DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
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FIRE RESISTANCE OF CLAY HOLLOW WALL TILE

Scope of Present Results

The fire tests of hollow tile completed by this Bureau were made on about 150 walls, four feet square, and 40 walls, 16 feet long and 11 feet high. These were of 8, 12, and 16-inch plastered and unplastered walls built of load bearing tile of the types and designs in common use. In some of the tests the walls were built within rigid frames giving restraint on all edges as in panel or curtain wall construction, others were built entirely unrestrained as in the upper story or one story construction, while others were built on beams and were free at the edges so that definite working loads could be applied during the fire exposure. The test consisted of subjecting one side of the test wall to a controlled test fire, with indicated furnace temperature near 832°C (1550°F) at 30 minutes, 927°C (1700°F) at one hour, 1010°C (2000°F) at 4 hours, 1177°C (2150°F) at 6 hours, 1260°C (2300°F) at 8 hours and 1371°C (2500°F) after 10 hours and 40 minutes.

The strength and other physical properties of individual tile representative of those subjected to the fire tests have been determined and preliminary results reported in papers before the American Ceramic Society and the American Society for Testing Materials. Progress reports have also been made and published in the Proceedings of the Hollow Building Tile Association*.

The walls tested under load were subjected to 120 pounds per square inch of gross bearing area for end construction tile and either 60 or 80 pounds per square inch for side construction tile. These loads were selected as being those design loads most commonly used in practice.

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* "Strength, Absorption and Freezing Resistance of Hollow Building Tile". Jour. Amer. Ceramic Soc., 7 (3) (1924).
"Report of Committee C-10 on Hollow Building Tile." Proc. A.S.T.M., Vol. 24. Part 1. (1924).
"Report of Research Work on Hollow Load Bearing Wall Tile." Proc. Eighth Annual Meeting Hollow Building Tile Association, (1926).

General Fire Test Performance

As indicated from tests of material from 30 sources representative of the typical classes of clay used in hollow building tile manufacture, the ability to withstand fire exposure varies widely and is governed by the class of clay, the design of the units and the construction of the wall. A few 8-inch walls of weak tile failed under working load after a fire exposure of from 25 minutes to 2 hours. Most 8-inch and all heavier walls withstood the fire exposure for periods equal to or greater than the useful limit of the wall as determined by the temperature rise on its unexposed side.

The fire damage varies greatly in amount depending mainly on the kind of clay from which the tile are made, and the design of the units, some tile showing little effects after the fire exposure, others suffering material damage after relatively short fires. What mineral or mineral combinations in the clay are responsible for the difference in fire effects noted, is not as yet definitely known, although indications are that minor constituents recurring consistently with given clays and acting as fluxes are important factors. The extent of the damage and its influence on the strength of the wall is governed in a degree by the number of cells through the thickness of the wall, decreasing as the number of cells increased, the damage where present being confined to portions of the shell or cell on the exposed side. With two-unit walls the damage is confined to portions of the exposed unit. The susceptibility to damage also decreases with increase of shell thickness. As would be expected the temperature on the unexposed side after given fire exposures on the opposite side also are lower where the thicker shells or greater number of cells are present. No difference in fire resistance was noted between end construction and side construction tile having comparable shell thickness and number of cells, this statement also applying to such tile of special design as were tested.

One half of many of the large walls tested were plastered on the fire side or on both sides to bring out, with comparable tests, the protection afforded by the plaster. It was found that an acceptable grade of gypsum or cement plaster would stay in place throughout any fire exposure. A lime plaster, however, always fell off very soon after the fire was started.

Four large walls were subjected to fire and water tests. These walls were made up of sections so that each wall contained tile of all typical designs and clays being studied. The fire hose stream washed out some mortar in the joints and flakes and parts of shells that apparently had loosened during the fire exposure. The condition of the units after the fire and water tests was about the same as would be expected from moderate fire exposures. Although no loads were applied to these walls during the fire and water tests, compression tests of sections cut from the wall after the fire exposure indicate that walls of any of the tile would have carried the usual work-

ing load during the fire and water test.

Two walls, plastered on the fire side and faced and bonded on the other side with brick, were tested. One of these was built of 4 inches of tile and 4 inches of brick while for the other 8 inches of tile was used. Both of these walls carried the usual working load during the fire exposure and also a 50 per cent over-load which was applied at the conclusion of the fire exposure.

The following table gives the average time required to reach temperatures of 150°C (302°F) on the unexposed side of the various types of walls. This temperature was chosen because of the common use of 300°F as a limit of permissible temperature for the unexposed side of partitions in specifications for fire tests of such constructions. While this temperature is below the ignition point of ordinary combustible materials, excepting hazardous materials like celluloid, matches, and a number of chemical compounds, it is probably not too high as a limit for general temperatures on the unexposed surface, considering that higher temperatures are likely to prevail at cracks and open joints and under combustible materials that may be piled against the wall.

Thickness of wall in inches	Kind of unit or construction	Plaster	Time required to reach 150°C (302°F) on the unexposed side as measured by unprotected couples.
8	Partition tile	None	1 hr. 15 min.
8	Load bearing tile of 2 cell thickness	None	1 hr. 45 min.
8	Load bearing tile of 2 cell thickness	Plaster on both sides	3 hr. 30 min.
8	Load bearing tile of 3 cell thickness	None	2 hr. 15 min.
8	Load bearing tile of 3 cell thickness	Plaster on both sides	4 hr. 0 min.
8	Four inches of tile faced with 4 inches of brick	Plaster on tile or fire side	5 hr. 0 min.
12	Eight inches of tile faced with 4 inches of brick.	Plaster on tile or fire side	6 hr. 0 min.*
12	Single unit load-bearing tile	None	3 hr. 30 min.
12	Single unit load-bearing tile	Plaster on both sides	6 hr. 0 min.*
16	Multiple unit wall	None	6 hr. 0 min.*
16	Multiple unit wall	Plaster on both sides	10 hr. 0 min.

* No test beyond 6 hours. Surface temperatures below 110°C (230°F) at end of test.

The above time periods should not be taken as the safe fire resistance periods, in deriving which the results of the tests must be discounted to allow for the greater range in quality of material and workmanship obtaining in building construction as compared with that incident with the relatively few duplications of test specimens possible to introduce. Even considering these limitations it appears probable that 8-inch unplastered walls of load bearing hollow tile will satisfactorily hold back fires in intensity and duration equivalent to the first hour of the fire test exposure and the 12-inch walls, fires equal to the first 2 1/2 hours. This would make 8-inch walls adequate in residence, office and institutional occupancies where no considerable accumulation of combustible material is present. For the more severe exposures from mercantile and manufacturing occupancies with moderate amounts of combustible materials the 12-inch wall will apparently be adequate. Walls heavier than 12-inches may be required for the heavy manufacturing warehouse or storage occupancies. These conclusions are based on tests with unplastered walls. As indicated in the table, plaster adds from 1 3/4 to 3 hours to the ultimate fire resistance of the wall.

The above conclusions refer particularly to bearing partitions and party and fire walls in fire resistive buildings. In cases where combustible or non-fire resistive members are framed into the wall, they should not project more than 3 1/2 inches into the wall for 8 and 12-inch walls, and the ends in the wall should have not less than 4 inches of solid material above, below and between them, if the full fire resistance of the wall is to be developed. With fire resistive interior building construction designed to withstand a complete burning out of the building without collapse, the floor members should be framed farther into the wall to insure safe bearing after fires that may have damaged the exposed side of the wall.

The above is submitted for your information and is not intended for publication.