960	500	
Oak, white or red	Select	1,400	125	1,000	500	1,500
	Common	1,120	100	800	500	
Pine, southern yellow	Dense select	1,750	128	1,283	379	1,600
	Common	1,200	88	880	325	
Pine, northern white, western white, and western yellow.	Select	900	85	750	250	1,000
	Common	720	68	600	250	
Pine, Norway	Select	1,100	85	800	300	1,200
	Common	880	68	640	300	
Spruce, red, white, and Sitka	Select	1,100	85	800	250	1,200
	Common	880	68	640	250	
Spruce, Engelmann	Select	750	70	600	175	800
	Common	600	56	480	175	
Tamarack	Select	1,200	95	1,000	300	1,300
	Common	960	76	800	300	

[1] Data furnished by the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, August, 1930.

[2] The select and common and dense-select grades are those specified in American Society for Testing Materials "Standard Specifications for Structural Wood Joists, Planks, Beams, Stringers, and Posts," serial designation D245–27.

4. Shearing stress for joint details may, for all grades, be taken as 50 per cent greater than the horizontal shear values permitted in the select grade.

Sec. 7–3. Sills, Joists, Girders, and Rafters.

1. Each tier of floor joists when they enter masonry walls shall be securely anchored thereto with T-shaped steel anchors at intervals of not more than 6 feet. Anchors shall be so attached as to release the ends of the joists from the wall in case of fire.

The ends of lapped joists resting upon girders or bearing partitions shall be securely spiked together. When abutted they shall be connected with steel straps or dogs or by wood splices well spiked on each side.

Joists running parallel to masonry inclosing walls shall be anchored to the walls at intervals of not more than 8 feet. Such anchors shall extend back and engage at least three joists.

Girders shall be anchored to the walls and fastened to each other where they intersect or abut with steel straps.

When inclosing walls are of wood, each joist, beam, and girder in the wall shall be securely spiked or anchored to the wall construction.

Wood structures and roofs where resting on masonry foundations or walls shall have anchors of not less than ⅝-inch bolts. Such anchors shall be spaced not over 6 feet apart and shall extend down into the wall not less than 2 feet except over openings, where they shall be anchored in a suitable manner. (See Appendix, par. 35.)

Wood rafters shall be spiked to the plates to develop a tie equal to that obtained by spiking each rafter to the plate with at least three 16-penny nails. (See Appendix, par. 35.)

2. Support of joists and rafters: When supported by masonry, joists shall have bearing at least 3 inches in length.

When the ends of joists enter masonry walls, they shall be beveled to release the joist from the wall in case of fire.

Joists supporting nonbearing partitions which are parallel to the joists shall be double. If nonbearing partitions cross joists near their center, these joists shall be of size required for normal loading, with a span 2 feet greater than the actual span. (See Appendix, par. 33.)

Rafters shall be vertically supported near the ridge when the slope is less than 6 inches per foot, and rafters shall be thus supported unless their feet are thoroughly tied at the plate.

3. Bridging: Floor and flat-roof joists and beams shall be rigidly bridged at intervals not exceeding 8 feet.

4. Separation of joist ends: Wood joists shall not enter 8-inch brick party or division walls unless recesses for timbers on both sides are provided at the time the wall is built; otherwise a 12-inch wall shall be required. In masonry walls the joists on opposite sides shall be so placed as to provide at least 4 inches of solid masonry between them.

Sec. 7–4. Bearing Partitions.

1. Bearing partitions shall be provided at the top with double plates, each at least 2 inches thick and of same width as stud. When the studs are placed directly below each joist, a single top plate may

be used. If properly fire stopped, studs may run through the floor and rest on girders or on partition plates. (See Appendix, par. 30.)

2. Partitions not resting upon girders, or of which the studs do not rest on partition plates below, shall have sole plates of dimensions not less than the studs.

3. Partitions unsupported by walls shall be supported on girders or double joists, or on sole plates if placed at an angle to the joists.

Sec. 7–5. Nonbearing Partitions.

Nonbearing partitions shall be provided with at least one 2-inch plate on top and bottom of same width as stud or be otherwise properly fire stopped at floor lines. (See Appendix, pars. 30 and 53.)

NOTE.—For information on the advisability of double flooring, see Appendix, paragraph 34.

SECTION 8. METAL FRAME CONSTRUCTION

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 8–1. Construction.

Inclosure or panel walls shall be of sufficient strength and rigidity to resist lateral forces and transmit them to the framework.

Structural members shall be designed in accordance with approved methods to carry safely the loads imposed. (See Appendix, pars. 37 and 57.)

SECTION 9. PARTY WALLS, PARTITIONS, AND CEILINGS

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 9–1. Party Walls.

Party walls between dwellings occupied by not more than two families each shall be of fire-resistive construction, consisting of wood studs covered on both sides with at least three-fourths inch gypsum or Portland cement plaster on metal lath or any other construction having an ultimate fire resistance of at least one hour. When constructed with wood studs, fire stops of incombustible material shall extend the full depth of the joists and at least 4 inches above the level of each floor. Such walls shall be supported below the first floor by a masonry wall not less than 8 inches in thickness. (See also Ceilings, sec. 9–2, and Appendix, pars. 47 and 52.)

Not more than four families shall be permitted in attached dwellings without a party wall of masonry.

Where party walls of masonry are required, they shall have the following thicknesses and shall be uniform in other respects to requirements for exterior walls of the same materials:

Solid brick party walls shall be of the same thickness as required for such exterior walls given in section 3–2.

Plain concrete party walls shall be of the same thickness as required for such exterior walls as given in section 3–2.

Party walls built of hollow masonry units or hollow walls of brick shall be not less than 12 inches thick throughout.

No party walls of hollow units or of hollow wall construction and no 8-inch solid walls shall be broken into, subsequent to erection, for the insertion of structural members.

A separation of at least 4 inches of solid masonry shall be provided in all masonry party walls between combustible members which may enter such walls from opposite sides.

Where combustible joists, beams, and girders enter masonry walls they shall be beveled so as to be self-releasing in case of fire.

Where combustible or unprotected steel building members frame into hollow party walls of thickness not greater than 12 inches, they shall not project more than 4 inches into the wall and shall be so spaced that the distance between embedded ends is not less than 4 inches on all sides of the members.

Open cells in tile or blocks occurring at wall ends shall be filled solid with concrete for at least a depth of 6 inches, or closure tile set in the opposite direction shall be used.

Sec. 9–2. Ceilings.

In dwellings having apartments over one another, the floor and ceiling construction separating such stories shall be a fire-resistive floor and ceiling consisting of wood joists, fire stopped, with a double board floor having an insulating layer between the boards and with a ceiling of at least three-fourths inch gypsum plaster on expanded metal lath or any other construction having an ultimate fire resistance of at least one hour. (See Appendix, par. 52.)

Sec. 9–3. Parapet Walls.

Masonry party walls shall project through combustible roofs to a height of at least 12 inches, shall have the full thickness of the top story wall, and shall be coped. No such wall shall exceed in height above the roof four times its thickness. (See Appendix, par. 48.)

Sec. 9–4. Interior Partitions.

1. Bearing: Interior bearing walls, except party and division walls, are considered as bearing partitions.

For bearing partitions, materials meeting the ordinary accepted local standards for the purpose may be used.

Where not utilized as party or division walls, bearing partitions built of solid masonry units shall be not less than 8 inches thick and those built of hollow masonry units shall be not less in thickness than one-eighteenth of the height between floors or floor beams.

For bearing for concentrated loads, see section 4–4.

2. Nonbearing partitions: For nonbearing partitions, materials meeting the ordinary accepted local standards for the purpose may be used.

Nonbearing partitions built of solid or hollow masonry units or hollow walls built of solid units shall be built solidly against floor and ceiling construction below and above, and shall not exceed the following unsupported heights:

Thickness exclusive of plaster	Maximum unsupported height
Inches	*Feet*
2	8
3	12
4	15
6	20
8	25

Gypsum block shall not be used for partitions where exposed continuously to dampness.

SECTION 10. MISCELLANEOUS

(These requirements apply to small dwellings and may not apply to larger buildings or other types of buildings.)

Section 10–1. Chimneys and Fireplaces.

1. Chimneys shall be built upon concrete or masonry foundations properly proportioned to carry the load without danger of settlement or cracking. The footing for any exterior chimney shall be below the frost level. Chimneys in frame buildings shall not rest upon or be carried by wood floors, beams, or brackets, nor be hung or supported by metal stirrups from wood construction. (See Appendix, par. 50.)

2. Masonry or concrete walls of buildings may form part of chimney when the chimney walls are securely bonded into the walls of the building and when the flue is lined the same as an independent chimney. Flues in party walls shall not extend beyond the center of the walls.

3. Corbeled chimneys shall not be supported by hollow walls or walls of hollow units. Solid walls supporting corbeled chimneys shall be not less than 12 inches thick, and corbeling shall not project more than 1 inch per course and not more than 6 inches in any case. (See Appendix, par. 50.)

The total offset, overhang, or corbel of an independent chimney shall not exceed three-eighths the width of the chimney in the direction of the offset.

4. Chimneys shall be built at least 3 feet above flat roofs and not less than 2 feet above the highest point of the roof. Unless provided with a stone, terra-cotta, concrete, cast-iron, or other special cap or top, the chimney lining shall project not less than 4 inches. No chimney top shall decrease the required flue area.

5. Chimneys built of brick, stone, or other masonry units shall be lined throughout with fire-clay flue lining, provided that in chimneys having solid brick walls 8 inches or more thick the flue lining may be omitted. Flue linings shall be at least five-eighths of an inch thick, and shall be suitable for the purpose and adapted to withstand high temperatures and the resultant gases from burning fuel. The flue sections shall be set in mortar of quality at least as

rich in cement as that required for walls. The joints shall be smooth on the inside.

When two or more flues are contained in the same chimney withes of brick or mortar not less than 3¾ inches thick shall be provided at intervals not exceeding 30 inches horizontally. Where flue linings are not separated by withes, the joints shall be staggered and the vertical distance between joints in adjoining flue linings shall be not less than 7 inches.

The masonry shall be built around each section of lining as it is placed, and all spaces between masonry and linings shall be filled with mortar. Linings shall start at least 8 inches below the center line of smoke-pipe intakes or, in the case of fireplaces, from the apex of the smoke chamber and shall be continuous the entire height of the flue. No smoke-pipe intake shall be cut into a flue lining already set in place. Flues shall be built as nearly vertical as possible, but in no case at an angle greater than 45° from the vertical. Where flues change direction, the abutting linings at the angle joints shall be cut to fit closely, and at no point shall the cross-section area be reduced.

6. Concrete for chimneys cast in place shall flow readily, be well rodded, and shall be reinforced vertically and horizontally. The walls shall be at least 3¾ inches thick and shall be lined throughout with fire-clay flue lining, provided that when the walls of the chimney are at least 6 inches thick, and provided further that quartz gravel be not used as the coarse aggregate, the flue lining may be omitted.

7. Concrete blocks used in chimney construction shall be at least 3¾ inches thick, and blocks inclosing more than one flue shall have suitable reinforcement completely encircling the blocks and well embedded in them.

8. The walls of chimneys built of sawed or dressed stone in courses, properly bonded at corners and tied with metal anchors, shall be at least 3¾ inches thick. Chimney walls of other stone shall be at least 8 inches thick.

9. Hollow masonry units shall not be used for the walls of an independent chimney, but may be used for chimneys built in connection with exterior walls of buildings built of hollow units, in which case the chimney walls shall be at least 8 inches thick. The outer 8 inches of a building wall may serve as the outside wall of the chimney, but the remaining chimney walls shall be constructed of two layers of 4-inch hollow units set with broken joints, or they may be built of 4 inches of solid masonry. In either case the outside walls of the chimney shall be securely bonded into the wall of the building. No chimney shall be corbeled from a wall built of hollow units.

10. The inside effective area of flue linings shall be at least 70 square inches for warm-air furnaces, steam or hot-water boilers; at least 50 square inches or at least one-twelfth the opening for fireplaces; and at least 40 square inches for stoves, ranges, and room heaters when coal, coke, or wood is the fuel used. (See Appendix, par. 50.)

The construction and size of flues to be used for oil and gas fired furnaces, boilers, and automatic water heaters shall be the same as required for corresponding appliances burning solid fuel. Vent flues for nonautomatic water heaters, stoves, ranges, and other domestic gas appliances having relatively small gas consumption shall have a flue area of at least 10 square inches, provided, however, that this shall not apply to gas plates and portable gas heating appliances. Such flues, unless inclosed in solid masonry walls, shall be of incombustible material at least three-fourths inch thick, with airtight joints, and shall vent through and above the roof.

11. Connections between chimneys and roofs shall be made with sheet-metal cap and base flashing arranged to allow for any lateral or vertical movement between chimney and roof.

12. No change in the interior dimensions of chimneys shall be made within a distance of 6 inches above or below the rafters or roof joists.

13. Flues shall be thoroughly cleaned and left smooth on the inside.

14. The walls of fireplaces shall be at least 8 inches thick, and if built of stone or hollow units at least 12 inches thick. The faces of such minimum-thickness walls exposed to fire shall be lined with fire brick, soapstone, cast iron, or other suitable fire-resistive material. When lined with at least 4 inches of fire brick, such lining may be included in the required minimum thickness. When the fire-brick lining is less than 4 inches thick, such lining shall not be included in the required thickness.

15. Fireplaces, except when designed and used for approved gas appliances only, shall have hearths of brick, stone, tile, or other approved incombustible material supported on masonry arches. Such hearths shall extend at least 20 inches outside of the chimney breast, not less than 12 inches each side of the fireplace opening along the chimney breast. The arches shall be of brick, stone, hollow tile, or other approved masonry at least 4 inches thick. A flat stone or a reinforced concrete slab may be used to carry the hearth instead of an arch if it is properly supported and a suitable fill be provided between it and the hearth. Hearths shall be of brick, stone, tile, or concrete, as may be specified. The combined thickness of the hearth and supporting arch or slab shall be not less than 6 inches at any point.

16. No coal-burning heater shall be placed in a fireplace which does not conform to the foregoing requirements.

Sec. 10–2. Combustible Construction Around Chimneys and Fireplaces.

1. No combustible beams, joists, or rafters shall be placed within 2 inches of the outside face of chimneys or from masonry inclosing a flue. No combustible studding, lathing, furring, or plugging shall be placed against any chimney or in the joints thereof. Combustible construction shall either be set away from the chimney or the plastering shall be directly on the masonry or on metal lath and furring or on other incombustible lathing and furring material. Combustible furring strips placed around chimneys to support base or other trim shall be insulated from the masonry by asbestos paper, at least one-eighth inch thick, and metal wall plugs or approved incombustible nail-holding devices attached to the wall surface shall be used for nailing

2. No combustible construction shall be placed within 4 inches of the back wall of any fireplace. Combustible or unprotected header beams supporting trimmer arches at fireplaces shall be not less than 20 inches from the face of the chimney breast.

3. No combustible mantel or other combustible construction shall be placed within 8 inches of either side nor within 12 inches of the top of any fireplace opening.

4. All spaces between the masonry of chimneys and combustible joists, beams, headers, or trimmers shall be filled with loose cinders, loose mortar refuse, gypsum block, or other incombustible material.

Sec. 10–3. Heating Appliances.

1. Not more than one smoke pipe shall be connected to a flue.

2. Smoke pipes shall enter the side of chimneys through a fireclay or metal thimble or flue ring of masonry. Neither the intake pipe nor the thimble shall project into the flue.

3. No smoke pipe shall pass through a ceiling, floor, or roof construction of combustible material.

4. Smoke pipes shall not pass through combustible partitions; provided that smoke pipes from ordinary stoves and ranges may do so if protected by double metal ventilated thimbles 8 inches larger in diameter than the pipe or 4 inches larger in diameter than the pipe if the space between the pipe and the thimble is filled solidly with mineral wool or other approved incombustible material. (See Appendix, par. 51.)

5. The clear distance in all directions between a smoke pipe and combustible construction, including plaster on a combustible base, shall be not less than 12 inches; provided that this clearance may be reduced one-half when such construction is protected by cement-asbestos board or asbestos millboard not less than one-fourth inch thick or equivalent approved covering extending the full length of the smoke pipe and not less than 12 inches beyond it on both sides, or where plaster is on metal or wire lath.

6. The clear distance between warm-air pipes leading from the furnace to vertical or wall stacks and combustible construction shall be not less than 1 inch unless such construction is covered with asbestos paper and the paper covered with galvanized or bright sheet metal.

7. No warm-air pipe shall enter a floor, partition, or other construction of combustible material unless it is at least 6 feet distant in a horizontal direction from the furnace or unless it is covered with asbestos paper or millboard at least one-eighth inch thick or equivalent approved protection. A clearance of not less than $\frac{5}{16}$ inch shall be maintained between combustible construction and warm air heating stacks, floor or wall ducts and their inlets and outlets, and they shall be covered with not less than one thickness of asbestos paper weighing not less than 12 pounds per 100 square feet, or equivalent protection.

8. Stoves or ranges the lower surface of which is a portion of the fire box shall be set on hearths supported by masonry trimmer arches extending not less than 6 inches on all sides beyond such appliances; provided that when such appliances have legs giving an

open air space of not less than 5 inches below the bottom of the appliance they may be set on sheet metal underlaid with not less than one-quarter inch of asbestos or other equivalent approved incombustible material; and provided further that where such appliances have ash boxes under the entire fire box and are set on legs giving an open air space of not less than 5 inches below the bottom of the appliance, they may be set on sheet metal. (See Appendix, par. 51.)

9. No stove or range shall be placed within 24 inches from combustible construction nor within 18 inches of combustible supports or combustible base of plastered construction; provided that when such construction is protected by a shield of galvanized or bright sheet metal or other equivalent approved incombustible material extending from the floor to 1 foot above and 1 foot beyond the sides of such appliances, these distances may be reduced one-half. (See Appendix, par. 51.)

10. Domestic gas ranges shall have a distance between the burners and a combustible floor of not less than 12 inches unless such floors are protected with asbestos board under sheet metal or other equivalent approved incombustible material. The space between the oven back or side of the cooking top shall be not less than 6 inches from combustible material unless such material is protected as described in the paragraph immediately preceding.

Sec. 10–4. Fire Stopping.

1. Fire stopping shall be arranged to cut off all concealed draft openings and form an effectual fire barrier between stories and between the upper story and the roof space. (See Appendix, pars. 53 and 54.)

2. Furred walls: For all walls furred with wood the masonry between the ends of wooden beams shall project 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 or other masonry above and below the beams shall project beyond the face of the wall the full thickness of the furring. (See Appendix, par. 55, and fig. 29, 3 and 4.)

Where floor beams are parallel to a wall furred with wood, there shall be a space of not less than 2½ inches between such wall and the nearest beam. This space shall be filled solidly with masonry or incombustible material the full depth of the floor beams.

3. Walls studded off: Where walls are studded off, the space between the inside face of the wall and the studding directly over such space shall be fire stopped with incombustible material for a depth of at least 4 inches, supported by metal lath and plaster or other suitable means.

4. Partitions: Where stud partitions rest directly over each other and cross wood floor beams at any angle, and the studs run down between the floor beams and rest on the top plate of the partition below, the spaces between the studding shall be filled in solid for a depth of at least 4 inches above each floor level with incombustible materials.

5. Exterior walls: Exterior walls shall be properly fire stopped at each floor level and at the level where the roof rafters connect with the wall plate. (See Appendix, par. 53.)

6. Cornices: Cornices built of wood or having wood frames on rows of buildings shall be either fully fire stopped between each building or shall be completely separated.

7. Stairs: The space between stair carriages shall be fire stopped by a header beam at top and bottom. Where a stair run is not all in one room or where a closet is located beneath the stairs, the stair carriages shall have an intermediate fire stop, so located as to cut off communication between portions of the stairs in different rooms, or between the closet and the room in which it is placed. Such stops shall be made of plank or other suitable material.

If a flight of stairs leading to the second story is over a flight of stairs leading to the basement, the underside of the stairs to the second story shall be covered with expanded metal lath plastered with gypsum or Portland-cement mortar, or with ⅜-inch gypsum lath plastered with unsanded gypsum plaster at least one-half inch thick.

8. Warm-air pipes and registers: Where a furnace warm-air pipe passes through a floor, the space between the pipe and floor construction shall be filled with incombustible material supported by sheet metal or metal lath.

The space between a register box set in a floor and the casing protecting the floor construction shall be filled with incombustible material. This shall include the space around that portion of the warm-air pipe attached to the register box down to the bottom of the joists in wood floor construction, and a layer of sheet metal or metal lath shall surround the pipe and be securely nailed to the underside of the joists to support the fire stopping. When a register box is fire stopped in this manner, the space between the box and the casing may be reduced to 2 inches; otherwise it shall be 4 inches. (See Appendix, par. 55. See also fig. 33, 1 and 2, for details.)

9. No fire stopping shall be concealed from view until opportunity has been given the owner or his representative to inspect same.

Sec. 10–5. Private Garages Combined with Dwellings.

When a garage is located beneath or attached to a dwelling, the following regulations as to its construction shall be observed:

1. The floor and ceiling construction above the garage when it is located beneath the building, or the roof of the garage when it is attached to the building, shall be unpierced and shall be of fire-resistive construction, consisting of wood joists, fire stopped, with a double board floor having an insulating layer between the boards and with a ceiling of at least ¾-inch gypsum plaster on expanded metal lath or any other construction having an ultimate fire resistance of at least one hour.

2. Walls and partitions between the garage and dwelling shall be a fire-resistive wall or partition consisting of wood studs covered on both sides with at least three-fourths inch gypsum or Portland-cement plaster on metal lath or any other construction having an ultimate fire resistance of at least one hour.

3. Openings from a dwelling into a garage shall be restricted to a single doorway; such opening shall be protected by an approved

swinging, self-closing fire door with approved fire-resistive frame and hardware. No glass shall be permitted in such door. The door-sill shall be raised at least 1 foot above the garage floor level. (See Appendix, par. 56.)

4. Garage floors shall be made of concrete or equally fire-resistive and impervious material.

NOTE.—For information on plumbing and electrical requirements, see Appendix, paragraphs 58 and 59.

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PART 3.—APPENDIX

Purpose.

The appendix consists of explanatory matter referring to part 2 and includes information submitted through various national organizations and other sources. It is a vital part of this report. The committee has been singularly fortunate in its facilities for obtaining data and test records from all parts of the country. It has had for consideration a large accumulation of reliable material on which many of its recommendations have been based, thus adding greatly to their significance. The appendix is the merest digest of this wealth of material and is submitted for its educational value.

The Building Code Committee is convinced that the requirements of a building code should be as brief and simple as possible. It should contain merely the minimum requirements necessary and not be a set of specifications covering methods of building. The committee further believes that every such document should be accompanied by an appendix, which should not be a law or ordinance, but which should contain such general explanatory statements of the requirements in the code as would make them easily understandable and such other information of value as could not be obtained elsewhere in concise form, if at all, for the education of the home builder. The committee strongly recommends that in the event of any State or municipality using part 2 as the basis of a building ordinance for dwellings such an appendix be published accompanying the ordinance for the direct benefit of builders.

It should be further stated that the committee, after prolonged study of the voluminous data at its disposal, has placed the requirements in part 2 as low as it considers safe for durable and proper building, as indicated in part 1 of this report. The appendix contains many suggestions for better methods of building, so that they will be available for those who are financially able to take advantage of such opportunities.

Paragraph 1. Heights and Areas.

The requirements for heights given in section 1–3, part 2, are those recommended in the committee's report entitled "Recommended Minimum Requirements for Fire Resistance in Buildings."

In order further to simplify the requirements for wall heights, the permissible height of all types of 8-inch walls has been set at 35 feet. For small dwelling construction this height is considered safe in so far as affected by considerations of loading. Other factors, such as fire resistance, climatic conditions, earthquakes, or high wind pressures, may make it desirable to use thicker walls for this height. (See par. 16 of this appendix.)

In the ordinary case the 35-foot height allowed for any wall is measured from the top of the wall to the top of the foundation. In the case where walls do not extend more than 5 feet below the ground level and certain types of foundation walls are therefore permitted to be 8 inches thick, or in the case of solid concrete foundation walls which may also have an 8-inch thickness, the foundation wall must be included in the allowable height; that is, the foundation wall must be increased in thickness according to the requirements in sections 3–2, 4–2, and 5–2, part 2, if the total height of foundation and exterior wall exceeds a height of 35 feet.

The requirements for area in the committee's report on fire resistance state that frame dwellings may be permitted to have an area not exceeding 4,000 square feet. Inasmuch as the area of the average small dwelling falls below this figures, no limitations on area for this class of structure have been proposed. Attention is called to the definition of a dwelling in section 1–1, part 2.

Par. 2. Weights of Materials.

For the purpose of estimating dead loads, in the absence of more definite information, the approximate average weights of some of the more common construction materials may be taken as follows:

	Pounds per cubic foot
Brickwork, solid	120
Concrete, stone	150
Concrete, solid cinder	110
Structural tile, wall bearing	60
Structural tile, partition	54
Hollow concrete block, cinder	60
Hollow concrete block, stone	80
Plaster, mortar	96
Granite, bluestone, and marble	170
Limestone	160
Sandstone	145
Pine, longleaf	41
Pine, shortleaf	38
Pine, northern white	25
Douglas fir	34
Redwood	30
Spruce, red, white, or Sitka	28
Hemlock	29
Cypress	32
Oak	48
Cedar, Port Orford	29
Cedar, western, northern white	23

	Pounds per square foot
Weight of partition tile (unplastered):	
Solid gypsum block 2-inch	9.5
Solid gypsum block 3-inch	13
Hollow gypsum block—	
3-inch	10
4-inch	13
5-inch	15.5
6-inch	16.5
Structural clay tile—	
3-inch	15
4-inch	16
6-inch	22
8-inch	30
10-inch	35
12-inch	40

Par. 3. Quality of Materials.

Standard specifications for the quality of a number of structural materials have been adopted by the American Society for Testing Materials. These specifications are the result of long and thorough investigation and represent the agreement of producers, consumers, and general interests as to the standards of quality necessary for practical, successful results. They are intended for incorporation in working agreements of all sorts and under any conditions, and are, therefore, especially to be recommended for the general purposes of building code. Copies of the specifications may be obtained from the offices of the American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pa. Following is a partial list of commonly used building materials for which standard specifications have been adopted:

Material	Serial No. of specification
Portland cement	C9–30
Natural cement	C10–09
Quicklime for structural purposes	C5–26
Hydrated lime for structural purposes	C6–31
Gypsum plaster	C28–30
Gypsum plastering sand	C35–30
Gypsum plaster board	C37–30
Gypsum wall board	C36–25
Gypsum partition tile or block	C52–27
Keene's cement	C61–30
Building brick (made from clay or shale)	C62–30
Sand-lime building brick	C73–30
Structural-clay load-bearing wall tile	C34–31
Structural-clay fireproofing partition and furring tile	C56–31
Structural-clay floor tile	C57–31
Clay sewer pipe	C13–24
Cement-concrete sewer pipe	C14–24
Draintile	C4–24
Structural steel for buildings	A9–29
Billet steel concrete reinforcing bars	A15–30
Rail steel concrete reinforcing bars	A16–14
Cold-drawn steel wire for concrete reinforcement	A82–27
Cast-iron soil pipe and fittings	A74–29
Structural wood joist and planks, beams and stringers, posts and timbers	D245–30
Standard definitions of terms relating to timber	D9–30

Tentative specifications, representing the best information and experience obtainable to date, have been prepared for the following additional materials:

Material	Serial No. of specification
Concrete building brick	C55–28T
Concrete aggregates	C33–31T
Fire tests of building construction and materials	C19–26T
Sand for use in lime plaster	C66–27T
Reinforced concrete pipe	C75–30T
Gypsum wall board	C36–31T
Gypsum lath	C37–31T
Gypsum sheathing board	C79–31T
High early strength Portland cement	C74–30T
Load-bearing concrete masonry units	C90–31T

The Bureau of Standards has established a procedure under which specifications developed by nationally recognized organizations, when properly indorsed by the affected groups, are promulgated as "commercial standards." This service, available on request, has been found helpful in many lines of business. Among such commercial standards now in effect for materials entering into construction may be cited the following:

CS4–29. Staple porcelain (all-clay) plumbing fixtures.
CS9–29. Builders' template hardware.
CS20–30. Staple vitreous china plumbing fixtures.
CS22–30. Builders' hardware.
CS26–30. Aromatic red-cedar closet lining.
CS31–31. Red-cedar shingles.

Federal specifications for materials, drafted by the Federal Specifications Board, are used by the Government as a basis for making purchases. Many materials available commercially meet these standards.

