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FIRE ENDURANCE TEST OF PREFABRICATED ROOF PANEL

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ABSTRACT

A fire endurance test was made on one roof specimen, representative of prefabricated construction for use in very cold climates. Screws and washers were used as a means of prolonging the retention of gypsum board on the fire exposed surface. The fire endurance of the specimen ~~is~~ was 40 minutes.

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1. INTRODUCTION

At the request of the U. S. Naval Civil Engineering Laboratory, Port Hueneme, California, and Headquarters, U. S. Air Force, a test was conducted on prefabricated panels representative of a roof construction. This construction was designed for use in polar regions.

2. SPECIMEN

The test specimen was assembled from prefabricated panels. Each panel consisted of a wooden frame and a resin impregnated paper honeycomb insulation with a metal skin cemented to each face. The individual panels locked together to form the specimen.

The specimen was made by assembling the panels as received. No extra panels were available for disassembly and detailed examination. Therefore, the description is based in part on the representations of the designer, some of which could not be checked during examination of the debris after the tests.

The specimen was 16 ft long by about 12 ft 8 in. wide, made up of three roof panels, marked R2, plus an angle panel, marked R1, for transition from roof to side wall. The R2 panels were 16 ft long, 44 in. wide, and 4-9/16 in. thick; and had perlite fill in the honeycomb. The panels were received with a preapplied rubber, or rubber-like, roofing of .068 in. thichness.

After assembly of the panels, gypsum boards were applied to the underside of the roof deck. The area was divided approximately along the East-West centerline (along the short dimension of the furnace and transverse to the prefabricated panels). In the north half, 5/8 in. thick United States Gypsum Company Firecode 60 Wallboard was applied as follows: a full coat of Minnesota Mining and Manufacturing Company adhesive EC1357 was applied and allowed to become tacky, the board was then pressed against the deck and held there while 1 in. long, no. 12 self-tapping sheet metal screws with 13/32 in. diameter pan beads, and 3/4 in. od washers, were driven into holes drilled through the gypsum board and lower metal skin of the panels at 16 in. oc in both directions. The wallboards were 4 ft wide and 8 ft long. The joints between butted ends did not fall under the parallel joints between deck panels. In the south half of the area, a two layer application was made as follows: 5/8 in. thick United States Gypsum Company Firecode Boxboard, in V-edged sheets 2 ft wide and 8 ft long, was was given a full coat of Minnesota Mining and Manufacturing Company adhesive EC1357, the adhesive allowed to become tacky, and the boards applied to the deck parallel to the joints between deck panels so that the latter joints were covered by the Boxboard. Flat head 1 in. long, no. 12 self-tapping sheet metal screws were driven (until the heads were flush) into holes drilled through the Boxboard and into the lower metal skin of the deck panels at 2 ft oc along the centerline of each sheet of board. The second layer consisted of 3/8 in. thick United States Gypsum Sheetrock Gypsum Wallboard in 2 by 8 ft sheets. United States Gypsum Perf-A-Tape Joint Cement was applied to the upper surface with a trowel having notches that left 1/4 in. strips of cement at 2 in. oc. The board was immediately applied transversely to the first layer. The butt joints did not fall under joints between the Boxboard or the deck panels. Holes were drilled through both layers at

16 in. oc in both directions and 1-1/2 in. long no. 12 self-tapping sheet metal screws, having 13/32 in. diameter cap heads, with 3/4 in. od washers were driven into the holes.

All the exposed joints were given the recommended treatment of joint cement, paper Perf-A-Tape pressed into the cement and then a second layer of cement; sanded when dry, given a thin coat of finishing cement, and sanded when dry. The gypsum wallboard was then covered with a two coat application of Interior Semigloss Coating MIL-P-17971B Ships green formula 125, Stock No. GT 8010-286-9090.

3. TEST METHOD

The floor furnace was designed in such a manner that specimens must be built or assembled in the frame that is an integral part of the furnace.

