FPL FACILITY FOR EVALUATING STRENGTH-PERFORMANCE OF WALLS EXPOSED TO FIRE

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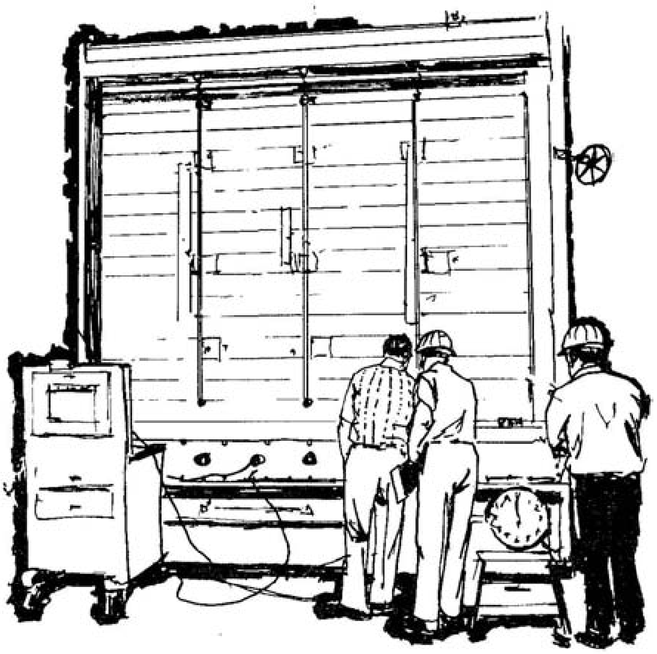

ABSTRACT

To simulate the designloads on wall panels of homes when one surface is exposed to fire, the FPL facility used for 40 years to evaluate 10- by 10-foot panels was modified so that: (1) It would support a conventional 8-foot-high by 10-foot-wide wall panel of a home; (2) it would apply compressive, edgewise, vertical loads along the 10-foot edge; (3) the applied loads would be uniformly distributed by a hydraulic system of jacks; (4) the loads could be monitored by electronic load cells; and (5) the system would have a load capacity of 40,000 pounds.

It was estimated that design loads on such a panel in a first-story wall of a two-story home would be 1,250 pounds per linear foot. The capacity of this facility exceeds the minimum requirements because it is intended to accommodate future considerations.

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FOREST SERVICE
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INTRODUCTION

According to ASTM E 119,[2] fire test guidelines, tentative standards, and standards have been in existence in one form or another since 1917. Quoting in part--"They prescribe a standard exposing fire of controlled extent and severity. Performance is defined as the period of resistance to standard exposure elapsing before the first critical point in behavior is observed." . . . "Reports of tests involving wall, floor, beam, or ceiling constructions in which restraint is provided against expansion, contraction or rotation of the construction shall describe the method used toprovidethe restraint."

ASTM E 119 however also specifies conditions for bearing walls and nonbearing walls. For bearing walls, it specifies that ". . . a superimposed load shall be applied to the construction in a manner calculated to develop theoretically, as nearly as practicable, the working stresses contemplated by the design."

Basically, walls must be sufficiently sound to allow time for the occupants to evacuate a burning building.

The need for more efficient use of building materials and the introduction of new types of wall construction now makes it necessary to know how these structural elements perform in fire--to insure the safety of individuals even in single-family houses.

Heretofore, the Forest Products Laboratory has evaluated the performance of 10- by 10-foot wall panels without restraint (in an unloaded state while exposed to fire) because of lack of loading facilities as part of the furnace equipment. With increasing demands for knowledge of fire performance under service conditions of conventional framing, stressed-skin construction, and sandwich panels, FPL has modified the existing supporting framework so designloads could be superimposed on conventional-sized walls (8 ft. high by 10 ft. wide) during exposure to fire.

This report describes the frame, load apparatus, restraint at the edges, load transducers, deflection gages, and protective measures that facilitate this type of testing of walls.

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] American Society for Testing and Materials. ASTM E 119, Standard Methods of Fire Tests of Building Construction and Materials. 1967. Philadelphia, Pa.

EQUIPMENT

(1) Existing Framework

The fire testing facility of FPL (fig. 1) consists of a vertical gas furnace and a portable structural steel frame for supporting experimental walls. The overall dimensions of the frame are about 12 feet, 9 inches high by 11 feet, 4 inches wide. The interior dimensions are 10 feet, 1 inch by 10 feet, 1 inch. The top and bottom I-beams are 12-inch, 40-pound members and the two vertical channel irons are 9-inch, 20-pound members. All members are protected by concrete,

