U. S. DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS

Building and Housing No. 14

RECOMMENDED MINIMUM REQUIREMENTS FOR FIRE RESISTANCE IN BUILDINGS

REPORT OF THE
DEPARTMENT OF COMMERCE
BUILDING CODE COMMITTEE

U. S. DEPARTMENT OF COMMERCE
R. P. LAMONT, Secretary
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GEORGE K. BURGESS, Director

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APPENDIX

FIGURES

LETTER OF SUBMITTAL

WASHINGTON, D. C.,
August 21, 1930.

Hon. R. P. LAMONT,
Secretary of Commerce,
Washington, D. C.

SIR: In pursuance of its program the Building Code Committee has completed, and now submits to you, its report entitled "Recommended Minimum Requirements for Fire Resistance in Buildings."

The subject is one of extreme interest and importance. The report will aid in the preservation of life and the prevention of conflagrations, which have in the past caused great suffering and dislocation of business. In searching for test data to serve as a basis for conclusions the committee has been impressed by the fact that the science of fire protection is in a stage of development as compared with the knowledge of other properties of materials and constructions. The program of tests under way and contemplated by the Bureau of Standards has advanced this science very greatly.

The committee has followed its usual course in bringing the combined judgment of its members to bear upon the results of research and upon the many and detailed suggestions which have followed the submission of a preliminary mimeographed report to some 500 correspondents. In a sense, therefore, the report is not alone the work of the committee but of these qualified critics to whom indebtedness is acknowledged.

Our experience has again been confirmed that this process of "intellectual legislation," as it has been termed, furnishes a broad basis for general acceptance when the report comes to final publication.

The method of presentation follows that of previous reports, and consists of an introduction, recommended minimum requirements, and an appendix in which general principles are discussed and additional information supplied.

The report is submitted for your approval with the recommendation that it follow the usual procedure as to publication.

Yours very truly,

WM. K. HATT,
Chairman Building Code Committee,
Department of Commerce.

LETTER OF ACCEPTANCE

DEPARTMENT OF COMMERCE,
OFFICE OF THE SECRETARY,
September 10, 1930.

DR. WILLIAM K. HATT,
Chairman Building Code Committee,
Department of Commerce, Washington, D. C.

DEAR DR. HATT: The report on "Recommended Minimum Requirements for Fire Resistance in Buildings" represents another forward step in the program of the Building Code Committee. I am gratified to receive it and have it published by the Department of Commerce.

The report forms a substantial and authoritative basis for use wherever revision of building codes is taken up. It strikes at two sources of human and economic loss in the building industry. One is the great annual destruction of property and human life as the result of fires; the other is that in our anxiety to guard against this loss we have sometimes required excessive amounts of protective materials at certain points, yet have not provided adequate protection at others.

The results of years of research and collective experience embodied in this report should go far toward placing the subject on a rational basis, and thus give prompt effect to the united efforts of business men, architects, engineers, building officials, and civic leaders to do away with code provisions that are inadequate, wasteful, and generally ill adapted to present-day conditions. Adoption of the recommendations should help to conserve buildings that now exist, and to lessen the cost of future construction.

Let me add my appreciation to that which you richly deserve from the public, for the arduous and disinterested public service to which the members of the committee have devoted themselves.

Very sincerely,

R. P. LAMONT.

RECOMMENDED MINIMUM REQUIREMENTS FOR FIRE RESISTANCE IN BUILDINGS

Part 1.—INTRODUCTION

This is the sixth of a series of reports prepared by the Building Code Committee, which was appointed by Secretary Hoover in 1921 with the object of determining basic requirements that could be recommended to ensure public safety and at the same time promote economy in construction. The previous reports have attained wide acceptance and it is hoped that this will prove equally useful to those entrusted with the preparation of building-code requirements.

As the title indicates, the provisions are stated in terms of minimum requirements. Local conditions may in some cases indicate the necessity for more detailed or more drastic sections. It should be remembered, however, that as ordinances enforced by public authorities under the police power, building codes can not legally control construction, except as they relate to the safety, health, or welfare of those in or about buildings. Codes can not legally, according to current interpretations, require good building practice on purely economic grounds, desirable though this may be.

In those phases of building codes which have to do with fire-resistive construction the expression "safety or welfare of those in or about buildings" has come to have certain accepted interpretations. These constitute the fundamentals upon which fire protection in building codes depends.

The fundamentals in fire-protection requirements are that the likelihood of fires must be minimized, that loss of life must be prevented as far as possible, and that conflagrations, which endanger the safety and welfare of whole cities, must be guarded against.

The first corollary to these assumptions is that attention must be given to details of design which will definitely limit the chances for fire to get a start; the second, that buildings shall be so constructed that egress in case of fire is sure and safe; and the third, that construction must prevent communication of fire from building to building and between portions of buildings, to decrease the possibility of conflagration. This report is primarily concerned with the first and third, the second being held to belong to a separate chapter on exit requirements. Safety for those engaged in fighting fire is also a necessary consideration, and requires that in buildings of considerable height or extent the members which carry loads or resist stresses must be protected from collapse.

Safety from conflagration requires first, that very large fires in any building be prevented; and second, that buildings closely exposed to fires in other buildings be protected against them and vice versa. These considerations obtain much more frequently in the congested parts of cities, and the custom has grown up of enforcing more stringent code requirements in such districts. The characteristics by which the location of boundaries between congested and outlying districts should be established are discussed in this report.

A completely logical system of fire resistance for buildings would require, as a minimum, detailed knowledge of the severity and effect of fires in many different occupancies and of the resistance shown by various materials under conditions of similar fire hazard in fire tests. By comparing the one with the other, requirements would at once suggest themselves. The problem is not quite so simple, however. It is true that there has accumulated a considerable body of information derived from tests on various materials, chiefly as a result of work done under the auspices of Columbia University, the Bureau of Standards, and the Underwriters' Laboratories (Inc.). The committee is fortunate to have this for use. Pioneer work has also been done at the Bureau of Standards in measuring the fire hazard of different occupancies as disclosed in experimental fires. While the data are admittedly incomplete, the results of tests for fire resistance and of experience in experimental fires have been coordinated in the case of the most resistive type of buildings considered by the committee. The hazard is indicated for buildings of a considerable range of combustible content, and available information for use is cited in the appendix. Ultimately this method may be expected to have a broader application than has been found possible to present in the existing state of knowledge. Types of construction not fully fire resistant must be recognized, however, since to make all buildings fully resistive to fires caused by their contents would not be consistent with the fundamentals already stated and would be economically indefensible.

The committee wishes to reiterate statements made in previous reports that safety in buildings must continue for a time to depend on the standards of those in the building industry, supplemented by the vigilance of public-building officials. It believes that experience has demonstrated the wisdom of providing the necessary organization and facilities for an effective application of a building code.

The report was initiated during the chairmanship of Ira H. Woolson, whose death occurred in May, 1927. To his work as chairman Mr. Woolson brought not only a wealth of experience, but also a high conception of public duty which has left an indelible impression upon his associates. His influence upon safety and health through wise building regulations that he advanced will continue for many years. His loss is keenly felt by the members of the committee. They feel fortunate, however, that the outline and guiding principles of the present report were established before his death, and that association with him for six years has given them familiarity with his views.

As the report was finished, the committee suffered another loss in the death of Edwin H. Brown, a member since its original appointment in 1921. An architect of high distinction, Mr. Brown brought to the committee's deliberations a wide knowledge of design and a keen perception of essentials, which was of great assistance in achieving balanced judgment. His wise counsel, fortunately available throughout the period during which the report was in preparation, was of inestimable value.

To the large number of architects, engineers, building officials, and others who have cooperated by supplying information and offering criticism the committee wishes to express its appreciation. In par-

ticular it acknowledges its indebtedness to S. H. Ingberg, chief of the fire-resistance section of the Bureau of Standards.

Part 2.—RECOMMENDED CODE REQUIREMENTS

Chapter 3.—CLASSIFICATIONS [1]

Section 3–1. Classification of Buildings by Occupancy.

Buildings or parts of buildings shall be classified by occupancy or use into the following groups:

Class 1.—Public.
Class 2.—Institutional.
Class 3.—Residential.
Class 4.—Business.
Class 5.—Garages, hangars, barns.

Each class is intended to embrace buildings or parts of buildings as hereinafter defined and those of similar character or use. Wherever there is any uncertainty as to the classification of a building, the administrative building official shall fix the classification within which it falls. (See Appendix, par. 2 (5).)

Class 1. Public.

This classification includes buildings or parts thereof in which people come together for transaction of public business; for civic, political, social, or religious purposes; for educational purposes; or for entertainment or recreation; such as city halls, churches, schools, theaters, and grand stands.

Class 2. Institutional.

This classification includes buildings or parts thereof in which people are harbored for medical, charitable, or other care or treatment or in which people are detained for penal or correctional purposes; such as hospitals, sanitariums, homes for the aged, prisons, and reformatories.

Class 3. Residential.

This classification includes buildings or parts thereof in which families or households live or in which sleeping accommodations are provided, such as apartment houses, hotels, dormitories, and dwellings.

Class 4. Business.

This classification includes buildings or parts thereof in which goods are manufactured, stored, converted, or sold, or in which business or professional services are rendered; such as factories, warehouses, stores, and office buildings.

Class 5. Garages, Hangars, Barns.

This classification includes buildings or parts thereof used for the storage or repair of automotive vehicles and airplanes,[2] such as public and private garages and hangars; also for the keeping of horses and cattle, such as stables and riding academies.

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[1] The numbering of chapters corresponds with that given in the committee's report "Recommended Practice for Arrangement of Building Codes." The minimum requirements here given should be used in a complete code as indicated by the numbering.

[2] Salesrooms containing automobiles or airplanes having no volatile inflammable fuel in their tanks do not come under this classification.

Section 3–2. Classification of Buildings by Type of Construction.

Construction shall be classified into six general types according to the character of materials employed and their method of assembly as follows:

Type 1. Fully protected.
Type 2. Protected.
Type 3. Heavy timber.
Type 4. Masonry wall and joist.
Type 5. Wood frame.
Type 6. Unprotected metal.

Type 1. Fully Protected.

Type 1.—Fully protected construction is that in which walls are of masonry or of reinforced concrete and the structural members are of incombustible materials having an ultimate fire resistance sufficient to withstand the hazard involved in the occupancy, but not less than 4 hours for bearing walls, fire walls, party walls, piers, columns, trusses, and for girders which support walls; 2½ hours for walls and girders not otherwise specified, floors including beams and girders, and for roofs; and in which the degree of fire resistance for other construction features and the materials acceptable for the purpose are as given in chapter 11. (See Appendix, par. 3 (2) and pars. 6 and 16.)

Type 2. Protected.

Type 2.—Protected construction is that in which walls are of masonry or reinforced concrete and the structural members have an ultimate fire resistance of not less than 4 hours for fire walls and party walls; 3 hours for bearing walls, piers, trusses other than roof trusses, and columns and girders supporting walls; 2 hours for walls, columns, and girders not otherwise specified; 1½ hours for floors, including beams and girders, roof trusses except as provided for in section 11–2–3, and for roofs except as provided for in section 11–8–1; and in which the degree of fire resistance required for other construction features and the materials acceptable for the purpose are as given in chapter 11. (See Appendix, par. 3 (3), and pars. 6 and 16.)

Type 3. Heavy Timber.

Type 3.—Heavy timber construction is that in which walls are of masonry or reinforced concrete and the interior framing is of timbers, or in part of protected steel or reinforced concrete having an ultimate fire resistance of at least 1 hour, except for roof trusses as specified in section 11–2–4, the plank floors and roof being arranged in heavy solid masses and smooth flat surfaces, avoiding thin sections, sharp projections, and concealed or inaccessible spaces; and in which the degree of fire resistance required for other construction features and the materials acceptable for the purpose are as given in chapter 11. (See Appendix, par. 3 (4), and pars. 6 and 16.)

Type 4. Masonry Wall and Joist.

Type 4.—Masonry wall and joist construction is that not included in type 3 in which the exterior walls are of masonry or reinforced concrete and the interior framing is partly or wholly of wood or unprotected iron or steel. (See Appendix, par. 3 (5).)

Type 5. Wood Frame.

Type 5.—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. (See Appendix, par. 3 (7).)

Type 6. Unprotected Metal.

Type 6.—Unprotected metal construction is that in which the imposed loads are carried by an unprotected metal frame and in which the exterior walls and roof are of sheet metal or other incombustible material. (See Appendix, par. 3 (6).)

Chapter 4.—GENERAL BUILDING RESTRICTIONS

Section 4–1. Restrictions as to Location Within Fire Districts.

For the purpose of this code there shall be established two fire districts or zones, which shall be known as the first and second fire districts. (See Appendix, par. 4 (1), (2).)

Within the first fire district every building hereafter erected shall be of type 1, fully protected; type 2, protected; type 3, heavy timber; type 4, masonry wall and joist construction; or type 6, unprotected metal construction. Roof coverings shall conform to the requirements for class 1 or class 2 roof coverings as defined in section 11–8–2.

Within the second fire district every building hereafter erected, except dwellings, shall be of type 1, fully protected; type 2, protected; type 3, heavy timber; type 4, masonry wall and joist; or type 6, unprotected metal construction. Roof coverings shall conform to the requirements for class 1 or class 2 roof coverings as defined in section 11–8–2, except that roof coverings for dwellings may conform to class 3.

Outside the foregoing districts all types of construction may be permitted, provided they comply with the provisions of this code that apply regardless of location. Roof coverings shall conform to the requirements for class 1, class 2, or class 3 roof coverings as defined in section 11–8–2. (See Appendix, par. 4 (10).)

Each fire district shall include the area or portion of city included within or between the boundaries described as follows:

4–1–1. Boundary Between the First Fire District and Second Fire District.

(See Appendix, par. 4 (3).)

4–1–2. Boundary Between the Second Fire District and Outside Area.

4–1–3. Changes to Buildings Within Fire Districts.

Within the foregoing fire districts no existing building shall be hereafter increased in height unless it is of a type of construction permitted for new buildings within such fire districts or is altered to comply with the requirements for such type of construction.

Within the foregoing fire districts no existing building shall be hereafter extended on any side, unless such extensions are of a type of construction permitted for new buildings within such fire districts.

Nothing in this section, however, shall prohibit other alterations within the fire districts, provided there is no change of occupancy that is otherwise prohibited.

No building shall hereafter be moved from one fire district into another or to another lot in the same district unless this type of construction is permitted in the district into or within which it is to be moved.

4–1–4. Buildings Located in Two Districts.

Any building located partly in more than one fire district shall be of a type of construction required for the most highly restricted district, unless the major part of such building lies outside of such district and no part is more than 10 feet inside the boundaries of such district.

4–1–5. Exceptions to Restrictions in Fire Districts.

The preceding provisions of this section shall not apply to one garage or stable used exclusively as such not more than one story in height nor more than 500 square feet in area, located on the same lot with a dwelling; nor to buildings intended to serve their purposes temporarily, under such conditions as may be prescribed by the building official; nor to builder's shanties for use only in connection with a duly authorized building operation; nor to storm inclosures not more than 12 feet high nor more than 2 feet wider than the doors they serve, located entirely within the lot lines and with roofs covered with fire-resistive roof covering; nor to wood piazzas or porches not exceeding three stories in height nor projecting more than 10 feet from the wall of the building, but such piazzas or porches shall not be built less than 5 feet from a side lot line unless separated from similar adjoining structures by a masonry wall; nor to greenhouses not more than 15 feet high erected on the same lot with and accessory to a residence or store; nor to boathouses not more than two stories or 25 feet in height nor more than 900 square feet in area; nor to fences not exceeding 8 feet in height.

Section 4–2. Restrictions as to Height.[3] [4]

The height to which different construction types of buildings may be erected shall be governed by the occupancy as provided below. For the purpose of this section the height shall be taken as the vertical distance from the grade line to the highest point of the building, except that church spires, chimneys, bulkheads, or penthouses used solely to inclose stairways, tanks, elevator machinery, or ventilating apparatus; and parapet walls not over 4 feet high need not be considered in determining this point. No building shall hereafter be erected so as to exceed the limits of height fixed by this section. (See Appendix, par. 4 (4).)

Buildings over 80 feet in height shall be of type 1, fully protected construction.

The allowable height of buildings of type 2, protected construction, whose occupancy comes under the classification "public, institutional, residential, or business," as defined in section 3–1, shall not exceed 80 feet; for occupancies coming under the classification garages, hangars, barns, the height shall not exceed 50 feet.

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[3] All limits on heights of buildings in this section are made from the standpoint of fire only. (See Appendix, par. 4 (4).)

[4] Where a height of one story is given there is no restriction as to height in feet.

The allowable height of buildings of type 3, heavy timber construction, whose occupancy comes under the classification public, as defined in section 3–1, shall not exceed one story,[5] nor three stories in 55 feet; for occupancies coming under the classification institutional the height shall not exceed two stories in 45 feet; for occupancies coming under the classification residential the height shall not exceed four stories in 60 feet; for occupancies coming under the classification business the height shall not exceed 80 feet; for occupancies coming under the classification garages, hangars, barns, the height shall not exceed two stories.[6]

The allowable height of buildings of type 4, masonry wall and joist construction, whose occupancy comes under the classification public, as defined in section 3–1, shall not exceed one story,[5] nor 3 stories in 45 feet, except that such construction for educational occupancies shall not exceed one story,[5] nor two stories in 35 feet; for occupancies coming under the classification institutional, the height shall not exceed 45 feet and not more than two stories shall be allowed within this height; for occupancies coming under the classification residential, the height shall not exceed 45 feet and not more than three stories shall be allowed within this height except that a total of four stories may be allowed when the first-floor construction and the construction below it is at least equal to type 2, protected construction, as defined in section 3–2; for occupancies coming under the classification business the height shall not exceed 55 feet and not more than 4 stories shall be allowed within this height; for occupancies coming under the classification garages, hangars, barns, the height shall not exceed one story;[5] provided that a private garage may have a story above it if the garage is protected as required in section 4–4–5.