As a further aid to assist all purchasers in buying commodities, the Bureau of Standards has also introduced a "certification plan." Under this plan there are compiled for distribution, upon request, lists of manufacturers who have expressed their desire to supply material under contracts based upon certain selected Federal specifications and commercial standards, and their willingness to certify to the purchaser, upon request, that the material thus supplied complies with the requirements and tests of the specifications and is so guaranteed by them.

Par. 4. Simplification of Dimensions.

Recommendations for simplified lists of dimensions for a large number of materials entering into building construction have been proposed by industries and published by the division of simplified practice of the Bureau of Standards. These recommendations are issued only after they have been voluntarily approved by the affected groups. The economies that may be expected by adhering to the simplified practice recommendations are large enough to make their use of real value. Some of the simplified practice recommendations dealing with building materials are as follows:

R16–29. Lumber.
R7. Rough and smooth face brick; common brick.
R26–30. Steel reinforcing bars.
R32. Concrete building units.
R12. Hollow building tile.
R38. Sand-lime brick.

Information concerning these publications may be obtained by addressing the division of simplified practice, Bureau of Standards, Washington, D. C.

Par. 5. Floors.

The wide diversity of floor systems of various types makes it inexpedient to furnish design tables covering all the different systems, but the following publications or handbooks are an incomplete list which may be consulted for information:

Steel Construction, by the American Institute of Steel Construction.
Standard Specifications for Steel Joists, by the Steel Joist Institute.
Open Web Steel Joists, Simplified Practice Recommendation R94–30.
Combination Structural Clay Tile and Concrete Floor and Roof Construction, by the Structural Clay Tile Association.

Handbook of Reinforced Concrete Building Design, reprinted by the Portland Cement Association.

Maximum Spans for Joists and Rafters, by the National Lumber Manufacturers' Association.

For data on wood floor construction, see paragraphs 32, 33, and 34 of this appendix.

Par. 6. Roof Loads.

The minimum roof loads specified apply only in localities where snow loads are not an important consideration. Roofs having a slope of less than 20° are always liable to accidental loading, such as groups of moving people, storage of material, etc. Hence the necessity of moderate unit loads even where snow is not to be expected. Where large snow loads are to be anticipated the loadings prescribed in section 1–6, part 2, should be increased in accordance with local experience.

Par. 7. Soil Pressures.

Soil pressures should be uniform throughout the foundation to allow equal settlement and avoid cracks in walls. For example, diagonal wall cracks showing on the plaster near chimneys in dwellings indicate an unequal settlement between wall and chimney. The latter loads the soil to a greater degree than the neighboring lighter walls. It would be well to permit such unequal settlement to come to rest before papering the walls.

Allowable soil pressures to support footings, walls, and piers upon several classes of soils are fixed in many building codes. The values adopted are the expression of general practice and experience. In case of important structures the designer should explore the soil. The science of predicting supporting capacity upon the basis of laboratory test data resulting from samples secured by pits, borings, etc., is now under development.

In the absence of actual test data, the following table gives a general average of the supporting value in tons per square foot of different soils:

Character of soil	Supporting value, ton/square foot
Soft clay	1
Damp clay and fine sand	2
Dry, fine sand	3
Compact coarse sand	4
Coarse gravel or poorer rocks	6
Hard pan or hard shale	10

Par. 8. Foundation Walls.

It has been customary to require that foundation walls be made thicker than those immediately above them. Experience has indicated that this is not necessary in all cases. A foundation wall acts both as a bearing wall and a retaining wall. As a bearing wall it has few or no openings compared to the walls above it, and its unit compressive stresses are usually lower. As a retaining wall it owes practically all its stability to the weight resting upon it, and except in very thin walls the addition of 4 inches of thickness increases its resistance to side thrust very little. In extreme cases an analysis of the forces acting on the foundation may be necessary. If it is found that the forces produce stresses greater than those approved for the masonry intended for use, or where tension is caused in the masonry, the thickness of the foundation walls should be increased or the walls suitably reinforced.

Par. 9. Bearing for Foundation Walls.

It is of vital importance for the permanence and the stability of a dwelling that the walls and interior piers should be supported upon

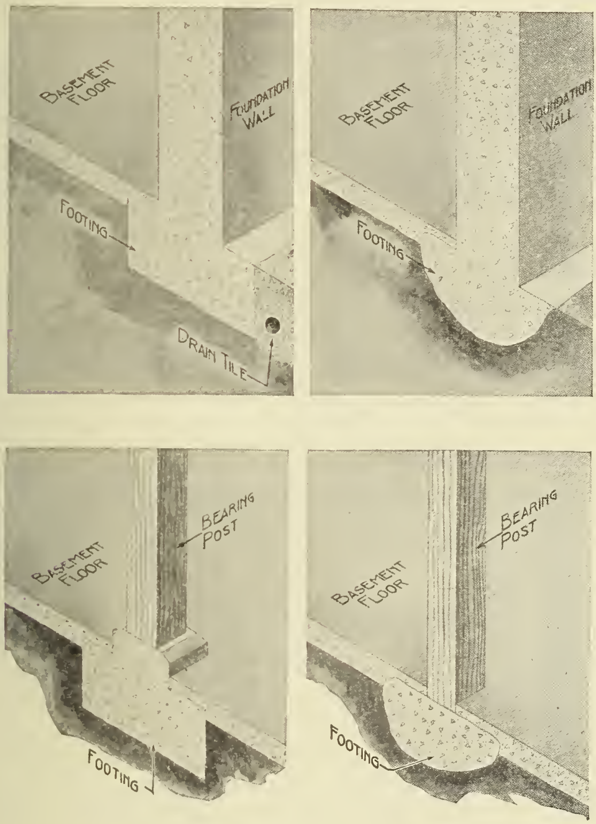

FIGURE 1

Broad and flat footings for foundation walls and basement columns are much more effective in preventing settlement than are undersized footings with rounded or wedge-shaped surfaces. Footings should rest on solid, well-packed material and should never be built on frozen soil. In damp soils a 4-inch tile pipe should drain the footing and discharge into a suitable outfall. Column footings should extend above the floor to protect the column from dampness.

a permanent and unyielding material. If a hard, dry sand, gravel, or clay is encountered at the level at which the walls would naturally rest, a very moderate spread of the foundation wall, or even no spread at all, will be sufficient to support the load. If, on the other hand, the material at the bottom of the wall is an artificial fill or is underlaid with mud or peat or organic matter, it is liable to settlement no matter how much the wall footing may be spread to distribute the load. It is inadvisable to attempt to support any building which is intended to be permanent on other than a stratum of natural ground, free from organic material. If such a stratum can not be reached by carrying the excavations for the entire wall down to its level, other means, such as piles, either wood or concrete, may be employed.

A line of small drainage tile with proper outfall extending around the outside of the foundation wall to drain the footing will help to prevent settlement and dampness of basements.

Par. 10. Provision for Air Circulation.

Where provision is not made for circulation of air within inclosed spaces next to the ground surface, dampness accumulates and timber decays rapidly. Openings for the admission of air help to prevent such decay and increase the life of the structure. The total area of such openings should be not less than 7 per cent of the ground area inclosed.

Par. 11. Piers.

Stone containing high percentages of quartz or similar siliceous material has been found to split and spall freely when subjected to intense heat. Posts of this material are therefore prohibited for use as supporting members in interior spaces, as their failure is liable to cause collapse of the building.

Par. 12. Quality of Brick.

The following table contains the values for strength of building brick made from clay or shale or sand lime as given in the standard requirements of the American Society for Testing Materials:

Name of grade	Compressive strength on mean gross area (bricks tested flatwise)		Modulus of rupture on gross area (bricks tested flatwise)	
	Mean of 5 tests	Individual minimum	Mean of 5 tests	Individual minimum
	Lbs./in.²		*Lbs./in.²*	
Grade A	4,500 or over	3,500	600 or over	400
Grade B	2,500 to 4,500	2,000	450 or over	300
Grade C	1,250 to 2,500	1,000	300 or over	200

NOTE.—The above classifications are based on strength and do not necessarily measure weather resistance.

In recommending that all brick exposed to the weather have a compressive strength of at least 2,500 pounds in section 3-1, part 2, experience shows that it is not imposing undue hardship on any particular product, and that for the purpose of this report it presents a simple standard that can be readily understood by the average person. Although a compressive strength requirement of 2,500 pounds per square inch does not guarantee a brick of good weathering qualities, it represents a fair average for brick suitable for ordinary use in small dwellings. Visual inspection will determine in most instances if a brick is underburned.

The standard size of building brick has been established as 2¼ by 3¾ by 8 inches, and this standard size forms the basis for the recommendations in part 2. Plus or minus variations of one-sixteenth of an inch in depth, one-eighth of an inch in width, and one-quarter of an inch in length are allowed. (See also par. 4 of this appendix.)

Par. 13. Quality of Mortar.

In proportioning cement and lime for mortar it is convenient to remember that a bag of Portland cement equals about 1 cubic foot and a bag of hydrated lime equals about 1¼ cubic feet; also that 1 cubic foot of stiff lime putty is approximately equal to a bag of dry hydrated lime. The proportions of sand and cement specified in section 3–1, part 2, are based on the assumption that loose damp sand will ordinarily be used. If sand is thoroughly dry, a slightly smaller relative volume is advisable. Care should be exercised where very wet sands are used to insure that the resulting mix maintains its required relative proportions.

It is also quite important when a mortar as lean in cement as 1–1–6, as specified in section 3–1, part 2, is used that the mixing be very thoroughly done in order to get uniform strength and quality.

Weakness in compression and slowness of set, coupled with its tendency to disintegrate under high temperatures, make the use of straight lime mortar undesirable in the construction of brick walls of the minimum thickness here permitted. Where walls of greater thickness are used or where 8-inch walls are used for a 1-story building and where reasonable care is taken to prevent undue loads, the use of straight lime mortar should be made optional.

Investigations at the Bureau of Standards [1] on various mortars to determine volume changes in brick masonry indicated that among those mortars studied the samples containing only lime and sand underwent the smallest volume changes subsequent to hardening. Little difference was noted in this respect between a mortar consisting of 1 part Portland cement, 1 part lime, and 6 parts sand by volume and a mortar of 1 part Portland cement and 3 parts sand. Using the same cement, lime, and sand in different mixes of mortar, a mix of 1 part Portland cement, 2 parts lime, and 9 parts sand by volume gave less volume changes subsequent to hardening than either of the two mixes mentioned above. Such a mortar has good plasticity and adheres well to the units after the masonry is in service. It is reported to have been used to a limited extent in field practice with good results.

Natural cement.—The use of natural cement conforming to the test specifications of the American Society for Testing Materials, wherever such cement is available, should not be prohibited, as experience has proved that it gives satisfactory results.

(For mortar requirements, see sec. 3–1, pt. 2.)

A number of special cements for mortar available commercially, and known as "masonry cements," are reported to have proved satisfactory on many construction projects. Standard specifications for their use are under study by a committee of the American Society

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[1] Volume Changes in Brick Masonry. B. S. Jour. Research, vol. 6 (RP321), p. 1003.

for Testing Materials. Such cements should be permitted whenever it is shown by tests under standard specifications that their performance is at least equal to that of other required cementing materials.

Par. 14. Thickness, Height, and Bonding of Solid Brick Exterior Walls.

1. When the first edition of this report was in preparation in 1921 the decision to recommend the use of 8-inch solid brick walls was governed by a thorough study of several compilations of information and opinion on the subject. Building codes then examined indicated a rather limited number permitting such walls.

Since that time further tests conducted at the Bureau of Standards on the compressive strength [2] and fire resistance [3] of such walls have served to strengthen the former conclusions that from these considerations the 8-inch solid brick wall, as permitted for dwellings, is amply safe.

2. *Lateral stability.*—While it is true that 12-inch walls by reason of their weight and thickness offer greater resistance than do 8-inch walls to lateral forces, such as eccentric floor loads, thrust from rafters, wind loads, and expansion due to temperature difference, it must also be recognized that even the heavier walls in use must be supported against lateral forces by cross walls or by floors at intervals measured horizontally or vertically not exceeding twenty times the wall thickness. It is believed that the stability of walls, except as insured by support from associated construction, is not an important consideration in determining the minimum thickness, and that the 8-inch wall is sufficiently satisfactory in this respect.

In general, it appears that the walls of small dwellings are short enough and sufficient reinforcement is afforded when the closely spaced partitions and floors are anchored to the walls to make additional buttresses or pilasters unnecessary. Furthermore, it is considered doubtful whether such masonry reinforcements, unless of disproportionate size and spaced not over 10 feet apart, would materially improve lateral stability of the wall.

Evidence has been received showing that 8-inch walls have suffered severely in localities subject to high winds, and in such regions and those liable to severe earthquake shocks walls thicker than 8 inches are deemed advisable.

The live-load impacts and vibrations incidental to residence occupancy are negligible.

Reinforced brickwork, in view of investigations of its adaptability and tests of its strength, appears to offer considerable promise. The design of brick masonry where reinforcing rods are embedded in the mortar joints is comparable to that of reinforced concrete. Careful workmanship and high-strength mortars are said to be essential if good results are to be obtained with this type of construction. In foundation walls and other constructions, where additional strength may be desired above what is provided by plain brick masonry reinforced brickwork should be advantageous.

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[2] Compressive Strength of Sand-Lime Brick Walls. B. S. Tech. Paper No. 276. Compressive Strength of Clay Brick Walls. B. S. Jour. Research, vol. 3 (RP108), p. 507.

[3] B. S. Letter Circulars Nos. 113, 228, and 229. B. S. Technical News Bulletins Nos. 120 and 124.

3. *Fire resistance.*—In one of the provisions of the standard fire test, wall constructions to be tested are required to have an exposed area of at least 100 square feet with neither dimension less than 9 feet. Several tests made at the Bureau of Standards under the standard conditions show that 8-inch solid brick walls afford a very high degree of resistance to fire. In no case did temperatures on the unexposed face of a wall during the first two hours of the test reach a point endangering ignition of combustible material, even at cracks and imperfections.

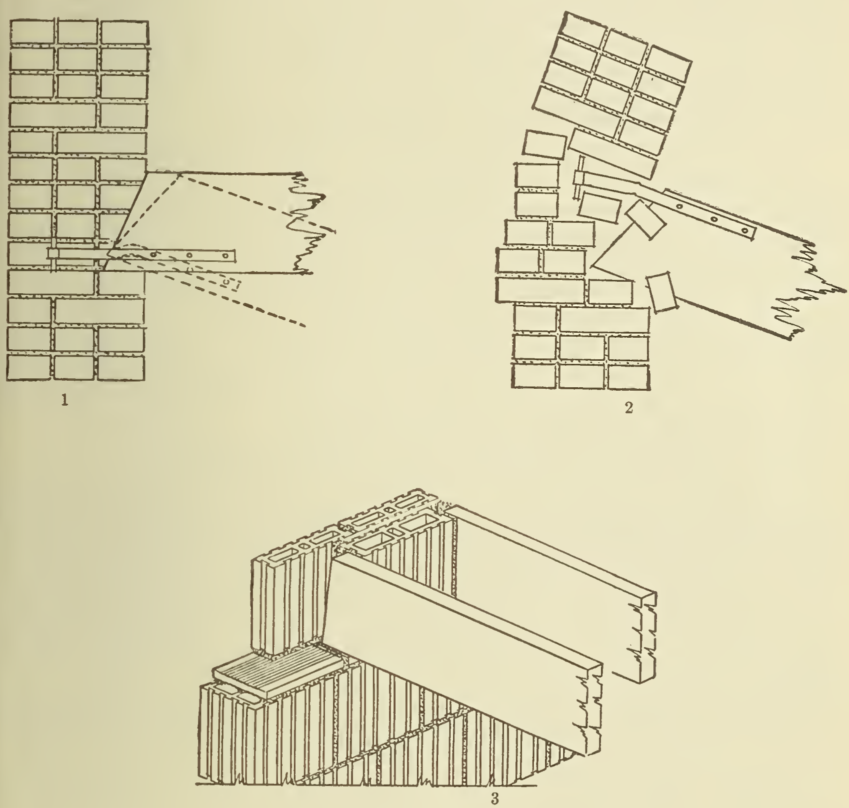

FIGURE 2

1 and 2 illustrate the release of joists correctly and incorrectly anchored, when burned through at the center. A good method of seating joists in thin tile walls is shown in 3.

It is evident that when a wall is exposed to fire from one side only the exposed surface will expand much more rapidly than the unexposed side. If the fire exposure is severe, this unequal expansion of the wall faces can be sufficient to cause collapse of the wall. Where buildings are sufficiently far apart the collapse of a wall is not so serious a matter, but where buildings are close together adjoining buildings are almost sure to suffer damage by such a collapse. Attention should be given to this reaction of masonry walls under fire with a view to providing walls thicker than 8 inches where severe conditions exist.

Par. 15. Conclusions on 8-Inch Walls.

A recent review of the existing codes of some 150 cities in various sections of the country reveals that more than 50 per cent are now permitting 8-inch solid brick walls for 2-story dwellings. In view of the fact that such walls are safe from a structural standpoint, that they provide sufficient resistance to fire exposures, and that they are more economical to build than 12-inch walls, there is reason to believe that a great many codes still penalize the home builder by requiring a greater thickness.

Par. 16. Advantages of 12-Inch Walls Recognized.

While 8-inch solid brick walls for dwellings are recommended as more economical and are proving generally satisfactory in use, nevertheless it is a recognized fact that 12-inch walls, due to increased mass, have superior stability, hence greater ability to resist high wind pressures. They are also less subject to moisture penetration and more resistant to intense cold. Some evidence has been presented indicating that such walls withstand earthquake vibrations better than thinner walls. With these thoughts in mind there is an appreciable advantage in the use of 12-inch brick walls for dwellings subject to extremely high winds or intense cold, and, in general, where cost considerations are not important.

Par. 17. Durability and Weathering of Brick Masonry.

A great deal of research has been made both in the laboratory and in the field on the durability and weathering qualities of brick, especially of clay brick. Brick are known to be affected by frost action; by chemical action, including the solvent effect of rain; by expansion and contraction due to moisture and temperature changes; and by the biological action of certain bacteria, such as lichens. As far as durability is concerned, frost action appears to be the only factor seriously affecting the life of the masonry.

Numerous tests on freezing and thawing of individual brick lead to the conclusion that the underburned or salmon brick are subject to disintegration which makes them unfit for use under exposed conditions. Well-burned brick usually show a high resistance to weathering and should be used for exterior walls and other exposed places.

Absorption requirements for brick have not been included. Investigations are still under way to determine whether or not the percentage of water absorption of a brick is a measure of its weathering resistance.

In the past there has been a rather widespread belief that moisture penetrated through the brick of brick masonry and thus caused dampness on the inside surface of the wall. A study of the water penetration into brick masonry conducted at the Bureau of Standards has shown that when the interior surfaces of brick walls have become wet during a rain it is likely that water has penetrated through the joints rather than through the brick themselves. Openings through the joints are caused by poor workmanship or by shrinkage of the mortar. With no openings through the joints there is little probability of water penetration through a solid brick wall.

As a matter of precaution, plastering directly on 8-inch walls should be avoided. Furring may be used to provide an air space between the wall and the plaster.

Par. 18. Laying of Brick.

During warm and dry weather brick should be wet just previous to being laid in order that a good bond may be obtained between brick and mortar, and so that sufficient water will be left in the mortar to permit its full set.

In a study on the durability and strength of bond between brick and mortar the Bureau of Standards in Research Paper No. 290, Durability and Strength of Bond Between Mortar and Brick, has the following to say regarding the wetting of brick:

> In this connection one should realize that it is the rate rather than the amount of absorption that must be given most consideration. A rapidly absorbing brick tends to dry the wet mortar very quickly when it is first applied. When so quickly dried, the mortar loses plasticity and does not make intimate contact with the entire surface as it should. At the same time a brick when laid should not be so thoroughly saturated that it can absorb no water. A little suction is necessary to form the best bond. It is difficult to draw any definite line even for one particular make of brick; however, each manufacturer should study his material and be able to make recommendations to the user as to the proper degree of wetting his brick.

It is common practice in our northern cities to build upon frozen brickwork for dwellings and other small structures, but if long-continued low temperatures prevail precautions against injury and overloading must be observed, and special care should be taken if brickwork is subjected to alternate freezing and thawing. Brick should be thoroughly dry when laid in cold weather, and for best results both bricks and mortar should be warm, so that the latter may obtain at least a partial set before it is frozen.

Par. 19. Quality of Hollow Masonry Units.

The following table contains the values for strength of structural-clay load-bearing wall tile as given in the standard requirements of the American Society for Testing Materials:

Class	Absorption, per cent			Compressive strength based on gross area			
				End construction		Side construction	
	Mean of 5 tests	Individual maximum	Individual minimum	Mean of 5 tests	Individual minimum	Mean of 5 tests	Individual minimum
				Lbs./in.²		Lbs./in.²	
Hard	6 to 12	15	5	2,000 or more	1,400	1,000 or more	700
Medium	12 to 16	19	5	1,400 or more	1,000	700 or more	500
Soft	16 to 25	28	5	1,000 or more	700	500 or more	350

Structural clay tile are now available commercially bearing the certification label of the Structural Clay Tile Association. Such tile is guaranteed by the manufacturer to be in accordance with the standard specifications of the American Society for Testing Materials. The tile are also marked, indicating the purpose for which they are intended.

The crushing strength allowable for acceptable concrete block and tile as given in section 4–1, part 2, is justified as being within the average demonstrated strength of the material, also by the fact that the comparatively thick shells and webs of blocks afford a better distribution of stress in the mortar joints.

Where manufactured under careful control, the quality of hollow concrete blocks and tile may be expected to be uniform. Because of the ease with which these blocks can be produced, however, a large number of them have been made by inexperienced persons in small plants where no regulated process of manufacture obtained. In some instances constant local inspection has been found necessary to insure a fair quality of material.

Par. 20. Exterior Masonry Walls of Hollow Units.

1. *Strength.*—Many investigations have been conducted in the past few years on the strength, stability, and fire resistance of walls built of hollow units, including those built of structural clay tile and tile and block made from various types of concrete. In general, the investigations show that a marked improvement has been made in the quality of such units. It is reported that in some localities a hollow sand-lime block is giving satisfactory results.

The quality of the mortar has been found to be one of the most important factors affecting the compressive strength of walls built of hollow masonry units, and for that reason either a mortar consisting of 1 part Portland cement to 3 parts sand, proportioned by volume, with an allowable addition of hydrated lime not to exceed 15 per cent of the cement by volume or a mortar consisting of 1 part Portland cement, 1 part lime, and 6 parts sand, proportioned by volume, has been recommended for use in this type of construction. A special mortar consisting of 1 part Portland cement, 1 part lime, and 4 parts sand has been advocated by some authorities as more desirable for use with hollow masonry units than a 1–1–6 mortar. When units of the quality required in section 3–1 and 4–1, part 2, of this report are used and the height limits and thicknesses also recommended are not exceeded, the compressive strength is well within safe limits.

Lateral stability.—Because of their lighter weight, walls constructed of hollow masonry units are less stable than walls of the same thickness built of solid units, but they have shown a very satisfactory degree of stability under test conditions. Such walls should be supported against lateral forces by cross walls or by floors at intervals, measured horizontally or vertically, not exceeding eighteen times the wall thickness. As with the 8-inch solid brick wall, the 8-inch wall of hollow masonry units is not recommended for use in regions constantly subject to high winds, or to earthquakes.

Fire resistance.—The 8-inch wall built of hollow units has been shown to have sufficient fire resistance for any of the uses to which it would be subjected in small dwellings. Masonry walls of any type have added fire resistance when plastered on one or both sides with at least one-half of an inch of gypsum or Portland cement plaster.

Par. 21. Hollow Walls of Brick.

Laboratory tests on hollow walls of clay brick have indicated that such walls when built in 8 or 12 inch thicknesses and with bonds of rolokbak, all rolok, or all rolok in Flemish bond are adequate in strength for the walls of dwellings. In these tests construction cost data on walls of this type showed that there was a saving in time and materials as compared with solid brick walls. The comments in paragraph 20 on walls built of hollow masonry units also apply to hollow walls of brick.

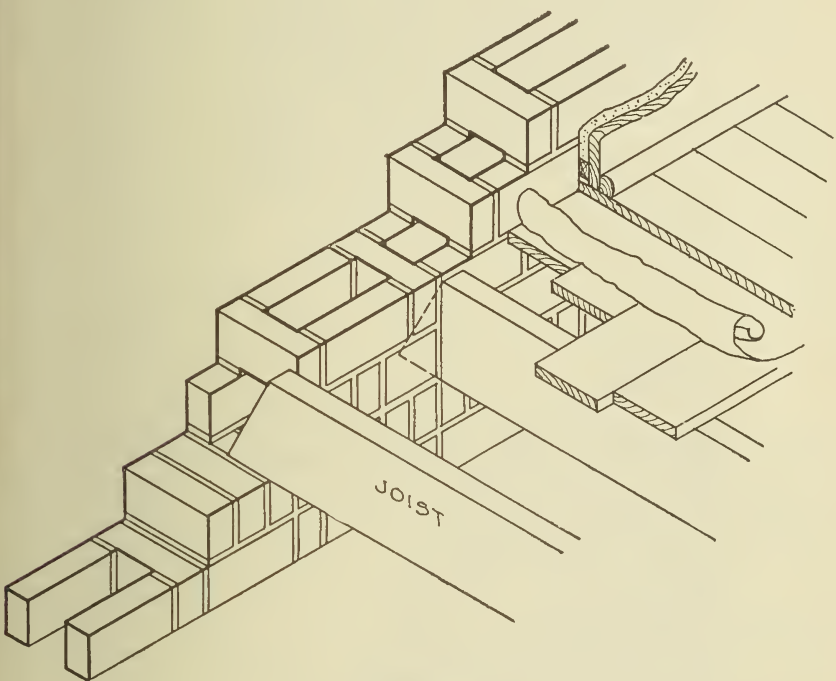

FIGURE 3

Details of 8-inch hollow wall of brick (all rolok), illustrating best methods of joist support.

Par. 22. Laying Structural Clay Tile.

1. A running bond of 6 inches will usually be found most satisfactory in providing for openings when using the standard sizes of tile. When hollow building tile is combined with a facing of brick or cut stone, a masonry bond between the two materials should be used, so that the entire thickness may act as a bearing wall.

2. So far as possible, the cross webs of one course should rest upon those of the course below, and care should be taken to insure full mortar joints on all web-bearing surfaces.

3. Arch lintels may be constructed successfully of hollow tile, but the most practical form of tile lintel is made by butting a sufficient number of tile end to end, filling the cells with concrete, and insert-

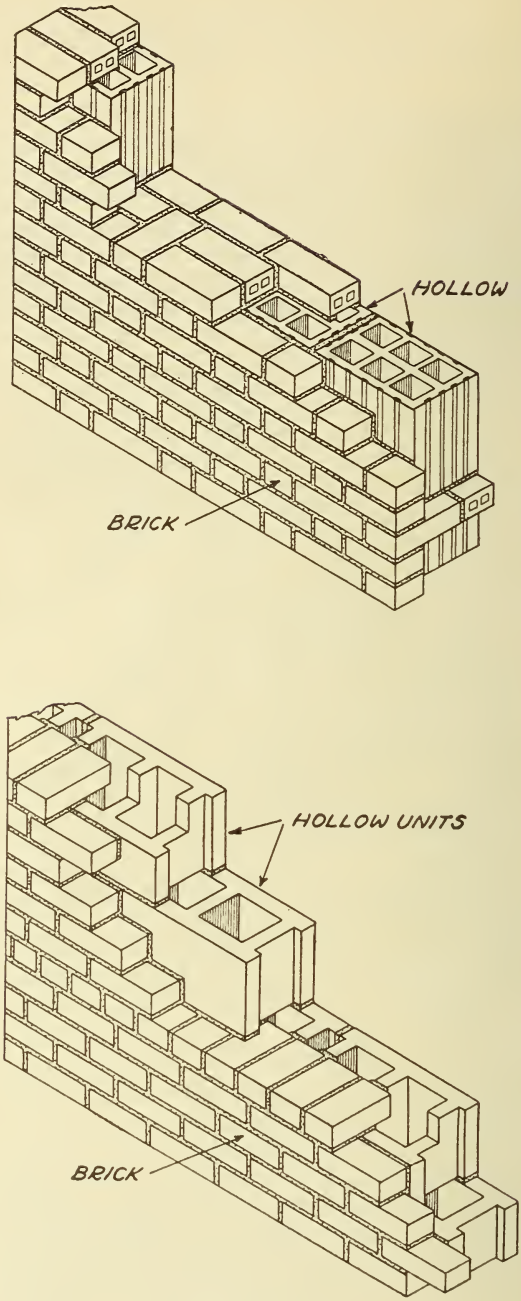

FIGURE 4

Details of faced walls.

ing reinforcing rods in the lower tier of cells, thereby obtaining the effect of a reinforced concrete beam. The coarse aggregate for such filling should not exceed one-half inch diameter.