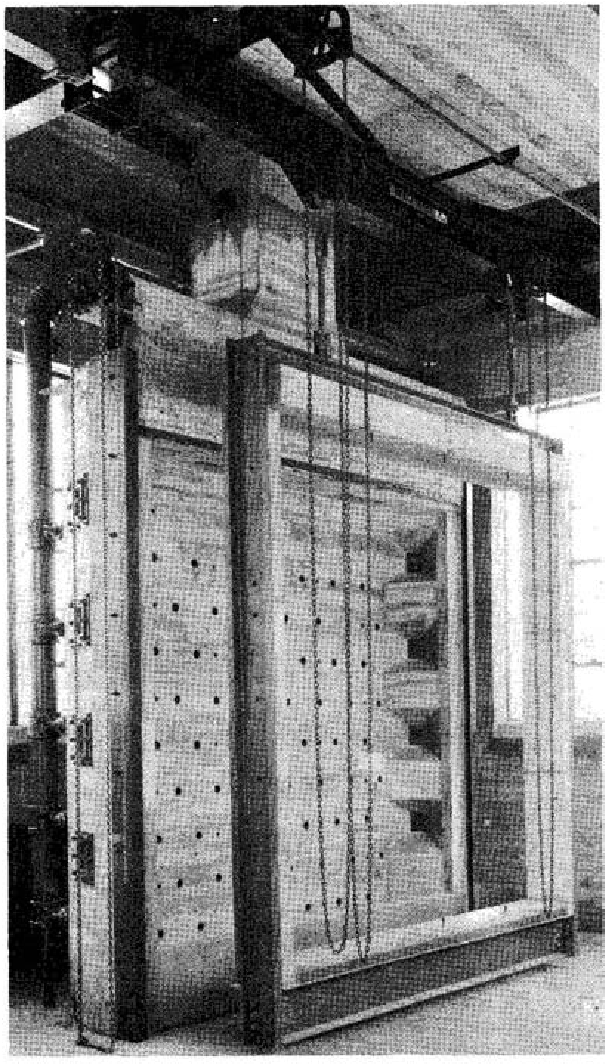

Figure 1.--Vertical furnace and original 10- by 10-foot frame. During a fire exposure test, the picture frame for holding the wall panel is fastened to the frame of the furnace. M 25310 F

(2) Frame Modification for Loaded Panels

The modified facility for loading panels (fig. 2) includes new structural steel members located about 2 feet above andparallel to the lower I-beam. The steel members, consisting of two 12-inch, 30-pound channel irons, a 1-inch bottom steel plate, and a 1/2-inch top steel plate, form a box beam which is bolted to the two existing vertical channels. This box beam (fig, 3) supports and encloses the following: (1) A movable platen consisting of a 4-inch-square steel tube that in turn supports the wall panel, (2) four hydraulic jacks, and (3) four electronic load cells. Holes in the channel iron on the "cool side" (fig. 2) provide access and cooling to the load equipment. Two 3- by 4-inch angle irons on the top plate are lateralguides for the vertical motion of the movable platen.

The interior dimensions after the modification are now 8 feet, 1 inch high by 10 feet, 1 inch wide.

(3) Loading Apparatus

Within the box beam and bolted to the movable platen are four 5-ton, 5-1/4-inch stroke, spring return, hydraulic jacks spaced on 30-inch centers. Each is attached to the platen and to the spherical seat of the electronic load cell. A set of four springs at each spherical seat assist in maintaining contact between jacks and load cells. All jacks are connected to a manifold to which oilpressure is applied manually by a hand pump (fig. 4). The system uses oil pressures up to 10,000 pounds per square inch.

(4) Load Transducers

Four electronic load transducers are located between the jacks and 1-inch-thick bottom plate. Each is a resistance-type strain gage precision compression-only cell, having 10,000 pounds capacity, single bridge, 350 ohms resistance and rated output is 4 millivolts per volt input. Individual power supplies provide 10 volts d.c. to each cell whose output is connected in series. The sum of their output is connected to a variable span volt-reading strip chart recorder that has "time" on the X-axis. At 12,500 pounds (proposed design load) the indicator is at midscale or 25 millivolts.