The allowable height of buildings of type 5, wood frame construction, whose occupancy comes under the classification public or institutional shall not exceed one story[5]; for occupancies coming under the classification residential, the height shall not exceed 35 feet and not more than two stories shall be allowed within this height, provided that dwellings may be 40 feet and have two and one-half stories; for occupancies coming under the classification business the height shall not exceed one story,[5] nor two stories in 30 feet; for occupancies coming under the classification garages, hangars, barns, the height shall not exceed one story;[5] provided that a private garage may have a story above it if the garage is protected as required in section 4–4–5. (See Appendix, par. 4 (9).)

Buildings of type 6, unprotected metal construction, shall not exceed one story[5] in height; provided that a private garage may have a story above it if the garage is protected as required in section 4–4–5.

Mezzanine floors or galleries not exceeding 10 per cent of the aggregate ground floor area may be permitted in 1-story buildings.

(An alternative method for presenting allowable heights appears in Table 1 below.)

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[5] Where a height of 1 story is indicated there is no restriction as to height in feet.
[6] Without restriction as to height in feet.

TABLE 1.—*Allowable heights*[1][2] *of buildings*

Class of occupancy	Type 1, fully protected	Type 2, protected	Type 3, heavy timber	Type 4, masonry wall and joist	Type 5, wood frame	Type 6, unprotected metal
Class 1, public	No restrictions.	80 feet	1 story; or 3 stories in 55 feet.	1 story; or 3 stories in 45 feet.[3]	1 story	1 story.
Class 2, institutional[4]	do	do	2 stories in 45 feet.	2 stories in 45 feet.	do	Do.
Class 3, residential	do	do	4 stories in 60 feet.	3 stories in 45 feet.[5]	2 stories in 35 feet.[6]	Do.
Class 4, business	do	do	80 feet	4 stories in 55 feet.	1 story; or 2 stories in 30 feet.	Do.
Class 5, garages, hangars, barns.	do	50 feet	2 stories	1 story[7]	1 story[7]	Do.[7]

[1] All limits on heights of buildings in this section are from the standpoint of fire only.
[2] Where a height of 1 story is indicated there is no restriction as to the height in feet.
[3] The allowable height of type 4 construction for educational occupancies shall not be more than 1 story, nor 2 stories in 35 feet.
[4] See sec. 4–5.
[5] When the first floor construction and the construction below it is of at least type 2 construction as defined in sec. 3–2, 4 stories may be allowed.
[6] Dwellings may be 40 feet and have 2 ½ stories.
[7] A private garage may have a story above it if the garage is protected as required in sec. 4–4–5.

NOTE.—Mezzanine floors or galleries not exceeding 10 per cent of the aggregate ground floor area may be permitted in 1-story buildings.

The limitations on number of stories contained in this section shall be exclusive of basement. (See Appendix, par. 16 (4).)

Section 4–3. Restrictions as to Floor Areas.[7]

The maximum area of buildings of different types of construction shall not exceed the limits fixed below; provided that no building shall be limited in area if it is divided into sections none of which exceeds these limiting areas. Such subdivision shall be effected by means of walls or partitions of at least two hours ultimate fire resistance in the case of buildings of type 2, protected construction, and by fire walls in the case of buildings of type 3, heavy timber; type 4, masonry wall and joist; and type 5, wood frame construction. (See Appendix, par. 4 (5), (6), and par. 16 (9), (11).)

Buildings exceeding 25,000 square feet in undivided area shall be of type 1, fully protected; type 2, protected; or type 6, unprotected metal construction; provided that buildings of type 2, protected construction, whose occupancy comes under class 4, business, or class 5, garages, hangars, barns, shall not exceed 25,000 square feet in undivided area. (See Appendix, par. 4 (5), (6).)

The maximum area undivided by fire walls in buildings of type 3, heavy timber construction, whose occupancy comes under the classification public, as defined in section 3–1, shall not exceed 15,000 square feet for buildings one story in height, 10,000 square feet for buildings two stories in height, and 7,500 square feet for buildings three stories in height, except that public-assembly occupancies not more than one story in height may have an unlimited area if not subdivided or with only minor subdivisions along the walls; for occu-

[7] Irrespective of the type of construction, hazardous occupancies should be separated from other occupancies by fire walls or fire partitions.

pancies coming under the classification institutional the area shall not exceed 15,000 square feet for buildings one story in height, and 10,000 square feet for buildings two stories in height; for occupancies coming under the classification residential the area shall not exceed 10,000 square feet; for occupancies coming under the classification business the area shall not exceed 20,000 square feet for buildings one story in height, 15,000 square feet for buildings two or three stories in height, and 10,000 square feet for buildings over three stories in height; for occupancies coming under the classification garages, hangars, barns the area shall not exceed 20,000 square feet for buildings one story in height, and 10,000 square feet for buildings two stories in height. (See Appendix, par. 4 (5).)

The maximum area undivided by fire walls in buildings of type 4, masonry wall and joist construction, whose occupancy comes under the classification public as defined in section 3–1 shall not exceed 7,500 square feet for buildings one story in height and 5,000 square feet for buildings two or three stories in height except that public assembly occupancies in buildings not more than one story in height may have an area not to exceed 20,000 square feet; for occupancies coming under the classification institutional the area shall not exceed 7,500 square feet for buildings one story in height and 5,000 square feet for buildings two stories in height; for occupancies coming under the classification residential the area shall not exceed 7,500 square feet; for occupancies coming under the classification business the area shall not exceed 10,000 square feet for buildings one story in height, 7,500 square feet for buildings two or three stories in height, and 6,000 square feet for buildings four stories in height; for occupancies coming under the classification garages, hangars, barns the area shall not exceed 10,000 square feet. (See Appendix, par. 4 (5).)

The maximum area undivided by fire walls in buildings of type 5, wood frame construction, whose occupancy comes under the classification public or institutional, as defined in section 3–1, shall not exceed 3,000 square feet; for occupancies coming under the classification residential the area shall not exceed 3,000 square feet, except that dwellings may have an area not to exceed 4,000 square feet; for occupancies coming under the classification business the area shall not exceed 5,000 square feet for buildings one story in height and 3,000 square feet for buildings two stories in height; for occupancies coming under the classification garages, hangars, barns, the area shall not exceed 3,000 square feet. (See Appendix, par. 4 (5).)

(An alternative method for presenting allowable areas appears in Table 2 below.)

TABLE 2.—*Allowable area of buildings in square feet*

Class of occupancy	Type 1, fully protected	Type 2, protected	Type 3, heavy timber	Type 4, masonry wall and joist	Type 5, wood frame	Type 6, unprotected metal
Class 1, public.	No restrictions.	No restrictions.	1 story,[1] 15,000; 2 stories, 10,000; 3 stories, 7,500.	1 story,[2] 7,500; 2 or 3 stories, 5,000.	3,000	No restrictions.
Class 2, institutional.	do	do	1 story, 15,000; 2 stories, 10,000.	1 story, 7,500; 2 stories, 5,000.	3,000	Do.
Class 3, residential.	do	do	10,000	7,500	3,000 [3]	Do.
Class 4, business.	do	25,000	1 story, 20,000; 2 or 3 stories, 15,000; over 3 stories, 10,000.	1 story, 10,000; 2 or 3 stories, 7,500; 4 stories, 6,000.	1 story, 5,000; 2 stories, 3,000.	Do.
Class 5, garages, hangars, barns.	do	25,000	1 story, 20,000; 2 stories, 10,000.	10,000	3,000	Do.

[1] Public assembly occupancies in buildings not more than 1 story in height may be of unlimited area if not subdivided or with only minor subdivisions along the walls.
[2] Public assembly occupancies in buildings not more than 1 story in height may have an area not to exceed 20,000 square feet, if not subdivided or with only minor subdivisions along the walls.
[3] Dwellings may have an area of 4,000 square feet.

No building shall hereafter be extended on any side so as to exceed the limits of undivided area fixed in this section, but this shall not prohibit such extension of a building heretofore lawfully erected which already exceeds the limiting area, provided such extension does not exceed the area limitations fixed by this section and such extension is separated from the existing building by a fire wall.

The limiting areas of this section for class 4, business occupancies, and for class 5, garages, hangars, barns, may be increased by 50 per cent when the building has a frontage on two streets and by 100 per cent when it has a frontage on three or more streets. The same allowances may be made when the building is not located on a street line, but is directly accessible to fire apparatus on two or more sides.

The limiting areas fixed in this section, as modified on account of street frontage, for class 4, business, and for class 5, garages, hangars, barns, may be increased by 100 per cent when the building has an approved automatic sprinkler system.

Section 4–4. Restrictions as to Mixed Occupancies.

4–4–1. General Provisions.

When a building is used for the purpose of two or more classes of occupancy and exceeds the limits of height for any one of its occupancies the whole building shall be constructed to conform with the provisions of that class requiring the greatest fire resistance unless the parts used for the several classes of occupancy are separated from one another by construction having an ultimate fire resistance of at least one and one-half hours.

4–4–2. Residential and Business Occupancies.

When a building contains occupancies falling under both class 3, residential, and class 4, business, the several occupancies shall be separated by construction having an ultimate fire resistance of at least one hour.

4–4–3. Theaters.

No public theater or place of public entertainment shall be located within or attached to any building unless it is separated by walls having an ultimate fire resistance of at least three hours, and by floors having an ultimate fire resistance of at least two and one-half hours. There shall be no openings in such walls or floors, except that in buildings of type 1, fully protected, or type 2, protected, construction whose occupancy comes under class 4, business, but is not devoted to manufacturing or storage, openings in walls protected as required in section 11–6–2 may be permitted. (See Appendix, par. 16 (24).)

4–4–4. Garages.

No garage, except as indicated in section 4–4–5 below shall be located within or attached to another building unless it is separated from other occupancies by walls having an ultimate fire resistance of at least three hours, and by floors having an ultimate fire resistance of at least two and one-half hours. Openings in such walls shall be protected as required in section 11–6–2. Door sills between the occupancies shall be raised at least 1 foot above the garage floor level. (See Appendix, par. 16 (13).)

4–4–5. Private Garages Combined with Dwellings.

When a private garage is located beneath or attached to a dwelling, the following regulations as to its construction shall be observed (see Appendix, par 4 (9)):

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 have an ultimate fire resistance of at least one hour.

Walls and partitions between the garage and dwelling shall be of such construction as will insure an ultimate fire resistance of at least one hour.

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 doorsill shall be raised at least 1 foot above the garage floor level.

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

Section 4–5. Restrictions as to Special Occupancies.

Buildings in which persons are restrained under lock and key shall be of type 1, fully protected, or type 2, protected, construction.

Chapter 11.—FIRE PROTECTION

Section 11–1. Determination of Fire Resistance.

The fire resistance of building materials or assemblies shall be determined by performance shown under tests made in accordance with the Specifications for Fire Tests of Materials and Construction A2–1926 of the American Standards Association. (See Appendix, par. 1 (3).)

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Results of tests made in accordance with the foregoing specifications by an approved laboratory shall be accepted as establishing the fire rating for the materials and construction assembly involved.

In the absence of specific performance requirements, either in this code or promulgated by the administrative building official or other duly constituted authority, for fire doors, curtains, shutters, windows, or other protections for openings, the appliances enumerated for specific locations in the list of Inspected Appliances of the Underwriters' Laboratories (Inc.) or by any other approved laboratory may be accepted as meeting the purpose of this code. (See Appendix, pars. 1 (4) and 16 (2).)

Section 11–2. Protection of Structural Members.

11–2–1. Requirements for Walls.

Party walls which function also as fire walls shall conform to the requirements for fire walls.

A separation of at least 4 inches of solid masonry shall be provided in all fire and 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 building members enter hollow party or fire walls of thickness not greater than 12 inches, they shall project not more than 4 inches into the wall. The space above, below, and between them, and the space between the ends and the opposite face of the wall shall be filled solidly with burnt-clay materials, mortar, concrete, or equivalent fire resistive material, to a depth of at least 4 inches.

Party or division walls between dwellings occupied by not more than two families each may be constructed of wood studs covered on both sides with at least ¾-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 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.

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

No fire 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.

All open cells in tile or block 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.

Fire or party walls shall project through the roof as parapets, except that when the roof construction has an ultimate fire resistance of not less than 1½ hours and the walls are carried up to connect with it solidly such parapets may be omitted.

Parapet walls shall be at least 32 inches high except in the case of dwellings, where they shall be at least 12 inches high; such walls shall not be higher than four times their thickness unless laterally supported.

11–2–2. Protection of Columns, Girders, and Beams.

Columns, girders, and beams in type 1, fully protected; type 2, protected; and type 3, heavy timber, construction shall be protected against fire to the extent prescribed in section 3–2. (See Appendix, par. 6.)

The extreme outer edge of lugs and brackets on steel and cast-iron columns shall not extend nearer than 1 inch to the outer surface of the fire-resistive covering.

Where the fire-resistive covering of columns is exposed to damage from trucking or handling of merchandise it shall be jacketed for a height of at least 5 feet from the floor with a substantial covering.

No pipes, conduits, wires, cables, or other service equipment shall be embedded in the required fire-resistive covering of columns or of other structural members.

11–2–3. Requirements for Structural Members in Type 2, Protected Construction.

Steel roof trusses in buildings of type 2, protected construction, shall be protected against fire by a suspended ceiling or by other protection of such materials and thickness as to insure an ultimate fire resistance of at least one and one-half hours; provided that when such trusses in buildings of class 1, public occupancy, are over interior spaces having a clear height of at least 20 feet below the bottom chords of the trusses such protection and protection of roof beams and purlins may be omitted.

Wood roof trusses may be permitted in type 2, protected construction, wherever unprotected steel trusses are allowed, provided the least nominal dimension of timber is 4 inches. (See Appendix, par. 16 (18).)

11–2–4. Requirements for Structural Members in Type 3, Heavy Timber Construction.

Timber columns of type 3, heavy timber construction, shall be at least 8 by 8 inches in nominal size. Wood girders of type 3, heavy timber construction, shall be of at least 6-inch nominal width and at least 10-inch nominal depth. Wood beams shall be at least of the size given in section 11–3. (See Appendix, par. 16 (18).)

Columns, girders, beams, and trusses, except roof trusses hereinafter specified, of type 3, heavy timber construction, which are not wood shall be protected in such a manner as to insure an ultimate fire resistance of at least one hour. Steel roof trusses in buildings of type 3, heavy timber construction, shall be protected by a suspended ceiling or by other protection of such materials and thickness as to insure an ultimate fire resistance of at least one hour; provided that when such trusses in buildings of class 1, public occupancy, are over interior spaces having a clear height of at least 20 feet below the bottom chords of trusses such protection and protection of roof beams and purlins may be omitted.

Wood roof trusses in buildings of type 3, heavy timber construction, shall be of timber of at least 4 inches least nominal dimension. (See Appendix, par. 16 (18).)

11–2–5. Requirements for Structural Members in Type 4—Masonry Wall and Joist Construction.

Wood roof trusses in buildings of type 4, masonry wall and joist construction, shall be of timber at least 2 inches in least nominal dimension. (See Appendix, par. 16 (18).)

11–2–6. Lintels.

Stone lintels shall not be used in type 1, fully protected construction, unless supplemented on the inside of the wall with iron or steel lintels or with suitable masonry arches, reinforced concrete, or reinforced masonry beams.

Iron or steel lintels over openings in walls shall be protected so as to have an ultimate fire resistance at least equal to that of the wall in which used; provided that when over openings less than 4 feet wide or spanned by adequate masonry arches such protection may be omitted. (See Appendix, par. 6 (4).)

Section 11–3. Floors.

In type 1, fully protected construction, where steel beams or other steel supporting or constituting part of the floor or roof construction are used they shall be rigidly connected to one another or to girders or columns with sufficient bolts, rivets, or welds to transmit their entire loads. When they rest on masonry or reinforced concrete walls the ends shall be anchored thereto.

In type 2, protected construction, metal beams or metal joists constituting part of the panels of the floor or roof construction if not rigidly connected to the supporting beams or girders may be carried by metal hangers, supported on the upper flanges of the beams or girders, or supported in some other approved manner. When they rest on masonry or reinforced concrete walls they shall have at least 4-inch bearing.

In type 3, heavy timber construction, wood beams shall be of at least 6-inch least nominal dimension and floor construction shall be of splined or tongued and grooved planks of at least 3-inch nominal thickness or of laminated planking laid on edge. Beams other than wood shall be protected sufficiently to insure an ultimate fire resistance of at least one hour. (See Appendix, par. 16 (18).)

Section 11–4. Partitions.

In buildings of type 1, fully protected construction, partitions shall be constructed to have an ultimate fire resistance of at least one hour, and no combustible material shall be used in their construction; provided that in such buildings whose occupancy comes under class 4, business, partitions of less fire resistance, such as metal, or wood and glass, may be used within rooms or spaces not exceeding 5,000 square feet.

In buildings of other types of construction, partitions separating apartments from one another or from public hallways, and partitions in class 2, institutional occupancy, shall be constructed to have an ultimate fire resistance of at least one hour.

Openings in partitions for which a definite fire resistance is required shall be protected as provided in section 11–6–2.

Section 11–5. Protection of Vertical Openings.

In buildings, other than dwellings, of type 1, fully protected; type 2, protected; and type 3, heavy timber construction; and of type 4,

masonry wall and joist construction more than two stories in height, there shall be no openings in a floor unless the space in the stories immediately above and below such openings is inclosed by walls or partitions. Such walls or partitions shall have an ultimate fire resistance of at least one hour in buildings of class 3, residential occupancy, and at least 2 hours in other buildings. No combustible material shall enter into the construction of such walls or partitions in buildings of type 1, fully protected construction.

