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THE FIRE RESISTANCE OF BRICK WALLS

WALLS MADE OF CONCRETE OR SAND-LIME BRICKS

There has recently been completed at the Bureau of Standards a series of fire tests of brick walls to determine the fire protection, strength and stability under fire conditions afforded by this construction. The present letter circular, which is confined to the results obtained with concrete and sand-lime bricks, is intended to supply information until the report can be published.

Materials and Test Specimens. - Sand-lime and concrete bricks from two sources for each were included. The harder sand-lime brick would be graded as medium under present A.S.T.M. specifications and the other as soft, mainly on the score of absorption, the compressive strengths on edge ranging from 1690 to 4720 lbs. per sq. in. and the modulus of rupture from 460 to 930 lbs. per sq. in. The concrete bricks would pass the present A.S.T.M. tentative specifications for concrete building bricks with some margin, the average compressive strength flatwise being 2780 and 2920 lbs. per sq. in. for bricks from the respective sources. The aggregate used for both the sand-lime and the concrete bricks was siliceous sand. The bricks were built into walls 16 feet long and 10 to 11 feet high for tests in the large furnace and 4 feet wide and 4 feet high for tests in the small furnace, 8 tests being made with walls of each size. Sand-lime and concrete bricks also formed parts of six walls subjected to fire and water tests.

The walls were laid up with Portland cement-lime mortar consisting of 1:1¼:6 volume parts of cement, hydrated lime and dry sand, respectively, which was mixed with water to the consistency required by the masons. The bricks were laid flat as in common or running bond, with one full header course for every five stretcher courses. The greater number of walls tested in the large furnace were built by a masonry contractor who was awarded the work on the basis of competitive bids, and the workmanship was apparently barely up to what obtains on the average in building construction. The other walls were built by masons in the employ of the Bureau and the grade of workmanship as it concerns the degree to which the joints were filled and pointed was probably a little above the commercial average.

Method of Testing. - The walls were built into movable frames, and for the test were placed to form one wall of the furnace chamber. Some of the walls were built solidly into the frames,

which were rigid enough to restrain the greater portion of the expansion of the wall during test, thus duplicating conditions where fire division walls are built between heavy floors and columns. Six walls were tested under working load of 160 lbs. per sq. in. of gross area, maintained constant during the fire test, to determine the adequacy in this particular. Other walls were built free from the containing frames at the sides and top, permitting free movement of the wall during test, which is representative of the unrestrained condition of walls in minor buildings, or the top story of walls in higher buildings, where light, non-fire resistive interior and roof construction does not appreciably restrain the wall at the floor and roof lines.

The furnace temperatures were controlled to conform with that standard for American fire testing practice, with indicated temperatures near 927°C (1700°F) at one hour after the start of the test, 1010°C (1850°F) at 2 hours, 1093°C (2000°F) at 4 hours, 1260°C (2300°F) at 8 hours and a maximum of 1371°C (2500°F) at 10 hours and 40 minutes, this temperature being maintained constant until the end of any test extending beyond this time. Temperatures were measured at five or more points on the unexposed side as well as at points within the wall. The lateral deflections at nine or more points were also determined in the tests of large walls.

In the fire and water tests the walls were exposed to fire for one hour when they were pulled away from the furnace and a hose stream from a 1 1/8 inch nozzle under 50 lbs. per sq. in. water pressure applied over the hot side.

Stability and Load-Carrying Ability. The deflections of restrained and loaded walls were toward the fire and attained a maximum at the center of the wall. For 8-inch walls the maximum deflections of the large walls averaged 2 inches and for the 12-inch walls, 1¼ inches, at from 2 to 6 hours after the start of the test. For the unrestrained walls the maximum deflections obtained at the top of the wall and were away from the fire, the average of maximums obtaining at the end of 6 hours being about 9¼ inches for 8-inch walls. The recovery from deflections on cooling ranged from one-fourth of the maximums obtaining during test to full recovery.