4. Sills should project at least 1 inch beyond the finished surface of stucco, and to prevent passage of moisture a window sill of solid material should in no case extend entirely through the wall.

Par. 23. Concrete.

Laboratory experiments have shown that concrete of the best quality in respect to strength and durability is produced with the minimum amount of mixing water that is practicable. The practice of using a measured quantity of water in concrete mixes is well established, and such mixing is governed by what is referred to as a "water-cement ratio." For the 2,000-pound concrete required in section 5–1, part 2, approximately 7½ U. S. gallons of water is commonly used for each sack (94 pounds) of cement.

For the purpose of classification of sand and gravel according to size for concrete mixes it is standard practice to state that given percentages of the material pass or be retained on a sieve having openings of a designated size. Sieves are classified by number or by the size of openings. A ¼-inch sieve means that the openings are one-fourth inch or that there are four meshes to the linear inch. Such a sieve is also referred to as a No. 4. In the smaller sizes the numbers alone are usually given, and a No. 100 sieve means that there are approximately 100 meshes to the linear inch. By making use of mechanical analysis of the aggregates better concrete may be obtained.

Par. 24. Construction Methods for Concrete Houses.

Construction practice has developed the following general types:

1. Monolithic construction, in which the concrete is placed in forms and remains in place in the structure. Monolithic construction is accomplished with various systems of forms, ranging from those for casting a complete house in one operation to those for casting small portions of walls in courses.

2. Unit construction, in which precast units different from ordinary concrete block or concrete tile are employed. These structural parts range from the special forms of small units, which serve merely as inclosure walls between members of a load-carrying framework, to large slabs forming an entire side wall of the building, or even to the members for an entire house which are precast and transported.

3. Reinforced-concrete structural frame with light inclosure and partition walls of reinforced concrete. This type has a structural frame of reinforced-concrete columns, beams, and girders and floor slabs cast in place, and thin inclosure walls plastered and back plastered or shot with a cement gun on wire mesh or metal lath attached to columns and beams.

4. Blocks, brick, or tile of concrete laid into walls with mortar joints.

City building codes do not, in general, provide for the construction of concrete houses of all four types described. These codes usually contain a table of wall thicknesses, but these refer only to masonry walls composed of units laid with mortar joints. Often the units

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allowed for such walls are enumerated and include brick, tile, and concrete block. Some codes refer to brick only.

The various systems of unit construction and the systems which utilize structural concrete frame with light inclosure walls are generally not permitted because not mentioned in city building codes. City building departments are prone to allow only just what is provided for in the code regardless of the merit of any proposed new type of construction. Satisfactory, meritorious types of construction obviously should be covered with general requirements for structural adequacy, and the building department should be clothed with the power of selection and should be furnished with the necessary means of investigation.

Par. 25. Concrete Houses with Monolithic Walls.

The vertical loads on bearing walls of buildings not more than three stories high are comparatively small, and the stability of the completed structure as a whole should be considered in any analysis of wall thickness requirements for dwellings.

In plain concrete walls it is customary to place a small amount of reinforcement over openings, at the corners of openings, and at wall junctions or returns.

This reinforcement usually consists of two rods of from three-eighths up to three-fourths inch in diameter, and it appears that monolithic walls with this amount of reinforcement may be properly classed as plain concrete. Where concrete walls contain more than two-tenths of 1 per cent of reinforcement and the two materials act together in resisting forces they should be classed as reinforced concrete, and the thickness should be determined by the dead, live, and wind loads and the amount of reinforcement used.

Several systems of construction have been successfully used which produce double concrete walls. Usually these systems produce two walls, each 4 inches thick, with an air space between. These walls are connected together with metal ties, which contribute something to stability; but if the area of both walls is required to carry the loads, positive means should be provided to transmit floor reactions to both walls.

Par. 26. Concrete Houses of Unit Construction.

The strength of large precast concrete units can be computed and verified by tests. The structural adequacy of a system employing units of sufficient strength will depend largely on the details of the connections, the support afforded by adjacent units, and the stability of the structure as a whole. Systems that employ relatively small units should be judged on the basis of the structural adequacy of the framework carrying the units. If the units themselves are reinforced-concrete structural members, they are susceptible of theoretical analysis, and a decision as to structural adequacy will therefore be based on engineering design.

Par. 27. Structural Concrete Frame with Light Inclosure or Panel Walls.

The adequacy of a structural concrete frame proposed for dwelling houses is susceptible of analysis according to principles of reinforced-concrete design, and building codes should specifically provide for the use of such a system. Inasmuch as the structural frame carries all the loads, the inclosure walls need have only such strength as is necessary to transmit wind loads to the structural frame. This has been successfully accomplished by a thickness of 1½ inches of cement mortar plastered and back plastered on metal lath which is attached to the structural frame of the building. The interior portion of exterior walls is formed by plastering on metal lath to a thickness of seven-eighths to 1 inch. An air space is thus provided for insulation. The total thickness of such exterior walls is governed by the width required for window and door frames, and is usually not less than 6 inches.

Instead of constructing the inclosure or curtain walls by plastering on metal lath, the cement gun or other mechanical means of applying concrete or mortar may be used.

In view of the relatively light types of reinforcement customary for concrete dwelling construction, it is strongly recommended that the concrete covering over such reinforcement be of such thickness as to provide for full protection against corrosion. Metal lath or other lightweight metal reinforcing fabric should be thoroughly galvanized or painted.

Par. 28. Masonry Veneer on Frame Construction.

Frame structures veneered with a single layer of brick or structural stone attached at frequent intervals to the wood framework or sheathing are popular in many parts of the country, and the committee has investigated these structures from various points of view to determine what regulations are desirable for their construction.

1. So far as structural stability is concerned, well-built veneered dwellings can be safely constructed of the same height and under the same circumstances as those with 8-inch masonry walls. The structural frame should be adequately braced, as described in paragraph 35, and should be so designed as to afford a minimum of shrinkage across the grain.

2. Although additional resistance to exterior fire exposure is furnished by veneering with incombustible materials over wood frame, this is not sufficient to justify any significant differentiation as to type between such construction and the ordinary wood-frame type, in view of the fact that the internal resistance is about that of frame and the building when burning offers approximately the same hazard to near-by structures.

3. Anchorage between veneer and wood sheathing should be frequent, noncorrodible, and substantial. Openings should be carefully flashed to prevent entrance of water behind the facing, and the use of a building paper between veneer and sheathing to prevent penetration of moisture and the infiltration of air is strongly recommended. Some types of sheathing that have been used have a heavy paper backing attached to a sheet of welded wire fabric. With this type of sheathing it is common practice to slush in mortar between the sheathing and the veneer. Adequate fire stops should be installed at the floor lines and at intersection of partitions with walls.

Par. 29. Stucco Construction.

1. *General.*—If stucco construction is to give satisfactory service, there are four basic factors which must be given careful consideration: (*a*) The building must be correctly designed and constructed for stucco, (*b*) the stucco must be applied to a suitable base, (*c*) the stucco mortar must be correctly proportioned and mixed from materials meeting standard specifications, and (*d*) the stucco must

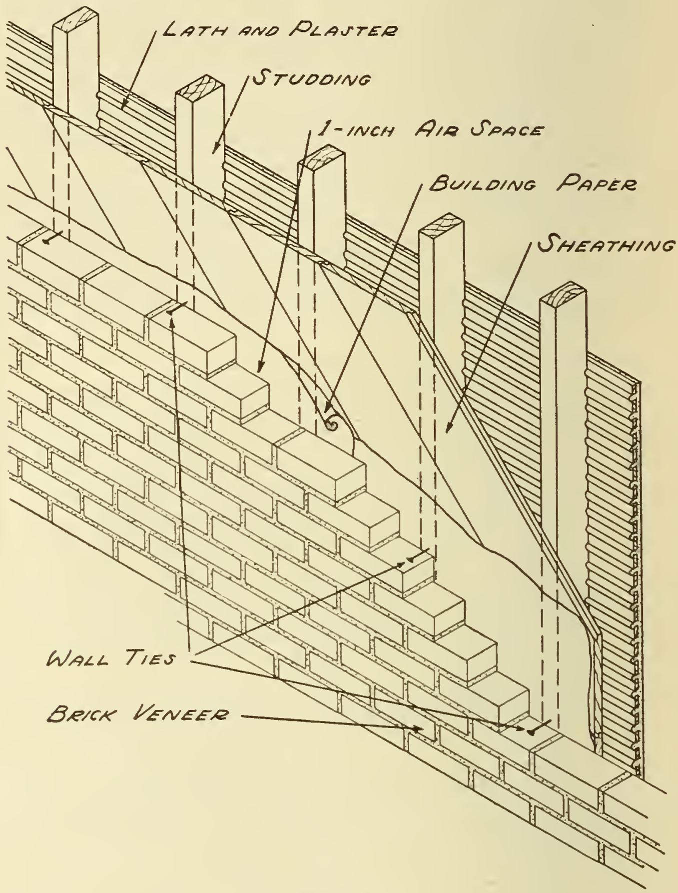


FIGURE 5

Details of construction for brick veneer on frame backing.

be applied by skilled workmen familiar with the material and its application.

It is essential that penetration of moisture behind stucco surfaces be prevented. Poorly drained stucco surfaces should be avoided; copings, cornices, exterior trim, and the frames of all openings should be carefully flashed or otherwise designed to carry water away from the stucco surface.

2. *Wood framing.*—Wood-frame dwellings to be finished with stucco should be erected on well-built foundations to avoid settle-

ment and should be adequately braced to prevent any possible distortion of the frame or unsightly cracking of the stucco surface. Tests indicate that stucco cracks are less likely to occur with horizontal sheathing than with diagonal sheathing. Diagonal bracing strips of 1 by 4 inch boards let in to either face of the studs, or other effective bracing, should be used with such sheathing to insure stability. Where wood sheathing is omitted, bridging between the studs in each story, as well as diagonal bracing, should be used, and the studs should preferably not be spaced over 12 inches apart.

3. *Building paper.*—Substantial building paper between furring and sheathing improves the heat and moisture excluding properties of the wall and prevents the sheathing from extracting moisture from the stucco during the curing period. The bottom layer of paper should overlap the baseboard, and each succeeding strip should lap the one below at least 2 inches. Building paper may also be used effectively between back-plastered construction and the inner plastered wall.

4. *Reinforcement.*—Metal furring and metal or wire lath should be fabricated from galvanized sheets or should be given a galvanized coating or painted and securely stapled to the sheathing or to the wood frame at intervals of not more than 8 inches apart. Metal lath should preferably be laid horizontally, the joints being lapped a distance of at least one mesh and securely tied or laced with wire. Lapped vertical joints should occur over supports and should be well stapled to avoid lines of weakness. Wood lath is not recommended for cement stucco, but is satisfactory for use with lime stucco.

5. *Back-plastered and open construction.*—In back-plastered construction the base for the stucco is attached directly to the studs. The back plastering between the studs serves fully to incase the metal lath, thus protecting it from corrosion, and reduces the fire hazard.

Open construction is similar to back-plastered construction, except that the three coats are placed on the outside face of the wall. In either of these two types of applying stucco, special attention should be given to proper bracing and adequate insulation.

6. *Masonry walls.*—Masonry walls offer an excellent base for stucco because of their inherent rigidity. Foundations for masonry walls should insure that settlement will be avoided. The joints should not project beyond the face of the wall, and, if the joints are raked, an additional key will be furnished. Where the masonry serves as a base for the direct application of the stucco, it should be thoroughly cleaned of all dirt, loose or weathered particles, paint, grease, or other substances which would impair bond. The masonry should also have a sufficiently rough texture so as to provide a good mechanical bond with the scratch coat.

7. *Wetting the surface.*—Surfaces to be stuccoed should be moist, but not wet enough to yield moisture to the coat applied.

8. *Mixing.*—Stucco should be mixed by machine where possible, and careful attention given to obtaining uniform proportions and thorough mixing.

9. *Proportions.*—A general proportion which is widely used for stucco mortar consists of 1 part of Portland cement and 3 parts of

sand with hydrated lime, in the proportion of 10 per cent, by weight, of the cement used.

10. *Application.*—Except on monolithic concrete or on masonry walls having very true surfaces, three coats of stucco are considered desirable. Plastering should be carried on continously in one direction without allowing the plaster to dry at the edge. The most common practice used in applying stucco at the present time favors keeping the scratch coat moist for a period of at least 48 hours, with an equal period of similar treatment for the brown coat, which is then allowed to become dry before application of the finish coat. All necessary precautions should be taken to prevent the plaster from drying out before attaining its set. A fine spray or mist of water has been found to be very successful in wetting stucco surfaces.

The time of application of the various stucco coats is an open question. It was noted in tests on stucco at the Bureau of Standards that shrinkage cracks which developed in the scratch coat later appeared in the brown coat, and finally the same cracks appeared in the finish coat, and therefore that it is more logical to apply all three coats one day apart, building up a fairly heavy thickness of mortar and keeping this uniformly wet for several days, than to expect a finish coat permanently to seal cracks which have worked through the first two coats.

11. *Protection.*—Stucco should be protected from sun, rain, and freezing weather. In general, stucco work should not be attempted when the temperature is below 40° F. unless protection can be given the stucco for at least 48 hours.

NOTE.—For a complete treatment of cement stucco, reference is made to Bureau of Standards Circular No. 311 and to the recommendations contained in the proceedings of the American Concrete Institute, volume 26, 1930. Recommendations for Portland cement stucco are also prepared and issued by the Portland Cement Association and for lime stucco by the National Lime Association, and may be obtained by writing to these associations at the addresses given in paragraph 60 of this report.

Par. 30. Sizes of Timber and Lumber.

Wherever timber or lumber is specified in part 2, the nominal size by which it is known and sold in the market is understood, provided that the actual dimensions are not less than those of the American lumber standards, established in Simplified Practice Bulletin R16–29, Lumber, by the United States Department of Commerce. The actual dimensions of seasoned and surfaced lumber are from one-eighth to one-half inch less than the nominal.

As given in the standards referred to in the preceding paragraph, the dressed thicknesses of structural joists, rafters, plank, factory flooring, etc., 2, 3, and 4 inches in nominal thickness are three-eighths inch less than the nominal. Widths are three-eighths inch less than nominal for pieces of nominal width from 4 to 7 inches and one-half inch less than nominal for widths 8 inches or more. The standard dressed thicknesses and widths of beams, girders, stringers, etc., 5 inches and thicker and square timbers 6 by 6 inches and thicker are one-half inch less each way than the nominal dimensions. The standard lengths of all lumber and timber are in multiples of 2 feet.

Par. 31. Removal of Overloads on Timber Construction.

The load which a wood member, such as a floor joist or a rafter, will sustain is dependent to a considerable extent upon the length of time the load remains on the timber. Ordinarily a timber will carry 10 per cent more load for 1 hour than it will for 10 hours. If a given load will break a timber in 40 days, a load about one-third greater will break the same timber in one hour. It is evident, therefore, that timber will sustain considerable overload for a time, and for this reason temporary stresses caused by wind or snow loads may be greater without danger or failure than those due to dead loads or long-continued live loads.

TABLE 2.—*Girder factor and maximum permissible lengths of floor joists* [1]

(Girder factor based on 30 pounds per square foot live load and 15 pounds per square foot weight of floor. Permissible length of joists based on 40 pounds per square foot live load and 10 pounds per square foot weight of floor. Lowest line in each group is based upon the deflection of one three-hundred-and-sixtieth of span, which is considered the maximum allowable with plastering and is based on 40 pounds per square foot live load only. Actual sizes used in all calculations.)

Species	Girder factor	Grade [2]	Stress	Modulus of elasticity	Nominal, 2 by 4 inches; actual, 1⅝ by 3⅝ inches, for joist spacings — 16 inches	24 inches	Nominal, 2 by 6 inches; actual, 1⅝ by 5⅝ inches, for joist spacings — 16 inches	24 inches	Nominal, 2 by 8 inches; actual, 1⅝ by 7½ inches, for joist spacings — 16 inches	24 inches	Nominal, 2 by 10 inches; actual, 1⅝ by 9½ inches, for joist spacings — 16 inches	24 inches	Nominal, 2 by 12 inches; actual, 1⅝ by 11½ inches, for joist spacings — 16 inches	24 inches
			Lbs./in.²	*1,000 lbs./in.²*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Cedar, northern white	0.270	Select	750		5 2	4 3	8 0	6 7	10 8	8 9	13 6	11 1	16 5	13 4
Spruce, Engelmann	.270	Common	600		4 7	3 8	7 2	5 10	9 7	7 9	12 1	9 10	14 8	11 11
				800	5 3	4 7	8 1	7 1	10 10	9 5	13 9	11 11	16 7	14 5
Chestnut	.225													
Cedar, western red	.225													
Fir, balsam	.241	Select	900		5 8	4 7	8 9	7 2	11 8	9 7	14 10	12 1	17 11	14 8
Pine, northern white	.225	Common	720		5 1	4 2	7 10	6 5	10 6	8 7	13 3	10 10	16 1	13 1
Pine, Idaho white	.225			1,000	5 8	4 11	8 9	7 8	11 8	10 3	14 9	12 11	17 11	15 8
Pine, western yellow	.225													
Maple, silver	.202	Select	1,000		5 11	4 10	9 3	7 7	12 4	10 1	15 8	12 9	18 11	15 5
Hemlock, eastern	.241	Common	800		5 4	4 4	8 3	6 9	11 0	9 0	13 11	11 5	16 11	13 10
				1,100	5 10	5 1	9 0	7 10	12 1	10 6	15 3	13 4	18 6	16 2
Spruce	.199													
Gum, red	.184	Select	1,100		6 3	5 1	9 8	7 11	12 11	10 7	16 5	13 5	19 10	16 2
Douglas fir (Rocky Mountain type)	.199	Common	880		5 7	4 7	8 8	7 1	11 7	9 5	14 8	12 0	17 9	14 6
Pine, Norway	.199			1,200	6 0	5 3	9 3	8 1	12 5	10 10	15 9	13 9	19 0	16 7
Tamarack	.178	Select	1,200		6 6	5 4	10 1	8 3	13 6	11 0	17 1	13 11	20 9	16 11
Larch, western	.169	Common	960		5 10	4 9	9 1	7 5	12 1	9 10	15 4	12 6	18 7	15 2
				1,300	6 2	5 5	9 6	8 4	12 9	11 1	16 2	14 1	19 10	17 1
Cypress	.169	Select	1,300		6 10	5 7	10 7	8 8	14 1	11 6	17 10	14 7	21 7	17 7
Hemlock, western	.225	Common	1,040		6 1	5 0	9 5	7 8	12 7	10 3	15 11	13 0	19 4	15 9
				1,400	6 4	5 6	9 9	8 7	13 1	11 5	16 7	14 6	20 0	17 6

Oak	.144	Select	1,400		7	1	5	9	10	11	8	11	14	7	11	11	18	6	15	1	22	5	18	3
		Common	1,120		6	4	5	2	9	10	8	0	13	1	10	8	16	7	13	6	20	0	16	4
				1,500	6	5	5	7	10	0	8	9	13	4	11	8	16	11	14	10	20	6	17	11
Maple, hard	.144	Select	1,500		7	4	5	11	11	4	9	3	15	1	12	4	19	2	15	8	23	2	18	11
		Common	1,200		6	6	5	4	10	1	8	3	13	6	11	0	17	1	13	11	20	9	16	11
				1,600	6	7	5	8	10	3	8	11	13	8	11	11	17	3	15	0	20	11	18	4
Douglas fir, coast	.169	Dense select	1,750		7	11	6	5	12	3	10	0	16	4	13	4	20	8	16	11	25	0	20	5
		Select	1,600		7	7	6	2	11	9	9	7	15	7	12	9	19	9	16	2	23	11	19	6
Pine, southern yellow	.135	Dense common	1,400		7	1	5	9	10	11	8	11	14	7	11	11	18	6	15	1	22	5	18	3
		Common	1,200		6	6	5	4	10	1	8	3	13	6	11	0	17	1	13	11	20	9	16	11
				1,600	6	7	5	8	10	3	8	11	13	8	11	11	17	3	15	0	20	11	18	4

[1] Data furnished by the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, August, 1930.

[2] The select and common and dense select grades are those specified in American Society for Testing Materials "Standard Specifications for Structural Wood Joists, Planks, Beams, Stringers, and Posts," serial designation D245-27.

TABLE 3.—*Maximum permissible unsupported lengths of rafters measured from plate to ridge*

(Based on 30 pounds per square foot live load for flat roofs and 20 pounds per square foot for wind load acting perpendicular to the roof for a rise of 1 foot per foot. Weight of roof assumed to be 10 pounds per square foot roof surface.)

Size of rafter (in inches)	Spacing of rafters center to center	Rise	Stress (in pounds per square inch)																					
			600		700		800		900		1,000		1,100		1,200		1,300		1,400		1,500		1,600	
			Maximum permissible lengths for sizes																					
	Inches		*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Nominal, 2 by 4; actual, 1⅝ by 3⅝	16	Flat	5	2	5	7	6	0	6	4	6	8	7	0	7	4	7	7	7	11	8	2	8	5
	24	do	4	3	4	7	4	10	5	2	5	5	5	9	6	0	6	2	6	5	6	8	6	11
	16	12 inches in 1 foot	7	8	8	4	8	11	9	5	9	11	10	5	10	11	11	4	11	9	12	2	12	7
	24	do	6	3	6	9	7	3	7	8	8	1	8	6	8	11	9	3	9	7	9	11	10	3
Nominal, 2 by 6; actual, 1⅝ by 5⅝	16	Flat	8	0	8	8	9	3	9	10	10	4	10	10	11	4	11	10	12	3	12	8	13	1
	24	do	6	7	7	1	7	7	8	0	8	5	8	10	9	3	9	8	10	0	10	4	10	8
	16	12 inches in 1 foot	11	11	12	11	13	9	14	7	15	5	16	2	16	11	17	7	18	3	18	10	19	6
	24	do	9	9	10	6	11	3	11	11	12	7	13	2	13	9	14	4	14	11	15	5	15	11
Nominal, 2 by 8; actual, 1⅝ by 7½	16	Flat	10	8	11	7	12	4	13	1	13	10	14	6	15	1	15	9	16	4	16	11	17	6
	24	do	8	9	9	5	10	0	10	8	11	3	11	10	12	4	12	10	13	4	13	10	14	3
	16	12 inches in 1 foot	15	11	17	2	18	5	19	6	20	7	21	7	22	6	23	5	24	4	25	2	26	0
	24	do	13	0	14	0	15	0	15	11	16	9	17	7	18	5	19	2	19	10	20	6	21	3
Nominal, 2 by 10; actual, 1⅝ by 9½	16	Flat	13	7	14	8	15	8	16	7	17	6	18	4	19	2	19	11	20	8	21	5	22	1
	24	do	11	1	11	11	12	9	13	7	14	3	15	0	15	8	16	3	16	11	17	8	18	1
	16	12 inches in 1 foot	20	2	21	9	23	4	24	8	26	0	27	4	28	6	29	8	30	10	31	11	32	11
	24	do	16	6	17	9	19	0	20	2	21	3	22	3	23	4	24	2	25	2	26	0	26	11
Nominal, 2 by 12; actual, 1⅝ by 11½	16	Flat	16	5	17	8	18	11	20	1	21	2	22	2	23	2	24	1	25	1	25	11	26	9
	24	do	13	5	14	5	15	6	16	5	17	4	18	2	18	11	19	8	20	5	21	2	21	11
	16	12 inches in 1 foot	24	5	26	5	28	2	29	11	31	6	33	1	34	7	35	11	37	4	38	7	39	11
	24	do	19	11	21	6	23	0	24	5	25	9	27	0	28	2	29	4	30	5	31	6	32	7

How to use Table 3.—The proper stress for the species and grade of lumber used may be found in Table 2. Immediately below this stress heading in Table 3 the permissible length of rafter is given for a size and spacing shown at the left. If an exact stress value in Table 2 is not given in the column headings of Table 3, use a length that corresponds to the next lower stress given.

Roof with rise other than given in the table.—For roofs with a slope up to 4 inches per foot, the horizontal projection (span) of rafter is the same as the length given in the table for a flat roof. When the slope is between 4 inches per foot and 12 inches per foot the horizontal projection of the rafter may be taken as 1 inch per foot of length greater than the rafter length given for a flat roof. For roofs with a slope greater than 12 inches in 1 foot (45°) the length of rafter should be limited to that given for a rise of 12 inches in 1 foot.

Heavier roof coverings.—If heavier roof coverings are used, the weight must be calculated and the spacing or length reduced. For a flat roof weighing 20 pounds per square foot the rafter length permissible would be the same as the floor joist lengths given in Table 2.

Length of rafters when limited by deflection.—If for any reason the deflection under the live load is to be limited to one three-hundred-and-sixtieth of the span, the maximum permissible length of rafter for a light roof can be estimated by reference to Table 2. Under each group of species the lower line gives the maximum length of joist for the various sizes and 16 and 24 inch spacing. For a flat roof the permissible length of rafter with the same limit of deflection would be 1 inch per foot of length greater than the corresponding joist length. For steep roofs the length of rafter would be 4 inches per foot of length greater than the corresponding joist length.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
FOREST PRODUCTS LABORATORY,
Madison, Wis., November 13, 1931.

It is, however, important to remove the load from any overloaded wood floor or roof within a short time, since it is not certain that the floor or roof will not fail merely because it has held the load for a few hours or days.

Par. 32. Bearing Values for Joists.

The reasons for allowing a greater stress in compression across the grain when the joists rest upon a ribbon or ledger board than when the ends rest upon or in masonry are that they are more certain of being dry and are consequently stronger; that the stress is not at the extreme end of the joist and in case of a slight overload they will not yield so much; and that the joists are to be spiked to the studding, thus gaining some support through the nails.

Par. 33. Explanation and Comments Relative to Table on Girder Factor and Maximum Permissible Lengths of Floor Joists.

Use of Table No. 2.—The size of girder necessary in any small dwelling may be found as follows:

Add together the joist spans in feet meeting at the girder. Multiply this width by the figure given in Table No. 2 under "girder factor" and opposite the species of which the girder is to be made. This will give for select-grade timbers the minimum width of the girder, in inches, to support one floor when the distance between supports of the girder is twelve times its height. To get the thickness of the girder for more than one floor, multiply the thickness for one floor by the number of floors. When the supports under the girder are placed closer together, the thickness of the girder can be proportionately decreased. When the distance between supports is not over ten times the girder height, common-grade timbers may be used, except that the shakes and checks should conform to the requirements of select grade. When it is desirable to place the posts farther apart than given by the above rule, the girder should always be calculated by a competent engineer or architect. Joints in built-up girders should occur only over supports. In determining from the table the maximum permissible lengths of joists, all figures (except the girder factors) grouped opposite any one bracket apply to all the species in the bracketed lines. Find the species which it is proposed to use and the grade of material; then run horizontally across to the first length as great or greater than the proposed joist span. The head of this column will be found marked "16 inches." This means a spacing of 16 inches center to center, and the figures above give the nominal and actual sizes of joists. Three columns farther to the right, ordinarily, the required length for 24-inch spacing will be found, although occasionally it will be found that the same size joist is required with either 16 or 24 inch spacing. Where the floor joists are to support plastering, the length of joist should never be greater than that given in the lowest horizontal line in each group of species, since this length is considered to be the maximum which can be used without serious cracking of the plastering, and lengths greater than this will give floors which shake considerably.

Par. 34. Flooring.

Wherever cost will permit, the committee recommends that all flooring be double, with a layer of heavy asbestos paper or incombustible floor felt, gypsum board, or other incombustible material between the finish and rough flooring. This will make the floor warmer, decrease sound transmission, and will delay the passage of fire through the floor. In any event, it is advisable to put some good type of building paper between the flooring.