In class 3, residential buildings having apartments over one another, the stairways shall be inclosed by walls or partitions having an ultimate fire resistance of at least one hour. No combustible material shall enter into the construction of such walls or partitions in buildings of type 1, fully protected construction.

Whenever a stairway is so constructed that the several flights are not directly above one another the necessary connecting hallways or passages shall be inclosed in walls or partitions of the same ultimate fire resistance as required for the stairway.

Walls or partitions inclosing shafts or inclosing connecting hallways or stairways when not continuous through all stories from foundation to roof shall be supported by floors or other construction having an ultimate fire resistance at least equal to that required for the partition inclosure.

Openings in the shaft inclosures shall be limited to those necessary for the purposes of the shaft, and be protected as required in section 11–6–2.

The bottom of such shafts and the top when not extended through the roof, shall have an ultimate fire resistance of not less than one and one-half hours. (See Appendix, par. 10 (3).)

Shaft inclosures which extend into the top story of a building of type 3, heavy timber, or type 4, masonry wall and joist construction, shall continue through the roof and shall project not less than 3 feet above the roof surface; the walls of the shaft above the roof shall be equal in fire resistance to the walls of the shaft and shall be weatherproof. Every such shaft which extends above the roof shall have a thin glass skylight at least three-fourths the area of the shaft at the top story unless otherwise ventilated. (See Appendix, par. 10 (3).)

Shafts open at the top shall have walls equal in fire resistance to the exterior walls of the building and shall have openings protected as required in section 11–6–1.

Nothing in this section shall require the inclosure of a flight of stairs from the main entrance floor to the floor next above in buildings of class 1, public, class 3, residential, and class 4, business occupancy, provided that such stairs are not part of a required exit stairway.

Section 11–6. Protection of Wall and Partition Openings.

11–6–1. Exterior Openings.

Every window or other opening above the first story except show windows on the second story, in the exterior walls of every building, shall be protected by an approved fire door, fire shutter, fire window, open sprinkler, or other approved device when such opening is distant in a direct line less than 30 feet from any building of type 5, wood frame construction, or from any opening in

any other building or in another area separated by a fire wall in the same building and does not face in the same direction with such openings, or when said opening is not more than 50 feet above a neighboring roof; provided that such protection may be omitted in the case of churches, dwellings, and private garages. (See Appendix, par. 11 (5), (6).)

For the purpose of this section two or more buildings located on the same lot may be regarded as one building. (See Appendix, pars. 11 (8) and 16 (2).)

In buildings whose occupancy or use brings them within the classification of business or garages, hangars, barns (except private garages), windows vertically above each other and not required to be protected against fire shall have a distance of at least 3 feet between the top window sill and bottom of lintel of the window directly beneath.

11–6–2. Interior Openings.

Openings in fire walls, fire partitions, or party walls shall be limited to those necessary for the business of the occupancies on either side and for exit requirements and in no case shall the total width of such openings in any one story exceed 25 per cent of the length of the wall. Openings shall not exceed 80 square feet each in area except when proof satisfactory to the administrative building official is furnished that a larger size is necessary, in which case they may be increased to 180 square feet if provided with approved protective devices. (See Appendix, par. 11 (4).)

Openings in fire walls or party walls shall be protected on each side by approved automatic fire doors or other approved protective devices; provided that when such openings serve as required exits one door or device shall be self-closing. (See Appendix, par. 11 (1), (2).)

Openings in walls or partitions inclosing stairways or shafts shall be protected by approved automatic fire doors, fire windows, or other approved protective devices; provided that when such openings serve as required exits the doors or other devices shall be self-closing, and provided further that in buildings not over three stories in height whose occupancy comes under the classification residential, wood slab doors at least 1⅜ inches thick in all parts may be permitted.

Openings in partitions separating apartments from one another or from public hallways shall be protected by approved fire doors, fire windows, or other approved protective devices; provided that in buildings of type 4, masonry wall and joist, and type 5, wood frame construction, wood slab doors at least 1⅜ inches thick in all parts may be permitted.

Fire doors and shutters shall be installed with approved frames and hardware.

Section 11–7. Ceilings.

Buildings more than one story in height of type 4, masonry wall and joist construction, except dwellings and except those whose occupancy falls under class 4, business, or class 5, garages, hangars, barns, shall have ceilings of such materials and thickness as to insure an ultimate fire resistance of at least one hour for the floor construction

as a whole; and when ceilings are used in buildings whose occupancy falls under class 4, business, or class 5, garages, hangars, barns, they shall be of the same kind. (See Appendix, par. 12.)

Hung ceilings shall be of such materials and thickness as to insure an ultimate fire resistance of at least one hour for the floor construction as a whole.

In class 3, residential buildings having apartments over one another, the ceilings shall be of such materials as will insure an ultimate fire resistance of at least one hour for the floor construction as a whole. (See Appendix, pars. 6 and 12.)

Section 11–8. Roof Construction and Roofing.

11–8–1. Roof Structures.

Roofs of buildings of type 2, protected construction, covered in accordance with section 11–8–2 may be built of formed sheet steel, or of wooden planks not less than two inches nominal thickness attached by means of wood spiking pieces to a metal framework, provided the roof is wholly separated from the stories below by construction having an ultimate fire resistance of at least one and one-half hours.

Walls and roofs of penthouses, bulkheads, dormers and similar structures upon roofs of buildings shall afford at least the same fire resistance as the roof structure and shall be covered with materials at least equal in fire resistance to the roof covering of the building.

In buildings required to have class 1 or class 2 roof coverings as defined in section 11–8–2, skylights shall have approved metal frames and sash.

When over stairways, the stages of theaters, or places used by the public, unless otherwise ventilated, skylights shall be glazed with thin plain glass protected above and below with approved wire screens. (See Appendix, par. 13 (3).)

11–8–2. Roof Coverings.

Roof coverings shall be divided into the following classes whose use shall be governed by the requirements of section 4–1. (See Appendix, pars. 4 (10) and 13 (1).)

Class 1 roof coverings shall be of brick, concrete, slate, tile, slag, or any other material or form of protective covering approved by the administrative building official after satisfactory evidence that it is effective against severe fire exposure, does not carry or communicate fire, affords a fairly high degree of heat insulation to the roof deck, does not slip from position, possesses no flying-brand hazard, and does not require repairs to maintain its fire-resistant properties. (See Appendix, par. 13 (1), (2).)

Class 2 roof coverings shall be of incombustible material approved by the administrative building official after satisfactory evidence that it is effective against moderate fire exposure, is not readily flammable under such exposure, does not readily carry or communicate fire, does not slip from position, possesses no flying-brand hazard, and requires only infrequent repairs to maintain its fire-resistant properties. (See Appendix, par. 13 (1), (2).)

Class 3 roof coverings shall be of material approved by the administrative building official after satisfactory evidence that it is effective against light fire exposure, is not readily flammable under

such exposure, does not readily carry or communicate fire, and does not slip from position. (See Appendix, par. 13 (1), (2), (3).)

Section 11–9. Fire Stopping.

11–9–1. General.

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, par. 14.)

11–9–2. Pipes, Belts, and Shafting.

Openings around exposed pipes or power shafting shall be filled with incombustible material or shall be closed off by close-fitting metal caps at the ceiling and floor line or on each side of the wall.

Openings for belts shall be provided with approved slotted doors or be otherwise closed off. Belts shall not pass through fire walls.

11–9–3. Walls and Partitions.

Walls, including masonry walls furred with wood, and stud partitions shall be effectually fire stopped at floors and ceilings and at all junctions with roofs.

11–9–4. Wood Flooring.

In buildings of type 1, fully protected, or type 2, protected, construction having wood flooring, any space between such flooring and the floor construction beneath shall be filled solidly with approved incombustible material. (See Appendix, par. 14 (3).)

11–9–5. Cornices.

Cornices built of wood or having wood frames and extending along successive buildings shall be either fire stopped or entirely separated between each building.

11–9–6. Stairs.

Stairs shall be fire stopped between wooden stair carriages at top and bottom. Except in dwellings no closet shall be located beneath stairs; and the underside, if of combustible construction, shall be covered with metal lath plastered to a total thickness of three-fourth inch or equivalent construction.

11–9–7. Inspection.

No fire stopping shall be concealed from view until opportunity has been given the owner or his representative and the administrative building official to inspect it.

APPENDIX

Paragraph 1. GENERAL CONSIDERATIONS

(1) Spread of fire in buildings is prevented in two ways. One consists in the efforts of city fire departments, the use of sprinklers, and other fire-fighting appliances. The other consists in building into each structure a reasonable degree of fire resistance.

Fire may threaten a building from without and from within. In the one case protection must be external and its nature will be determined by the proximity of other buildings. In the other case, the protection must be internal and will depend upon the nature of the contents of the building and of its interior finish.

Added height and greater congestion of buildings bring with them increased possibilities of a conflagration and complicate the problems of the fire department.

From these considerations, the requirements in part 2 of this report have been built up. Emphasis is placed upon inherent fire resistance in the building, this resistance varying with use, height, location, and other factors. The less severe requirements achieve a moderate degree of fire resistance in the smaller combustible structures by means of fire stopping and other simple measures. The more severe requirements call for a building having its structural members so protected that the contents may burn out completely without danger of collapse to the building.

Intermediate between these two are requirements for a moderate amount of " fireproofing " materials and provision for dividing buildings into areas so inclosed that fire may be confined and controlled. Attention is also given to exterior resistance when one building is dangerously exposed to fire from another.

(2) Code requirements on fire resistance deal chiefly with the construction of floors, walls, and partitions, the protection of structural members, the inclosure of vertical openings, and provision for fire-resistive doors and windows. It has been customary in past years to express minimum requirements for these in terms of dimensions and materials. This practice has had many undesirable results in preventing use or substitution of materials and methods equally efficient, but not mentioned in codes. It is gradually being abandoned in favor of a procedure in which performance standards are set up for each important part of the building, the standards relating in each case to the service required for the structural part when fire occurs, as disclosed in standard fire tests.[8] This method has been taken as the guiding principle of the requirements contained in this report. Certain details as to minimum dimensions are given

[8] Illustrations of this trend are to be found in the building codes of Pittsburgh, Pa., and Kansas City, Mo., the proposed uniform building codes prepared by the Pacific Coast Building Officials' Conference and the Florida Building Officials' Conference, and the Fireproofing Specification published by the American Institute of Steel Construction mentioned on p. 21.

in the requirements, but, in general, the requirements for a structure of given occupancy and type are presented in terms of the necessary ultimate fire resistance of various structural members, while dimensions and materials believed capable of affording the required fire resistance are not made a part of the requirements, but are listed in the Appendix as a matter of information. The order in which the various materials appear in each time classification given later in paragraph 6 has no special significance. Information presented there is based on tests, inferences from tests, or performance in actual fires. Thicknesses necessary to effect the proper degree of fire resistance should, wherever possible, be determined directly by appropriate tests. Where no data are available for a given material and no history of its performance under fire conditions, caution should be exercised in permitting its use.

(3) Fire testing of materials and assemblies under controlled conditions is a development of the last 40 years in this country, and some of the methods of procedure have become reasonably stabilized only in the last decade. Tests of floors and partitions were inaugurated by the bureau of buildings in New York City in 1896 and were later carried on in cooperation with Prof. Ira H. Woolson, who established a testing station at Columbia University. Some tests on columns were made in New York and elsewhere even earlier, but evidence regarding these members was slower to accumulate and it was not until 1918 that comprehensive data became available. The progress of such testing work was dependent upon general agreement as to procedure, and the appointment of a committee by the American Society for Testing Materials in 1905 to attack this problem was a significant step. This committee brought in recommendations in 1907 which have been modified several times in the light of experience and have culminated in the tentative standard C19–26T of the society, which has also been accepted as a tentative standard by the American Engineering Standards Committee, now the American Standards Association.

In the foregoing specification the control of the fire tests is governed by a standard time-temperature curve which specifies the furnace temperature at any time from the start of the test up to eight hours, and is determined from the average reading of several thermocouples symmetrically disposed and distributed to show the temperature near all parts of the panel. The method of taking the temperatures on the unexposed surfaces, the number of points at which such temperatures shall be taken, and the interval for reading the temperatures are also outlined under the description of the control of the tests.

The conduct of the fire tests is next outlined with a general requirement that the fire-endurance test on the sample with its applied load, if any, shall be continued until failure occurs, or until it has withstood the test conditions for a period equal to that specified in the conditions of acceptance for the given type of construction. Details governing the fire-stream test, where required, are also given.

Requirements are then set up for the methods to be employed in testing bearing walls and partitions, nonbearing walls and partitions, columns, floors and roofs, and tests for finish for walls, partitions, and ceilings. The size of the sample, the loading to be applied,

except in the case of nonbearing walls and partitions and finishes, and the conditions of acceptance are specified for each classification.

The required conditions in the tests of bearing walls and partitions, nonbearing walls and partitions, and floors and roofs are quite similar. In general, they specify that the construction shall have sustained the applied load, in case loading is required, during the fire-endurance test without passage of flame or gases hot enough to ignite cotton waste for a period equal to that for which classification is desired; that the construction shall sustain the applied load during the fire, and during the fire-stream test where required under the specified conditions; that the fire stopping, if any, shall have functioned to prevent passage of fire for a period equal to that for which classification is desired; and that transmission of heat through the construction during the fire-endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250° F. above its initial temperature.

In the tests of columns, the column is required to be loaded in a manner calculated to develop theoretically as nearly as practicable the working stresses contemplated by the design, and the test is not regarded as successful unless the column shall have sustained the applied load during the fire-endurance test for a period equal to that for which the classification is desired.

Numerous tests of this character have now been conducted under these specifications, and it is therefore possible to correlate the data that have been prepared at the different laboratories.

A suggested standard specification for fireproofing structural steel buildings has been promulgated by the American Institute of Steel Construction. This specification provides that the steel be insulated with a sufficient amount of material to protect it against a temperature rise which would seriously impair its ability to sustain the loads at the unit stresses used in the design. The maximum fire hazard to be expected from the occupancy as indicated by the amount of combustible contents present is used as the basis for determining what time rating is required of the protective covering. This hazard is determined by the same methods and with the same values as given on page 23.

The test procedure of the American Institute of Steel Construction specification includes that set forth in the tentative specification for fire testing of building construction and materials, serial designation C19–26T of the American Society for Testing Materials, but sets up an alternative method of defining the ultimate fire resistance based on the maximum temperature at which structural steel is estimated to carry the unit stresses used in the design.

(4) Tests of fire-resistive doors, shutters, windows, and other devices for protecting openings have been a feature of the work of the Underwriters' Laboratories at Chicago over a considerable period, and are universally recognized in the absence of any other standards. The devices are quite generally submitted for test by manufacturers and bear the underwriters' label when meeting the requirements for the location in which they are to be used. The ratings given by the underwriters are not in terms of time, which is somewhat unfortunate in view of the use of time ratings for other materials, but the test as conducted is of one hour duration. On the whole, the classifica-

tions are on a less satisfactory basis than that of floors, partitions, and columns and the question of what to require for given fire exposures is correspondingly difficult.

(5) Tests of various kinds of roofing have been conducted by the Underwriters' Laboratories and at the Bureau of Standards. The tests are designed to bring out such qualities as susceptibility of ignition from burning brands of various sizes, production of brands at various wind velocities, and rate of spread of fire after ignition has taken place.

(6) The maintenance of certain safeguards and precautions must be taken into account in drafting code requirements for fire-resistive construction. A large number of cities maintain competent and adequately equipped fire-fighting forces, and the services of such equipment are promptly available within a reasonable period after a fire is discovered. When standpipes, sprinklers, or other safeguards are recognized in determining code requirements it is assumed that these will conform to generally accepted standards. The maintenance of all such equipment in working condition, and the prevention of peculiarly hazardous conditions in the building, not ordinarily incidental to its use, are assumed.

In arriving at requirements for the highest type of construction from a fire-resistance standpoint, however, the committee believes it proper to recognize such possibilities as failure of apparatus or water supply, or delay in discovery of the fire, since this type is permitted with high concentration of combustible contents and must also serve as the chief bulwark in the event of a conflagration. Accordingly, the requirements contemplate that a possible complete burn out will not destroy the structural integrity of the building.

Where egress is a controlling consideration it is assumed that a choice of exits will be provided sufficient in number and size to insure the safety of the occupants.

(7) There are certain administrative provisions for effective control over construction which deserve consideration. These include the provision for changes in occupancy mentioned on page 26. Another provision frequently applied is that when a building is damaged by fire or other cause to the extent of 50 per cent of its value any rebuilding shall conform in all respects to the requirements for new construction. These provisions belong properly to the administration section of the code, but if for any reason they do not appear there they should be taken up in connection with the sections on occupancy and types of construction.

Paragraph 2. CLASSIFICATION BY OCCUPANCY

(1) Classifications of buildings are a necessary feature of building codes for a variety of reasons, such as provision for light, ventilation, and fire resistance.

(2) It is generally recognized that proper egress facilities alone can not be assumed to provide everything necessary for safety to life. The character of the fire that may occur has a large bearing on safety considerations, and this is of course dependent upon the nature of the occupancy. By successive steps of reasoning it becomes imperative to make at least rough classifications of occupancy

and then match structural protections of known efficiency against the hazard to be expected from the occupancies, so that the pathways to exits may be guarded, premature collapse of supporting members prevented, and a possible conflagration through spreading to other buildings stopped. Any logical basis for requirements must thus not be confined to narrow grounds, but must take into consideration the whole possible series of events.

(3) This report does not attempt to state where stair wells or horizontal fire barriers shall be placed to secure safe egress of occupancies, but merely describes the necessary fire-resistive inclosures or the resistance of fire walls or partitions when required to protect egress. There are, however, occupancies, such as small dwellings, where exit facilities are limited to some extent by economic considerations, and others, such as asylums, hospitals, etc., for which prompt egress is difficult or impossible for other reasons. These conditions have not been overlooked in preparing the list of occupancies and in drawing up the various requirements concerning them.