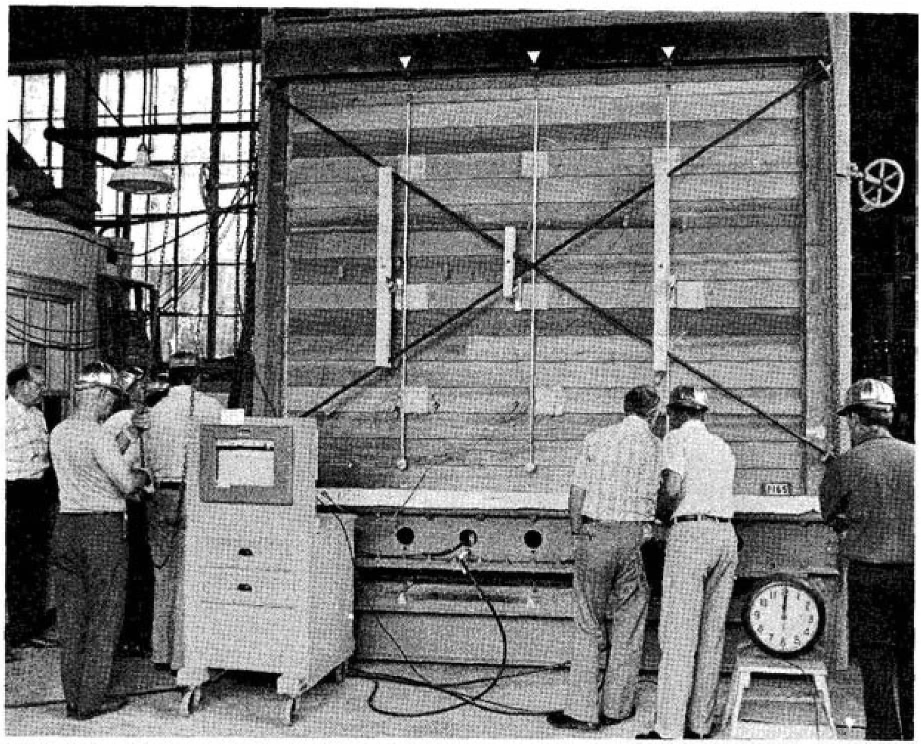

Figure 2.--Modified frame, showing new structural steel member supporting the wall panel. The wall panel is in place and ready for the test. M 140 434-7

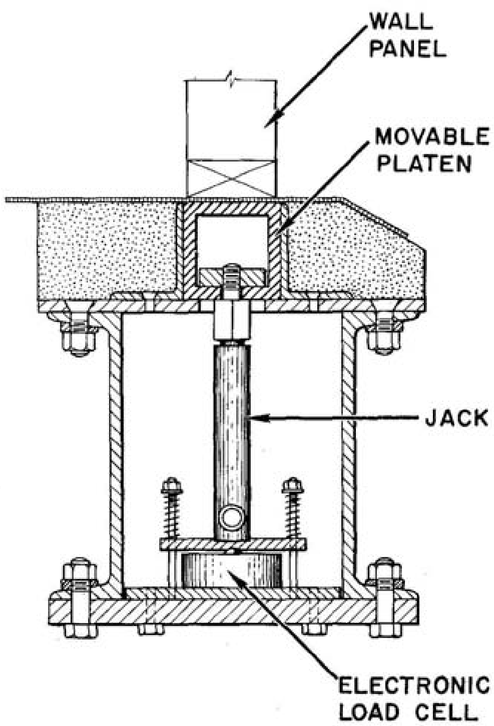

Figure 3.--Cross section of box beam showing devices for loading the wall panel during exposure to fire. M 140 712

Figure 4.--Hand hydraulic pump and electronic load indicator.

M 140 434-9

(5) Deflection Apparatus

The vertical deformations are measured with dials (which read to 1/1000 in.) attached to 7-foot, 9-inch aluminum tubes which have a ball and quick-disconnect socket at the top end (figs. 2 and 5A). The lateral deflection apparatus also uses dials which read to 1/1000 inch (fig. 6).

(6) Protective Alterations

Since the original overall dimensions of the gas flame opening of the FPL vertical furnace were about 10 feet by 10 feet, it was necessary to reduce the opening to 8 feet by 10 feet to accommodate the new test panels. This was done by constructing a lip of concrete about 5 inches thick, 2 feet high, and 10 feet long between the lowest rows of gas burners and the new steel box beam. In addition, the top of the box beam and the angle irons, except for the platen, was also covered with protective concrete.

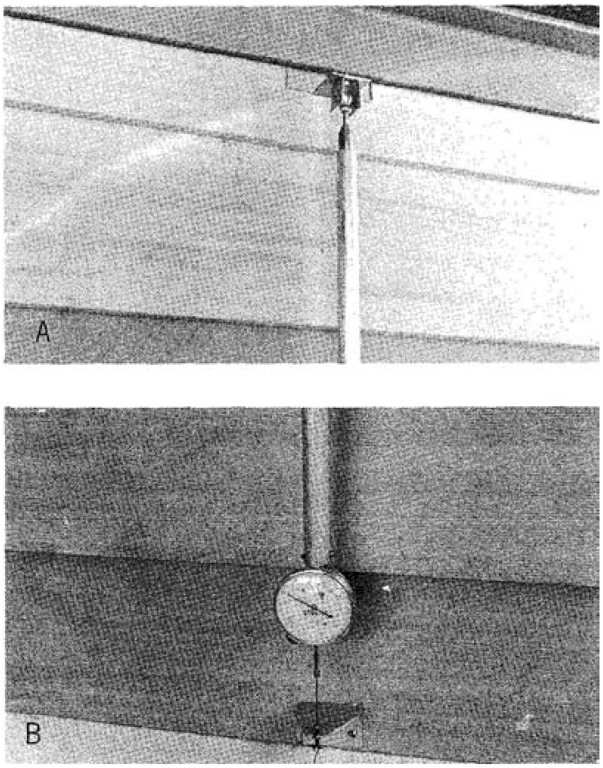

Figure 5.--Ends of aluminum tubes (see fig. 2) used to measure vertical deformation: A, ball and socket joint at upper end; B, dial gage for lower end. M 140 434-5