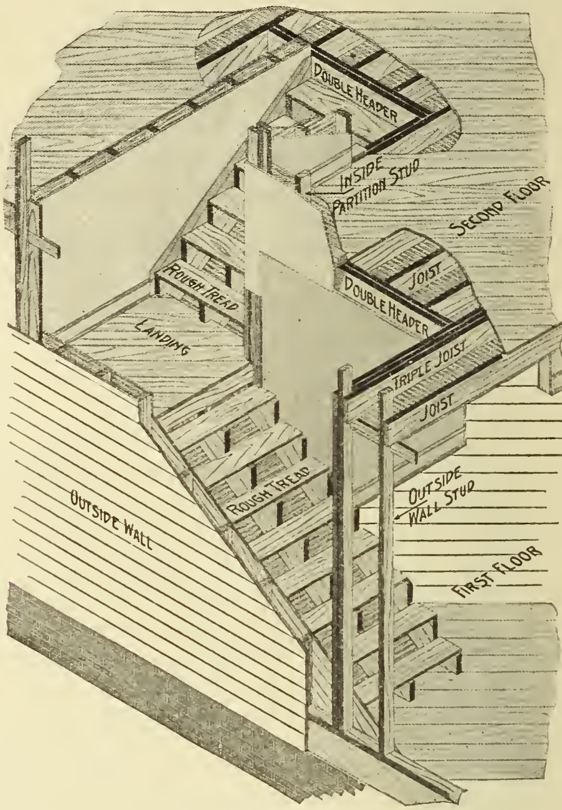


Figure 6

Desirable features of framing for stairways are illustrated above. Note that strength lost by cutting studs and joists is regained by reinforcing the remaining timbers.

Par. 35. Notes Bearing on the Use of Lumber and Timber in Small-House Construction.

1. *Desirability of protecting lumber.*—The care of lumber prior to use for building purposes and its condition at the time of use often determine to a large extent the value of the building or the rate at which depreciation will take place. Green or partially dry lumber, when not properly piled, will twist and warp in drying and will retain this twisted and warped condition after being taken from

the pile. Green lumber, when closely piled or stored without ample provision for the circulation of air, is very likely to become infected with decay. This is especially true in warm, damp weather. Decay

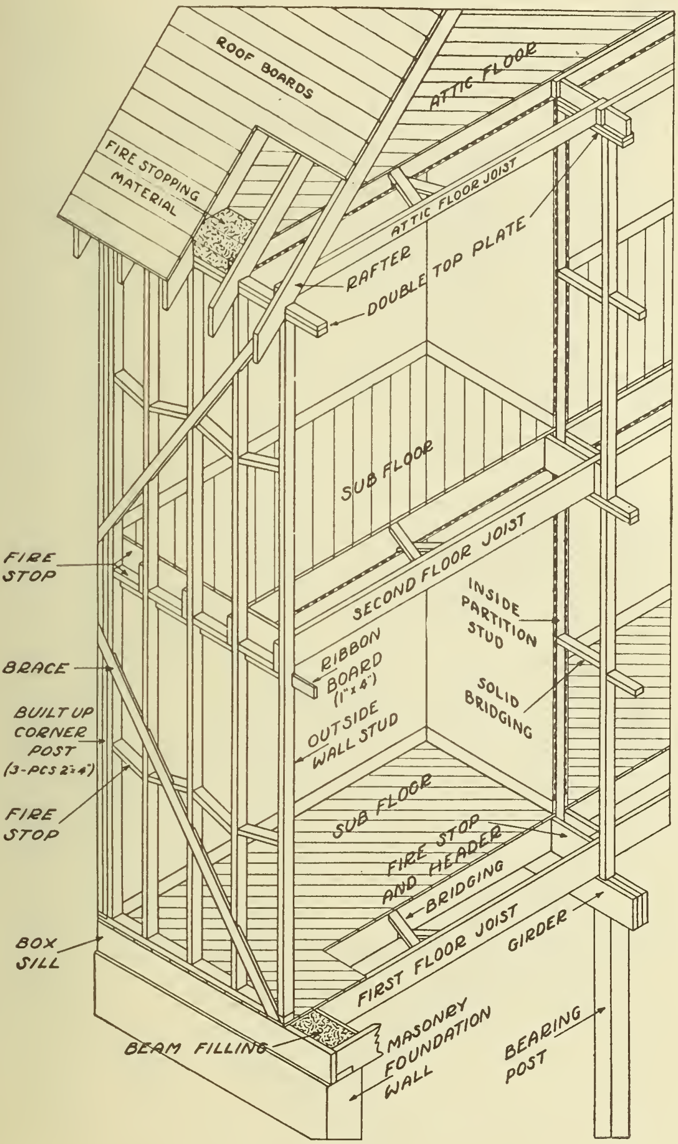


FIGURE 7

Approved details of balloon frame construction.

once started in a timber will quite frequently continue after the timber has been placed in the building, even though it be used in a relatively dry location where a perfectly sound, dry timber would

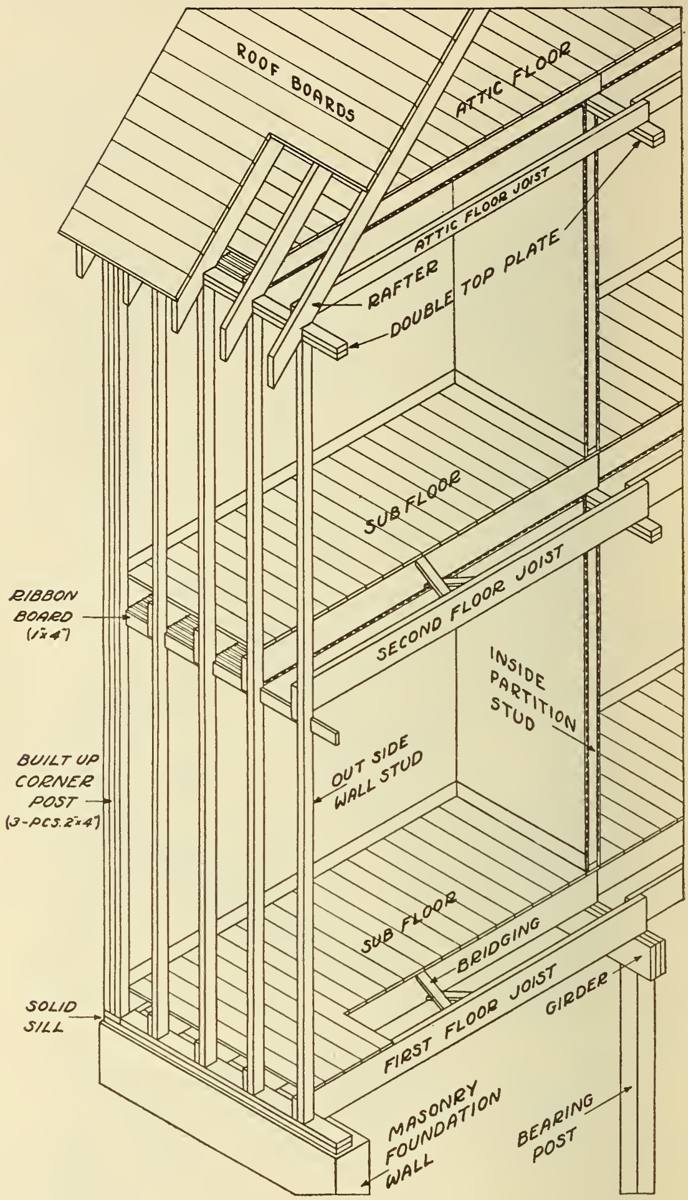


Figure 8

The above illustration shows some common defects in balloon frame construction, which are avoided on Figure 7. Omission of floor headers and of fire stops permits heat losses by free air circulation; lack of corner braces impairs rigidity; and unequal settlement results from resting partition studs on the subfloor.

never be attacked by decay. Timbers used in a building in a fairly green condition and so inclosed as partially to cut off circulation of the air are very likely to be attacked by decay. In this respect

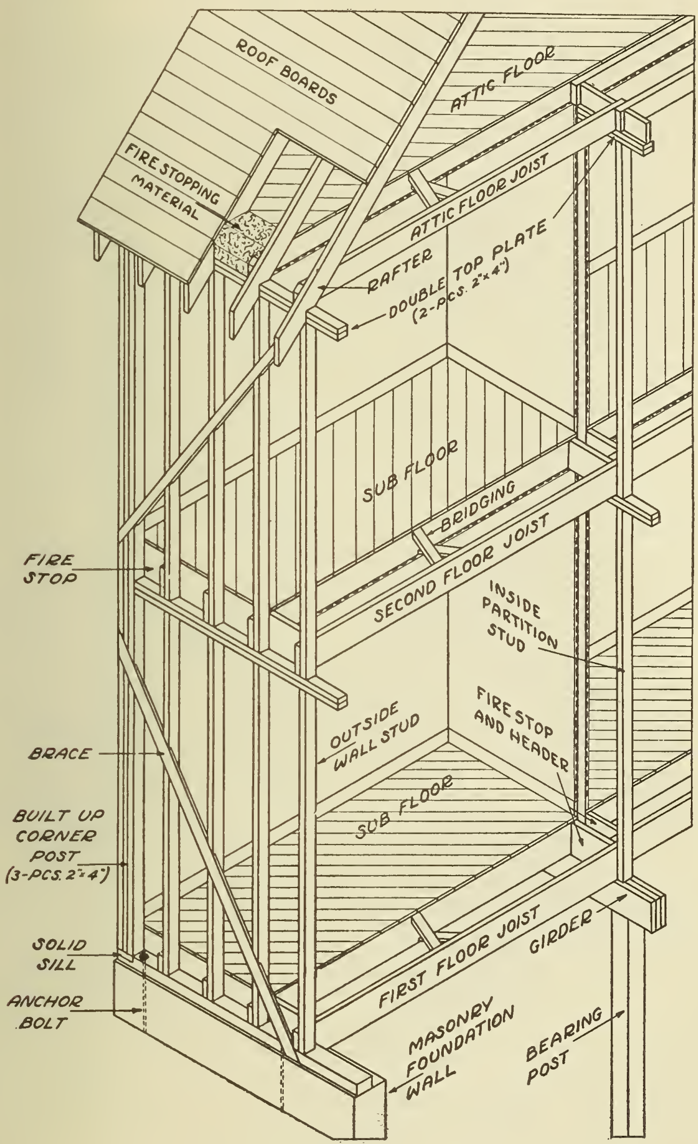


FIGURE 9

Approved details of braced-frame construction.

sapwood is much worse than heartwood, although in the strength of the sound material there is no difference.

When the rough lumber is delivered at a building site but little attention is generally paid to the piling or to the protection of the

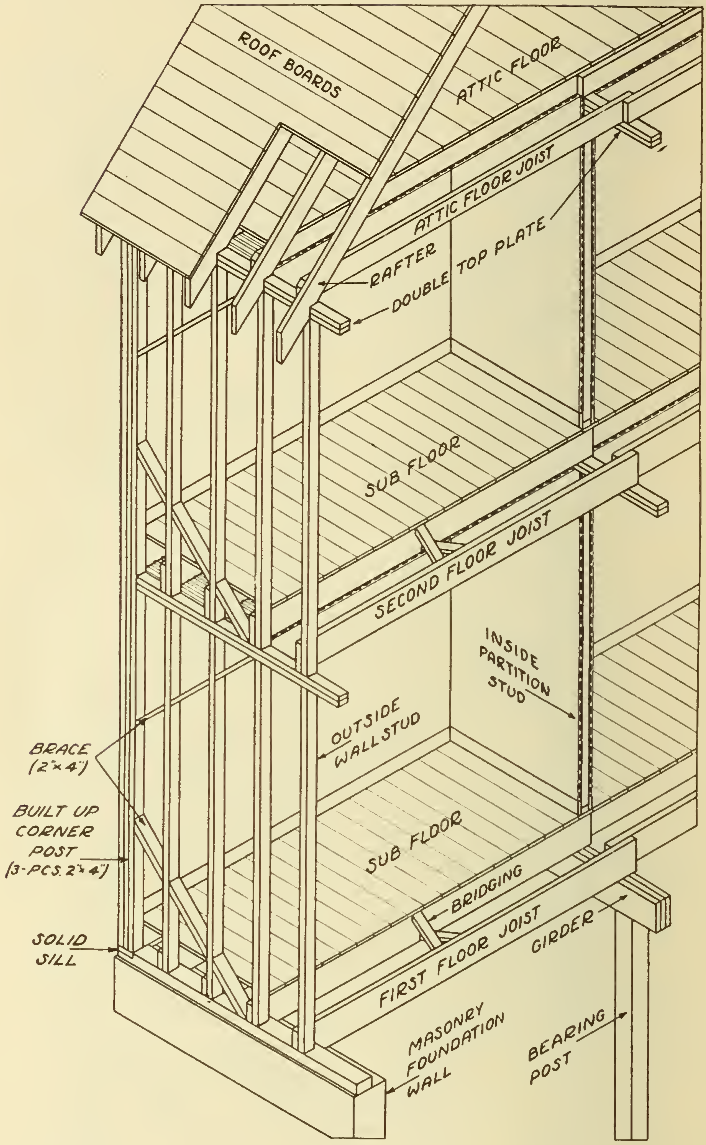


FIGURE 10

The above illustration shows some common faults in building modern braced-frame construction. Note that the floor headers and firestopping shown on Figure 9 are omitted, that the subfloor is laid perpendicular to joists, and that interior partition studs rest upon the subfloor instead of the partition plates below.

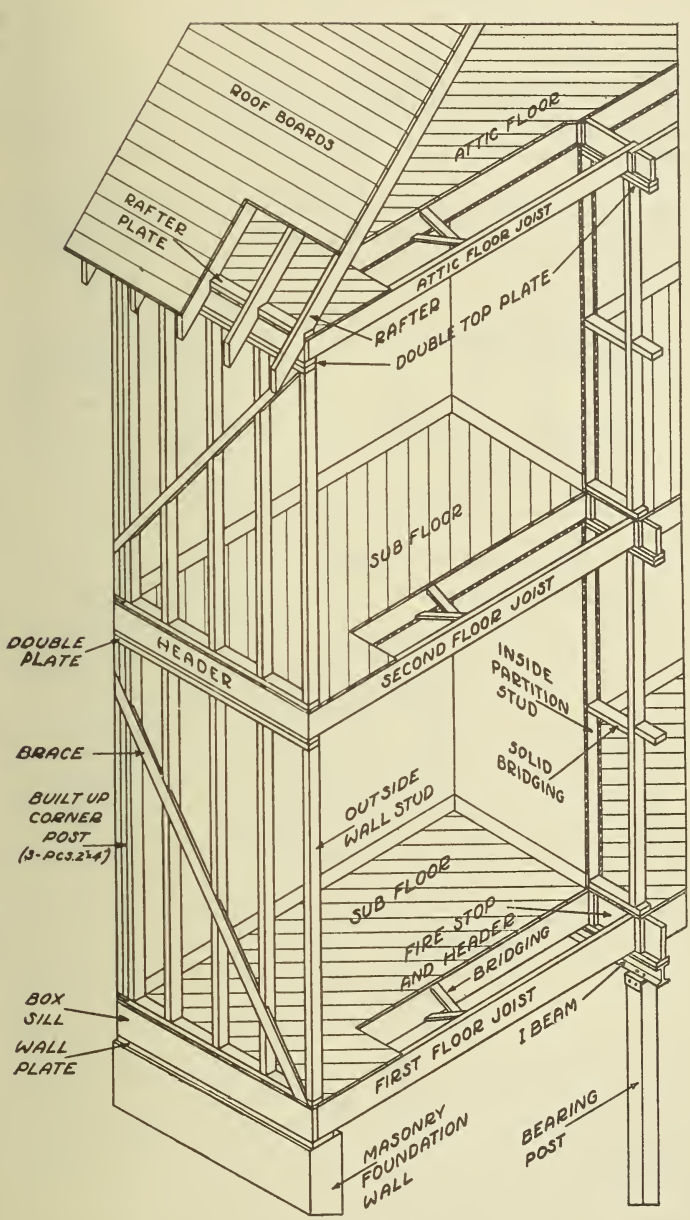


FIGURE 11

The above illustration shows details of the platform-frame type of construction, in which each story is built as a separate unit. Note settlement is equalized by making the height of horizontal timbers the same in exterior walls and interior partitions.

lumber from rain and sunshine. It is common practice to use some of the building material for concrete forms. This material when removed is not infrequently thrown around in a rather promiscuous pile. The effect on lumber of such treatment and the ensuing wetting and drying are often quite disastrous, resulting in development of checks, shakes, warping, twisting, and cupping. Joist material, for instance, may have been in the very best condition when received and practically fall to pieces between the rings under such treatment.

2. *Influence of shrinking and swelling.*—The use of seasoned lumber in the framing of dwellings is important in reducing the shrink-

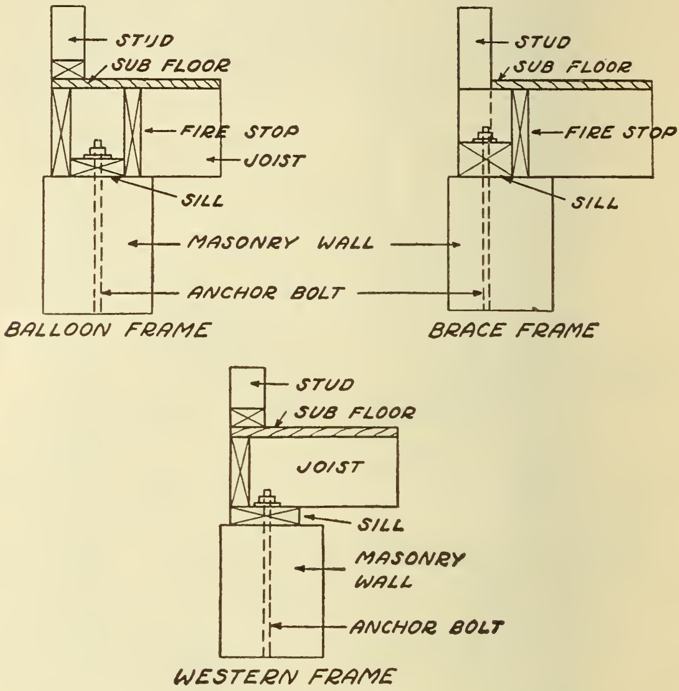


FIGURE 12

Details of sill construction.

age, which would otherwise cause considerable trouble if green lumber was used. Shrinkage can be partly eliminated by proper design, but both proper design and seasoned lumber are desirable in quality construction. If green lumber is used and one end of a joist rests on the foundation and the other end on the top of a timber girder, the girder will shrink and lower that end of the joist. It is generally good practice to place the girder flush with the top of joists, which can be accomplished by supporting joists on members spiked to the side of the girder.

Care should be exercised when installing either interior or exterior trim, which ordinarily is delivered to the job in a well seasoned, dry condition. If it is placed over wet plaster or allowed to become wet from other causes, such as being stored in the open, miter joints will first open at the outer corner, and later, when the material becomes dry, will open throughout their entire length. Some of this difficulty may be overcome by back painting or priming of trim and finish before it is put in place. The bad influence of shrinking and swelling will be much greater when flat-grained material is used than when quarter-sawed stock is used, since flat-grained material shrinks and swells about 50 per cent more than quarter-sawed stock with the same moisture changes. Quarter-sawed material is much less inclined to twist and warp than flat-sawed material, and also has the advantage of offering a more uniform resistance to wear. From this it will be seen that quarter-sawed finish flooring and the like are much superior to flat-sawed material, even when what is usually the chief factor, its appearance, is disregarded.

3. *Considerations affecting joist sizes.*—In determining the size of joists and the grade of material to be used, the following points should be borne in mind:

The stiffness of the floor is quite important if the dishes are not to rattle and the plastering to crack. The stiffness of a joist of a given span under a given load is proportional to the cube of its height. Thus, if the height is increased by a given per cent, the increase in stiffness is more than three times this per cent. This is true so long as it is not so thin and high that it buckles sidewise under the load. The stiffness of a joist is but little influenced by the grade of the material. The load which a joist of a given length will hold without breaking varies as the square of the height. The load which a beam or joist will sustain is dependent upon the defects and the quality of the clear wood. It is not good economy to skimp on the height of joists, since the lower-grade material with a greater height will probably give a more satisfactory floor at the same price than could be obtained from the higher-grade material and correspondingly shallower joist. It is not usually good economy to use joists over 16 feet long, since it requires additional bridging, a greater depth of joist, and there is usually a considerable advance in the price per board foot of the lumber.

4. *Cost influenced by length.*—In the manufacture of lumber, especially in the large mills that cut Douglas fir and pine, there is great advantage in having the lumber of uniform length. The most economical length to handle appears to be 16 feet. In the stacking of lumber it is very necessary to have it of uniform lengths, so that it can be properly held in place while drying. Even after the lumber is dry, ends of boards projecting from the pile will usually become checked and warped and of little value. On account of these and other reasons which might be mentioned, it is common to manufacture lumber in lengths which are multiples of 2 feet; 12, 14, and 16 feet being the ordinary standards. Shorter lengths may come in on account of the limited lengths of logs which it is economical to take from the tree or as a result of cutting off defects in trimming.

The National Committee on Wood Utilization has made a special study of the possibilities of utilizing short-length lumber and has pointed out that with more general use substantial economies might be effected both for the manufacturer and consumer.

Lumber and timbers are produced in lengths greater than 14 or 16 feet, but such material usually commands a greater price. In the designing of a house not infrequently the size of a room may be changed by 6 inches without any material inconvenience and joists 2 feet shorter may result. The height of the ceiling of a room may be changed an inch or two in order to avoid extra lengths of studding or the plate may be double in place of single, and many other expedients may be resorted to in order to utilize the full length of the lumber as it comes from the saw, the resulting building being just as satisfactory and just as well constructed, but at a lower cost.

5. *Laminated girders.*—Butt joints in laminated girders, such as to reduce the effective section to less than required to support the load, should occur over supports.

6. *Importance of thorough bracing.*—Proper bracing of a frame building is most important. If the exterior walls are to be sheathed, they may be braced most effectively by putting the sheathing on diagonally and thoroughly nailing it to the studs. Such placement of the sheathing is two to four times as effective as horizontal sheathing. Long, continuous braces let into the faces of the studs and thoroughly nailed to them will increase the rigidity of a horizontally sheathed wall to such an extent that it will compare favorably with a diagonally sheathed wall. Braces cut on a bevel and nailed in between the studs on a line are not so effective as continuous braces. If used at all corners, however, and made as long as the let-in braces, they will increase the rigidity of a horizontally sheathed wall about 50 per cent. So-called "bridge" or "herringbone" bracing placed at mid-story height does not increase the rigidity of a wall to an extent which would justify the expense of putting it in for this purpose.

Wood lath and plaster is more rigid than many types of sheathing or sheathing and bracing. Under normal conditions plaster may furnish all the rigidity required for most purposes. However, as the plaster begins to crack from shrinkage, settlement, or other causes, the rigidity of the sheathing comes more and more into play. Thus, in violent winds or earthquakes, it is the sheathing and bracing that become all important in preventing complete destruction. It is logical, too, that slightly more bracing than is needed to resist ordinary distorting influences will in the long run more than pay for itself through diminishing, if not entirely eliminating, maintenance costs that result from the structure getting out of alignment.

It is also important that the building be thoroughly tied to resist the thrust of the rafters. When it is not feasible to tie the building together at the foot of the rafters, the thrust may be transferred to the end walls by a system of diagonal bracing on the underside of the rafters. This in reality makes trusses of the two halves of the roof which are nailed together at the peak.

In small buildings this system of bracing may be used to eliminate very objectionable ties across the center of the building. In a garage the end containing the doors will not get out of shape if a proper system of bracing is used on the roof or underneath the ties and if the other three walls are well braced.

7. *Anchoring of roofs and of wood buildings to foundations.*—The necessity for anchoring roofs and buildings depends upon the char-

acter of the building and the severity of storms which may be encountered.

The most common storm damage is to roofs. A roof with large overhanging eaves, if not strong and well tied, is likely to be entirely torn off. The most general type of failure is for the side of the roof away from the wind to be lifted off. The greater part of the damage would be eliminated if the rafters were thoroughly nailed or otherwise tied to the plate and the tips of the rafters tied by collar beams thoroughly nailed.

Frame buildings are sometimes blown over, slid on the foundation, or picked up and carried by the wind. The following observations of damage done by the September, 1928, Florida hurricane and the Rockford (Ill.) tornado will help in determining the necessity for anchorage. The chief damage to most of the houses was in the roof. The Florida hurricane upset and tore to pieces many houses of light construction. Frame houses of good, fairly heavy construction (that is, well nailed, braced, and tied and having subfloors, sheathing, and plaster) suffered little damage even when exposed to the full force of the storm. None of this heavier type of construction appeared to have been moved on the foundation.

The Rockford (Ill.) tornado tore down or carried away many garages and roofs and lifted some of the heavier types of houses, moving two entirely free of their foundations and shifting others a few inches to 3 or 4 feet.

It is very evident from these examples that roofs should be well fastened, that the lighter buildings should be anchored, and that in a large part of the country it is advisable to fasten even the heavier frame buildings to the foundations.

8. A series of tests on the rigidity and strength of frame walls conducted at the United States Forest Products Laboratory, at Madison, Wis., in cooperation with the National Lumber Manufacturers' Association has answered many previously unsettled questions about the design of wood framing. The results of these tests as they affect the design of wood framing have been incorporated in the requirements and information contained in this report.

Nearly 50 frame walls about 9 by 14 feet, with 2 by 4 studs spaced 16 inches on centers, were tested; rigidity, as shown by the end thrust necessary to cause a given movement of the end posts from their upright position, and the strength, as shown by the end thrust necessary to cause failure of the whole panel, were measured.

A tabulation of the test data is given in Tables 4 and 5. The maximum loads producing failure under the assumed conditions are given in pounds. Comparisons of one type of framing or bracing with another type can be made by referring to the number given under the heading "Stiffness factor" or "Strength factor." The stiffness or strength of a horizontally sheathed panel with two nails in each board at each stud is taken as unity, and the stiffness and strength of all other panels are then compared with this panel. Thus a diagonally sheathed panel, two nails in each board at each stud, no braces, and the boards in tension, is approximately 4.2 as stiff and over eight times as strong as the horizontally sheathed unit panel.

TABLE 4.—*Results of tests of panels without window and door openings* [1]

Panel No.	Size of panel, height by length	Description of panel: Panel frames consisted of 2 by 4 inch upper and lower plates, vertical studs spaced 16 inches, and triple end posts	Stiffness factor	Maximum load	Strength factor	Remarks
	Ft. In. Ft. In.			*Pounds*		
2A	9 by 14					
19	7 4 by 12 1⅝	8-inch horizontal sheathing, two 8d. nails, no braces	1.0	2,588	1.0	No. 20 vibrated 50,000 cycles.
20	7 4 by 12 1⅝					
33	9 by 14					
5	9 by 14		4.3		(2)	Test stopped at 20,000-pound load.
26	7 4 by 12 1⅝	8-inch diagonal sheathing, two 8d. nails, no braces, boards in tension	4.3	17,100	6.6	
31	9 by 14		2.8		(2)	Do.
9A	9 by 14	8-inch diagonal sheathing, two 8d. nails, no braces, boards in compression	7.3	20,100	7.8	
4	9 by 14	8-inch horizontal sheathing, two 8d. nails, herringbone or bridge 2 by 4 inch braces.	1.3	2,800	1.1	
3A	9 by 14	8-inch horizontal sheathing, two 8d. nails, cut-in 2 by 4 inch braces	1.6	3,700	1.4	
3C	9 by 14	8-inch horizontal sheathing, two 8d. nails, let-in 1 by 4 inch braces, first arrangement.	2.6	9,250	3.6	
34	9 by 14	8-inch horizontal sheathing, two 8d. nails, let-in 1 by 4 inch braces, second arrangement.	4.2	9,000	3.5	
2B	9 by 14	8-inch horizontal sheathing, three 8d. nails, no braces	1.0	2,300	.9	
2C	9 by 14	8-inch horizontal sheathing, four 8d. nails, no braces	1.4	3,550	1.4	
6A	9 by 14	8-inch diagonal sheathing, three 8d. nails, no braces, boards in tension	5.2		(2)	Do.
6B	9 by 14	8-inch diagonal sheathing, four 8d. nails, no braces, boards in tension	7.5		(2)	Do.
28	9 by 14	8-inch horizontal sheathing, two 10d. nails, no braces	1.5	3,500	1.4	
36	9 by 14	8-inch horizontal sheathing, two 12d. nails, no braces	1.3	2,800	1.1	
32	9 by 14	8-inch diagonal sheathing, two 10d. nails, no braces, boards in tension	5.1		(2)	Do.
27	9 by 14	6-inch horizontal sheathing, two 8d. nails, end and side matched, no braces	1.0	2,550	1.0	
11	9 by 14	Plaster on wood lath, no sheathing	7.2	11,400	4.4	First plaster crack at 10,800 pounds.
13 and 24	9 by 14	Plaster on wood lath, 8-inch horizontal sheathing, two 8d. nails, no braces	7.9	14,500	5.6	First plaster crack at 9,900 pounds.
14	9 by 14	Plaster on wood lath, 8-inch diagonal sheathing, two 8d. nails, no braces	9.2	20,300	7.8	First plaster crack at 12,200 pounds.
25	9 by 14	Plaster on wood lath, studs and horizontal sheathing, green lumber then seasoned 1 month.	6.0	12,700	4.9	First plaster crack at 8,200 pounds.
17	9 by 14	8-inch horizontal green sheathing, two 8d. nails, no braces, panel seasoned 1 month.	.5	1,700	.7	
21	7 4 by 12 1⅝		.7	1,800	.7	Vibrated 1,000,000 cycles.
18	9 by 14	8-inch diagonal green sheathing, two 8d. nails, no braces, panel seasoned 1 month.	1.7			
22	7 4 by 12 1⅝		1.7			
30	9 by 14	8-inch horizontal sheathing, two 8d. nails, no braces, alternate sunshine and rain 1 month.	.7	2,175	.8	

[1] Data furnished by the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, July, 1929.
[2] Over 8.