(4) A few years ago resort to estimation would have been necessary in any system of requirements based upon the severity of fire to be expected from various occupancies. To-day carefully conducted tests, such as those performed at the Bureau of Standards under the direction of S. H. Ingberg, have provided valuable basic information. Present indications based on complete burn outs of typical office and record room occupancies, in test structures with no attempt to limit the duration by water or otherwise, are that the maximum fire effects will vary with the weight of combustible contents as follows:

Combustible contents (weight of furniture, flooring, trim, etc.)	Approximate B. t. u. content	Maximum fire hazard (destructive effect equivalent to standard fire test)
Lbs./ft.[2]		*Hours*
10	80,000	1
15	120,000	1½
20	160,000	2
30	240,000	3
40	320,000	4½
50	380,000	6
60	432,000	7½

The combustible contents referred to in the table represent the total weight of all combustible furniture, flooring, trim, etc. The maximum fire hazard given represents the period during which an equivalent destructive effect would be produced by a fire regulated to correspond to the standard time-temperature curve given in the standard fire test.

It is recognized that the character of fire in other combustible contents may differ from those mentioned, especially as the higher weights of combustible contents are reached. The number of heat units in many kinds of industrial contents is considerably above that

furnished by wood and paper in office occupancy. The figures given must be regarded merely as a guide to be used with judgment until a complete survey of occupancies discloses the relative hazards of each.

Mr. Ingberg suggests an approximate method of grouping combustible contents as follows: "In computing combustible contents, wood, paper, cotton, wool, silk, straw, grain, sugar, and similar organic materials shall be taken at their actual weight. The actual weight of animal and vegetable oils, fats, and waxes, petroleum products, asphalt, bitumen, paraffin, pitch, alcohol, and naphthalene shall be multiplied by two for the purpose of determining combustible contents." In the quarterly of the National Fire Protection Association for July, 1928, he gives a table of B. t. u. content which enables somewhat closer approximations to be made. This follows:

Calorific values of materials

Substance	Moisture calorific value		Reference
	Per cent	British thermal units per pound	
Coal:			
Anthracite (Pennsylvania only)	2.3- 2.2	12,520-13,830	1
Semianthracite (Pennsylvania only)	3.4- 3.2	13,120-13,360	1
Semibituminous	2.4- 2.0	13,710-14,810	1
Bituminous	14.2- 1.6	10,020-14,700	1
Subbituminous	20.5-13.5	8,690-11,140	1
Lignite	43.5-32.6	5,810- 7,360	1
Peat	90.3-54.7	510- 4,100	1
Cannel coal	1.5- 0.4	10,850-15,000	1
Coke	0.2- 0.1	11,690-12,810	1
Charcoal	3.2	12,920	1
Woods:			
Ash	Dry.	8,480	5
Beech	13	7,510	11
Birch	12	7,580	11
Elm	Dry.	8,510	5
Fir	Dry.	9,060	5
Hardwood (average several species)	10.8	8,120	6
Locust	(1)	8,640	3
Oak	13	7,180	11
Pine	12.3-10.5	8,000- 8,420	6
Soft wood, resinous	10.4	8,530	6
Straw:			
Buckwheat	Dry.	5,590	7
Flax	Dry.	6,750	7
Wheat	Dry.	6,290	7
Tanbark	Dry.	9,500	10
Bagasse	53	3,910	7
Petroleum products:			
Crude and fuel oil	(2)	18,610-19,710	6
Gasoline	(2)	19,800-20,520	6
Kerosene	(2)	19,710-19,890	6
Coal-tar oil	(2)	17,890-18,400	1
Gas oil	(2)	19,260-19,580	3
Asphalt (pure)	(2)	17,160	13
Bitumen (pure)	(2)	15,140	5
Ozokerite	(2)	19,170-19,710	1
Paraffin	(2)	17,960-20,110	1
Pitch	(2)	15,120	4
Gas:			
Natural (B. t. u. per cubic foot)	(2)	710- 2,250	1
Oil (B. t. u. per cubic foot)	(2)	510- 800	1
Coal (B. t. u. per cubic foot)	(2)	450- 670	1
Producer (B. t. u. per cubic foot)	(2)	100- 180	1
Water (B. t. u. per cubic foot)	(2)	300- 670	1
Cotton, combed	Air dried.	7,160	6
Silk, "fiber"	(1)	9,230	3
Wool, raw	Air dried.	9,790	6
Wool, scoured	Air dried.	8,890	6

[1] Moisture content not stated. [2] Moisture free or pure substances assumed.

Calorific values of materials—Continued

Substance	Moisture calorific value		Reference
	Per cent	British thermal units per pound	
Paper (ash, 7.0 to 1.4 per cent)	5.0– 4.8	6,710– 7,830	6
Cellulose	(2)	7,570	8
Starch	(2)	7,610	8
Guncotton	(1)	1,900	3
Dynamite, 75 per cent	(1)	2,320	3
Casein	(1)	10,550	12
Animal and vegetable oils:			
Cod liver	(2)	16,980	1
Lard	(2)	17,010	1
Menhaden	(2)	16,850	1
Shark	(2)	16,870	1
Sperm	(2)	17,900	1
Whale	(2)	17,050	1
Arachis	(2)	16,940	1
Almond	(2)	17,010	1
Castor	(2)	15,950	1
Cottonseed	(2)	16,920	3
Linseed	(2)	16,860	1
Maize	(2)	16,950	1
Olive	(2)	17,020	1
Poppy	(2)	16,890	1
Rapeseed	(2)	17,080	1
Sesame	(2)	16,910	1
Fats and waxes:			
Animal fats, mean	(2)	17,100	2
Butter fat	(2)	16,770–16,850	1
Goose fat	(2)	17,110	1
Lard	(2)	17,110–17,380	1
Oleomargarine	(2)	17,280	1
Tallow	(2)	17,100	12
Stearic acid	(2)	16,870	12
Chemicals:			
Carbon, graphite	(2)	14,540	14
Hydrogen	(2)	61,060	15
Sulphur	(2)	4,000	14
Acetylene	(2)	20,750	9
Amyl alcohol	(2)	16,120	14
Benzene	(2)	18,050	12
Benzoic acid	(2)	11,390	6
Carbon disulphide	(2)	6,130	8
Ethyl alcohol	(2)	12,930	14
Ethyl ether	(2)	22,000	2
Ethylene	(2)	21,340	14
Glycerin	(2)	7,770	12
Methyl alcohol	(2)	9,550	14
Naphthalene	(2)	17,320	6
Sucrose (sugar)	(2)	7,110	6

[1] Moisture content not stated.
[2] Moisture free or pure substances assumed.

References (refer to last column of table):
1. International Critical Tables.
2. Smithsonian Tables.
3. Landolt-Bernstein Physikalisch-Chemische Tabellen.
4. Van Nostram's Chemical Annual.
5. Poole: The Calorific Power of Fuels.
6. Bureau of Standards, by tests.
7. Kent's Mechanical Engineers' Pocket Book.
8. Berthelot.
9. Thomsen.
10. Sherman.
11. Gottlieb.
12. Stohman.
13. Slossen and Colburn.
14. Favre and Silbermann.
15. Roth.

Tests conducted at the Bureau of Standards indicate that the known calorific values of various materials may be utilized to great advantage in interpreting the probable fire hazard of such materials.

(5) In selecting the broad occupancy classifications used in part 2, section 3–1, a number of suggested classifications were studied from the point of view of inherent logic and feasibility of application.

The majority were rather elaborate, and yet failed to cover every possible contingency. Admitting that it is difficult to enumerate every existing occupancy, and to draw clear-cut distinctions between various groups, and that it is impossible to foresee classes that will develop with changing conditions, the conclusion is inevitable that a certain degree of discretion must be left to the building official. This has been done in part 2, broad classifications being given with the understanding that border-line cases are to be decided by the building official, from whose decisions there is provision for appeal in most cities in case of dissatisfaction. Within these classifications, again, the official will have to take note of the nature and amount of combustible contents when required by other provisions of the code.

There are certain kinds of occupancy which demand extra precautions. These include woodworking establishments, mattress shops, dry-cleaning plants, and similar places where a severe fire is likely to develop quickly. The peculiar requirements necessary for the safe conduct of such lines of business are frequently covered in a fire-prevention ordinance. Further reference to them is made in the discussion on undivided area requirements in paragraph 4.

Structures, such as coal tipples, ice houses, and material bins, have not been treated in the recommended minimum requirements because they have been deemed special cases not suited for inclusion in a building code. Permission for their erection and regulations concerning them have been considered matters for special municipal action as each case arises.

Paragraph 3. CLASSIFICATION BY TYPES OF CONSTRUCTION

(1) The choice of terms used in part 2 is felt to be in line with present-day thought. The term "fireproof" has been widely used but inadequately defined, with the result that structures varying considerably in fire resistance have been included within the term at various times and places. "Fully protected" and "protected" are believed to more nearly describe the fire-resistive capacity of each type.

(2) The conception of a "fully protected" building is that of one in which the structure is designed for the probable fire hazard due to the contents somewhat in the same way as it is designed for probable live load, except that it has been judged necessary to provide a fixed minimum of fire resistance for various structural members. Once having been built to the unlimited height and undivided area permitted, no change of occupancy involving a greater hazard than that provided in the design should be permitted unless in the rather improbable event of increasing the fire resistance of the structural members by appropriate proportions. As with the Building Code Committee's recommendations for live load assumptions, provision should be made preferably in the administration section of the code, for control over changes of occupancy in all types of buildings, including a requirement for changes providing a greater degree of fire resistance when needed in the opinion of the building official.

(3) The "protected" building offers considerably less fire resistance than the "fully protected," but this resistance is fixed. Where

economic conditions preclude the use of heavier construction, this type has a legitimate field within the height and undivided area limitations allowed it.

(4) The "heavy timber" building, frequently referred to as "mill construction," has been extensively built. It has made a notable record of fire resistance, particularly when provided with automatic sprinklers, as is customarily done when used for manufacturing or commercial purposes. The definition is taken with slight modifications from one of the National Fire Protection Association, to which acknowledgment is made.

(5) The "masonry wall and joist" type of building is frequently referred to as "ordinary" construction. Although this seems to be fairly well established usage, it has been felt that a less vague title would be better.

(6) The "unprotected metal" building is one somewhat difficult to define, but is intended to include not only metal-framed structures covered with sheet metal, but also covered with other materials similar in form, such as corrugated glass or inclosed by nonbearing masonry walls of less thickness than customarily required.

(7) The committee is of the opinion that, although additional resistance to exposure is furnished by exterior 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 building when burning offers approximately the same hazard to near-by structures as wood frame.

(8) It should be understood that the placing of the various types of construction in the order given is not a way of expressing their relative desirability. Each type has its legitimate place within the location, size limitation, and use for which it is fitted. Building codes should not be made a lever for forcing a particular type of construction upon a community, but should so adjust their requirements that each type ceases to be a fire menace.

Paragraph 4. GENERAL BUILDING RESTRICTIONS

(1) The creation of fire districts is a well-established method of dealing with varying hazards due to fire exposure. The probability of a fire assuming serious proportions is measured by the amount of material available for it to feed upon, and this increases as structures become crowded together in certain districts.

When fixing the boundaries of the "first fire district," a careful survey should be made of all closely built mercantile and adjoining manufacturing districts and of contiguous blocks on all sides which constitute an exposure to them or within which new construction of a mercantile or manufacturing character is developing.

(2) Various plans have been proposed to furnish additional protection against the sweep of a conflagration, such as the establishment of belts within the city where only construction such as that permitted in the "first fire district" is permitted and provision for a strip containing only similar construction 100 to 200 feet wide along each side of all main highways penetrating the outer fire zones

when the density of construction along the highways warrants such inclusion. With buildings of good exterior resistance and with openings protected as required in the code these should be effective. The latter method offers a means of gradually building up lines where a stand can be made against the sweep of a conflagration without making requirements unduly burdensome. Such expedients should be given consideration when fitting the fire-districting scheme decided upon to the local conditions.

(3) The location of fire district lines by whatever method employed must always be more or less arbitrary and is sure to create anomalous restrictions as to the character of construction permissible upon opposite sides of such lines. It is well to provide in the code for a commission to consider the matter of fire limits at fixed intervals of five years in order to avoid any seeming discrimination or arbitrary functioning of municipal action in determining when a relocation is necessary. Such a commission should include the city engineer and chief of the fire department.

(4) The height at which construction requirements should become more drastic from a fire-resistance standpoint is determined very largely by the height above which a city fire department can not cope successfully with fire from the exterior of a building because of limitations of water pressure and apparatus. This limit will vary to some extent in different cities, and building codes should vary accordingly.

(5) The undivided areas given in part 2 are based upon a study of existing requirements and recommendations. The committee has also had the benefit of an analysis of opinion offered by fire chiefs throughout the country during a survey by its late chairman, Ira H. Woolson. Some difference of opinion exists as to whether limiting areas should be required for all types of construction, but the committee has not felt this necessary where such limiting areas are omitted in section 4–3 of part 2.

Where increased undivided areas are permitted in section 4–3 for 1-story buildings of certain types of construction used for public assembly purposes, the accompanying requirement that such areas shall not be subdivided by minor partitions is not intended to prevent the use of ticket offices and similar necessary rooms of limited number and size.

(6) It is recognized that there are many manufacturing processes involving low hazard with only minor amounts of combustible material, which would be unable to function efficiently if limiting areas were required. Drastic and inflexible area limitations for all types of construction which do not recognize the economic necessity in such cases are not likely to find successful application. On the other hand, there are other cases, such as dry-cleaning, woodworking, and mattress-making establishments that require complete segregation from other parts of the building. As already stated in a previous paragraph, requirements for the latter kind of occupancy must often be so detailed and specific as to make a separate fire-prevention ordinance advisable.

(7) In undeveloped districts of some cities and where land is comparatively inexpensive, owners will occasionally desire to set large buildings back from the street line. Provided there is reasonable assurance that the space between the street and building will be kept

unobstructed so that the fire department can function efficiently, there appears to be no valid reason why such buildings should not be permitted the same undivided areas as if built directly to the street line. This has accordingly been recognized in the recommended requirements.

(8) Certain combinations of occupancies, such as theaters and business in the same building, are recognized as especially hazardous. The committee has not felt it necessary to make an elaborate list of these but has covered special cases that seemed to demand attention.

(9) The requirements for private garages combined with dwellings are similar to those in the committee's report entitled "Recommended Minimum Requirements for Small Dwelling Construction," issued in 1923. Reference should be made to paragraph 56 in the Appendix of that report for an extended discussion of reasons for the requirements. In general, the requirements in this report are less severe than in the former one, experience having indicated that the modifications are justified.

(10) Provision might be made in local codes for relaxing the requirements for roofing in section 4–1, part 2, when the roofing is on buildings outside the fire districts, provided that, in the opinion of the administrative building official, such buildings are sufficiently far apart to make communication of fire improbable. This would extend to permitting the use of edge-grain wood shingles of the thickness known as 5/2 or greater. These shingles, after weathering, have demonstrated superiority to weathered flat-grain wood shingles in resistance to fire.

Paragraph 5. MIXED OCCUPANCY PROVISIONS

(1) Accumulation of gasoline vapor is always a possibility in both public and private garages. Being heavier than air, such vapor flows from a higher to a lower level in much the same manner as water, although invisible. The provision in sections 4–4–4 and 4–4–5 that the doorsill of a doorway from a garage to another part of a building should be at least 1 foot above the garage floor level affords a barrier to the flow of the vapor. Wherever practicable it is better to have no opening from a garage into another part of a building, and this is especially true where the other part contains a heating appliance, electric generator, or other equipment capable of igniting the vapor.

Paragraph 6. PROTECTION OF STRUCTURAL MEMBERS

(1) The requirements of part 2 of this report are minimum requirements and are based upon certain broad principles. To apply these principles in writing a local code it may be considered necessary to state specific provisions for protection of structural members. In any event, it is obvious that authoritative information must be at hand to determine what will meet the requirements.

(2) Lists giving ultimate fire-resistance periods for various materials and thicknesses, based on a study of available test data and of experience in fires, are given later in this paragraph. Much of this information is tentative, as tests for fire resistance by no means cover the range given and have often been conducted under condi-

tions considerably different from those required to-day. As already noted, such testing is a comparatively recent development and its progress has lagged far behind testing for strength of materials. Fortunately there is a growing recognition of its importance. There is a nucleus of material about which can be built a science of fire resistance. In the lists which appear below it has been thought wise to set forth those materials and thicknesses which, on the basis of performance under fire conditions and in laboratory tests, are, in the committee's judgment, entitled to consideration in adopting specific requirements. Where information indicating that the particular material and thickness has passed the American Society for Testing Materials test has come to the attention of the committee this fact is emphasized by the use of **This Black-Face Type.** Similarly, where the test procedure of the New York Bureau of Buildings has been followed, this is indicated by ***This Black-Face Type.*** Values that are estimates believed to be reasonable are given in *italics.*

The various thicknesses given are not necessarily comparisons of materials thickness for thickness. Customary commercial sizes have been chosen, resulting in some variations between materials which would not obtain if these materials were manufactured in the same sizes.

In the case of hollow masonry unit protections the thicknesses given are, in general, predicated on the use of units conforming in weight, thickness of shells and webs, and other details to the current standards of the American Society for Testing Materials, the American Concrete Institute, or such other recognized standards as apply.

In a number of cases the given material has exhibited a considerably greater ultimate fire resistance than that shown, but must be used for the given period because the next smaller commercial size would not be sufficient.

(3) Based on the information available at this time the committee believes that the following protections or construction may be assumed to meet the periods of ultimate fire resistance required in part 2.

In the case of occupancies which develop a greater fire hazard than the maximum shown, the determination of necessary thicknesses for protections or construction should be arrived at by approved engineering design, using such test information as is shown in paragraph 7 or such other authentic information as is available.