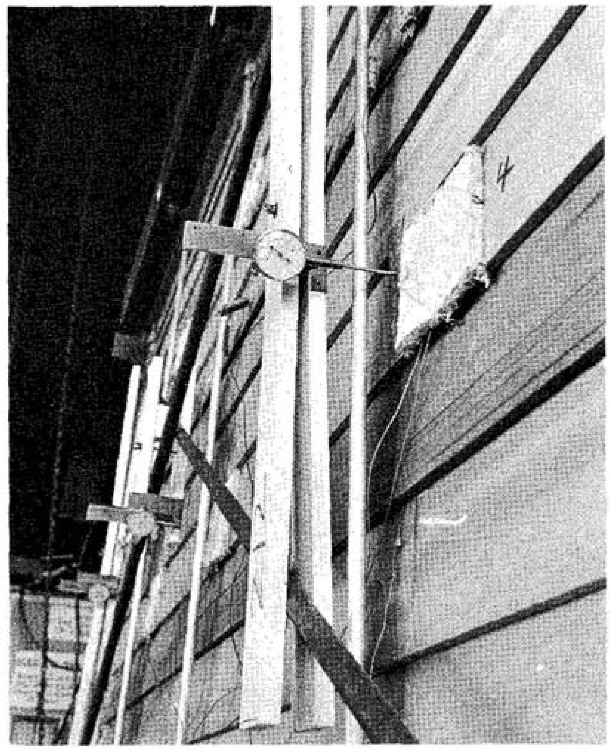

Figure 6.--Dial gages for observing lateral deformations. M 140 434-4

DISCUSSION

This facility will now accommodate a wall panel 8 feet high and 10 feet long, with about 1-inch clearance on the two sides and top. The clearance on the sides is filled with loosely packed mineral wool so that a minimum of friction exists during loading and yet no gases escape.

The 1-inch clearance on the top, however, is used to float the experimental panel on the platen and on the jacks so the tare load of the panel is zeroed out on the recorder. The 1-inch gap is then closed when the load is applied.

While the panel is floated, its top 2 by 4 plates are loosely fastened to angle iron guides, and its bottom 2 by 4 plate is secured to the platen by two 5/8-inch-diameter steel dowels. When the load is applied to the panel, there is no lateral restraint on its edges to prevent buckling and the flat end condition of the 2 by 4 plates on the concrete at top and on the platen at the bottom is more akin to simply supported than flat end. Thus, the test panel is essentially a column having length–to–depth ratio of about 24:1.

At loads of 12,500 pounds, which this facility will use to simulate design loads, the oil pressure is over 3,000 p.s.i. This pressure is distributed to the four jacks, and hence theloadis distributed through the stiff platen to the plates of the wall.

Hydraulic pressures could have been used to measure loads in the facility. However, separate electronic load cells for each jack were selected to provide frictionless indications of the total load on the test panel by measuring loads on the cells individually. By monitoring the total load on the strip chart, the operator can manipulate the hand pump (fig. 4) to increase the load or compensate for creep deformation of the panel during fire exposure.

It is recognized that the 8– by 10–foot–size of panel this load frame will accommodate does not meet the current minimum requirements of ASTM E 119; i.e., minimum of 9 feet high and minimum of 100 square feet area. However, for load–bearing tests of walls intended for housing, the 8–foot high section is more representative.

INITIAL TESTS

To determine the operating characteristics of this new load facility, two 8– by 10–foot wall panels were loaded while exposed to fire (fig. 2). These panels had 2– by 4–inch wood studs (Hem–fir) on 16–inch centers, 3/8–inch gypsum board interiors, 6–inch cedar siding exteriors, and 3–1/2–inch fiberglass insulation between studs. Experience with these two tests has shown that the 12,500–pound load could be held constant, plus or minus 150 pounds, until the wall either increased its rate of buckling away from the fire or collapsed. It also showed that more distance must be provided for the wall section to move laterally, i.e., the cross bracings need to be removed.

In general, these two tests showed that the facility can function satisfactorily and effectively for evaluating the performance of 8– by 10–foot wall sections under load and while exposed to fire so that according to ASTM E 119 ". . . the period of resistance to standard exposure, . ." can be measured.

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