TABLE 5.—*Results of tests of panels with window and door openings* [1]

Panel No.	Size of panel, height by length	Openings	Description of panel: Panel frames consisted of 2 by 4 inch upper and lower plates, vertical studs spaced 16 inches, and triple end posts	Stiffness factor	Maximum load	Strength factor	Remarks
	Feet				*Pounds*		
7A	9 by 14	Window	8-inch horizontal sheathing, 1 by 4 inch let-in braces	3.0	6,500	2.5	
8A	9 by 14	do	8-inch diagonal sheathing, no braces, boards in tension	3.1	13,000	5.0	
10A	9 by 14	Window and door	8-inch horizontal sheathing, no braces	.7	2,100	.8	
8B	9 by 14	do	8-inch diagonal sheathing, no braces, boards in tension	1.4	10,240	4.0	
9C	9 by 14	do		1.4	10,150	3.9	
8C	9 by 14	do	8-inch diagonal sheathing, no braces, boards in compression	.8	3,250	1.3	
9B	9 by 14	do		1.2	3,400	1.3	
7B	9 by 14	do	8-inch horizontal sheathing, 1 by 4 inch let-in braces	1.5	5,650	2.2	
10B	9 by 14	do	8-inch horizontal sheathing, no braces, 6-inch bevel siding	1.1	3,400	1.3	
10C	9 by 14	do	8-inch diagonal sheathing, boards in compression, 6-inch bevel siding	2.0	8,500	3.3	
29	9 by 14	do	8-inch diagonal sheathing, boards in tension, 6-inch bevel siding	3.3	13,900	5.4	
35	9 by 14	do	8-inch horizontal sheathing, 1 by 4 inch let-in braces, 6-inch bevel siding	2.7	8,880	3.4	
12	9 by 14	do	Plaster on wood lath, no sheathing	2.3	4,200	1.6	First plaster crack at 1,300 pounds.
15	9 by 14	do	Plaster on wood lath, 8-inch horizontal sheathing, no braces	2.4	5,800	2.2	First plaster crack at 800 pounds.
16	9 by 14	do	Plaster on wood lath, 8-inch diagonal sheathing, no braces	2.8	11,300	4.4	Do.
23	9 by 14	do	Plaster on wood lath, 8-inch horizontal sheathing, 1 by 4 inch let-in braces	4.1	9,360	3.6	First placter crack at 1,500 pounds.

[1] Data furnished by the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, July, 1929.

Par. 36. Lumber Grade Marking.

The practice of stamping lumber with a grade-mark and a trade-mark in order that its actual grade and its producer may be easily identified has been approved in the American Lumber Standards. (See par. 30.) Although this practice has not become universal, a number of the larger producers have adopted it. Lumber thus marked and when backed up by the guaranty of the producer assures the consumer that he is getting what he has ordered. Without such marking the purchaser is dependent on the dealer to furnish the grade specified, and, in the usual case, he has no way of telling if the material furnished meets the requirements for that grade.

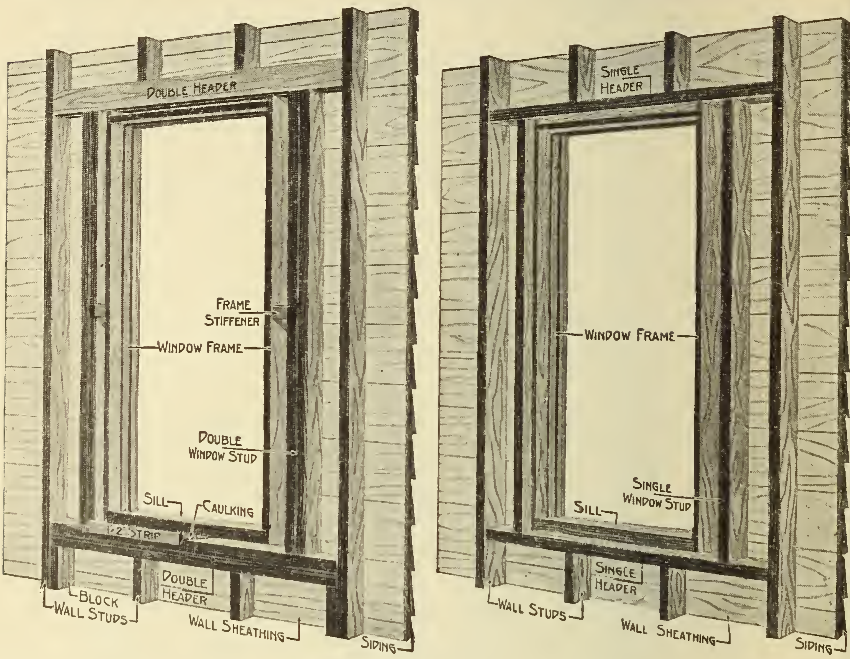


FIGURE 13

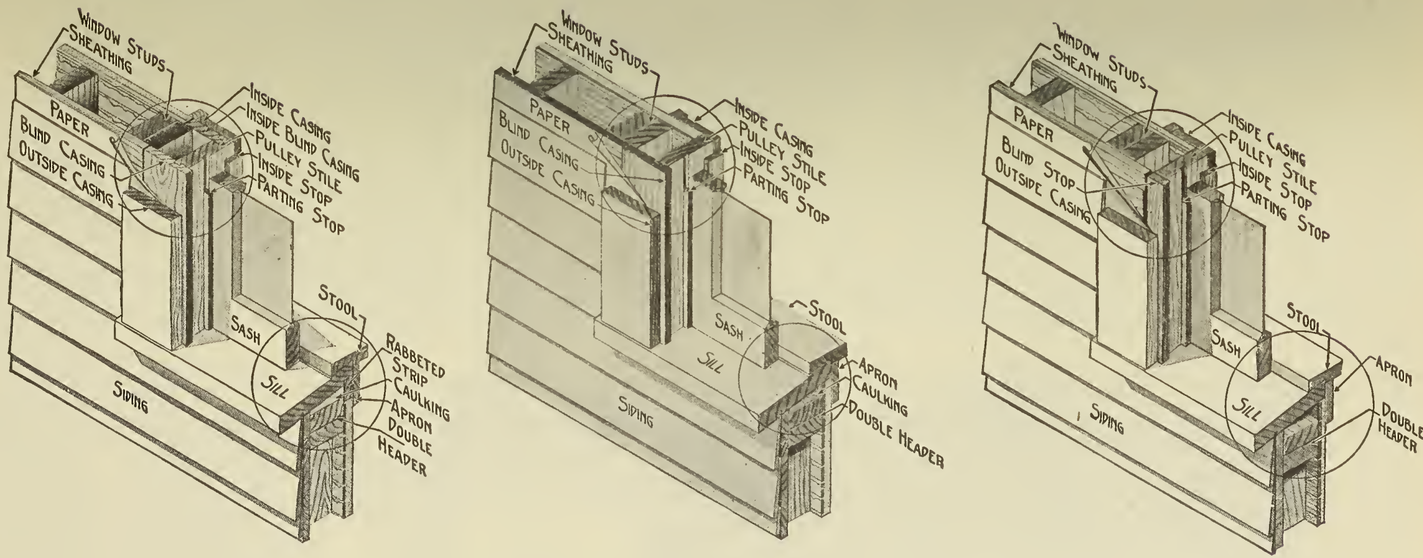
1. Right method

2. Wrong method

The illustrations show desirable and undesirable framing around window openings. The double headers and window studs in 1 are as strong and rigid as continuous studs, and with the stiffeners at the sides help to prevent windows from binding and rattling. The calking and rabbeted strip beneath the sill excludes air, which otherwise enters freely.

Par. 37. Metal Construction.

The use of a metal frame for small dwelling construction has been tried out in a number of cities. Such framing is, of course, easily susceptible to theoretical stress analysis, and questions as to its structural adequacy can be based directly on engineering design. While dwellings of this nature have not yet been developed extensively enough or have not yet been in use sufficient time to enable detailed requirements concerning their erection to be formulated, requirements of a general nature may be included.



1 2 3

FIGURE 14

Poorly built or fitted window frames admit air and moisture, and the adjacent interior walls shortly become unsightly with dirt and water stains. The type of frame shown in 1 will prevent this, and that in 2, carefully installed, will be found satisfactory. Note the provision, in the first two cases, of calking between sill and header; the siding and rabbeted strip let into the underside of sill in 1; the additional protection afforded by blind casings extending back to the window studs and sealed with building paper; and the rabbeting of the sill in 1 and 2 to receive the sash.

Metal studs for walls and partitions have been made up from angles and assembled with separation plates that are bolted, riveted, or welded. These members are perforated with holes spaced about 2 inches on centers for ease in assembling and for attaching the lath. Sills, girts, and plates are made up from standard channels or other sections and are also perforated for assembling.

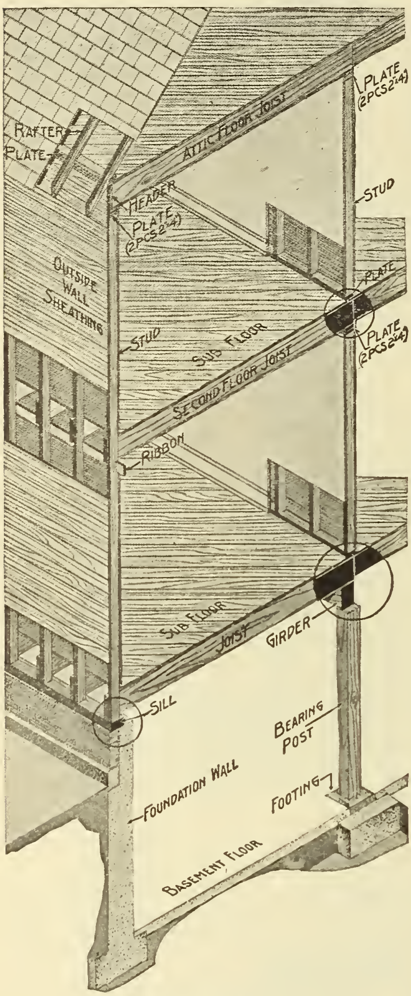


FIGURE 15

Wood shrinks crosswise, not lengthwise of the fiber. A dwelling framed as shown above will in time settle from 1 to 2 inches more in the center than at the walls. This renders floors uneven, causes plaster to crack, and makes doors bind and rattle. Equal settlement, as obtained by the method shown across, will greatly diminish these effects.

Floor systems for use with this framing are usually of steel joists or beams made up of bars welded together, expanded from rolled sections, built up of channels or angles of less than standard weight, or rolled into structural shapes of less than standard weight. Standard weight I beams and channels are also used. Tension bridging has been found to give good results with these joists.

Incombustible first floors for dwellings have been widely advocated to reduce the fire hazard, and the floor systems just described may be adapted to any type of construction. To develop at least one hour fire resistance, the top slab and ceiling construction should be at least equal in fire resistance to that listed for floors in paragraph 52 of this appendix.

Other developments in metal dwellings make use of metal sheets which are assembled by welding. Insulation is used to prevent heat transmission through the walls. Various types of interior and exterior finish are employed with this method of construction.

Par. 38. Termite Protection.

The Bureau of Entomology of the United States Department of Agriculture has made investigations for a number of years concerning the habits of the antlike insects known as termites. While at one time it was thought that termites were confined mostly to tropical countries, research has shown that many sections of the United States, particularly the Southeastern, Central, Western, Southwestern, and Pacific Coast States, are infested with them. In many instances the damage to wood and other material subject to attack by termites has been found to be serious. Much information has therefore been disseminated by the Bureau of Entomology in order properly to acquaint the public with the habits of the termite and to point out relatively simple methods by which protection may be secured.

For the most part, the termites which cause the greatest structural damage to building are those which live in the ground. Such termites are dependent upon moisture in order to live, and this moisture is obtained from the ground. When the insects are shut off from this supply, they dry up and die. Obviously, where wood members are in direct contact with the earth they are directly exposed to attack. Termites also penetrate masonry walls where they are not constructed with tight joints and, by means of shelter tubes built of earth and pulverized wood, they crawl up the exterior of masonry walls to the underside of the material to be attacked. It has been estimated that ample protection can be obtained at a cost of approximately 2 per cent of the first cost of a building. It should be remarked that an initial expense of this sort may save many times the amount in repairs and replacement at a later date, as well as prevent possible structural failure.

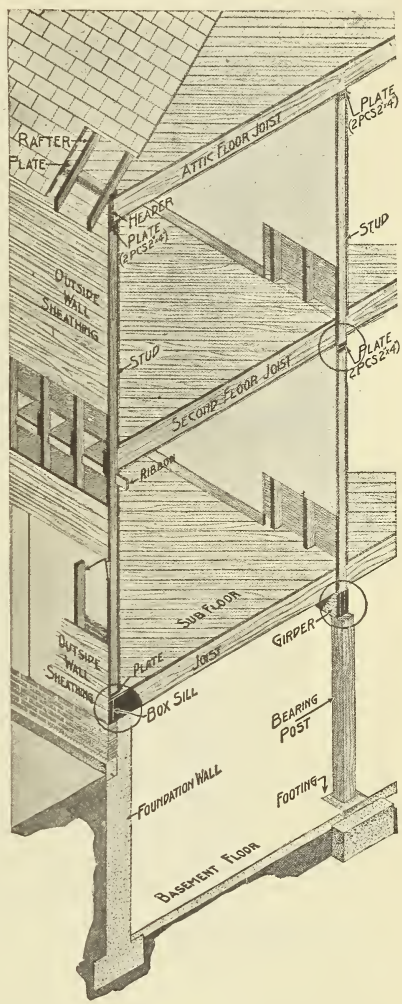


FIGURE 16

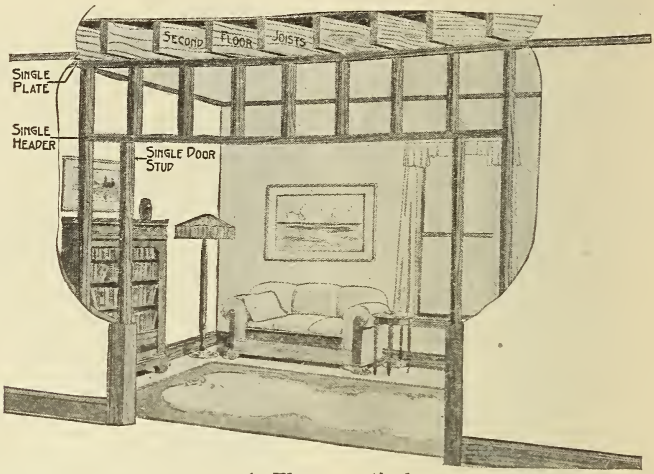
If a building is framed to equalize the total height of horizontal timbers in exterior walls and interior partitions, their relative positions remain the same after settlement occurs. This helps to avoid plaster cracks and other inconveniences. (See fig. 15.)

As a result of its investigations on this subject the Bureau of Entomology of the Department of Agriculture suggests the following regulations for preventing termite attack:

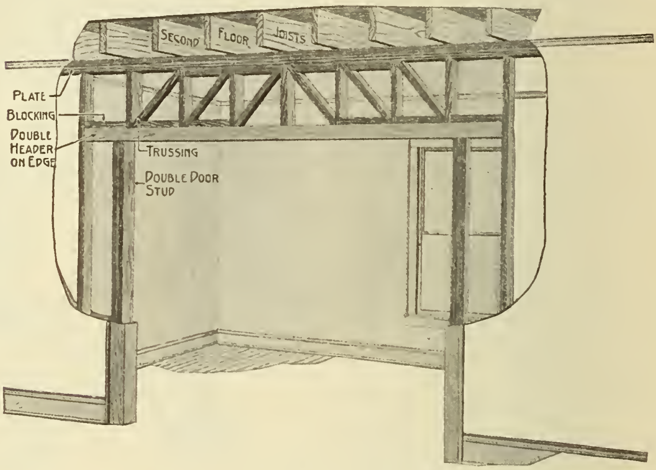
Wood or fiber products, when an approved preservative has not been forced into the product, shall not be placed in the earth or within 18 inches thereof, excepting wood columns or posts over a concrete floor, which columns shall be provided with noncorroding metal or concrete base plates or footings 6 inches above the floor. This applies to steps, which shall be laid over a concrete base, projecting at least 6 inches beyond the supports of the steps.

Timber to be used in contact with the earth shall be thoroughly impregnated by a standard-pressure process with coal-tar creosote or other equivalent preservative. Timber should be completely cut to proper dimensions before treatment whenever possible, but when cutting after treatment is unavoidable the cut surfaces shall be thoroughly coated with coal-tar creosote or other equivalent preservative.

Masonry foundations and footing shall be laid in Portland-cement mortar. Foundations built up of masonry units, whether hollow or solid, shall be



1. Wrong method



2. Right method

FIGURE 17

Inadequate framing over wall and partition openings, illustrated in 1, permits local settlement, causes unsightly plaster cracks, and spoils the fit of doors. The precautions shown in 2 help to prevent these undesirable results. Note that the plate, header, and door studs have been doubled, and the header turned on edge to afford greater strength. The short diagonal and horizontal members form a truss which provides rigid support for joists over the opening.

capped below woodwork with at least 1 inch of Portland-cement mortar, or the mortar and slate, or solid or joined noncorroding metal, or other equally efficient seal.

In the case of frame buildings, a metal termite shield shall be provided, continuing completely around the top of the masonry foundation, including all pillars, supports, and piping, below the woodwork of the building, or both the inside and outside surfaces. Such a shield may be formed of a strip of noncorroding metal (such as copper, or zinc, or an alloy composed of 28 per cent of copper, 67 per cent of nickel, and 5 per cent of iron, manganese, and silicon), firmly inserted in the surface of the masonry, or between the

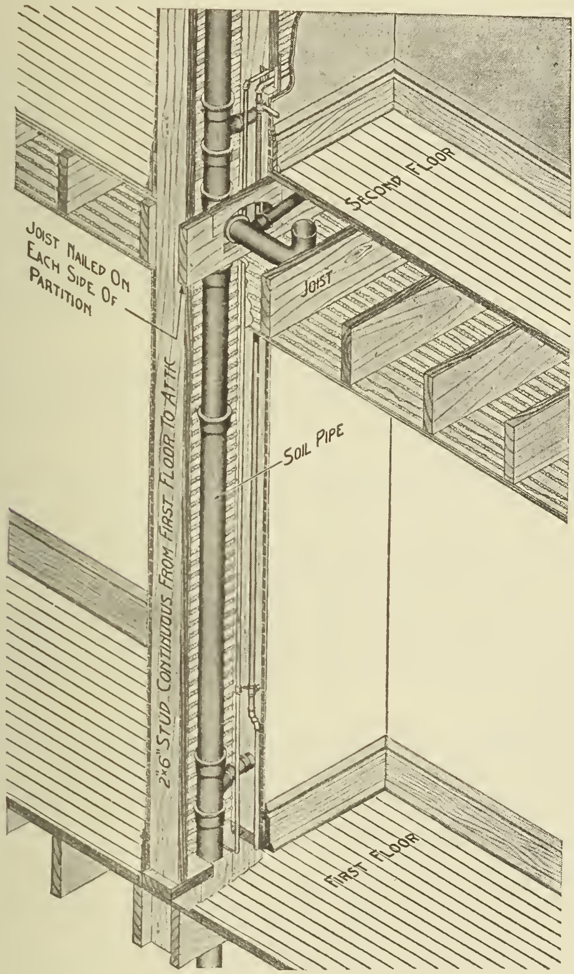


Figure 18

Careless cutting and notching of timbers often weakens floors unnecessarily; 2 by 6 inch partition studs accommodate vertical pipes readily and without undue loss of supporting capacity, when notched. Horizontal pipes should be run through the centers of joists to avoid weakening them and to leave a good nailing surface for the floor.

foundation and the wood, with the projecting edge bent downward at an angle of 45° and extending horizontally at least 2 inches from the face of the foundation. In masonry buildings this shield can be inserted in the masonry at a height at least 18 inches above the ground.

Floor sleepers or joists embedded in masonry or concrete, or laid on concrete which is in contact with the earth, shall be impregnated with an approved preservative.

Expansion joints between concrete floor and wall shall be filled with liquid asphaltum and the right-angle joint covered with a sanitary cement mortar or Portland-cement concrete finish of an arc of at least 2 inches in length.

The ends of wooden beams or girders entering masonry or concrete shall not be sealed in, but shall be provided with boxes affording an air space at the end of the piece of not less than 1 inch at side of member, unless the ends of such timbers are impregnated with coal-tar creosote or other approved preservative.

Where there are spaces under floors near the earth, they shall be excavated so that there will be no earth within 18 inches of the wood, and they shall be provided with cross ventilation. Such ventilating openings shall be proportioned on the basis of 2 square feet for each 25 lineal feet of exterior wall, except that such openings need not be placed in front of such building. Each opening shall be provided with 20-mesh noncorroding-metal screening, including windows in attics.

Where timber is used in roofs of the flat type, the roof shall, unless protected on the weather side with a waterproof covering, have a slope and run-off sufficient to provide proper drainage.

All wooden forms on foundations shall be removed from masonry work within 15 days; grading stakes shall be removed before laying concrete floors.

Par. 39. Rat Proofing.

Within the past few years considerable attention has been directed toward making buildings resistant to infestation by rats. Aside from the potentialities of spreading disease, rats destroy food and cause insanitary conditions.

Obviously, the individual dwelling presents its own problem, but there are two general principles that may well be considered in connection with making any building resistant to rat invasion. First, all exterior openings should be protected with tight screens, gratings, or doors; and, second, the walls, floors, or similar concealed spaces should not provide an uninterrupted passage for the rats to enter. Proper fire stopping of such spaces as recommended in section 10–4, part 2, will in a large measure prevent access to these locations.

Much work has been done in combating rats and bubonic plague by the United States Public Health Service and by the Department of Agriculture. Information concerning more detailed requirements of this nature can be obtained from these departments.

Par. 40. Plaster and Other Wall Coverings.

Plaster is recognized as having a number of valuable properties aside from its usual function of providing an interior finish for walls. When made with gypsum or Portland cement and applied to metal lath it provides a very considerable degree of fire resistance. Its weight also adds to the stability of a dwelling. When omitted, adequate anchorage to the foundations becomes increasingly essential.

In no place is the importance of good, honest construction more evident than in the plastering of a house. If the general construction is neglected or skimped, the results are shown by the unsightly cracking and sometimes dangerous falling of the plaster. Therefore the committee, realizing that under the best of conditions it is impossible to avoid all cracks in plastering, wishes to emphasize the necessity of good building. Following are some of the common causes which result in cracked plastering: (1) Inadequate or faulty footings under bearing posts, (2) too small girders or too few bearing posts, (3) joists of insufficient depth, (4) joists under partitions not doubled, (5) improper framing over wide openings, (6) uneven settlement due to shrinkage of wood frame improperly designed and constructed, (7) chimney not independent of the frame, (8) settlement of wall footings and foundations, (9) separation of partitions from walls, and (10) failure to conform to good plastering standards.

Measures by which some of the above causes of plaster cracks can be wholly or in part overcome are shown on Figures 1, 13, 15, 16, 17, 19, 24, and 26. Suitable design of footings is illustrated on Figure 1, proper framing over and around wide openings on Figures 13 and 17, framing to bring about uniform settlement on Figures 15 and 16, methods of framing around chimneys and fireplaces on Figures 24 and 26, and approved methods of attaching inside partitions to walls of frame dwellings on Figure 19.

When gypsum wall board is used in place of lath and plaster, it should conform to the specifications of the American Society for Testing Materials. Gypsum lath at least one-fourth inch thick may be used in place of wood lath. Gypsum lath three-eighths inch thick, with the joints covered with a 3 by 3 inch or wider strip of metal lath and plastered with at least one-half of an inch of gypsum plaster consisting of 2 parts of gypsum and 1 part of sand by weight, has a fire resistance of at least one hour. When gypsum lath is used it should conform to the specifications of the American Society for Testing Materials.

Fiber boards provide an economical wall surface. They should be kept in a thoroughly dry condition from the time they are manufactured until applied. (See also par. 46.)

Studies of fiber boards used as wall boards and insulating boards have been made by the Bureau of Standards.[4] The following extracts are from specifications suggested by the bureau in relation to this product.

In respect to dimensions, the boards may be secured ⅛, $\frac{3}{16}$, ¼, $\frac{5}{16}$, and $\frac{7}{16}$ inch thick, 32, 48, and 64 inches wide, and 6 to 16 feet long, with all intermediate lengths in even feet. The thickness is relatively unimportant; and, owing to the uncontrollable variation in the thickness of homogeneous boards, a tolerance of minus 5 per cent and plus 20 per cent in thickness is suggested. Suggested tolerance for width and length are, respectively, plus or minus one-eighth inch and plus or minus three-eighths inch.

Flexural breaking strength.—Not less than 10 pounds for the shorter direction of the board.

Water absorption.—Not more than 65 per cent of the original weight of the board.

Expansion.—Not more than 0.7 per cent in the shorter direction of the board.

Par. 41. Preparation of Base for Plaster.

When plaster is applied directly to masonry surfaces, these should be rough and of coarse texture but not uneven; free from dust, laitance, or other loose material which will prevent a good bond

[4] Properties of Fiber Building Boards. B. S. Miscellaneous Publication, No. 132.

between plaster and wall; and particularly from grease, which will cause discolorations. The wall surface should be wet enough so that it does not withdraw water from the plaster, but not so wet as to fill the surface pores and prevent good bond or interfere with hardening. Care in this respect is not so important with lime plaster as with gypsum, because lime holds water against suction better than gypsum and because water is not required for hardening lime, while it is for gypsum.

To prevent undue laterial expansion and contraction of wood lath, which shears and loosens the plaster keys, such lath should not be over 1½ by three-eighths inch in section and key spaces should be not less than three-eighths inch for lime plaster and one-fourth inch for gypsum plaster. Wood lath should be thoroughly wet when plaster is applied. Lath should be attached to at least three supports, and good practice requires broken joints at least every eighth lath.

Expanded metal lath, weighing at least 2.5 pounds per square yard, or No. 20 wire cloth having 2½ meshes to the inch, are recommended for a spacing of studs not exceeding 16 inches. Expanded metal lath for ceilings applied to the underside of wood joists should be not less than 3.0 and 3.4 pounds per square yard for joists, with a spacing of not more than 13½ and 16 inches on centers, respectively. Greater spacings demand heavier lath or special stiffeners. Ends of sheets should be joined over supports and horizontal edges lapped and laced securely with wire. Continuous sheets bent around corners tend to prevent cracks in the plaster. Metal lath should be fabricated from galvanized sheets or should be galvanized or painted.

Gypsum lath consists of an incombustible core of calcined gypsum surfaced with a fibrous material firmly bonded to the core. Gypsum lath is usually manufactured with a width of 16 inches, lengths of 32 inches and 48 inches, and with a ¼ and ⅜ inch thickness. In some localities the lath can be obtained in a 32 by 36 inch size. For a 16-inch spacing of studs or joists, ¼-inch lath may be used. Gypsum lath should be securely nailed at each support. Nails should be spaced not over 4 inches apart and joints so staggered that vertical joints in wall will not meet the ceiling joints. Vertical joints should be broken. The surface of the lath is finished so that plaster adheres readily and should not be wetted when plaster is applied.

Par. 42. Plaster Materials.[5]

The essential ingredients of plaster are a cementitious material, such as lime, gypsum or Portland cement, an inert aggregate of sand and water. Hair or fiber is customarily added to act as a reinforcement while the plaster is in a plastic state, and thus keeps it from breaking. A " neat " plaster contains no aggregate.