WALLS

Total thickness [9] exclusive of plaster. When plastering is required it should be at least ½-inch gypsum or Portland cement plaster unless otherwise specified. The thickness of the wall or partition must be sufficient from the standpoint of strength as well as that of fire resistance. (For this and other recommendations see the committee's report entitled "Recommended Minimum Requirements for Masonry Wall Construction.")

[9] When combustible members frame into solid walls the required thickness should be taken from 2 inches back of the end in the wall to the opposite outside face. When combustible members frame into hollow walls, the space above, below, and between them, and the space between the ends and the opposite face of the wall, should be filled solidly with burnt clay material, mortar, concrete, or equivalent fire-resisting material to a depth of not less than 4 inches.

Four hours

8 inches or more solid walls of clay, shale, concrete, or sand-lime brick, plastered or unplastered.

12 inches or more hollow walls of clay or shale brick, plastered or unplastered; or 8 inches or more if plastered on both sides.

12 inches or more hollow walls of concrete or sand-lime brick plastered or unplastered; or 8 inches or more if plastered on both sides.

12 inches or more hollow clay tile,[10] containing two units and not less than three cells in the thickness of the wall, plastered or unplastered.

8 inches or more hollow clay tile,[10] containing one unit and not less than two cells in the thickness of the wall, plastered on both sides with at least ½-inch gypsum plaster.

12 inches or more 1-piece concrete block,[11 12] containing not less than two cells in the thickness of the wall, plastered or unplastered.

8 inches or more 1-piece hollow concrete block,[11] shells and webs at least 1½ inches thick, plastered on both sides.

8 inches or more hollow Rolok-Bak walls of clay or shale brick, plastered on one side.

4 inches or more concrete block,[11] faced with at least 3¾ inches brick, limestone, or terra cotta, plastered on one side.

4 inches or more hollow clay tile [10] faced with at least 3¾ inches brick, plastered on one side.

8 inches or more hollow clay tile [10] faced with at least 3¾ inches brick, plastered or unplastered.

8 inches or more 1-piece concrete block [11] faced with at least 3¾ inches brick, limestone, or terra cotta, plastered or unplastered.

Six inches or more solid reinforced concrete, reinforced in both directions with not less than 0.4 of 1 per cent reinforcement. Maximum size of coarse aggregate not to exceed three-fourths inch.

Any other material or construction of such thickness as to develop four hours ultimate fire resistance under the conditions of the standard fire test.

Three hours

Any of the above or the following:

8 inches or more hollow clay tile [10] containing two units and not less than four cells in thickness of the wall, plastered or unplastered.

12 inches or more hollow clay tile,[10] containing one unit and not less than three cells in the thickness of the wall, plastered or unplastered.

8 inches or more 1-piece concrete block,[11 12] shells not less than 1½ inches thick, plastered on one side.

8 inches or more 1-piece concrete block,[11 12] shells not less than ? inches thick, coarse aggregate limestone or calcareous gravel, unplastered.

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[10] The ratings for hollow tile are predicated on the use of tile conforming to the Standard Specifications for Hollow Burned Clay Load Bearing Wall Tile, serial designation C34–30 of the American Society for Testing Materials.

[11] The ratings for concrete block are predicated on careful and uniform manufacture. Where the term "concrete block" only is used all aggregates, including cinders, are meant. Where the term is qualified the rating is limited to the aggregate given.

[12] Certain types of concrete block have obtained a greater ultimate fire resistance under the standard fire test.

8 inches or more 1-piece cinder concrete block,[11] shells not less than 2 inches thick, unplastered.

6 inches or more 1-piece cinder concrete block,[11] shells not less than 2 inches thick, plastered both sides.

12 inches or more concrete block, containing one cell in the thickness of the wall, plastered or unplastered.

4 inches or more 1-piece concrete block [11] faced with at least 3¾ inches brick, limestone, or terra cotta, plastered or unplastered.

8 inches or more 1-piece concrete block,[11] shells not less than 1½ inches thick, oval cores, coarse and fine aggregate of burnt clay or shale, unplastered.

5 inches or more solid reinforced concrete, reinforced in both directions with not less than 0.4 of 1 per cent reinforcement. Maximum size of coarse aggregate not to exceed three-fourths inch.

Two and one-half hours

Any of the above or the following:

8 inches or more hollow walls of clay or shale brick, plastered or unplastered.

8 inches or more hollow walls of concrete or sand-lime brick, plastered or unplastered.

8 inches or more concrete block, shells not less than 2 inches thick, unplastered.

8 inches or more concrete block,[11] shells not less than 1½ inches thick, coarse aggregate limestone or calcareous gravel, unplastered.

8 inches or more hollow clay tile [10] containing not less than three interior cells in the thickness of the wall and having double shells, plastered or unplastered.

8 inches or more T-shaped hollow clay tile containing not less than two cells in the thickness of the wall, plastered or unplastered.

Any other material or construction of such thickness as to develop two and one-half hours ultimate fire resistance under the conditions of the standard fire test.

Two hours

Any of the above or the following:

8 inches or more hollow clay tile [10] containing not less than three cells in the thickness of the wall, plastered or unplastered.

8 inches or more concrete block, shells not less than 1½ inches thick, unplastered.

Any other material or construction of such thickness as to develop two hours ultimate fire resistance under the conditions of the standard fire test.

PARTITIONS

Thicknesses refer to total thickness of the construction.[13] Where plastering is required, but no thickness given, it should be gypsum or Portland cement plaster at least one-half inch thick. Ratio of

[10] The ratings for hollow tile are predicated on the use of tile conforming to the Standard Specifications for Hollow Burned Clay Load Bearing Wall Tile, serial designation C34–30 of the American Society for Testing Materials.

[11] The ratings for concrete block are predicated on careful and uniform manufacture. Where the term "concrete block" only is used all aggregates, including cinders, are meant. Where the term is qualified the rating is limited to the aggregate given.

[13] An exception is made in the case of stud partitions of one hour ultimate fire resistance.

height of partition to thickness not to exceed 30 unless partition is rigidly anchored at top and bottom.[14]

Two hours

3¾ inches or more clay or shale brick, plastered both sides.

3¾ inches or more concrete or sand-lime brick, plastered both sides.

8 inches or more hollow clay tile containing two cells in the thickness of the wall, plastered on one side.

8 inches or more hollow clay tile containing three cells in the thickness of the wall, unplastered.

6 inches or more hollow clay tile, containing not less than two cells in the thickness of the wall, plastered on both sides.

4 inches or more concrete block,[15] plastered both sides.

3 inches or more hollow gypsum block, plastered both sides.

4 inches or more solid reinforced concrete, reinforced in both directions with not less than 0.4 of 1 per cent reinforcement, maximum size of coarse aggregate not to exceed three-fourths inch, unplastered; or 3 inches if plastered on both sides.

2 inches or more solid partitions of neat fibered gypsum plaster on expanded metal lath on incombustible studding.[16] [17]

2 inches or more solid partitions of neat fibered gypsum plaster on wire lath on incombustible studding.

Any other material or construction of such thickness as to develop two hours' ultimate fire resistance under the conditions of the standard fire test.

One hour

Any of the above or the following:

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,[15] 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 three-fourths inch.

2½ inches or more solid partition of Portland cement plaster on expanded metal or wire lath on incombustible studding.[18]

2½ inches or more solid partition of sanded gypsum plaster on expanded metal lath on incombustible studding.[17] [19]

2½ inches or more solid partition of sanded gypsum plaster on wire lath on incombustible studding.[19]

2 inches or more solid partition of sanded gypsum plaster on expanded metal lath or wire lath on incombustible studding.[20]

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[14] The height ratio requirement applies only to those partitions required to have definite fire resistance; for height ratio of other partitions see Recommended Minimum Requirements for Masonry Wall Construction, p. 18.

[15] The ratings for concrete block are predicated on careful and uniform manufacture. Where the term "concrete block" only is used all aggregates, including cinders, are meant. Where the term is qualified the rating is limited to the aggregate given.

[16] Weight of expanded metal or wire lath to be not less than 2.2 pounds per square yard; number of meshes 2½ per inch or equivalent.

[17] Based on temperature transmission in an actual test on a small-sized panel, using standard fire exposure.

[18] Mix should not be leaner than 1 cement, $\frac{1}{10}$ lime, 2 sand.

[19] Mix should not be leaner than 1 gypsum, 2½ sand.

[20] Mix should not be leaner than 1 gypsum, 2 sand.

Hollow partition of at least 5/8-inch neat fibered gypsum plaster on at least 3/8-inch gypsum plaster board on each side of incombustible studding.

Hollow partition of at least 1/2-inch wood fibered unsanded gypsum plaster on at least 3/8-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.[21]

Hollow partition of at least 3/4-inch gypsum plaster on expanded metal lath on each side of combustible studding, fire stopped.

Hollow partition of at least 3/4-inch Portland cement plaster on expanded metal lath on each side of incombustible studding,[17] *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 3/4-inch gypsum plaster on expanded metal lath on each side of incombustible studding.[17]

Hollow partition of at least 3/4-inch gypsum plaster on wire lath on each side of incombustible studding.

Any other material or construction of such thickness as to develop one hour ultimate fire resistance under the conditions of the standard fire test.

STEEL COLUMNS

All interior or reentrant spaces filled with concrete or the same material as the protection unless otherwise noted. When plastering is required, but the material and the thickness is not given, the plastering should consist of at least 1/2-inch gypsum or Portland cement plaster.

Four hours

2 inches or more concrete; coarse aggregate limestone, calcareous gravel or trap rock.

2 inches or more concrete; coarse aggregate blast-furnace slag, burnt clay, or shale.

2 1/2 inches or more concrete; coarse aggregate granite, sandstone, or cinders, wire ties or metal mesh reinforcement.

3 inches or more concrete; coarse aggregate siliceous[22] *gravel, metal mesh reinforcement.*

3 3/4 inches or more brick, brick fill.

Two 2-inch layers or more hollow clay tile,[23] hollow clay tile fill, metal mesh in horizontal joints.

2 inches or more hollow clay tile,[23] limestone concrete fill, wire mesh in horizontal joints, plastered with at least 3/4-inch gypsum plaster.

4 inches or more hollow clay tile,[23] limestone concrete fill, wire mesh in horizontal joints, plastered with at least 5/8-inch lime plaster.

2 inches or more hollow clay tire,[23] *shells and webs at least three-fourths inch thick, concrete fill, well anchored or bonded, plastered.*

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[17] Based on temperature transmission in an actual test on a small-sized panel, using standard fire exposure.

[21] Weight of lath should not be less than 2.2 pounds per square yard.

[22] The term siliceous as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar materials. It would be desirable to have investigations made of the gravel in use in a given locality so that no unnecessary thickness of protection is required.

[23] Hollow clay tile used for column protection should conform in quality to the specifications for Hollow Burned Clay Fireproofing Partition, and Furring Tile of the American Society for Testing Materials, serial designation C56-30.

4 inches or more hollow clay [23] *or concrete* [24] *tile; fill of concrete, coarse aggregate calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale, well anchored or bonded, plastered.*

Two 2-inch layers or more hollow concrete [24] *tile; or one 4-inch layer, well anchored or bonded, plastered.*

3 inches or more hollow gypsum block, well anchored or bonded, no fill, plastered with at least ½-inch gypsum plaster.

2 inches or more poured gypsum, wire mesh reinforcement, plastered with at least ½-inch gypsum plaster.

2 inches or more poured gypsum, wire mesh reinforcement.

2 inches or more solid gypsum block, well anchored or bonded, plastered with at least ½-inch gypsum plaster.

3 inches or more solid cinder concrete [24] *block or 4 inches or more hollow cinder concrete block, well anchored or bonded, plastered.*

Any other material of such thickness as to develop four hours ultimate fire resistance under the conditions of the standard fire test.

Three hours

Any of the above or the following:

2 inches or more concrete; coarse aggregate sandstone or cinders, wire ties or metal mesh reinforcement.

2 inches or more concrete; coarse aggregate granite, wire ties or metal mesh reinforcement.

1½ inches or more poured gypsum, wire mesh reinforcement, plastered or unplastered.

2 inches or more solid cinder concrete [24] *block, well anchored or bonded, plastered.*

2 inches or more hollow clay tile,[23] limestone or trap concrete fill extending at least ¾ inch outside flanges, well anchored or bonded.

2 inches or more hollow clay tile,[23] *fill of concrete, coarse aggregate calcareous gravel, blast-furnace slag, burnt clay or shale, extending at least three-fourths inch outside flanges, well anchored or bonded.*

Any other material of such thickness as to develop three hours ultimate fire resistance under the conditions of the standard fire test.

Two hours

Any of the above or the following:

1½ inches or more concrete; coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale.

1½ inches concrete; coarse aggregate granite, sandstone, or cinders, wire ties or metal-mesh reinforcement.

2 inches or more concrete; coarse aggregate siliceous [22] *gravel, wire ties or metal-mesh reinforcement.*

2 inches or more hollow clay tile, well anchored or bonded, plastered or unplastered.

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[22] The term siliceous as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar materials. It would be desirable to have investigations made of the gravel in use in a given locality so that no unnecessary thickness of protection is required.

[23] Hollow clay tile used for column protection should conform in quality to the specifications for Hollow Burned Clay Fireproofing Partition, and Furring Tile of the American Society for Testing Materials, serial designation C56–30.

[24] The ratings for hollow concrete block or concrete tile protections are predicated on careful and uniform manufacture.

2 inches or more solid gypsum block, plastered or unplastered, wire mesh in joints.

2¼ inches brick, outside wire ties.

1 inch or more poured gypsum, wire-mesh reinforcement, plastered or unplastered.

2 inches or more solid cinder concrete[24] *block, well anchored or bonded, plastered or unplastered.*

Two ⅞-inch layers Portland cement plaster on expanded metal lath with three-fourths-inch air space between.

Two ⅞-inch layers gypsum or Portland cement plaster on expanded metal or wire lath with ¾-inch air space between.

Any other material of such thickness as to develop two hours ultimate fire resistance under the conditions of the standard fire test.

One hour

Any of the above or the following:

1 inch or more concrete; coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale.

1½ inches or more concrete; coarse aggregate granite, sandstone, cinders, siliceous[22] *gravel; wire ties or metal-mesh reinforcement.*

2¼ inches or more brick, brick fill.

2 inches or more hollow clay tile,[23] granite or cinder concrete fill.

2 inches or more hollow clay tile,[23] well anchored or bonded, no fill.

2 inches or more hollow concrete[24] *tile, well anchored or bonded, no fill.*

1 inch or more Portland cement plaster on expanded metal lath, no fill.

1 inch or more gypsum or Portland cement plaster on expanded metal or wire lath, no fill.

Any other material of such thickness as to develop one hour ultimate fire resistance under the conditions of the standard fire test.

NOTE.—In the case of protections for steel columns ½-inch gypsum plaster may replace an equal thickness of poured gypsum, ½-inch Portland cement plaster may replace an equal thickness of required poured concrete in the given protection, and 1-inch gypsum or Portland cement plaster reinforced with expanded metal lath or wire lath may replace an equal thickness of poured protection.

Metal or wire mesh has proved more effective than wire ties in preventing spalling or dropping off of poured protections. Metal or wire mesh for such protections should weigh not less than 1.5 pounds per square yard, and mesh should measure not greater than 4 by 4 inches. Wire ties for poured concrete protections should be of not less diameter than No. 5 B. & S. gage and should be spaced not more than 8 inches.

Masonry units in order to provide adequate protection should be well anchored or bonded. Wall ties or metal mesh in the horizontal joints have proved effective. Other methods include the use of metal clips connecting one unit to another, outside tie wires not smaller than No. 12 B. & S. gage with at least one tie around each course, or special design of the unit so that positive anchorage to steel or other units is attained. It is recommended that outside tie wires be protected by plastering.

CAST-IRON COLUMNS

Three hours

2 inches or more concrete, coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale.

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[22] The term siliceous as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar materials. It would be desirable to have investigations made of the gravel in use in a given locality so that no unnecessary thickness of protection is required.

[23] Hollow clay tile used for column protection should conform in quality to the specifications for Hollow Burned Clay Fireproofing Partition, and Furring Tile of the American Society for Testing Materials, serial designation C56–30.

[24] The ratings for hollow concrete block or concrete tile protections are predicated on careful and uniform manufacture.

3 inches or more concrete, coarse aggregate granite, sandstone, cinders, siliceous [25] *gravel, wire ties or metal-mesh reinforcement.*

2 inches or more hollow clay tile [26] over three-fourths inch or more mortar, well anchored or bonded.

2 inches or more hollow concrete [27] *tile over three-fourths inch mortar, well anchored or bonded.*

1½ inches or more Portland cement plaster on high-ribbed expanded metal lath having one-half inch broken air space.

1½ inches or more gypsum plaster on high-ribbed expanded metal lath having one-half inch broken air space.

Any other material of such thickness as to develop three hours' ultimate fire resistance under the conditions of the standard fire test.

Two hours

Any of the above or the following:

1½ inches or more concrete, coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale.

2 inches or more concrete, coarse aggregate cinders.

2 inches or more concrete, coarse aggregate granite, sandstone, siliceous [25] *gravel, wire ties or metal-mesh reinforcement.*

Any other material of such thickness as to develop two hours' ultimate fire resistance under the conditions of the standard fire test.

One Hour

Any of the above or the following:

1 inch or more concrete, coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale.

1½ inches or more concrete, coarse aggregate granite, sandstone, cinders, siliceous gravel, wire ties or metal-mesh reinforcement.

1 inch or more gypsum or Portland cement plaster on expanded metal or wire lath.

Any other material of such thickness as to develop one hours' ultimate fire resistance under the conditions of the standard fire test.

NOTE.—In the case of protections for cast-iron columns ½-inch gypsum plaster may replace an equal thickness of poured gypsum, ½-inch Portland cement plaster may replace an equal thickness of required poured concrete in the given protections, and 1-inch gypsum or Portland cement plaster reinforced with expanded metal lath or wire lath may replace an equal thickness of poured protection.