No 8-inch walls failed due to excessive deflection or under the applied working loads. One 12-inch wall failed under the working load at a little before 10 hours after the start of the test due to weakening of the brick on the fire side.

Fire Effects on Brick and Masonry. For the restrained walls cracks on the side away from the fire of over 1/16 inch in width were rare. For the unrestrained walls cracks up to 5/8 inch were formed in 8-inch walls toward the end of the test, these being narrower or closed on the fire side.

The headers were seldom found cracked in the central portion of the wall so that the integrity of the wall as a building member was maintained.

Serious damage to the bricks was confined to those next to the fire except for tests lasting over 6 hours. Cracks parallel with the face of the wall were formed in some of the bricks from $\frac{1}{2}$ to $1\frac{1}{2}$ inches from the fire side. Hard bricks were more susceptible to cracking than the softer bricks although showing greater strength after the fire test. The full discussion of fire effects and possibility of reuse involves a greater amount of detail than can be given in the present letter circular.

Fire Resistance Classifications. According to present specifications for fire tests, the classification for load-bearing walls is based on ability to sustain working load and to prevent temperature transmission through the wall to such extent as to endanger combustible materials in contact with the unexposed side. The average temperature rise permitted is 139°C (250°F) or a maximum rise of 181°C (325°F) for any single point. The temperatures are measured under asbestos felt pads, 4/10 inch thick, placed against the unexposed side of the wall. The periods given in the following table are determined mainly by temperature transmission although the limit for the 12-inch walls is determined by load carrying ability of walls made from some of the bricks. The periods given are within the lower range of values obtaining in the fire endurance tests. The factor of safety that should be applied to them would depend on the variation in material and workmanship to be expected in building construction beyond that present in the tests, the drier condition of party and fire walls after years of service in the interior of heated buildings as compared with that of the walls tested, and the increase in temperature on the unexposed side after the prescribed temperature limit was reached and the fire shut off. Information on the extent of these effects was developed in the tests but a discussion of them, as of factors of safety generally, is considered beyond the scope of the present letter circular. Considering the efforts made to obtain representative material and workmanship and proper seasoning of the walls, it is believed that the test conditions were representative of what can generally be obtained in fire tests and that the results are correspondingly comparable.

The fire and water tests developed nothing that would change the conclusions based on the fire endurance tests.

ULTIMATE FIRE RESISTANCE PERIODS OF BRICK WALLS

Solid Walls made of Concrete or Sand-Lime Bricks

Kind of brick	Nominal thickness	Building members projecting into wall	Fire resistance period
Concrete	8-inch unplastered	none or incombustible	6½ hours
ditto	ditto	combustible	3 hours
ditto	12-inch unplastered	none or incombustible	15 hours
ditto	ditto	combustible	12½ hours
Sand-lime	8-inch unplastered	none or incombustible	8 hours
ditto	ditto	combustible	3½ hours
ditto	12-inch unplastered	none or incombustible	10 hours* 15 hours**
ditto	ditto	combustible	10 hours* 13 hours**

* Based on both load carrying ability and temperature transmission

**Based on temperature transmission only and obtained by comparison with results of tests with concrete brick walls.

The above periods apply for both bearing and non-bearing walls unless otherwise indicated (**) when for periods approaching that given, the non-load-bearing classification applies, although such walls are safe for bearing purposes at lower periods. For bricks laid flatwise and for periods not exceeding 6 hours, either Portland cement, cement-lime, or lime mortar of volume proportions not leaner than 1:3, cement or lime, and sand, respectively, can be used. For walls having periods of over 6 hours, Portland cement or cement-lime mortar should be used.

When combustible or non fire resistive floor members enter into solid walls they must project not more than 4 inches into the wall, and must be so placed and protected as to have not less than 4 inches of solid material between the if the given resistance periods are to be developed.

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