Lime, gypsum, or Portland cement may be used alone as the cementing material, lime may be mixed with Portland or Keene's cement, or Portland cement may be mixed with lime. Neither gypsum nor Keene's cement should be mixed with Portland cement. Lime will carry about twice as much sand as gypsum as ordinarily used, but the setting time of gypsum plasters can be more easily

[5] B. S. Circular No. 151, entitled " Wall Plaster, Its Ingredients, Preparation and Properties," gives a detailed description of wall plasters and their properties.

regulated. Gypsum plaster has greater inherent strength than lime plaster, and its better fire-resistive qualities are important when fire barriers are to be constructed. Lime plaster can be brought to equal strength by tempering with Portland or Keene's cement. Portland cement or lime plasters are more resistant to moisture than gypsum plasters. Selection of plasters should be made with reference to local practice, better work usually resulting if the workmen are familiar with the materials.

Ready-mixed (dry) plaster can be purchased which contains all the ingredients, gypsum or lime, sand, etc., so that all that is necessary is to add water to prepare the plaster for the scratch or brown coat. Such plasters offer the advantage that they are mixed by machinery and under careful supervision, thus securing a careful selection of ingredients, good proportioning, and a very thorough mixing. Their disadvantage is the cost of transportation, which might be offset in localities where a good sand is not available.

In some cities a ready-mixed mortar (ready-mixed lime plaster to which water has been added) can be obtained, and it is equally serviceable as a mortar, stucco, or plaster. The use of such a plaster saves storing and mixing on the site, offers an opportunity for more thorough aging of the lime putty, and allows the mixing to be more thorough than would result by hand methods. Its use is determined by whether or not the delivered cost compares favorably with the cost of preparing the plaster on the job.

Gypsum wall board represents the nearest present approach to manufacture of completed plaster at the factory, ready to be erected in place. Gypsum wall board consists of an incombustible core of calcined gypsum between two layers of tough, sized, protective fiber covering and is supplied in 32 or 48 inch widths, in lengths up to 12 feet, and in thicknesses of one-fourth, three-eighths, and one-half inch. It should be so erected that all ends and sides are always over a support. Metal tape, or fabric, and special wall-board finisher should be used in finishing the joints. The walls and ceilings may be paneled or the entire surface painted or papered, as desired. Wall board possesses the essential characteristics of rigidity, strength, and finished surface common to plaster.

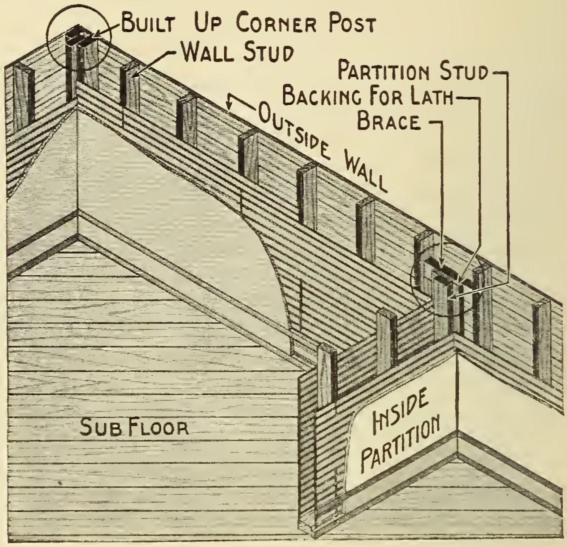
Par. 43. Mixing and Application of Plaster.

1. *Mixing.*—Machine mixing, due to more thorough mixing and better control of conditions, gives a more uniform and better plaster than usually results from hand mixing. In mixing plasters other than lime, which requires soaking before used, the dry materials should be mixed thoroughly to a uniform color and then added to the water and again thoroughly mixed to a uniform consistency.

Directions for slaking quicklime and for screening and aging the putty are given in the appendix to the Specifications for Quicklime of the American Society for Testing Materials, serial designation C5–26.

2. *Proportions.*—Proportions of sand and lime or gypsum will vary with each grade or make of materials. The following proportions by volume are in common use:

For scratch coat on lath, 1 part lime to 1½ of sand, 1 of gypsum to 2 of sand, or 1 of Portland cement to 3 of sand. In all cases,



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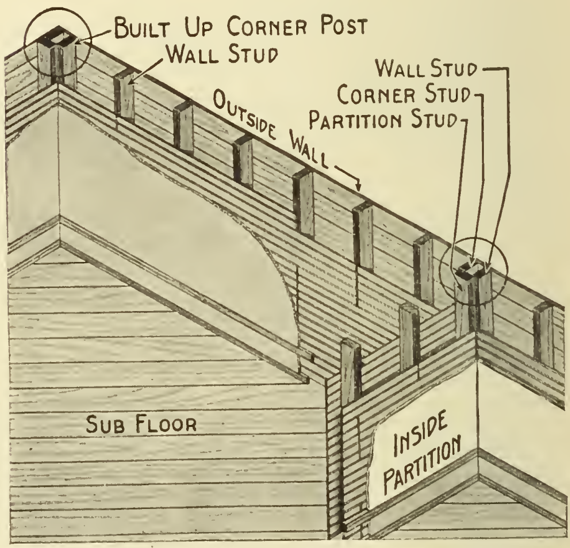

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Figure 19

1 and 2 show proper methods of securing backing for lath where partitions meet outside walls at or between wall studs. By such means firm backing is afforded for the ends of the lath and no lath extend through from room to room.

hair or fiber may be added in amounts not to exceed 3 bushels per cubic yard of sand.

For scratch coat on masonry, 1 part of lime to 3 of sand, 1 of gypsum to 3 of sand, or 1 part of Portland cement to 3 of sand. If a finish coat is to be used, hair or fiber may be added to the scratch coat in amounts not to exceed 1½ bushels per cubic yard of sand.

For brown coat, 1 part of lime to 3 of sand, 1 of gypsum to 3 of sand, or 1 of Portland cement to 3 of sand. If a finish coat is to be used, fiber may be added to the brown coat in amounts not to exceed 1½ bushels per cubic yard of sand.

For the finish coat the proportions of lime putty and gypsum should be left to the discretion of the plasterer.

3. *Application.*—The scratch coat on lathed surfaces should be applied with sufficient force to push the plaster through the openings in or between the laths, should be of such thickness to cover the lath at least one-fourth inch, should be brought to a reasonably true surface, and should be scratched vertically and horizontally. The scratch coat should be permitted to harden until the pressure of the thumb is not sufficient to break down the edges of the scratches.

The scratch coat on masonry should be applied with sufficient force to form an effective key with the depressions in the masonry, should then be built up to the desired thickness, and then rodded to produce a plane surface, flush with the grounds. It should then be permitted to become thoroughly harsh and dry before the finish coat or other decorative finish is applied.

The brown coat should be applied with sufficient force to provide a proper key with the scratch coat, should then be built up to the desired thickness and rodded to produce a plane true surface flush with the face of the grounds. It is then customary to go over this coat with a plasterer's darby to take out the irregularities left by the rod, after which the surface is floated as a final step in making a smooth and true surface. The floating process also assists in making the surface of the brown coat sufficiently porous to provide proper suction for the application of the finish coat.

The finish coat should be spread over the entire area of one side of the room, except where scaffolds are necessary, and then troweled just as the cementitious material is hardening. Much skill and care is needed for success in the application of the finish coat.

Par. 44. Number and Thickness of Plaster Coats Necessary.

Plaster on wood or metal lath or on other materials which support the plaster by keying should be not less than 2-coat work and at least five-eighth inch thick.

Plaster on masonry surfaces, plaster board, or on other materials which do not support the plaster by keying may be 1-coat work, but should be of sufficient thickness to cover the surface amply and to correct all unevenness.

The exposed aggregate method of making colored concrete is equally applicable to plaster and requires merely a little care in the selection of the sand. Wood fibers used in the brown coat may be dyed and exposed by washing the plaster after it has set to give effects in color and texture. The ordinary brown coat may be rubbed down to a sand-float finish, which is satisfactory for some purposes, and the appearance may be improved by painting.

Par. 45. Furring.

The furring out of all plaster surfaces from masonry walls is recommended by many authorities. The advisability of this measure is plainly shown by the following summary of experience reported from all parts of the country:

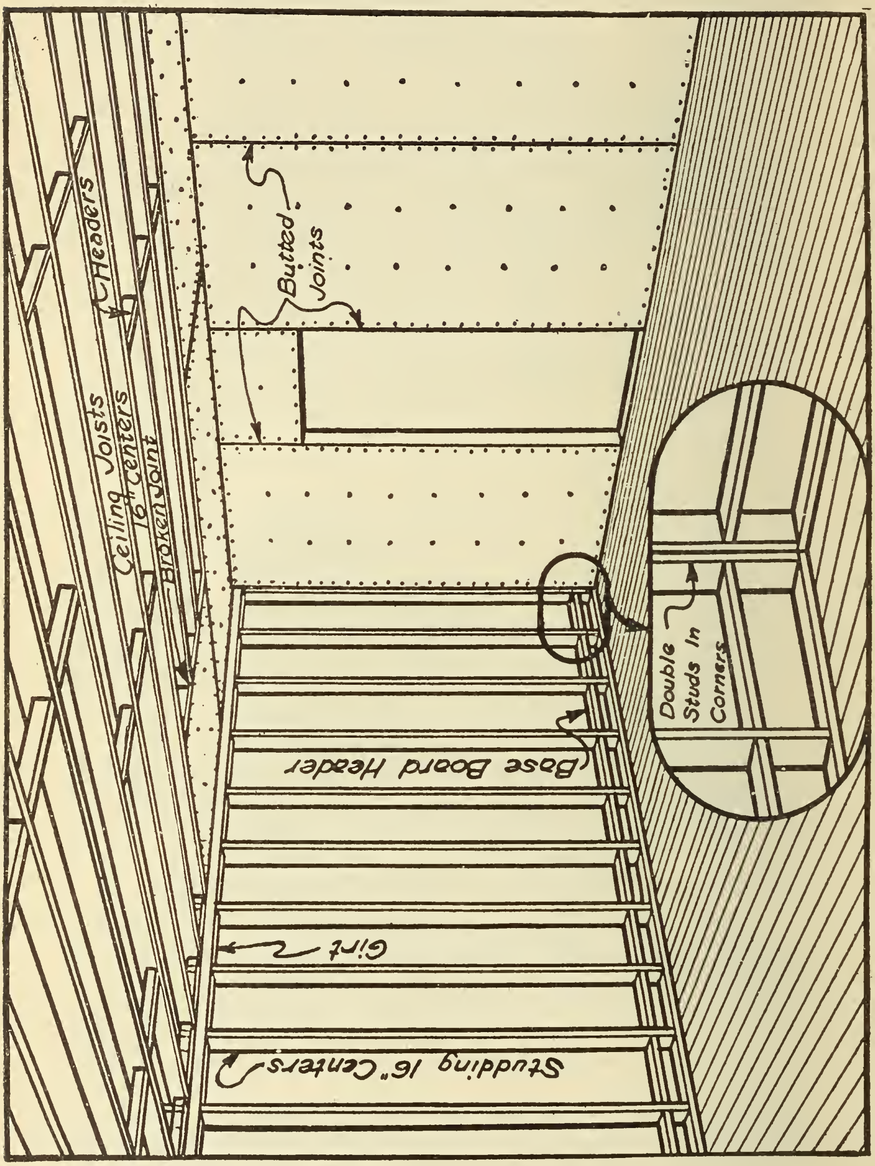

Figure 20

Methods of installing gypsum wall board.

1. In regions subject to low temperature, high winds, heavy rains, or extreme humidity of considerable duration, furring of masonry exterior walls is practically a necessity to avoid damp walls, also the danger of ruining wall decorations.

2. In arid localities, where low temperatures are infrequent, furring may be omitted without serious results, but should be used wherever economy in construction cost is a secondary consideration.

3. Waterproofing paints or compounds applied to the interior of masonry walls help considerably to prevent moisture penetration, but have little effect in preventing condensation, and make it difficult to bond plaster directly to such treated walls. (See par. 17 of this appendix for moisture penetration through masonry walls.)

4. Furring is somewhat less necessary on masonry exterior walls of hollow units, since the inclosed air cells help to check transmission of heat and moisture. However, when the joints run through the wall there is a possibility that moisture will find its way to the inner wall surface through cracks and crevices which may develop between the mortar and the masonry unit.

5. Furring a masonry wall lessens its heat conductivity, thus saving fuel, which saving, of course, continues throughout the life of the structure and may repay many times over the increased cost of furring.

6. When walls are built with hollow masonry units and the joints extend but part way through the wall, it is common practice in many localities to omit the furring and to apply the plaster directly on the wall.

7. In concrete-house construction provision for insulation of exterior walls is recommended. A dead-air space within the wall itself or formed by furring and plastering has been found effective, and this requirement seems to be favored by those recommending the use of concrete external walls.

In applying plaster to furring lath it is important that the keys shall not project through so as to touch the wall nor be allowed to drop off and form a solid mass between plaster and wall. In either case moisture from the wall is liable to be transmitted through the plaster producing troublesome results, such as staining the wall and ruining the lath—wood lath by dry rot and metal lath by corrosion. It is claimed that excellent results in furring 8-inch brick walls are obtained by attaching a layer of tarred paper to the back of the furring strips or by using a lath in which such paper forms an integral part.

Incombustible furring is excellent, since it entirely prevents a fire creeping along a wall from one story to another behind the plaster. Hollow tile or gypsum furring blocks are much used and are quite satisfactory. They have grooves in the back face which furnish air spaces between the wall and the plaster. There are also several forms of metal furring to which metal lath is attached and which serve the same purpose. Where walls are likely to be continuously damp, hollow tile furring will be more satisfactory than gypsum.

Par. 46. Insulation.

Since the first edition of the report was published, rapid strides have been made in the insulation of dwellings. This subject appears to be beyond the scope of a building code. Its value in securing fuel economy and comfort has come to be generally recognized. Obviously, the use of such material may repay many times its initial cost.

In general, heat losses from any building occur in two ways—(1) by infiltration of air around openings, such as doors and windows, and infiltration through the walls or roof assembly; and (2) by heat transmission [6] through the materials of which the walls and roof of the building are constructed.

In the first case a proper and careful fitting of doors and windows will materially decrease air infiltration. Where cost considerations are not too important, the addition of weather stripping will further decrease losses from this source. With respect to frame walls, air infiltration through the wall itself has been shown to be greatly decreased by the use of a good grade of sheathing paper. In the case of masonry walls, furring has been found materially to increase the insulating value of the ordinary types of walls.

Heat transmission through various assemblies of materials is known to be decreased by using an insulator either of fibrous materials in loose form or made into quilts confined between relatively thin layers of paper or textile, or by boards in which the components are bonded together in some way.

The selection of any particular material is dependent upon the particular needs and requirements in the way of fire hazard, structural strength, cost, etc. The final cost to be considered in this event is not the cost per square foot of any given material, but rather the cost per unit insulating value of the commercial thickness.

The following table, taken from Circular No. 376 of the Bureau of Standards, entitled "Thermal Insulation of Buildings," gives general information on the approximate fuel savings in dwelling houses. For more detailed information bearing on this subject reference is made to this publication.

TABLE 6.—*Approximate fuel savings in dwelling houses*

(Expressed in percentage of fuel which would have been required for similar house without insulation or weather stripping)

	Saving
	Per cent
No insulation, weather stripped	15 to 20.
Same, with double (storm) windows	25 to 30.
½-inch insulation, not weather stripped	20 to 30.
½-inch insulation, weather stripped	About 40.
½-inch insulation, with double windows	About 50.
1-inch insulation, not weather stripped	30 to 40.
1-inch insulation, weather stripped	About 50.
1-inch insulation, with double windows	About 60.

(Expressed in percentage of fuel which would have been required for similar house without insulation but with weather stripping)

	Per cent
With double windows, no insulation	10 to 15.
½-inch insulation only	25 to 35.
½-inch insulation, with double windows	40 to 45.
1-inch insulation only	35 to 45.
1-inch insulation with double windows	50 to 55.

Par. 47. Party Walls.

The thickness advisable for party walls depends on several factors not affecting exterior walls. Such separating walls also serve the

[6] For detailed information on heat transmission through walls, see B. S. Jour., vol. 6 (RP291), entitled "Heat Transfer Through Building Walls."

purpose of fire walls. The vertical loads, while higher than on exterior walls, produce no greater stresses, owing to the equalizing effect of floor loads from both sides. More bearing area is lost by insertion of joists on both sides, and the close proximity of these reduces the efficiency of thin walls as fire stops.

Party walls of hollow masonry units or hollow walls of brick, because of their lighter weight and the greater liability of destruction in case of fire as compared with solid masonry walls, are required to be at least 12 inches thick throughout. Consideration must also be given to the increased difficulty of inserting joists in such walls and obtaining support and protection for the ends.

When the building on one side only of a party wall is completed with the wall and where subsequent construction may require breaking into the wall for insertion of floor beams or other members, party walls built of hollow masonry units or hollow walls of brick should not be used. Where the disadvantages of breaking into such walls can be overcome—as, for instance, by solid wall construction extending at least one course above and below where the future line of joists will be inserted—party walls of this type are feasible for the purpose intended when constructed under the provisions outlined in section 4–2, part 2, of this report.

Par. 48. Parapet Walls.

The object of a parapet wall is to prevent a fire in a house from entering an adjoining house through the attic space, also to restrict flames from lapping over and igniting the adjoining roof. Where party walls do not extend through incombustible roofs, the joints between the wall and the roof may be effectively closed by metal lath bent into the angle between wall and roof and plastered with gypsum or Portland-cement plaster.

Careful workmanship on parapet walls and proper coping is necessary to prevent moisture from seeping down into the wall and injuring the plaster. Experience with building maintenance has indicated that the importance of coping has not been generally recognized, and many otherwise excellent buildings have been seriously damaged by a leaking coping. Soldered metal joints extending through the walls, either exposed or covered with masonry, make an excellent protection.

Par. 49. Roof Coverings.

No direct requirements for roof coverings are included in part 2, owing to the committee's decision not to consider in this report the influence upon construction of fire hazards created by building congestion, as explained in the introduction of this report (p. 3). Information regarding roof coverings in respect to fire-resistive considerations is contained in the Building Code Committee's Report, entitled "Recommended Minimum Requirements for Fire Resistance in Buildings."

Par. 50. Chimneys.[7]

Pure quartz gravel or other highly siliceous gravel concretes are not adapted to withstand high temperatures, and it is therefore

[7] For complete specifications covering construction and care of low-temperature chimneys, reference is made to "A Standard Ordinance for Chimney Construction," distributed gratis by the National Board of Fire Underwriters, 85 John Street, New York, N. Y.

recommended that they should not be used for chimneys when subject to direct attack of heat.

The reinforcement required in concrete chimneys cast as a unit, or when built of large blocks inclosing more than one flue, is to resist stresses due to temperature variations or unequal settlement of foundations.

Experience has indicated that good quality flue linings properly installed are a reliable material and an essential part of all thin-walled chimneys. Care and good workmanship in laying the flue lining will aid in preventing leaky flues having an unsatisfactory draft as well as an increased fire hazard. Parging the inner walls of the flue with mortar as the masonry progresses should not be allowed as a substitute for flue lining. The combined effect of wind, expansion and contraction due to temperature changes, and flue gases causes disintegration of such lining.

It is extremely advisable to construct flues as nearly vertical as possible, since each offset retards draft and offers a lodging place for soot to accumulate. If it becomes absolutely necessary to change the direction of a flue, it should not depart more than 30° from the vertical.

Experience has shown that more than one connection to a flue is bad practice. The draft is impaired and there is much danger, where only one of the connections is in active use, that fire will be communicated by way of the unused opening to connecting rooms.

Where a connection is not in use there is danger that the flue stop may be displaced or destroyed by corrosion, thus permitting sparks to pass through. Such unused connections also accumulate soot, which in time will burn and thus greatly increase the fire hazard.

Flue linings should project 4 inches above the chimney top to allow for a 2-inch wash and a 2-inch projection of the lining. It is important that the top of chimneys be properly capped by a 2-inch cement wash or other suitable means to prevent water entering the masonry work. Where freezing is likely to occur, this may cause disintegration of the exposed part of the chimney. Also the water might find its way down the chimney and cause discoloration or cracking of the plaster in the rooms where it was located.

A method of hearth-foundation construction that has proved satisfactory consists of a reinforced-concrete slab supported by steel members cantilevered from the masonry chimney.

In studies conducted by the American Society of Heating and Ventilating Engineers [8] on draft efficiency in lined and unlined round, square, and oblong flues it was found that round flues provide a better draft than other shapes having equal cross-sectional area and operating under the came conditions. In flues having a square cross-sectional area the corners are found to have little, if any, influence on the draft, and the so-called effective area of such a lining is the same as that of a round flue of equal internal diameter, no credit being allowed for draft in the dead corners. When square or rectangular flues are used, they should be chosen on the basis of "effective area" as given on page 88.

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[8] Code of Minimum Requirements for Heating and Ventilating of Buildings, by American Society of Heating and Ventilating Engineers, 51 Madison Avenue, New York, N. Y.

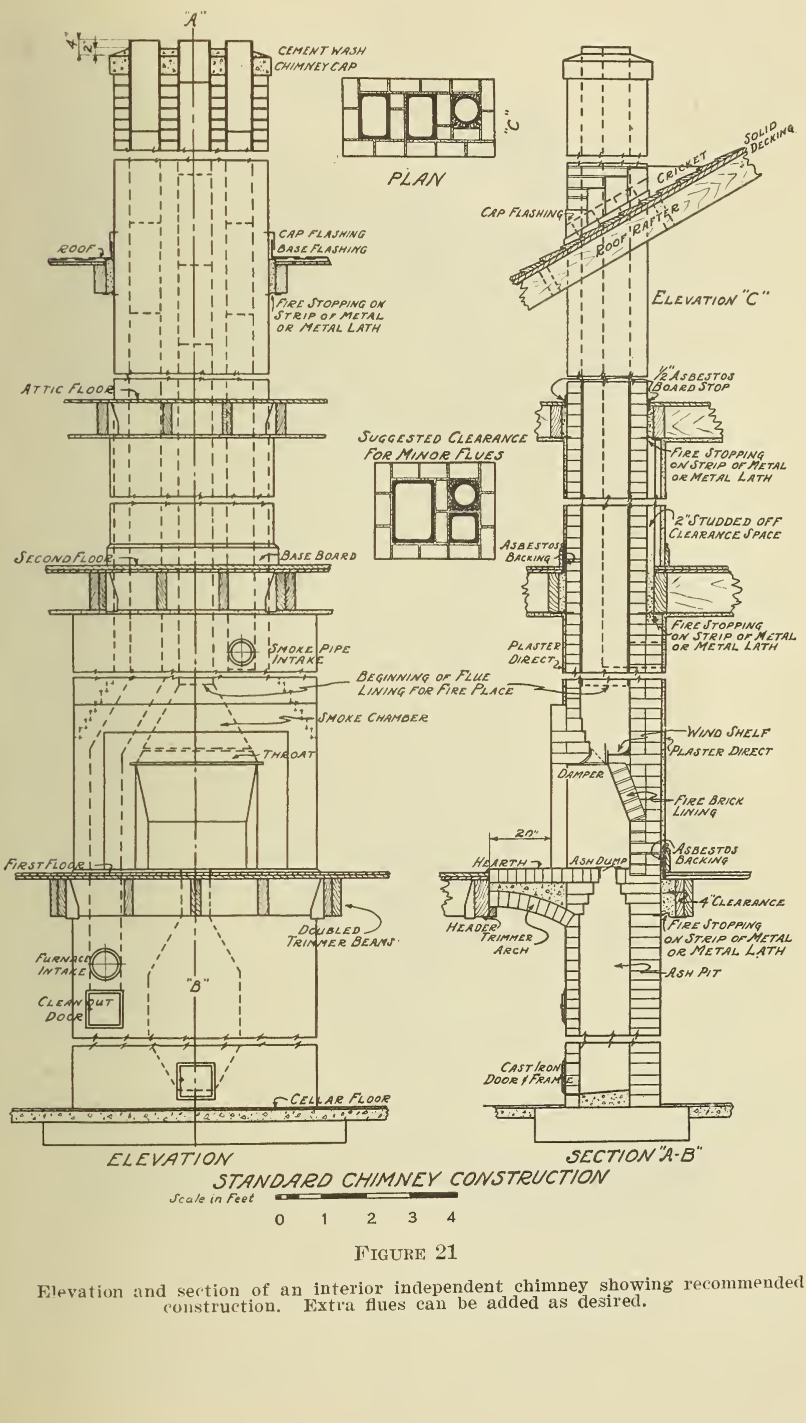

FIGURE 21

Elevation and section of an interior independent chimney showing recommended construction. Extra flues can be added as desired.

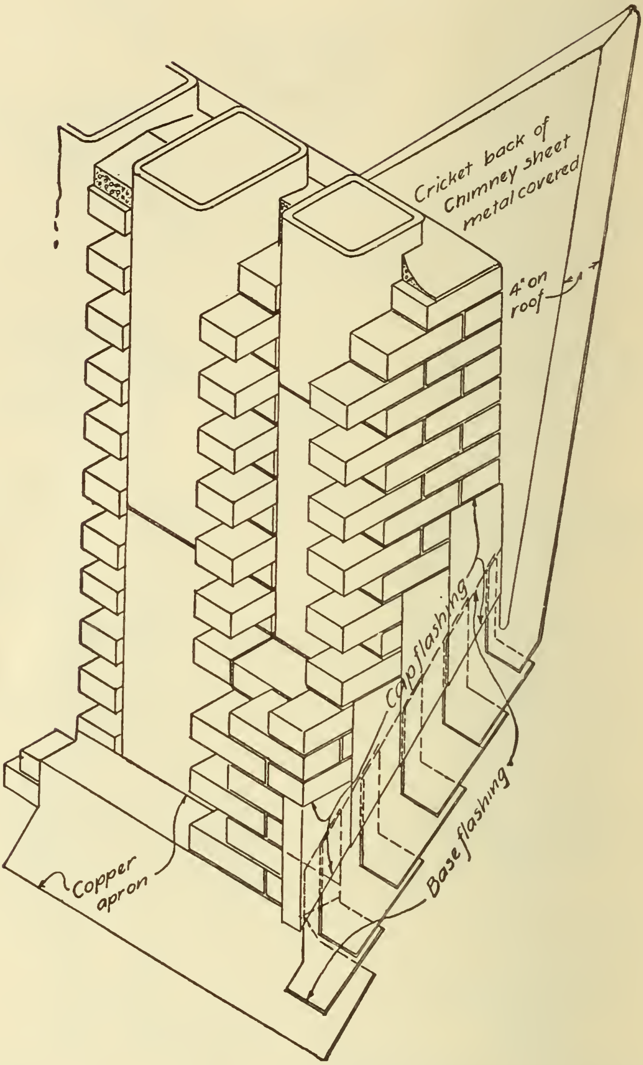

FIGURE 22

Details of chimney construction showing method of flashing at roof surface, also, a wash course, but no cap surrounding flues at top. (See fig. 21.) Underflashing or cap flashing may be substituted for copper apron shown.