Wire ties for poured concrete protections should be of not less diameter than No. 5 B. & S. gage, and should be spaced not more than 8 inches. Metal or wire mesh for such protections should weigh not less than 1.5 pounds per square yard. Mesh should measure not larger than 4 by 4 inches.

Masonry units in order to provide adequate protection should be well anchored or bonded. Wire ties or metal mesh in the horizontal joints have proved effective. Other methods include the use of metal clips connecting one unit to another, outside tie wires not smaller than No. 12 B. & S. gage with at least one tie around each course, or special design of the unit so that positive anchorage to steel or other units is attained. It is recommended that outside wires be protected by plastering.

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[25] The term siliceous as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar materials. It would be desirable to have investigations made of the gravel in use in a given locality so that no unnecessary thickness of protection is required.

[26] Hollow clay tile should conform in quality to the specifications for Hollow Burned Clay Fireproofing, Partition, and Furring Tile, serial designation C56–30 of the American Society for Testing Materials.

[27] The rating for concrete tile protection is predicated on careful and uniform manufacture.

REINFORCED CONCRETE COLUMNS

Protection outside reinforcing steel.

Four hours

1½ inches or more concrete; coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag.

1½ inches or more concrete, coarse aggregate burnt clay or shale.

2 inches or more concrete, course aggregate granite, sandstone or siliceous[28] *gravel. Coarse aggregate not to exceed ¾-inch in diameter.*

Any other material of such thickness as to develop four hours ultimate fire resistance under the conditions of the standard fire test.

Three hours

Any of the above or the following:

1½ inches or more concrete; coarse aggregate granite, sandstone, or siliceous[28] gravel.

Any other material of such thickness as to develop three hours ultimate fire resistance under the conditions of the standard fire test.

Two hours

Any of the above or the following:

Any other material of such thickness as to develop two hours ultimate fire resistance under the conditions of the standard fire test.

One hour

Any of the above or the following:

1 inch or more concrete, coarse aggregate not to exceed ¾ inch in diameter if siliceous.[28]

Any other material of such thickness as to develop one hour ultimate fire resistance under the conditions of the standard fire test.

NOTE.—In the case of protections for reinforced concrete columns ½-inch gypsum or Portland cement plaster may replace an equal thickness of required poured protection and 1-inch gypsum or Portland cement plaster reinforced with expanded metal lath or wire lath may replace an equal thickness of poured protection.

STEEL BEAMS, GIRDERS, AND TRUSSES

Protections to cover lower flanges and portions of webs or members not protected by arches or slabs. When plastering is required, but the material and thickness not given, plastering should be not less than ½-inch gypsum or Portland cement plaster.

Four hours

2 inches or more concrete; coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale, wire ties or metal mesh reinforcement.[29]

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[28] The term "siliceous" as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar materials. It would be desirable to have investigations made of the gravels in use in a given locality so that no unnecessary thickness of protection is required.

[29] Wire ties for poured concrete protections should be of not less diameter than No. 5 B. & S. gage and should be spaced not more than 8 inches. Metal or wire mesh for such protections should weigh not less than 1.5 pounds per square yard. Mesh should measure not larger than 4 by 4 inches. Masonry units in order to provide adequate protection should be well anchored or bonded. Methods include the use of metal clips connecting one unit to another, outside tie wires not smaller than No. 12 B. & S. gage with at least one tie around each course, or special design of the unit so that positive anchorage to steel or other supported units is attained. It is recommended that outside tie wires be protected by plastering.

2 inches or more concrete; coarse aggregate cinders, wire ties or metal mesh reinforcement.[29]

2½ inches or more concrete; coarse aggregate granite or sandstone, wire ties or metal-mesh reinforcement.[29]

3 inches or more concrete; coarse aggregate siliceous[30] *gravel, metal-mesh reinforcement.*[29]

3 inches or more hollow clay[31] *or concrete*[32] *tile, well anchored or bonded, plastered.*

2 inches or more solid precast gypsum units, well anchored or bonded, plastered with at least ¾-inch gypsum plaster.[33]

2 inches or more poured gypsum, plastered with at least ¾-inch gypsum plaster.[33]

3 inches or more hollow-gypsum units, well anchored or bonded, plastered with at least ½-inch gypsum plaster.

3 inches or more solid cinder concrete[32] *block, well anchored or bonded, plastered.*

Any other material of such thickness as to develop four hours ultimate fire resistance under the conditions of the standard fire test.

Three hours

Any of the above or the following:

1½ inches or more poured gypsum, plastered with at least ½-inch gypsum plaster.

3 inches or more solid cinder concrete block, well anchored or bonded.

2 inches or more hollow clay[31] *or concrete*[32] *tile, well anchored or bonded, plastered.*

Any other material of such thickness as to develop three hours ultimate fire resistance under the conditions of the standard fire test.

Two and one-half hours

Any of the above or the following:

1½ inches or more concrete; coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale, granite, sandstone, or cinders.

2 inches or more concrete; coarse aggregate siliceous gravel, metal-mesh reinforcement.

1½ inches or more poured gypsum.

2 inches or more solid cinder concrete block, well anchored or bonded, plastered.

Any other material of such thickness as to develop two and one-half hours ultimate fire resistance under the conditions of the standard fire test.

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[29] Wire ties for poured concrete protections should be of not less diameter than No. 5 B. & S. gage and should be spaced not more than 8 inches. Metal or wire mesh for such protections should weigh not less than 1.5 pounds per square yard. Mesh should measure not larger than 4 by 4 inches. Masonry units in order to provide adequate protection should be well anchored or bonded. Methods include the use of metal clips connecting one unit to another, outside tie wires not smaller than No. 12 B. & S. gage with at least one tie around each course, or special design of the unit so that positive anchorage to steel or other supported units is attained. It is recommended that outside tie wires be protected by plastering.

[30] The term "siliceous" as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar material. It would be desirable to have investigations made of the gravels in use in a given locality so that no unnecessary thickness of protection is required.

[31] Hollow clay tile should conform in quality to the specifications for Hollow Burned Clay Fireproofing, Partition and Furring Tile, serial designation C56–30 of the American Society for Testing Materials.

[32] The rating for concrete tile protection is predicated on careful and uniform manufacture.

[33] Although three-fourth-inch plaster was applied in the actual test, one-half inch is believed sufficient and more in accord with usual practice.

Two hours

Any of the above or the following:

1 inch or more poured gypsum.

Any other material of such thickness as to develop two hours ultimate fire resistance under the conditions of the standard fire test.

One and one-half hours

Any of the above or the following:

1 inch or more concrete; coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale.

2 inches or more solid cinder concrete block, well anchored or bonded.

1 inch or more gypsum or Portland cement plaster on expanded metal or wire lath.

Any other material of such thickness as to develop one and one half hours ultimate fire resistance under the conditions of the standard fire test.

One hour

Any of the above or the following:

1½ inches or more concrete; coarse aggregate siliceous[30] *gravel, wire ties or metal mesh reinforcement.*[29]

⅞ inch or more gypsum or Portland cement plaster on expanded metal or wire lath.

Any other material of such thickness as to develop one hour ultimate fire resistance under the conditions of the standard fire test.

NOTE.—In the case of protections for steel beams, girders, and trusses ½-inch gypsum plaster may replace an equal thickness of poured gypsum, ½-inch gypsum or Portland cement plaster may replace an equal thickness of the required poured concrete, and 1-inch gypsum or Portland cement plaster reinforced with expanded metal lath or wire lath may replace an equal thickness of poured protection.

REINFORCED CONCRETE BEAMS, GIRDERS, AND TRUSSES

Protection outside reinforcing steel.

Four hours

1½ inches or more concrete; coarse aggregate limestone, calcareous gravel, trap rock, blast-furnace slag, burnt clay or shale.

2 inches or more concrete; coarse aggregate granite, sandstone, or siliceous[30] *gravel, coarse aggregate not to exceed ¾ inch in diameter.*

Any other material of such thickness as to develop four hours ultimate fire resistance under the conditions of the standard fire test.

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[29] Wire ties for poured concrete protections should be of not less diameter than No. 5 B. & S. gage and should be spaced not more than 8 inches. Metal or wire mesh for such protections should weigh not less than 1.5 pounds per square yard. Mesh should measure not larger than 4 by 4 inches. Masonry units in order to provide adequate protection should be well anchored or bonded. Methods include the use of metal clips connecting one unit to another, outside tie wires not smaller than No. 12 B. & S. gage with at least one tie around each course, or special design of the unit so that positive anchorage to steel or other supported units is attained. It is recommended that outside tie wires be protected by plastering.

[30] The term "siliceous" as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar material. It would be desirable to have investigations made of the gravels in use in a given locality so that no unnecessary thickness of protection is required.

Three hours

Any of the above or the following:

1½ inches or more concrete; coarse aggregate not to exceed ¾ inch in diameter if siliceous.[34]

Any other material of such thickness as to develop three hours ultimate fire resistance under the conditions of the standard fire test.

Two hours

Any of the above or the following:

Any other material of such thickness as to develop two hours ultimate fire resistance under the conditions of the standard fire test.

One hour

Any of the above or the following:

1 inch or more concrete; coarse aggregate not to exceed ¾ inch in diameter if siliceous.[34]

Any other material of such thickness as to develop one hour ultimate fire resistance under the conditions of the standard fire test.

NOTE.—In the case of protections for reinforced concrete beams, girders, and trusses ½-inch gypsum or Portland cement plaster may replace an equal thickness of required poured protections and 1-inch gypsum or Portland cement plaster reinforced with expanded metal lath or wire lath may replace an equal thickness of poured protection.

FLOORS AND ROOFS

When plastering is required but the material and thickness not given, plastering should be not less than ½-inch gypsum or Portland cement plaster.

Two and one-half hours

4½ inches or more reinforced concrete slabs or arches having at least ¾-inch protection below steel reinforcement.

3¾ inches or more brick arches, concrete fill level with crown of arch.

8 inches or more 2-cell hollow clay tile, consisting of flat arches laid in Portland cement or cement-lime mortar, floor fill of 2 inches incombustible material, plastered.[35]

6 inches or more 2-cell hollow clay tile, consisting of segmental arches laid in cement or cement-lime mortar, concrete fill level with crown of arch, plastered.[35]

4 inches or more poured gypsum slabs, plastered with at least ¾-inch*[36] *gypsum plaster.

Floor construction consisting of 2 inches or more top slab of poured or precast gypsum on standard steel channels and bottom slab of 2 inches or more poured or precast gypsum, plastered with at least ¾-inch gypsum plaster.[37]

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[34] The term siliceous as applied to aggregates in concrete means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar materials. It would be desirable to have investigations made of the gravels in use in a given locality so that no unnecessary thickness of protection is required.

[35] Definite test data tending to show the performance of this construction under standard fire tests are lacking, but the thickness given is believed to be suitable in the light of experience.

[36] Although ¾-inch plastering was applied in the actual test, one-half inch is believed sufficient and more in accord with actual practice.

[37] Although no test information is available it is believed that the same thickness of gypsum used with other structural steel shapes and with steel joists would give at least two and one-half hours ultimate fire resistance. It is also believed that ½-inch plaster would be sufficient.

Floor construction consisting of 2 inches or more top slab of cinder concrete on steel joists with ceiling of at least 1½ inches Portland cement mortar on metal lath furred out to furnish 1-inch air space between bottom flanges of the joists and ceiling.

Floor construction consisting of 2 inches or more top slab of poured or precast gypsum on steel joists with ceiling of at least 1½ inches of gypsum plaster on metal lath furred out to furnish 1-inch air space between bottom flanges of the joists and ceiling.

Composite floors consisting of reinforced concrete beams with fillers of hollow tile, cinder concrete block, slag block, or gypsum block, thickness of filler to be 4 inches or more, with a 2-inch or more concrete slab, unplastered; at least ¾-inch concrete protection for steel reinforcement.[35]

Concrete joist construction, not more than 24 inches between joists, thickness of slab 2½ inches or more if with ceiling of at least ¾-inch gypsum or Portland cement plaster on metal or wire lath or 3½ inches if without ceiling; at least ¾-inch concrete protection below reinforcement.[35]

Any other material or construction of such thickness as to develop 2½ hours ultimate fire resistance under the conditions of the standard fire test.

One and one-half hours

Any of the above or the following:

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.[35]

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.[35]

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.[38]

Any other material or construction of such thickness as to develop one and one-half hours ultimate fire resistance under the conditions of the standard fire test.

One hour

Any of the above or the following:

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.

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[35] Definite test data tending to show the performance of this construction under standard fire tests are lacking, but the thickness given is believed to be suitable in the light of experience.

[38] Under the heading steel joists are to be taken structural steel members 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.

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 [39] on at least three-eighths inch gypsum plaster board. Joints of plaster board covered with expanded metal lath at least 3 inches wide.[40]

Any other material or construction of such thickness as to develop one hour ultimate fire resistance under the conditions of the standard fire test.

NOTE.—The total thickness of incombustible floor finish or two-thirds of the thickness of incombustible floor fill may be counted as part of the required thickness of floor construction.

(4) The requirement in the second paragraph of section 11–2–6 in part 2 is intended to apply only to girders or beams furnishing support for spandrel walls. Shelf angles, plates, or similar members supported by masonry at the ends, if the opening is not more than 4 feet wide or hung from the protected girder or beam in the case of wider openings, need not be protected.

Paragraph 7. INFORMATION ON PERFORMANCE OF FIRE RESISTIVE MATERIALS AND APPLIANCES

General.

Much basic information on the behavior of various structural materials and protections under fire tests and in actual fires is to be found in proceedings of various professional and technical societies and in other scientific literature. Especially valuable sources are as follows:

Standards of the American Society for Testing Materials, 1929 (published triennially by the society, 1315 Spruce Street, Philadelphia, Pa.).
Tentative Standards of the American Society for Testing Materials (published annually by the society).
Proceedings of the American Society for Testing Materials (published annually by the society).
Proceedings of the National Fire Protection Association (published annually by the association, 60 Batterymarch Street, Boston, Mass.).
Quarterly of the National Fire Protection Association (published quarterly by the association).
Proceedings of the American Concrete Institute (published annually by the institute, 2970 West Grand Boulevard, Detroit, Mich.).
Proceedings of the Building Officials' Conference (published annually by the conference).
Technologic Papers of the Bureau of Standards (up to July, 1928); Bureau of Standards Journal of Research (published monthly since July, 1928, Bureau of Standards, Washington, D. C.).
Technical News Bulletin of the Bureau of Standards (published monthly by the Bureau of Standards).
The British Fire Prevention Committee. List of the committee's publications (with supplements), London.

Thermal Conductivity.

There have been a number of tests on temperature transmission of various protective materials. These include tests at Columbia University, reported by Prof. Ira H. Woolson; by the British Fire

[39] Plaster should not be leaner than 2 gypsum: 1 sand.
[40] Weight of lath should not be less than 2.2 pounds per square yard.

Prevention Committee; by W. A. Hull at the former Pittsburgh Laboratory of the Bureau of Standards; and by R. L. Humphrey at the Underwriters' Laboratories in Chicago, as well as others incidental to the testing of walls, columns, and various construction features. The apparatus used, severity of fire exposure, and method of reporting temperatures has varied from time to time so that allowance must be made in interpreting, but valuable information has been developed.

Especially useful sources are as follows:

Thermal Conductivity of Different Concrete Mixtures and Effect of Heat Upon Their Strength and Elastic Properties, by Ira H. Woolson, Proceedings American Society for Testing Materials, vol. 5, p. 335, 1905; also vol. 6, p. 433, 1906; and vol. 7, p. 404, 1907.

Fire Resistive Properties of Various Building Materials, by R. L. Humphrey, Bulletin 370, U. S. Geological Survey, 1909.

A Comparison of the Heat Insulating Properties of Some of the Materials Used in Fire Resistive Construction, by Walter A. Hull, B. S. Technologic Paper No. 130; 1919.

Tests for Conductivity of Heat Through Concrete Slabs of Various Aggregates, by C. H. Lees, Redbook No. 251, British Fire Prevention Committee, 1921.

Columns.

A very comprehensive series of tests on columns under conditions approximating these required to-day was made by cooperative arrangement between the Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, and the Bureau of Standards, at the Underwriters' Laboratories in Chicago in 1917–18. Subsequently, tests were made on more than 60 reinforced concrete columns at the former testing laboratory of the Bureau of Standards in Pittsburgh.

In the tests at Chicago, the working loads applied were about 10 per cent in excess of the calculated loads. Tests were continued eight hours if failure did not occur, and at the end of that period the column was immediately loaded to failure under full fire exposure.

Figure 1 summarizes the results of these tests, giving in each case the ultimate fire resistance obtained. For a full understanding of the results reference should be made to the complete reports of the tests listed below.

In the tests at Pittsburgh, which were confined to plain and reinforced concrete columns, the columns were subjected to their calculated load and the test period was limited to four hours. All columns which did not fail under the maximum load of the testing equipment after four hours' fire exposure were later broken cold elsewhere. Comparisons were made between the ultimate strength of columns exposed to fire and similar ones not exposed.

Figures 2 and 3 summarize the results of these tests. As in the case of Figure 1 a reading of the accompanying text, in this instance to be found in Bureau of Standards Technologic Paper No. 272, is advisable for intelligent interpretation of the results.

In both series, temperature determinations were made at various distances in from the surface of the column protection, thus giving some measure of the rate of heat penetration.

Especially valuable sources are as follows:

Fire Tests of Building Columns, by Ingberg, Griffin, Robinson, and Wilson, B. S. Technologic Paper No. 184; 1921.

Fire Tests of Building Columns by Associated Factory Mutual Fire Insurance Companies; National Board of Fire Underwriters; Bureau of Standards, Department of Commerce; Underwriters Laboratories, Chicago, Ill.; 1920.
Report of Fire Tests of Building Columns; Laboratory Data (Underwriters' Laboratories), vol. 3, p. 182; 1922.