The specimen was 16 ft long by about 12 ft 8 in. wide whereas the furnace frame was designed for specimens 18 ft long by 13 ft 6 in. wide. This discrepancy made it necessary to place supplementary steel in the furnace to support the specimen. The supplementary steel provided bearing for the long edge of one R2 unit, for both ends of all three R2 units and for the horizontal portion of both ends of the R1 unit. The fourth edge of the specimen, that edge of the R1 unit that would bear on wall panels in actual use, bore on the regular furnace bearing angles. This steel was protected with metal lath and plaster which also sealed the joint between steel and specimen.

Temperatures were measured on the unexposed surface and at the gypsum-deck interface, by thermocouples distributed as shown in figure 1; and in the furnace chamber by thermocouples encased in porcelain insulators and iron pipes. The furnace fires were regulated to provide temperatures as close as feasible to those defined for the standard time-temperature curve given in ASTM E-119, which include: 1000°F at 5 min, 1300°F at 10 min, 1550°F at 30 min, and 1700°F at 1 hr. During the test, the specimen was subjected to an applied load of 50 lb per sq ft of roof area. Vertical deflections were measured at the center of the specimen.

4. RESULTS

The fire endurance test was conducted on June 6, 1960 and witnessed by members of the staff of the Fire Protection Section, National Bureau of Standards, Mr. James R. Powers, Headquarters, U. S. Air Force , and Mr. M. Herrman, BuYards and Docks.

The exposed surface was ablaze immediately but the flames died out in about 40 seconds. There were lazy flames on the surface for about 20 sec, starting at 3 min. Approximately 3 ft^2 of the 3/8 in. thick wallboard fell in the southeast area at 18 min, followed by about 8 ft^2 in the southwest at 19 min. By 24 min, about 40 ft^2 had fallen in the south half; none in the north (single layer area). After each drop-out, heavy flames covered the exposed base layer of the two layer application. At 26 min there were flames from all the joints between wallboard sheets in the north half, which continued until the first of this wallboard fell at 39-1/2 min. By this time the center deflection of the specimen was about 7 in. and was increasing rapidly. The specimen was judged to have failed under load at 40-1/4 min. Flames came through the joint between the west and center roof panels, which had opened as a result of the load failure. A stream of water was applied to extinguish the burning specimen and the test was stopped.

The deflection and temperature data are summarized in figure 2. At 8 min, when the first wallboard fell, the deflection was 1.04 in. or about 1/180 of the span. The maximum temperature between the wallboard and deck was 214°F under the double layer and 261°F under the single layer application.

Figure 1 shows the distribution of thermocouples on the unexposed surface and between the gypsum board and deck panels. The following is a tabulation of the readings from the individual thermocouples at 40 min:

Unexposed Surface

TC	1	2	3	4	5	6	7	8	9	10	11	12
°F	110	82	176	79	79	79	96	88	124	82	82	82

Gypsum-Deck Interface

TC	13	14	15	16	17	18	19	20	21	22	23	24
°F	487	214	226	783	---	354	712	816	1555	1067	1180	1332

The fire endurance of the specimen was limited to 40 min by load failure, and flame penetration through a joint. The furnace control was such that no correction was applicable to this time.

Examination after test showed that the glue joint between the paper honeycomb and the lower metal skin was broken in all the panels. In many places the glue had adhered to the honeycomb, closing the cells over areas as great as 2 ft^2. Except in these areas, the perlite had fallen from the cells. The paper was blackened over only a few small areas and was a medium brown over the remainder. The lower metal surface of one R2 panel had fallen from place and those of the other two panels were loose from the wood frame along the long edges. The wood frame members were charred lightly and were broken at or near midspan in most instances. Even after cooling, most of the base layer of 5/8 in. gypsum board in the south half and about half the single layer in the north half were in place.

5. DISCUSSION

The comparison between the single layer and two layer applications of gypsum board must be based almost entirely on the temperature data obtained from the thermocouples placed at the gypsum-deck interface. The temperatures at those in the half with the single layer started to rise significantly about 15 min before any of those above the two layer application. When one of the latter started to rise, it was equal to the minimum of the former.

Although most of the finish layer of the two layer application fell from place, nearly all the base layer remained, whereas a significant amount of the single layer application fell.

6. SUMMARY

The results of the test indicated a fire endurance of 40 min for the particular specimen. It is not practical to attempt to predict how much, if any, longer this might have been had the entire exposed surface been covered with the two layer application of gypsum wallboard.