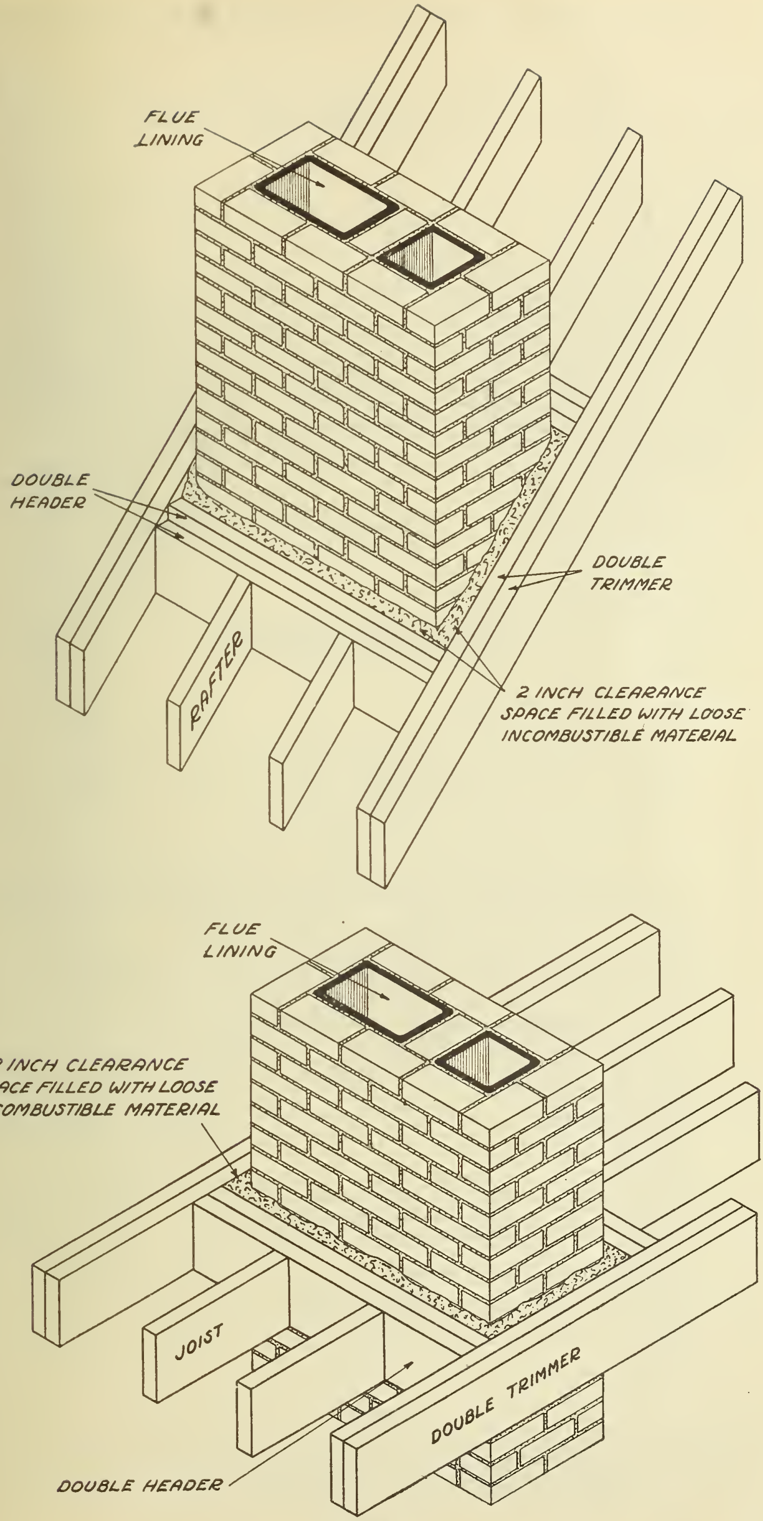

FIGURE 23
Details of chimney construction at floor and roof.

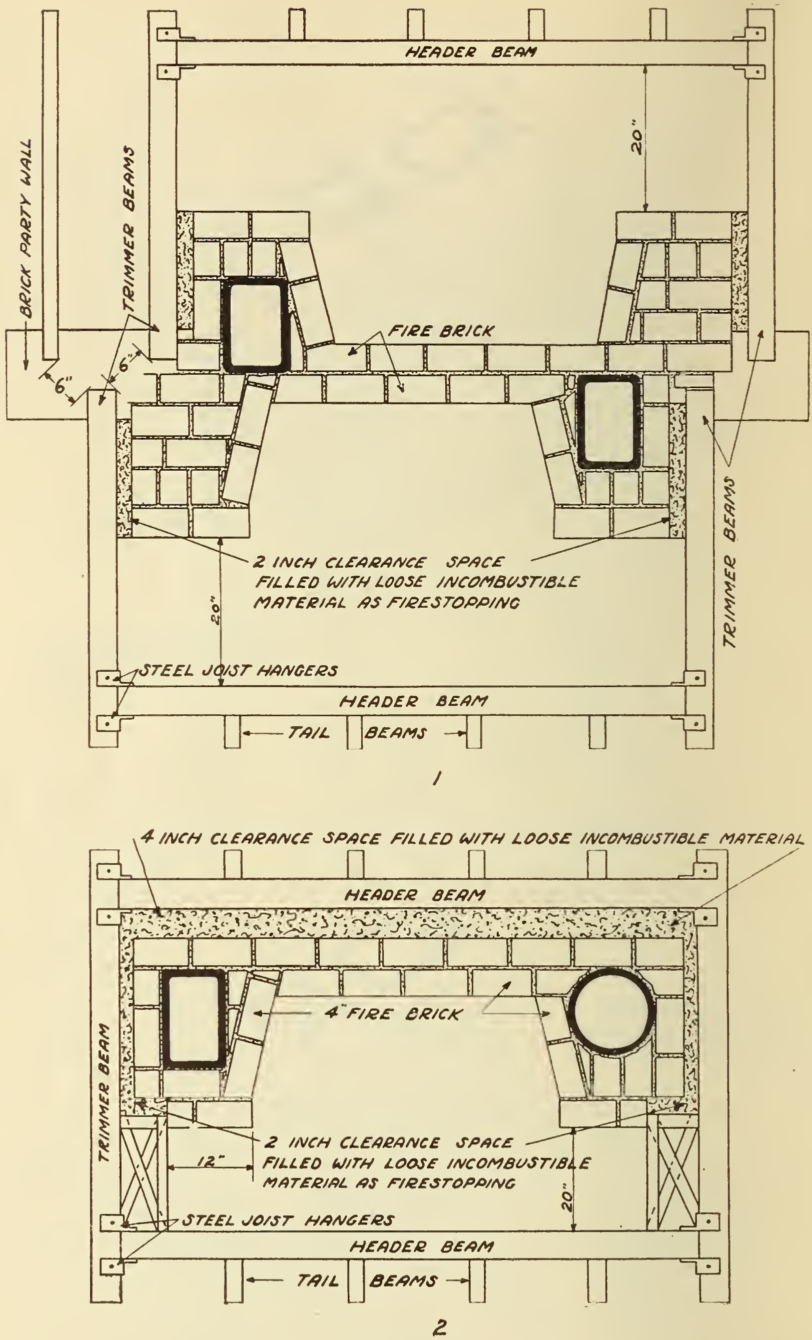

FIGURE 24

1. Method for building two fireplaces back to back in a brick party wall to secure proper spacing between ends of floor joists.
2. Floor framing around a single fireplace. Note filling between framing and brickwork, which serves both as insulator and fire-stop.

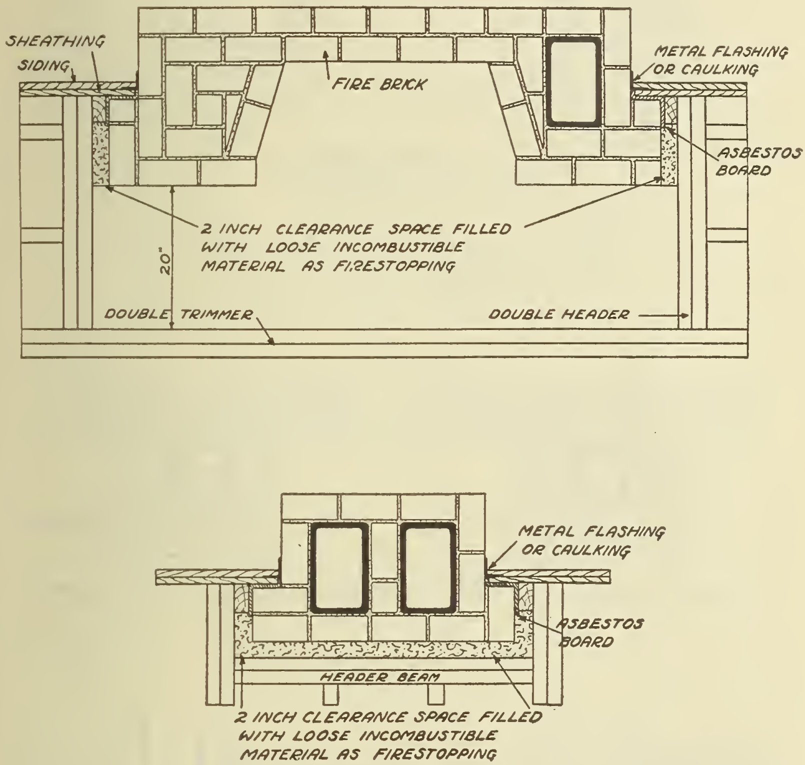

FIGURE 25

Method of framing around a fireplace and chimney construction with exposed back wall and chimney.

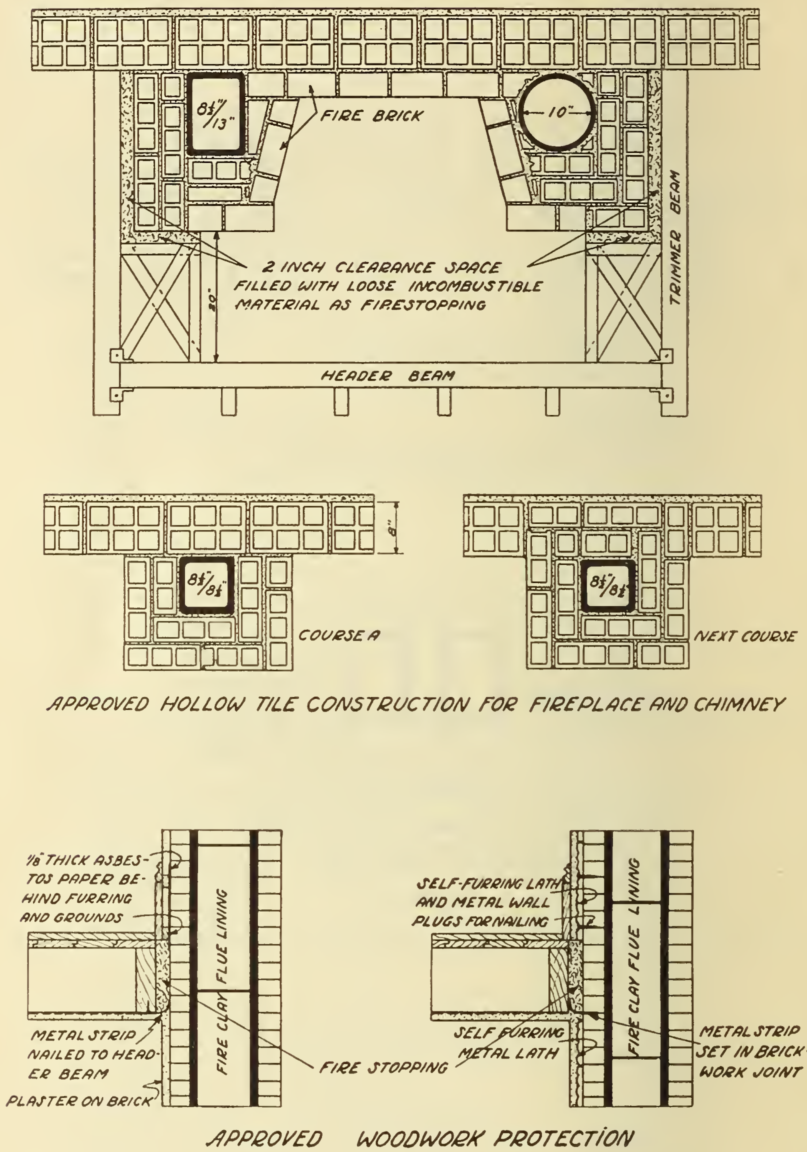

FIGURE 26

Details of hollow tile chimney construction and of woodwork protection.

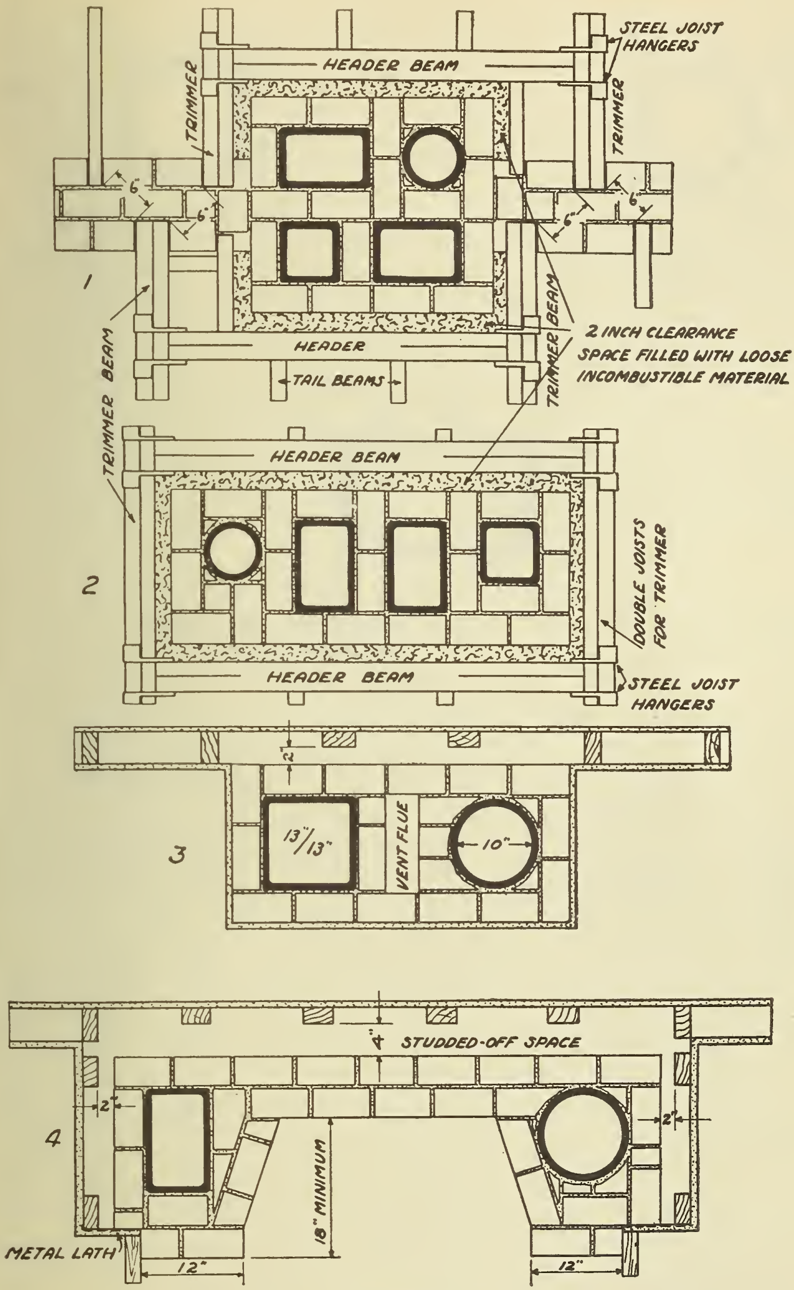

FIGURE 27

1. Floor framing around chimney in a party wall, to secure proper space between ends of floor joists.
2. Ordinary floor framing around a chimney. All timbers 2 inches clear of brickwork and space filled with fireproofing material.
3. Stud partition across back of a chimney showing proper method of arranging studs.
4. Stud partition across back of a fireplace and around the ends of the chimney breast, showing proper arrangement of studs. Method of fire-stopping this space is shown on chimney section, Figure 21.

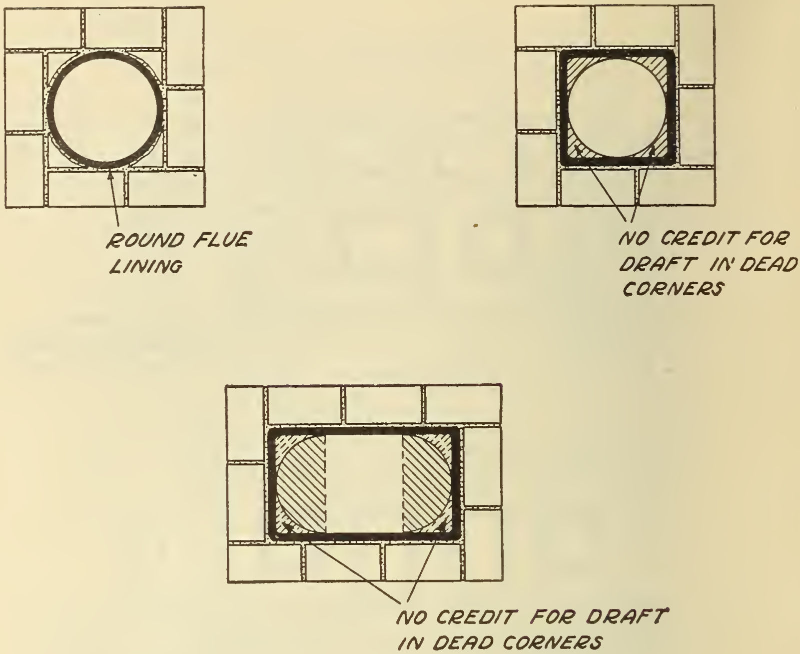

FIGURE 28

Details of effective area of flue linings.

Data on flues, areas, and chimneys with and without flue linings

Nominal sizes: Round flue lining (inside diameter)	Nominal sizes: Rectangular flue lining (outside dimensions) (inches)	Unlined chimneys (inside dimensions) (inches)	Actual inside area	Effective area "E"	Minimum thickness of chimney wall
Inches			*Square inches*	*Square inches*	*Inches*
		4 by 8	32	11. 1	3¾
		4 by 12	48	19. 1	3¾
	4½ by 8½		23. 6	21. 3	3¾
6			28. 3	28. 3	3¾
		8 by 8	64	28. 3	8
	7½ by 7½		39. 1	30. 7	3¾
	4½ by 13		38. 2	35. 9	3¾
	8½ by 8½		52. 6	41. 3	3¾
8			50. 3	50. 3	3¾
		8 by 12	96	52. 3	8
	8½ by 13		80. 5	70	3¾
10			78. 5	78. 5	3¾
		12 by 12	144	78. 5	8
	8½ by 17½		106	96. 5	3¾
	13 by 13		127	100	3¾
12			113	113	3¾
		12 by 16	192	126	8
	13 by 17½		177	150	3¾
15			177	177	3¾
	17½ by 17½		233	183	3¾
	20 by 20		298	234	8
18			254	254	8
	20 by 24		357	295	8
20			314	314	8
	24 by 24		461	346	8
22			380	380	8
24			452	452	8

Various studies on the height of chimneys for dwellings indicate that the minimum height should be between 30 and 35 feet. While dwellings of the bungalow type and other 1½-story houses have chimneys less than this height, if a good draft at all times is desired chimneys less than 30 feet in height are not desirable, as drafts in such chimneys are likely to be erratic in their action.

For fireplaces it is especially important for good draft to design the flue on the "effective area" principle, and an effective area of flue of one-twelfth of the area of the fireplace opening is desirable.

A smoke test of the chimney is recommended before its acceptance. The method of test is to build a smudge fire at the bottom of the flue and while smoke is flowing freely from the flue to close it tightly at the top. Escape of smoke into other flues or through the chimney wall indicates openings that should be made tight before the chimney is accepted.

In the foregoing pages are shown elevations and sections of typical chimney and fireplace construction supplied through the courtesy of the National Board of Fire Underwriters, and which are at least equal to the requirements given in sections 10–1 and 10–2, part 2.

Par. 51. Heating Appliances.

A review of the origin of fires in dwellings indicates that many of them are caused by overheated smoke pipes, by placing heating appliances too close to combustible construction, and by poor maintenance. Many of the requirements written in the past for the purpose of controlling the hazards causing these fires have been based, for the most part, on the judgment of those experienced in fire protection and fire underwriting. Actual test data have been available to a very limited extent. The Building Code Committee, believing such data to be essential for the formulation of practical and economical code requirements, requested the Bureau of Standards to conduct tests on these appliances with this purpose in mind.

Under the direction of S. H. Ingberg a series of such tests have been conducted by G. Q. Voight, of the bureau. In order to establish experimental conditions closely related to typical installations, a survey was made of equipment in use in the District of Columbia, as well as a survey of the causes of fires from household equipment for the period 1928–1930. With this information as a guide, some 34 individual tests were made on different assemblies of appliances.

In general, temperatures were determined at critical points for smoke pipes, stoves, and furnaces in order to discover their potential fire hazard with respect to partitions, floors, and ceilings within various distances, either unprotected or protected.

Where wood is heated for short durations to temperatures in the range of from approximately 482° to 572° F., ignition may result. No definite cases of ignition of wood exposed for long periods around heating installations were found where temperatures were below 300° F. Between temperatures of 300° and 375° F. browning and initial charring may occur, but, in so far as direct evidence is concerned, ignition has not resulted from these temperatures. The danger when combustible construction is heated for long periods is

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that, by a process of slow carbonization, a condition may gradually be produced favoring ignition at lower temperatures than would result from shorter periods of heating. As a basis for interpreting the test data in this formulation of requirements, a temperature of 300° F. has been assumed as the maximum allowable even for short infrequent periods of exposure.

2. *Smoke pipes and thimbles.*—The actual temperatures at the surface of wood joists spaced at 6, 10, and 12 inches from smoke pipes indicated that at least a 12-inch clearance should be maintained between such pipes and unprotected combustible construction. Reductions in this distance should be permitted only when protection of asbestos board or equivalent approved incombustible material is used.

Because of the increased likelihood of open joints where long runs of horizontal pipe occur, much less hazardous conditions can be effected by short runs well supported and with tight riveted joints.

In the thimble tests the data obtained showed that the ordinary thimble available commercially, providing a 1-inch ventilated air space around the smoke pipe, offered insufficient protection. With a thimble 8 inches larger in diameter than the smoke pipe having a vented air space, or a thimble 4 inches larger in diameter than the pipe with the space between the pipe and thimble filled solidly with insulating material, such as mineral wool, temperatures approximately at the maximum from safety considerations were obtained. A thimble 8 inches larger in diameter than the smoke pipe filled with insulating material gave temperatures that would provide a very considerable factor of safety. It should be borne in mind that the tests represent extremely severe conditions, but that conditions of this nature can and do obtain.

3. *Wall and partition protection.*—To insure that excessive temperatures will not occur on the surfaces of wall and partitions adjacent to stoves or ranges burning solid or liquid fuel, a clearance of 24 inches between these appliances and combustible studding or sheathing appears necessary where no protective covering is employed. When shields of incombustible material extending at least 1 foot on all sides and from the floor to at least 1 foot above the stove or range are provided, the clearances can be reduced one-half. In the case of plastered construction having combustible supports, these as well as any combustible plaster base should have a clearance of at least 18 inches with an allowable decrease to 9 inches where bright metal or equivalent protection is applied over the plaster.

The tests indicated that the difference in performance between black iron and galvanized iron used as a shield to protect combustible construction is very marked, both as applied directly to the wall and as forming one side of closed air spaces. Galvanized iron will, with time, lose some of its heat reflecting properties, although it is not known to what extent this would occur. Metal initially brighter than galvanized iron that would retain this property would apparently give greater protection than that obtained in the tests.

4. *Floor protection.*—Heating furnaces, boilers, laundry stoves, or similar devices in which hot fires may be maintained should rest upon masonry foundations.

When it is necessary that stoves or ranges without legs and which burn solid or liquid fuel be set directly on wood floors, the floors should be protected by a hearth consisting of at least one course of brick on edge or other masonry of the same thickness. This hearth should extend not less than 6 inches on the sides and rear, and it is well to have it extend at least 2 feet in the front in order to prevent hot coals from falling on the floor. The necessity for protection decreases as the distance from the surface of the floor to the bottom of the stoves increases. In the tests a clearance of 5 inches between the floor and stove, when the floor was covered with one-quarter inch of asbestos board overlaid with black iron, gave temperatures close to the end point for safety considerations. Inasmuch as the bottom of a sheet-metal stove may fall out from deterioration of the metal, it is always wise to set such stoves on some sort of an incombustible covering. (See also par. 52 of this appendix.)

5. *Warm-air pipes.*—Interpretation of the test data for warm-air furnaces shows that some protection of these pipes is essential where conditions are severe. The number of fires caused by overheated warm-air ducts is comparatively small. The requirements for warm pipes given in section 10-3, part 2, are considered sufficient for conditions producing maximum temperatures.

Where pipeless furnaces are installed, a distance of at least 3 feet from the top of the radiating dome to the finished floor surface is desirable. The down draft of cold air at the sides of the register was found to reduce the temperature of the air from the warm-air flow to a very marked extent. The temperatures measured on combustible floor construction adjacent to register boxes connected with this type of furnace were not high enough to be hazardous. Temperatures sufficient to cause eventual ignition of combustible material or goods were found to exist in the path of the warm-air flow at the top of the register. Partitions should never be built over registers, as is sometimes done to facilitate heat distribution. Furniture, rugs, clothing, or other combustible materials placed on a warm-air register introduce a very definite fire hazard which can be easily avoided.

6. *Steam and hot-water pipes.*—Experienced observers have expressed the belief that after a period of long-continued heating combustible construction in contact to steam or hot-water pipes may be subject to spontaneous ignition. No test data on this are available. Simple precautions, such as preventing any direct contact between combustible construction and steam or hot-water pipes, covering the pipes with some form of insulation, and, where they pass through combustible floors or partitions, providing a metal sleeve for the pipe, are desirable. Some authorities recommend that these pipes be kept an inch away from combustible construction.

Par. 52. Fire-Resistive Requirements.

Where an ultimate fire resistance of one hour is referred to in sections 9 and 10, part 2, the fire-resistance rating of the materials and construction assembly involved, as determined by tests made in accordance with the Specifications for Fire Tests of Materials and Construction A2–1926 of the American Standards Association, is meant. These standards are the ones employed by the Bureau of

Standards, the Underwriters' Laboratories, and other testing authorities in the conduct of fire tests on building construction materials and assemblies.

For the sake of clearness a typical construction having a 1-hour ultimate fire resistance has been given in the requirements in part 2, and any other construction meeting the requirements for 1-hour ultimate fire resistance is of course permissible.

In the case of walls and partitions the following constructions have been listed as having a 1-hour rating in the committee's report entitled "Recommended Minimum Requirements for Fire Resistance in Buildings," and this report should be consulted wherever a more thorough investigation of fire-resistance ratings becomes necessary:

3¾ inches or more clay or shale brick.
3¾ inches or more concrete or sand-lime brick.
3 inches or more hollow gypsum block, unplastered.
2 inches or more solid gypsum block, plastered both sides.
4 inches or more cinder concrete block, unplastered; or 3 inches or more plastered on both sides.
3 inches or 4 inches hollow clay tile, plastered on both sides.
3 inches or more solid reinforced concrete, unplastered, reinforced in both directions with not less than 0.4 of 1 per cent reinforcement.
Maximum size of coarse aggregate not to exceed ¾ inch.
2½ inches or more solid partition of Portland-cement plaster on expanded metal or wire lath on incombustible studding.
2½ inches or more solid partition of sanded gypsum plaster on expanded metal lath on incombustible studding.
2½ inches or more solid partition of sanded gypsum plaster on wire lath on incombustible studding.
2 inches or more solid partiton of sanded gypsum plaster on expanded metal lath or wire lath on incombustible studding.
Hollow partition of at least ⅝-inch neat fibered gypsum plaster on at least ⅜-inch gypsum plaster board on each side of incombustible studding.
Hollow partition of at least ½-inch wood fibered unsanded gypsum plaster on at least ⅜-inch gypsum plaster board on each side of combustible studding, fire stopped. Joints of plaster board covered with expanded metal lath at least 3 inches wide.
Hollow partition of at least ¾-inch gypsum plaster on expanded metal lath on each side of combustible studding, fire stopped.
Hollow partition of at least ¾-inch Portland-cement plaster on expanded metal lath on each side of incombustible studding, or on wire lath on each side of incombustible studding, or on expanded metal or wire lath on each side of combustible studding.
Hollow partition of at least ¾-inch gypsum plaster on expanded metal lath on each side of incombustible studding.
Hollow partition of at least ¾-inch gypsum plaster on wire lath on each side of incombustible studding.

In the case of floors and ceilings, constructions having a rating of one hour or more are listed in the report mentioned above, as follows:

3½ inches or more reinforced concrete slabs or arches having at least ¾-inch protection below steel reinforcement.
Composite floors consisting of reinforced concrete beams with filler of hollow tile, cinder concrete block, slag block, or gypsum block, thickness of filler to be 6 inches or more if without top slab, plastered, or 4 inches or more if with 2-inch or more concrete slab; at least ¾-inch concrete protection for steel reinforcement.
Concrete-joist construction, not more than 24 inches between joists; thickness of slab 2 inches or more if with ceiling of at least ¾-inch gypsum or Portland-cement plaster on metal or wire lath or 3 inches if without ceiling; at least ¾-inch concrete protection below steel reinforcement.
Steel-joist construction consisting of a 2-inch or more reinforced concrete or gypsum top slab and at least a ⅞-inch gypsum or Portland-cement plaster ceiling on expanded metal or wire lath.