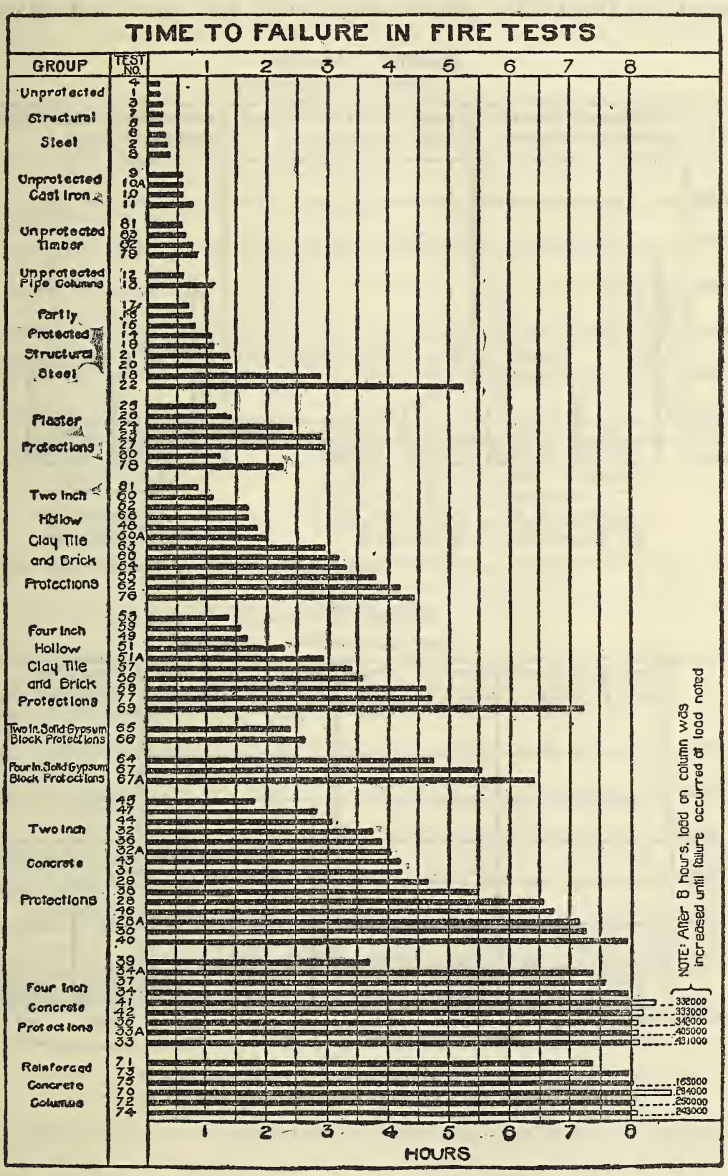
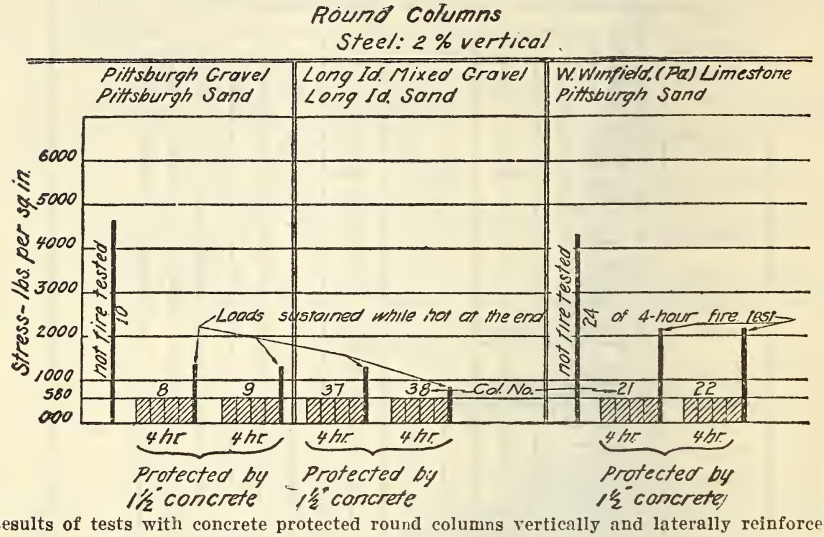


FIGURE 1.—*Time to failure of columns in fire test series*

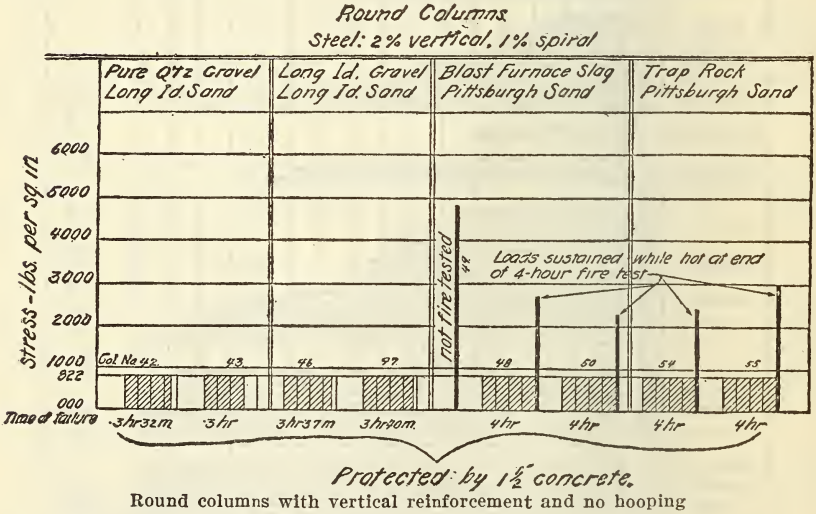
Fire Resistance of Concrete Columns, by W. A. Hull, and S. H. Ingberg, B. S. Technologic Paper No. 272; 1925.
Compressive Strength and Deformation of Structural Steel and Cast-Iron Shapes at Temperatures up to 950° C., by S. H. Ingberg and P. D. Sale, Proceedings of American Society for Testing Materials, vol. 26 pt. 2; 1926.

Floors.

Numerous tests on floors have been made at the fire-testing laboratory of Columbia University, chiefly on behalf of the New York bureau of buildings and at this bureau's own testing station. The information from this source constitutes the principal informa-



Results of tests with concrete protected round columns vertically and laterally reinforced

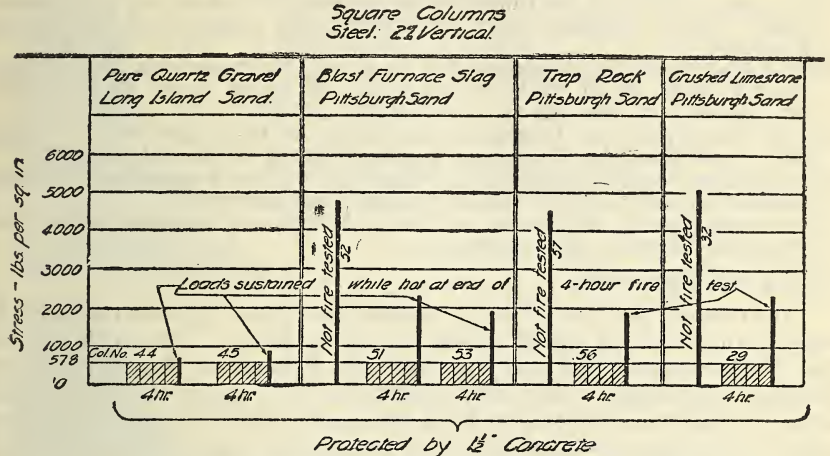


Round columns with vertical reinforcement and no hooping

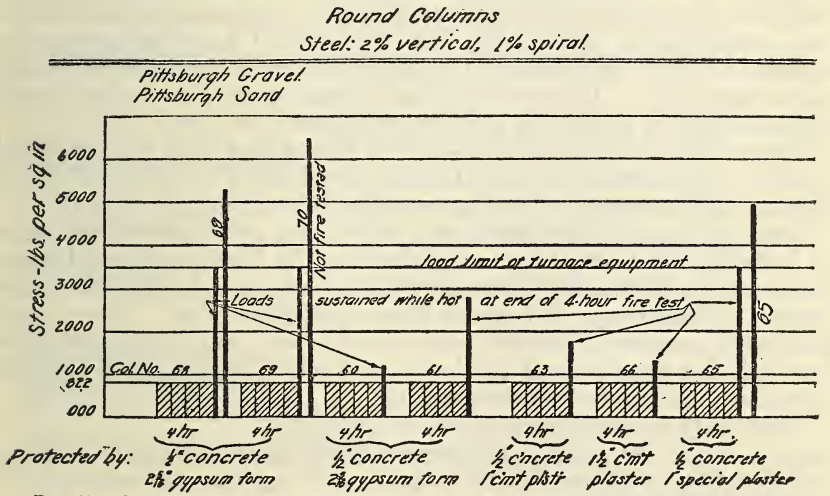
FIGURE 2.—*Results of fire tests on reinforcement concrete columns*

tion on the subject. Some tests were also made by the British Fire Prevention Committee. The New York tests are severe as to subsequent loading of the test panel, the requirements calling for a 150-pound per square foot uniformly distributed load during the fire, to be increased to 600 pounds afterwards, with specified allow-

able limits for deflections. On the other hand, there is no temperature transmission requirement such as is now contained in the present standard test. The purpose of this requirement is presumably to prevent ignition of goods stacked on a floor above a fire. Most of the existing test data, being limited to tests on load-carrying capacity under fire exposure and resistance to water ero-



Square columns with vertical reinforcement and no hooping



Results of tests of typical plastered columns and columns cast in gypsum forms

FIGURE 3.—*Results of fire tests on reinforced concrete columns.*

sion, give results which in some cases might not qualify under the heat-transmission requirements of the present standard test if the figures on heat conductivity for the materials used are accepted. It is only fair to say with respect to those that have not passed the temperature-transmission test that had such a test been in effect at that time some floors might have been finished with an additional coat of cement, with cinder concrete and finish flooring,

or in some other way instead of being tested in a rough condition and that the addition of this finish would very likely have brought the temperature transmission within that which is acceptable to-day. It is also noted that most of these tests were terminated at four hours if failure did not occur before that time.

Especially valuable sources are as follows:

Fire Tests of Floors in the United States, by Ira H. Woolson and R. P. Miller, paper XXVII, 2d sec., 1912, of International Association for Testing Materials.

British Fire Prevention Committee Red Books on "Fire Tests with Floors," numbered 7, 14, 16, 18, 21, 23, 34, 38, 45, 48, 55, 56, 61, 64, 71, 73, 78, 79, 96, 101, 103, 106, 107, 108, 109, 112, 114, 118, 119, 169, and 188.

British Fire Prevention Committee Red Books on Fire Tests with "Ceiling, Girder, and Stanchion Coverings," numbered 19, 28, 43, 62, 104, and 105.

Reports of the Testing Laboratories, Department of Civil Engineering, Columbia University, on fire tests of various materials and assemblies.

Reports contained in the files of the New York bureau of buildings on fire tests of various materials and assemblies.

Walls and Partitions.

Fire tests of walls covering a considerable range of materials, thicknesses, and kinds of construction have been made. The work done at the Underwriters' Laboratories and the Bureau of Standards is especially important. The test conditions have approximated closely those in use to-day or have been the same, with the exception that most of the underwriters' tests and the earlier ones at the bureau did not subject the walls to load during the fire exposure. However, load tests were made separately in all cases and in the recent series at the bureau brick walls were tested under 80 and 160 pounds per square inch load and hollow tile walls under 60, 80, and 120 pounds per square inch. Concrete tile and block were also tested by the underwriters in 1927 at 80 pounds per square inch load.

Figure 4 summarizes the results of recent fire tests on hollow-tile walls at the Bureau of Standards. Research Paper No. 37 of the Bureau of Standards should be consulted in connection with it.

Testing of partitions has been particularly active, the chief source of information being results obtained at the Underwriters' Laboratories, at the Columbia University testing station, for the New York bureau of buildings, and at the Bureau of Standards. Here, again, procedure and requirements have varied, there being no temperature-transmission requirement in the New York tests, although some observations on this factor were made.

Especially valuable sources are as follows:

Letter Circulars 113 (1926), 223 (1917), 228, 229 (1927), Bureau of Standards.

Technical News Bulletins No. 120 (April, 1927) and No. 124 (August, 1927), Bureau of Standards.

Fire Tests for Brick Walls, by S. H. Ingberg, American Architect; September 26 and October 10, 1923.

Fire Resistance of Hollow Load Bearing Wall Tile, by S. H. Ingberg and H. D. Foster, Research Paper No. 37, Bureau of Standards Journal of Research, vol. 2; 1929.

Fire Resistance of Gypsum Partitions, by S. H. Ingberg, Proceedings of the American Society for Testing Materials, vol. 25, pt. 2; 1925.

Reports of the Testing Laboratories, Department of Civil Engineering, Columbia University, on fire tests of various materials and assemblies.

Fire Retardant Reports of the Underwriters' Laboratories (Inc.), on various materials and assemblies.

Reports contained in the files of the New York bureau of buildings on fire tests of various materials and assemblies.

The Fire Resistive Properties of Various Building Materials, by R. L. Humphrey, Bulletin 370, U. S. Geological Survey; 1909.

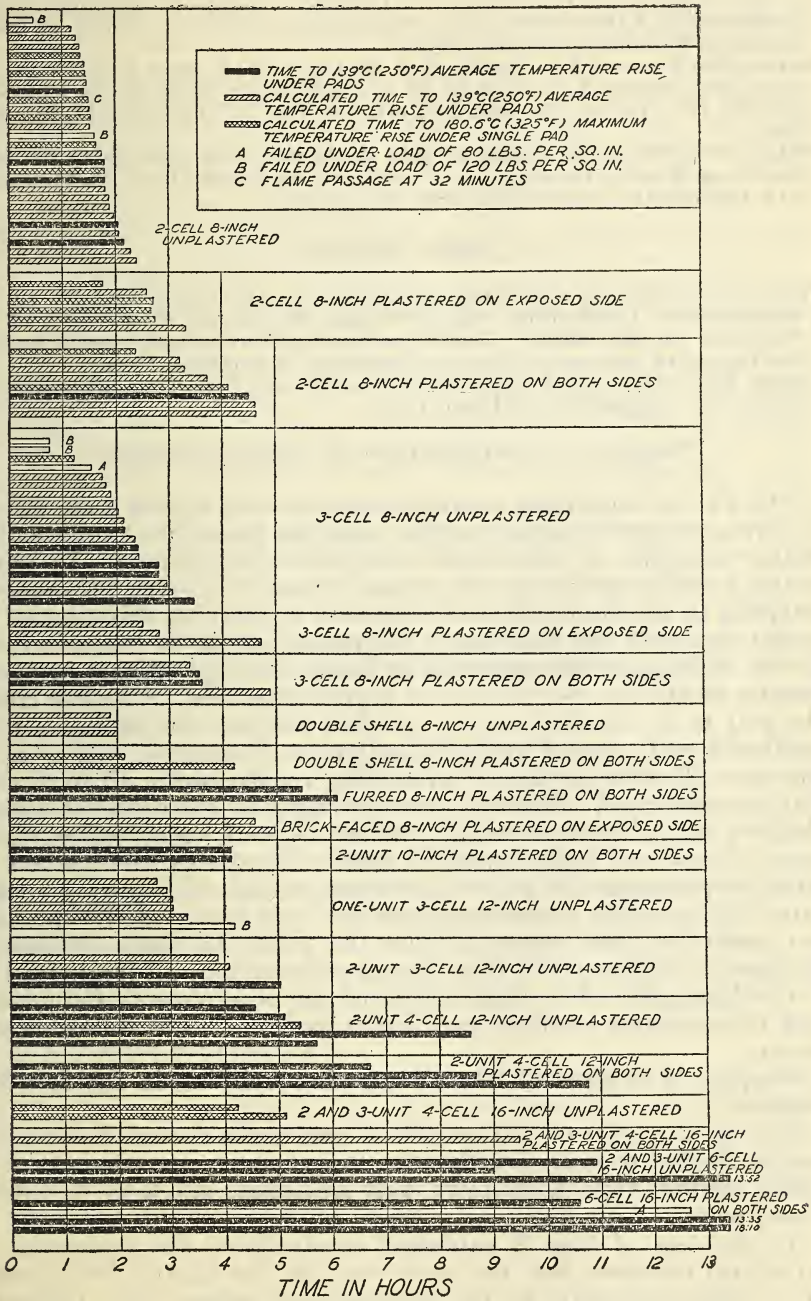


FIGURE 4.—*Ultimate fire-resistance periods of hollow tile walls*

British Fire Prevention Committee Red Books on "Fire Tests with Partitions and Partitioning Materials," numbered 22, 27, 37, 44, 47, 52, 53, 58, 63, 74, 83, 84, 86, 88, 92, 93, 99, 102, 164, 187, 192, 193, and 195.

Protection for openings

The list of Inspected Fire Protection Appliances (published annually by the Underwriters' Laboratories (Inc.), Chicago, Ill.) is the chief source of information in this country on this subject.

British Fire Prevention Committee Red Books on "Fire Tests with Doors and Shutters," numbered 24, 25, 26, 35, 39, 40, 49, 50, 54, 59, 60, 67, 68, 69, 70, 76, 77, 98, 100, 111, 117, 135, 137, 138, 139, 141, 144, 146, 147, 149, 163, 173, 183, and 194.

British Fire Prevention Committee Red Books on "Fire Tests as to the Protection of Window Openings, etc.," numbered 20, 29, 30, 31, 32, 33, 91, 95, 97, 113, 116, 166, 171, 172, 178, 182, 196, 197, and 198.

Roofing materials

The List of Inspected Fire Protection Appliances (published annually by the Underwriters' Laboratories (Inc.), Chicago, Ill.) is the chief source of information on this subject. Reports of extensive experiments performed at the Bureau of Standards are not yet available in published form.

British Fire Prevention Committee Red Books on "Fire Tests with Roofing Materials," numbered 72, 151, and 174.

Paragraph 8. APPLICATION OF REQUIREMENTS

(1) The recommended minimum requirements of part 2 are chiefly in terms of performance, specific materials being cited only as familiar examples of what will accomplish the purpose. In paragraph 6 and in paragraph 13 of this appendix is given information intended to aid the writers of local codes in carrying this citation of actual materials and thicknesses to greater lengths in the code itself if this is thought desirable and to assist building officials in determining what is proper for use in a given location. Whether citing the end to be attained or the detailed methods of attaining it is preferable will depend upon the judgment of the code writers as to the most effective method of presenting requirements, all local conditions considered. The way should always be left open for admitting the use of new materials and methods of construction which prove themselves under standard tests. Eventually the method of citing requirements on a pure performance basis of requiring results rather than specific methods or materials may be expected to prevail, but doubt has been expressed that the public has been sufficiently educated to this way of presenting requirements in all localities.

(2) Examples of the application of the requirements for protection of structural members may aid in their use. The following are given:

Suppose it is planned to erect an office building in the first fire district.

By the provision of section 4–1 in part 2 the choice of construction is limited to type 1, fully protected; type 2, protected; type 3, heavy timber; type 4, masonry wall and joist; and type 6, unprotected metal.

In the case of type 2, protected construction, the protection of structural members does not vary with the fire hazard, but is cited at a certain minimum by the provisions of section 3–2. Information as to what thicknesses of various protective materials will

accomplish the required result can be obtained from paragraph 6 of this appendix. For instance, when it is found that buildings of this type must have fire walls with an ultimate fire resistance of at least four hours, code writers or the building inspector can turn to the list of walls in paragraph 6 under four hours and can take directly from that list such items as appear there. A building of this type as erected may not withstand a complete burn out of its contents, but it will provide a very considerable degree of fire resistance. It will also be limited in height and in some cases in undivided floor area by the provisions of sections 4–2 and 4–3.

In the case of a building of type 1, fully protected construction, the situation is somewhat different. Although this building has no limits as to height and undivided floor area, the protections for structural members must be such that there can be a complete burn out of contents, whatever they may be, without collapse or spread of fire. It, therefore, becomes necessary to determine what the fire hazard of the occupancy will be. Recalling that this is an office building, a class of occupancy which has been subjected to definite burn-out tests, if it is found that the weight of combustible contents, including flooring and trim, will be 20 pounds per square foot of floor area, reference to the table on page 23 of this appendix will indicate a probable maximum fire hazard of two hours. Since a type 1, fully protected building, by definition must have floors and certain other members with a minimum ultimate fire resistance of two and one-half hours, this minimum is believed to be sufficient If the load of combustible contents was 30 pounds per square foot, however, indicating a probable maximum fire hazard of three hours, the matter of providing sufficient fire resistance would become one for skilled engineering design.

Test data for periods exceeding four hours are meager in the case of most structural protections. The importance of securing adequate protection for occupancies involving large amounts of combustible contents is so great that the services of a skilled designer versed in the subject are desirable. None of the lists given in paragraph 6 is carried beyond four hours, but the bibliography and other information in paragraph 7 has been prepared to assist designers and to enable building officials to check designs submitted to them.

The building could be erected in type 3, heavy timber, or type 4, masonry wall and joist construction. The allowable heights and areas between fire walls would be limited by the provisions of sections 4–2 and 4–3 of part 2.

There are general provisions pertaining to openings and other matters in chapter 11 of part 2 which must be consulted and observed in the case of all types of construction to which they apply.

The way in which the major requirements of part 2 work out in the case of a given occupancy and a particular type of construction is presented in the following table:

Occupancy	Type of construction	Height	Undivided area	Required ultimate fire resistance of structural members
Public	Type 2	80 feet	Unlimited	1. Fire walls, 4 hours. 2. Party walls, 4 hours. 3. Bearing walls other than (1) and (2), 3 hours. 4. Walls other than (1), (2), and (3), 2 hours. 5. Piers, 3 hours. 6. Columns supporting walls, 3 hours. 7. Girders supporting walls, 3 hours. 8. Fire partitions, 2 hours; 1 hour according to location. 9. Columns other than (6), 2 hours. 10. Girders other than (7), 2 hours. 11. Beams, 1½ hours. 12. Floors, 1½ hours. 13. Roofs, 1½ hours (except as in sec. 11–8–1.)

Paragraph 9. PARTITIONS

The committee believes that intermediate partitions require definite fire resistance only where they have a clearly demonstrable relationship to safety of occupants or are obviously consistent with the scheme for a particular type of construction. Accordingly, requirements for such partitions have been limited to cases where these conditions are met.

Paragraph 10. PROTECTION OF VERTICAL OPENINGS

(1) To form a practically impenetrable barrier to upward spread of flames it is necessary that fire-resistive floors, fire stopping, and shaft protection all be given proper attention. Neglect of one will defeat the purpose of the others. Poorly protected shafts are one of the principal causes for the rapid progress of fire from story to story. The shaft itself forms a chimney creating an upward draft, and inadequately protected openings or substandard walls permit the flame to "mushroom" horizontally.

(2) There are certain situations in buildings where a requirement for shaft inclosure of a single opening in a floor would be relatively expensive or inconvenient and where a simple method of closing the opening, such as a trapdoor or elevator platform, will normally suffice. This condition should be recognized in the requirements adopted locally.

(3) It is considered good practice to carry shafts above the roof and cover them with thin glass skylights. This provides for carrying off smoke and gases in case of fire as the glass soon drops out under fire conditions. Practical considerations of design and the difficulty of making junctions with the roof water-tight, however, have led to permit closing off the shaft at the top by fire-resistive construction in certain cases.

(4) Properly constructed and with openings, well protected by standard devices a shaft ceases to be a menace, and in many cases becomes a valuable auxiliary in fire fighting.

Paragraph 11. PROTECTION OF WALL AND PARTITION OPENINGS

(1) The Underwriters' Laboratories publish lists of fire doors, metal window frames, wired glass, fire shutters, and other equipment for the protection of interior and exterior openings which have

passed the prescribed test and may be used under various limitations. Although the appliances are tested under definite time conditions, the lists as published have no specific basis of resistance in terms of time. This introduces certain difficulties in correlating the protection of openings and the resistance of walls or partitions in which they appear. It may seem illogical to require a definite time resistance for walls and partitions and then permit a number of openings in them, protected by appliances of indefinite resisting power, but this appears necessary, at least for the present.

(2) The opinion has been advanced that protection of openings in interior walls and partitions need not be on a par with the resistance of the walls and partitions in which they appear, for the reason that combustible goods are usually kept away from such openings. Although no check on this from the standpoint of actual experience has been made, it has been given weight as a reasonable assumption.

(3) There are three general classes of use for appliances that protect openings:

(*a*) The closure of openings in fire walls, presumably doorways only.

(*b*) The closure of openings in fire-resistive partitions, both those around vertical shafts and at other places in the building which may require either doors or windows.

(*c*) Protection of openings in adjacent buildings, or parts of the same building, from exposure hazards, this requiring both door and window equipment.

(4) Any opening in a fire wall, fire partition, or party wall, is admittedly a point of weakness which subtracts in a measure from the full efficiency of the separation. Good strategy requires that such points of weakness in a defense erected against fire should be made as few, as small, and as well protected as possible. This is the intent of the requirements in part 2.

(5) The protection required for exterior openings is irrespective of the fire district in which the building stands. The prospect of a general conflagration is admittedly less in the outer districts, but the fire-fighting facilities are also generally inferior. Resistance to exposure until adequate fire-fighting apparatus can be brought to bear is often of special importance in the case of isolated groups of buildings.

(6) There is no one best method for protecting exterior openings. The devices mentioned have all given good accounts of themselves when properly constructed and installed. The choice must vary with local conditions. Open sprinklers, for instance, have proved effective where an ample supply of water at good pressure can be depended upon and watchman service is dependable. Fire doors and shutters are excellent when closed, as they should be, during nonworking hours, and in such condition that they can be quickly closed at other times. Wired glass is capable of affording a marked degree of protection but softens at about 1,600° F. In cases where the exposure is exceptionally severe, good judgment would indicate the use of two methods of protection, such as shutters and wired glass, or open sprinklers and wired glass.

(7) The purpose of the requirement in part 2 regarding vertical separation of windows in the same building is to guard against fire

bursting out of an opening and lapping up into a too closely spaced opening above, thus transmitting fire from story to story even though interior vertical openings are well protected.

(8) The effect of the provision in section 11–6–1, that buildings located on the same lot may be regarded as one building, is to permit two or more buildings so located to have unprotected openings between them, provided the total space occupied by the buildings does not exceed the undivided area permitted for the given occupancy and type of construction or is subdivided by fire walls into spaces none of which exceed this permitted area.

Paragraph 12. CEILINGS

The requirement for ceilings given one hour ultimate fire resistance for certain occupancies in buildings of type 4, masonry wall and joist, and type 6, wood frame, construction, as given in section 11–7, part 2, accomplishes a very considerable degree of fire protection in buildings having combustible floor members, and it is believed to do this without creating an undue hardship. Tests at the Underwriters' Laboratories and elsewhere have indicated that such protection may be gained by the use of metal lath and gypsum or Portland cement plaster, with suitable fire stopping and double flooring. Although this is not required in single family dwellings, its desirability in such structures should not be overlooked, particularly for basement ceilings, for statistics indicate that a considerable proportion of fires in dwellings originate in the basement. In the event that a sprinkler system is provided throughout a building this, of course, makes it unnecessary to require any particular kind of lath and plaster. Recognition of such a variation should be made in local codes.

Paragraph 13. ROOFING

(1) The subject of the relative merits of different roof coverings from the standpoint of fire resistance has been under systematic investigation at the Bureau of Standards for some time, the tests including old roofings that have been exposed to the weather for as long as 20 years as well as materials fresh from the factory or mill. The program has been a very exhaustive one.

From consideration of the results of these tests, the following roof coverings and materials of equivalent fire resistance are believed suitable for filling the general requirements given in section 11–8–2 of part 2:

Roof Coverings Suitable for Use in First Fire District.

Brick; tile; concrete; slate; cement-asbestos sheet roofing, tile, or shingles; galvanized or tin-coated steel sheets or shingles [41]; copper sheets or shingles [41]; asphalt saturated asbestos felt weighing not less than 60 pounds per 108 square feet, exclusive of surfacing material; built-up asphalt or coal-tar saturated roofing of class A or B as established by the Underwriters' Laboratories (Inc.)[42]; any other material or form of protective covering approved by the administra-

[41] Underlaid with unsaturated asbestos felt weighing not less than 14 pounds per 108 square feet when over combustible roof.

[42] Slag or gravel surfacing for this type is not considered necessary if the roofing is laid upon an incombustible roof deck.

tive building official after satisfactory evidence that it is equivalent to any of the preceding materials in resistance to brands, heat, or flame penetration and spread of fire and freedom from brand production.

Roof Covering Suitable for Use in Second Fire District.

Brick; tile; concrete; slate; cement-asbestos sheet roofing, tile or shingles; galvanized or tin-coated steel sheets or shingles; copper sheets or shingles; zinc sheets or shingles; sheet lead; asphalt-saturated asbestos felt weighing not less than 43 pounds per 108 square feet exclusive of surfacing material; prepared asphalt-saturated rag felt granular surfaced strip or individual shingles, laid in not less than two thicknesses, or two layers of asphalt-saturated roll roofing, weighing as laid not less than 180 pounds per 100 square feet of roof surface; built-up asphalt or coal-tar saturated roofing of class A, B, or C as established by the Underwriters' Laboratories (Inc.); any other material or form of protective covering approved by the administrative building official after satisfactory evidence that it is equivalent to any of the above materials in resistance to brands, heat or flame penetration and spread of fire, and freedom from brand production.

(2) Fire tests on asphalt-saturated rag felt roll roofings of the types described above and wood shingles indicate that the former are superior except as to spread of fire, where the difference is not great. In respect to resistance to brands lodging on the roof and production of flying brands the tests show that the rag felt roofings are less hazardous. (See Appendix, par. 4 (10).)

(3) In some manufacturing processes, acid fumes are produced which attack the frames of metal skylights. Wood frames should be permitted under such circumstances.

Paragraph 14. FIRE STOPPING

(1) The requirements for fire stopping are based on those that appeared in 1923 in the report of the committee entitled "Recommended Minimum Requirements for Small Dwelling Construction," with such changes as have appeared necessary to cover other kinds of buildings. For a discussion of the necessity for and means of fire stopping reference should be made to paragraphs 53 to 55, inclusive, in the appendix of the report mentioned. The following statement sums up the importance of fire stopping:

> 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.

(2) It is to be noted that the requirements for fire stopping apply without exception to buildings wherever located.

(3) The requirement in section 11–9–4 that any space between wood flooring and floor construction in type 1, fully protected, and

type 2, protected, construction shall be filled solidly with approved incombustible material is intended to prevent spread of fire in a manner that has proved troublesome in a number of instances. When such flooring is laid on sleepers without proper filling of the space between, a hidden avenue is provided for fire to travel and burst out again at unexpected places.

Paragraph 15. CHIMNEYS AND HEATING APPLIANCES

The committee has decided to defer presenting detailed recommended requirements under this heading pending further study of the subject. In some cases experiments appear necessary to develop authoritative information. There are several publications available, however, which code writers or administrators are advised to consult. These include the revised chimney ordinance of the National Board of Fire Underwriters, the code prepared by the National Warm Air Heating and Ventilating Association, and the committee's own report entitled "Recommended Minimum Requirements for Small Dwelling Construction."

Paragraph 16. DEFINITIONS

(1) *Apartment.*—A room or suite of rooms which is occupied or which is intended or designed to be occupied by one family for living and sleeping purposes.

(2) *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.

(3) *Barn.*—A structure or portion thereof used as a shelter for horses or cattle.

(4) *Basement.*—Is that portion of a building between floor and ceiling which is partly below and partly above grade (as defined in this paragraph), but so located that the vertical distance from grade to the floor below is less than the vertical distance from grade to ceiling.

(5) *Bearing wall.*—A wall which supports any vertical load in addition to its weight.

(6) *Bulkhead.*—The term "bulkhead" as used in this code includes all such structures above the roof of any part of a building as inclose only stairways, tanks, elevator machinery, ventilating apparatus, or shafts.

(7) *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 accommodations or both.

(8) *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.

(9) *Fire partition.*—A partition which subdivides the interior space in any story or incloses the openings in floors to restrict the spread of fire.

(10) *Fire shutter.*—A shutter which under approved fire-test conditions meets the requirements for the location in which it is to be used.

(11) *Fire wall.*—A wall having an ultimate fire resistance of at least four hours which subdivides a building to restrict the spread of fire by starting at the foundation and extending through all stories to or above the roof.

(12) *Fire window.*—A window consisting of frame, sash, and glazing which under approved fire-test conditions meets the requirements for the location in which it is to be used.

(13) *Garage.*—A structure, or portion thereof, in which one or more motor vehicles containing volatile inflammable liquid in their fuel storage tanks are stored, demonstrated, repaired, used, or kept, and includes all space in such structure which is not separated from any other portion of the structure by an unpierced wall or floor construction having an ultimate fire resistance of at least two and one-half hours.

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.

(14) *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 aproximately parallel to and not more than 5 feet from a street line are to be considered as adjoining a street.

(15) *Hangar.*—A structure or portion thereof used as a shelter for aircraft.

(16) *Lot.*—Means a portion or parcel of land considered as a unit, devoted to a certain use or occupied by a building or a group of buildings that are united by a common interest or use, and the customary accessories and open spaces belonging to the same.

(17) *Masonry.*—Stone, brick, plain concrete, 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.

(18) *Nominal.*—As applied to timber or lumber in this code means the ordinary commercial size by which it is known and sold in the market, provided that the actual dimension corresponds with the American Lumber Standards as published in Simplified Practice Bulletin 16, Lumber, by the United States Department of Commerce.

(19) *Nonbearing wall.*—A wall which supports no load other than its own weight.

(20) *Parapet wall.*—Any part of a wall extending above the roof line.

(21) *Party wall.*—A wall used or adapted for joint service between two buildings.

(22) *Penthouse.*—Any inclosed structure other than a bulkhead extending not more than 12 feet above a roof.

(23) *Pier.*—All bearing walls having a horizontal cross section of 4 square feet or less and not bonded at the sides into associated masonry shall be considered as piers.

(24) *Public.*—As applied to theaters means open to all persons either free or upon payment of a fee, or having a seating capacity of more than 300 persons.

(25) *Roof.*—The construction used to close in the top of a building including all structural members and the slabs or planking to which roofing or surfacing is applied.

(26) *Roof covering.*—The covering applied to a roof to make it waterproof.

(27) *Siliceous.*—As applied to gravel aggregates means that the aggregate contains approximately 60 per cent or more of quartz, chert, flint, or similar materials.

(28) *Standard fire test.*—The fire test formulated under the auspices of the American Standards Association and issued by that organization as "American Standard" or as "Tentative American Standard."

(29) *Story.*—That portion of a building included between the top surface of any floor and the top surface of the floor or roof next above.

(30) *Street.*—A thoroughfare dedicated or devoted to public use, and includes avenue, road, alley, lane, highway, boulevard, terrace, concourse, driveway, sidewalk.

(31) *Veneered wall.*—A wall having a facing which is not attached and bonded to the backing so as to form an integral part of the wall for purposes of load bearing and stability.

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DEPARTMENT OF COMMERCE

WASHINGTON

PUBLICATIONS IN RELATION TO HOUSING AND MUNICIPAL REGULATIONS

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