Wood-joist construction, fire stopped, with double board floor having insulating layer between boards and with ceiling of at least ¾-inch gypsum plaster on expanded metal lath.

Wood-joist construction, fire stopped, with double board floor having insulating layer between boards and with ceiling of at least ¾-inch Portland-cement plaster on expanded metal lath.

Wood-joist construction, fire stopped, with double board floor having insulating layer between boards and with ceiling of at least ¾-inch gypsum or Portland-cement plaster on wire lath.

Wood-joist construction, fire stopped, with double board floor having insulating layer between boards and with ceiling of at least ½-inch wood fibered gypsum plaster on at least ⅜-inch gypsum plaster board. Joints of plaster board covered with expanded metal lath at least 3 inches wide.

Statistics on fires in dwellings indicate that a large number of these fires originate in the basement. Such fires originating at night have often gained such headway before being discovered that the occupants have either been trapped on the second story or have been compelled to jump from the windows. When it is remembered that most dwellings now have but one stairway, the desirability of confining the fire to the point of origin as long as possible is easily seen.

To accomplish this purpose it is desirable to have the first floor built of incombustible construction, or of a combustible construction as described in this paragraph which has a fire-resistance rating of at least one hour.

If it is not feasible to attempt this because of cost considerations, a fire-resistive ceiling directly over the heating plant will reduce the hazard somewhat.

Sprinkler systems are also available that may be installed in the entire basement or in any portion thereof. Their use in locations of this nature is a distinct aid in preventing serious fires.

Par. 53. Importance of Fire Stops.

The committee desires to emphasize the fact that fire stops are an extremely important though inexpensive aid in preventing rapid distribution of fire.

Fire in buildings spreads by the movement of high-temperature air and gases through every open channel. In addition to halls, stairways, and other large spaces, these heated gases also follow with equal facility the concealed spaces between floor joists, between the studs in partitions and walls of frame construction, and between the plaster and the wall where the former is carried on furring strips. In a dwelling or even in a large building where these hidden channels are not obstructed at suitable points, a fire will find its way in a few minutes to all parts of the structure, and either will destroy it entirely or will result in much greater loss than would have occurred if fire stops had been installed.

It is not practical to introduce cut-offs in hallways and stairways of the ordinary small-size dwelling, but fire stopping of all hidden channels is easy to accomplish.

1. In general, fire stops should be so located as to separate the open spaces within the walls and floor of each room from those of adjacent rooms. Especial care should be taken to shut off the cellar or basement from the first floor. A large proportion of residence fires start in such lower stories where the heating equipment is located and are readily communicated to all parts of the structures by way of hollow partitions and walls and the spaces around warm-

air pipes and floor registers. Hence the importance of having them all carefully fire stopped.

2. Wherever possible, fire stops should be of incombustible material and should form a practically air-tight obstruction, for the hot air and gases generate pressure and will find their way through very small crevices.

3. Precautions such as described above, by delaying the spread of fire, will afford time for help to arrive, and result in saving many buildings and even lives which otherwise might be lost.

4. Experiments upon the thermal conductivity of walls indicate that heat losses are appreciably decreased by breaks in the furring spaces at each story, and that fire stops, in addition to their normal functions, save fuel.

5. Fire stops, if properly installed, provide a valuable barrier to rats and other rodents.

Par. 54. Vigilance Necessary to Secure Fire Stops.

The greatest obstacle to securing efficient fire stops in a building is in getting architects and builders to realize the supreme importance of such precautions. The ordinary carpenter or builder is ignorant of the serious annual life and property loss due to fires in combustible dwellings, and considers the possibility of such a fire too remote to worry about. Some one must be responsible for rigid inspection to insure that such work is concientiously performed. Wherever possible the building inspector should be required to inspect all fire stopping before it is concealed from view. Usually the owner lacks experience and does not know what should be required.

Par. 55. Fire-Stopping Materials.

1. Two courses of brick, tile slabs, or other masonry are required to cut off a furring space, for mortar joints may drop out of a single course and render it useless.

2. Incombustible material suitable as dry fill for fire stopping may be crushed refuse mortar, plaster, concrete, hollow tile, gypsum block, or other similar material containing sufficient fine stuff to fill voids when it settles. Loose boiler cinders is one of the best fire-stopping materials, and a mixture of sand and gravel with cinders or ashes, or even dry earth, will also serve the purpose. The weight of sand or gravel alone or of crushed concrete would be objectionable when supported on metal lath. Some of these materials are always found about a new building, and their use involves no expense except for labor.

3. Gypsum blocks are excellent for fire stopping in dry locations. Ordinary partition blocks can easily be sawed to fit any space. Any open joints between such blocks should be mortar filled. Gypsum products, however, should not be used where likely to become wet. Under such conditions it would be liable to induce dry rot in adjoining woodwork. Metal lath and plaster is also excellent fire-stopping construction, especially where considerable surfaces are to be covered.

4. Metal lath is a convenient and inexpensive material for supporting fire-stopping material between studs or joists. It can be easily

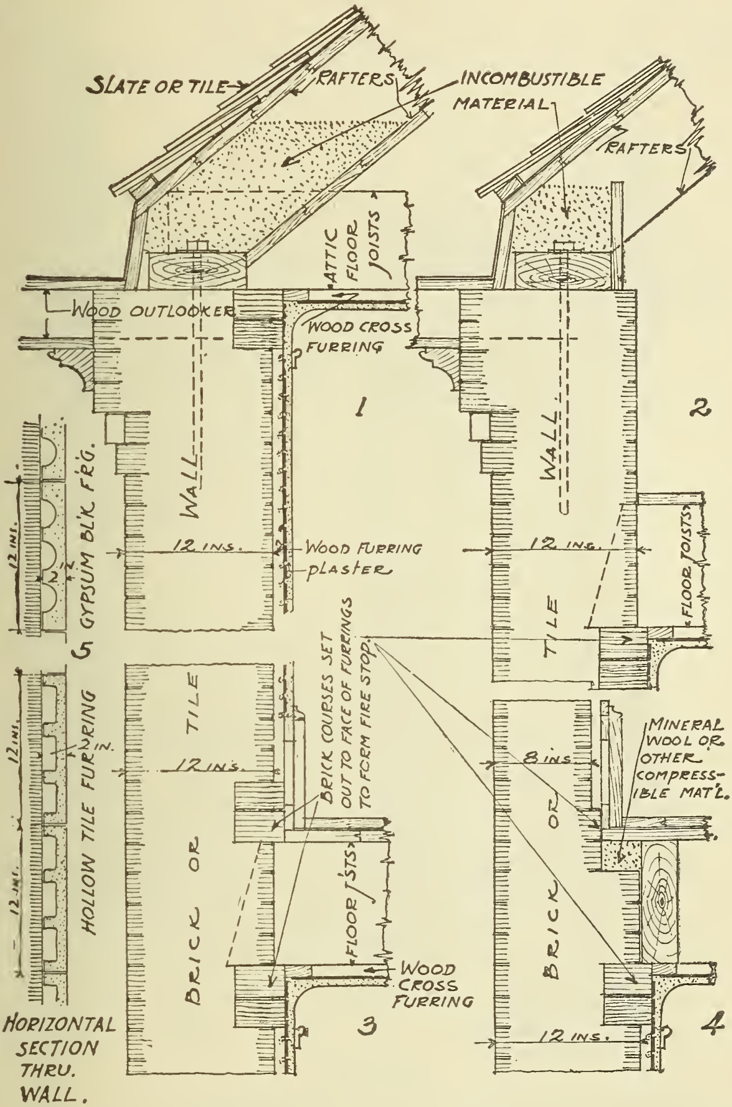

FIGURE 29.—*Dwellings with Walls of Brick or Other Masonry*

1. Method of fire stopping at eaves when attic floor joists are level with plate; 2. Same as 1, except that attic floor joists are any distance below the plate and built into the wall. Support for fire stopping might be same as in 1 if more convenient; 3. In this and the other figures of this plate, note fire stopping of wooden furring by two courses of brickwork being set out to face of furring above and below floor joists all around the building. Other types of masonry walls should be built out in the same manner; 4. Fire stopping at a floor level when the wall is thinner above the floor than below.

bent into shape to fit such spaces and then nailed to place. To avoid having the fine material sift through the lath, it is best to cover it with a layer of plaster or mortar before applying the fill material. Such fire stopping will yield with the shrinkage of the woodwork and always maintain its full protective efficiency.

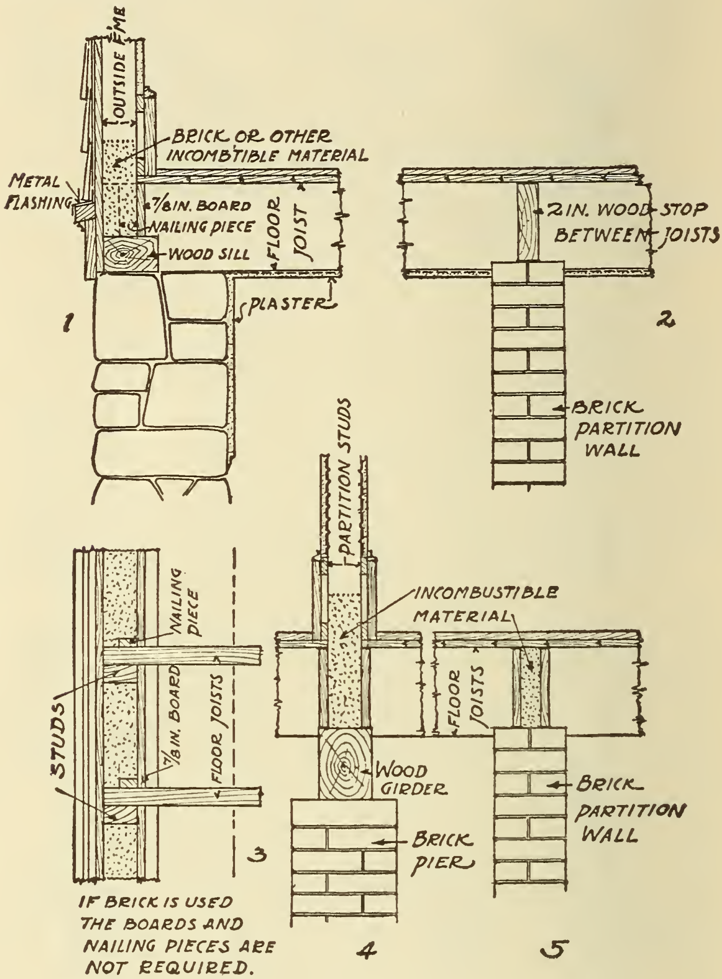

FIGURE 30

1 and 3. Elevation and plan showing fire stopping of wall of frame building at line of sill and between studs and floor joists.
2. Fire stopping with timber cut between floor joists on top of brick partition.
4. Fire stopping of partition resting on wooden girder.
5. Same as 2, except that incombustible compressible material between two boards is used instead of a timber.

5. There are some places, such as between floor joists resting on a brick cellar partition, where concrete fire stopping should not be used, because the shrinkage of the timber joists will bring the flooring to bear upon the rigid fire stopping and the floor will bulge. Metal lath and plaster could also be used if proper precautions were taken to insure complete cut-offs.

6. Metal lath and cement or gypsum plaster are excellent fire-stopping construction for the under side of a box cornice or a flat finish under the eaves.

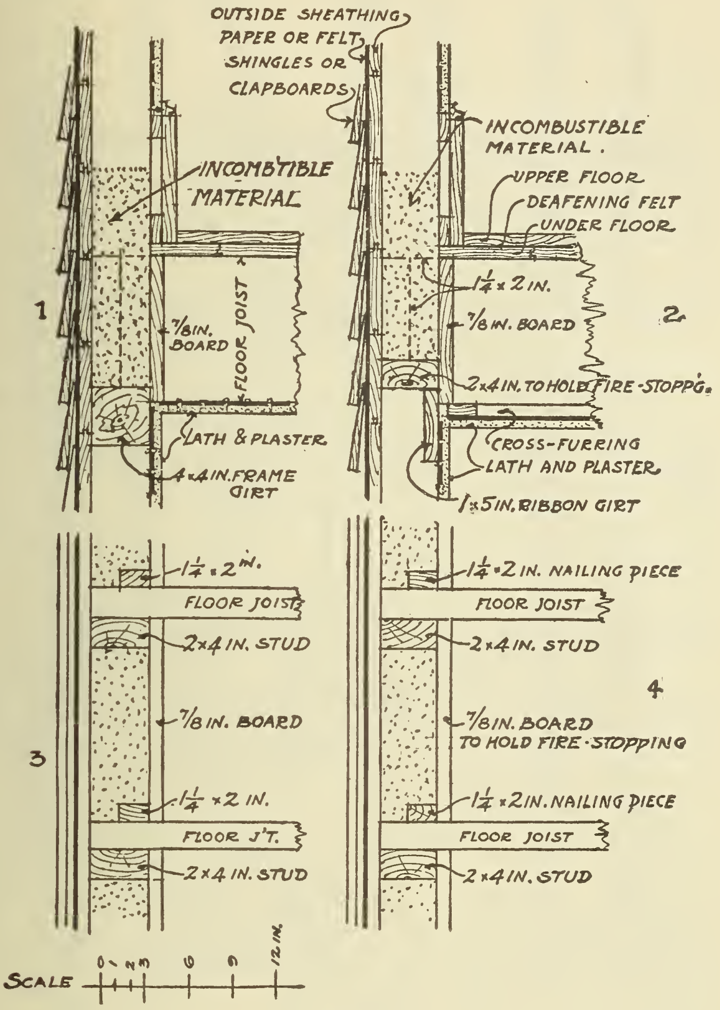

FIGURE 31

1 and 3. Elevation and plan showing fire stopping in frame wall at connection of upper floor joists with girt.
2 and 4. Fire stopping at same place for "balloon frame."
NOTE.—Wherever boards are indicated as supports to hold incombustible fire stopping in place, metal lath is recommended as a superior substitute. It is easier installed and will not burn.

7. Fire stopping around warm-air pipes and registers is important, but seldom done. Any such space should be fire stopped irrespective of floor construction. In fireproof floor construction, register boxes should fit the floor opening snugly, and so make fire stopping un-

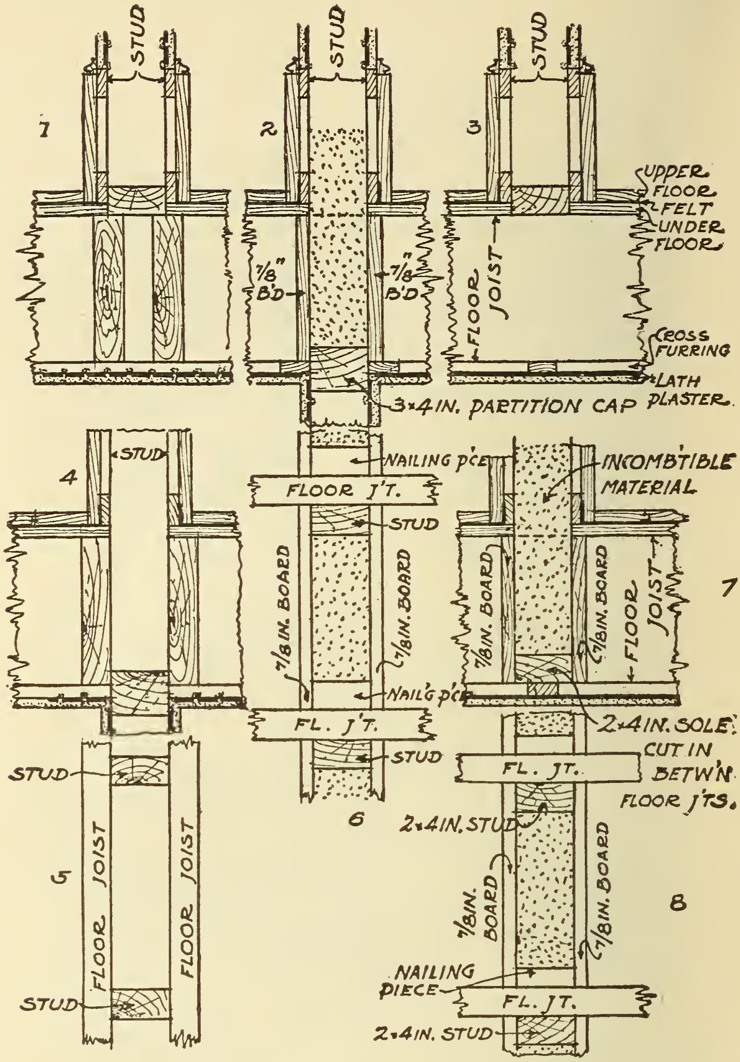

FIGURE 32

1. Interior partition running same direction as floor joists supported on double joists, fire-stopped at bottom by 2 by 4 inch sole.
2 and 6. Elevation and plan of partition footing on 3 by 4 inch cap of partition below running crosswise to joists, showing method of fire stopping between joists.
3. Partition running crosswise to floor joists footing on sole used as a fire-stop. This would be improved by addition of some incombustible material on top of sole.
4 and 5. Elevation and plan of partition running same direction as floor joist footing on 3 by 4 inch cap of partition below used as a fire stop, and floor joists placed alongside studs.
7 and 8. Elevation and plan of partition running crosswise to joists footing on sole fitted between joists at bottom and fire-stopped with mineral wool between two boards. Brickwork or other solid incombustible material could be used.

necessary. The protection of woodwork, as elsewhere required around a register, will safeguard the wood from the heat of the pipe itself, but the open space provided around the pipe and register box forms an easy entrance for fire occurring in the lower story to

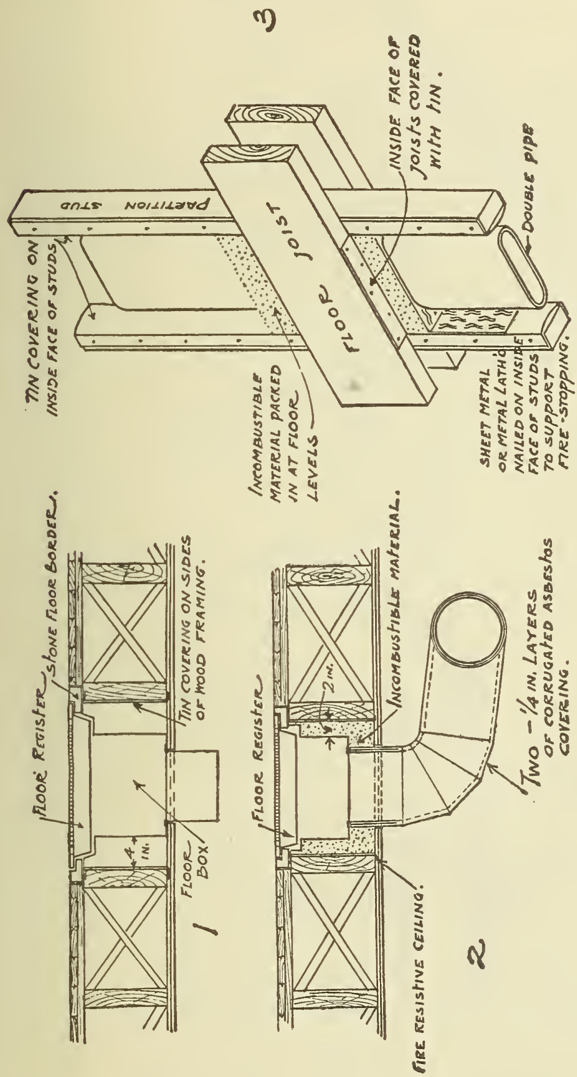

FIGURE 33

1. Method of fire stopping around floor register. Note register box extended to line of ceiling protection, which simplifies installation.
2. A more complete method of fire stopping, and one well suited for existing buildings.
3. Isometric sketch showing method of fire stopping between floor joists around a warm-air pipe carried up in a partition.

gain access to the story which the register serves. (See fig. 33, 1 and 2.)

Par. 56. Garage Construction.

Walls and partitions and floors and ceilings for private garages combined with dwellings may be called upon at any time to resist a fire starting in such a location. A minimum rating of one hour ultimate fire resistance has been required for these locations, and

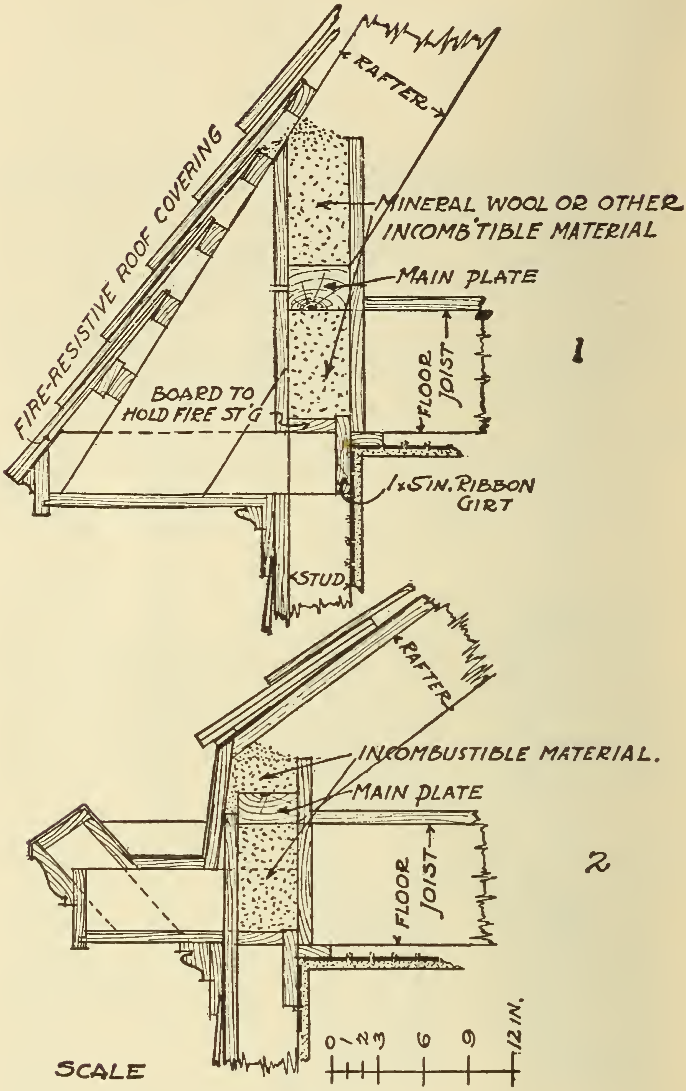

FIGURE 34

1. Connection of floor joists with outside "balloon" frame. Method of fire-stopping cornice and "gambrel" roof construction. Metal lath and cement plaster or stucco would make better fire protection than wood for the flat surface under the eaves.
2. Connection of floor joists with outside "balloon" frame at plate level, showing "box" cornice, gutter trough, and foot of roof rafters, and method of fire stopping. This retards fire entering building if cornice burns. Same methods employed for girt framing.

constructions meeting this requirement have been given in paragraph 52 of this appendix.

Roof construction should be equivalent to that for overhead floor and ceiling.

Only products approved by competent authorities should be used. A large variety of fire doors and windows have been tested and approved by the Underwriters' Laboratories and are a standard commodity in the building-material market. Only fire doors and windows thus approved or which have withstood tests of equal severity conducted by other responsible parties should be used for the purposes mentioned in section 10–5, part 2. It is important, however, that such devices should be installed in metal frames and with hardware, the same as that with which they are equipped when tested; otherwise they may fail to meet expectations when subjected to fire. Fire doors are made in both swinging and sliding types, and many of the former are as artistic in appearance as wood doors.

A self-closing fire door as required in section 10–5, part 2, is one that is normally kept in a closed position by some mechanical device. Wired glass is excluded from this door because such glass is liable to soften and sag from its fastenings at a temperature of about 1,600° F., which is a heat easily produced by burning gasoline or oil.

Although provision is made in section 10–5, part 2, for entrance from the dwelling into the garage, it is recognized that even with the precautions specified some fire hazard still exists, and it is strongly recommended that when a garage is placed underneath or attached to a dwelling there should be no opening whatever between the two occupancies. It is much safer to enter the garage from the outside.

Par. 57. Developments in Construction.

The committee recognizes that much research has been and is still being made with a view to developing new types of construction for dwellings. New materials and new forms of old materials are also constantly being put on the market. Sound and meritorious advancements in this field should be recognized promptly in order that the potential home owner may have the benefits of reduced costs through elimination of waste at many points.

In this respect attention should be directed toward building codes from two standpoints: (1) That their provisions deal with safety in construction rather than specifying best methods of construction, and thus act toward encouragement of new methods rather than blocking all progress in this direction; and (2) that when necessary their provisions be brought up to date in order that desirable legislation may not lag too far behind construction progress, thus causing unnecessary expense and even seriously hindering logical advancement.

Committees of experts from all parts of the country chosen to study the problems relating to the purchase, building, equipment, and other features related to homes, and known as the President's Conference on Home Building and Home Ownership, made tenative reports of their findings in December, 1931. The publications of various committees of this conference contain much detailed and valuable information on the many subjects which were considered. Information concerning these reports may be obtained by addressing the President's Conference on Home Building and Home Ownership, Commerce Building, Washington, D. C.

Par. 58. Plumbing.

Requirements for plumbing in dwellings, as well as other buildings, have been issued by a special subcommittee on plumbing of the Building Code Committee. The most recent publication of this committee, entitled "Recommended Minimum Requirements for Plumbing," contains detailed plumbing regulations, as well as an appendix giving much other useful information in this field.

Par. 59. Electrical Requirements.

Proper electrical installation is essential to prevent unnecessary fire hazard. The requirements of the "National Electrical Code," being the Regulations of the National Board of Fire Underwriters for Electric Wiring and Apparatus as approved by the American Standards Association, are generally accepted as the most approved methods and practices.

Par. 60. Value of Publications.

The following is a partial list of national and in some cases local organizations, the publications of which have come under observation of the committee:

American Concrete Institute, 2970 West Grand Boulevard, Detroit, Mich.
American Face Brick Association, 130 North Wells Street, Chicago, Ill.
American Institute of Steel Construction, 200 Madison Avenue, New York, N. Y.
American Society of Heating and Ventilating Engineers, 51 Madison Avenue, New York, N. Y.
American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pa.
American Standards Association, 29 West Thirty-ninth Street, New York, N. Y.
Asphalt Shingle and Roofing Institute, 2 West Forty-fifth Street, New York, N. Y.
Associated Tile Manufacturers, 420 Lexington Avenue, New York, N. Y.
Building Stone Association of Indiana (Inc.), Bloomington, Ind.
California Redwood Association, 405 Montgomery Street, San Francisco, Calif.
Clay Products Association, 111 West Washington Street, Chicago, Ill.
Clay Products Institute of America, 906 Colonial Building, Philadelphia, Pa.
Common Brick Manufacturers' Association of America, 2121 Guarantee Title Building, Cleveland, Ohio.
Gypsum Association, 211 West Wacker Drive, Chicago, Ill.
National Board of Fire Underwriters, 85 John Street, New York, N. Y.
National Building Units Corporation, 1600 Arch Street, Philadelphia, Pa.
National Fire Protection Association, 60 Batterymarch Street, Boston, Mass.
National Lime Association, 927 Fifteenth Street NW., Washington, D. C.
National Steel Fabric Co., Union Trust Building, Pittsburgh, Pa.
National Lumber Manufacturers' Association, 1337 Connecticut Avenue, Washington, D. C.
National Sand & Gravel Association, Munsey Building, Washington, D. C.
National Warm Air Heating Association, 3440 A. I. U. Building, Columbus, Ohio.
Portland Cement Association, 33 West Grand Boulevard, Chicago, Ill.
Red Cedar Shingle Bureau, 4445 Stuart Building, Seattle, Wash.
Sand Lime Brick Association, Saginaw, Mich.
Structural Clay Tile Association, 1400 Engineering Building, Chicago, Ill.
Southern Pine Association, Interstate Bank Building, New Orleans, La.
Steel Joist Institute, 1736 Dime Bank Building, Detroit, Mich.
Underwriters Laboratories (Inc.), 207 East Ohio Street, Chicago, Ill.

West Coast Lumbermen's Association, White-Henry-Stuart Building, Seattle, Wash.

Weyerhaeuser Forest Products, First National Bank Building, St. Paul, Minn.

The Building Code Committee desires to call attention to the large number of publications distributed by national and local organizations included in the above list for the purpose of promoting correct practice in the use of their products. The committee does not necessarily agree with nor should it be quoted as indorsing the statements made in such publications. It believes, however, that the helpful information contained therein should be given careful consideration by those interested in building.

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