TESTS OF CARGO FLOORING - L FOR AIRCRAFT

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UNITED STATES DEPARTMENT OF AGRICULTURE
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FOREST PRODUCTS LABORATORY
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In Cooperation with the University of Wisconsin
TESTS OF CARGO FLOORING L FOR AIRCRAFT

By

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Summary

This report presents the results of tests performed at the Forest Products Laboratory on aircraft flooring L, a type of flooring that has seen considerable service in cargo planes in operation. Also type H which was earlier subjected to similar tests and which has had only a short period of service as a substitute or alternate to type L in planes of the same model, is compared to type L. The data for type H are taken from an earlier report.1

Floor L consists essentially of an aluminum alloy sheet formed to typical rounded corrugations and surmounted by a central and two adjacent side tread strips of flat aluminum-alloy sheet spot-welded to the corrugations. Floor H is similar, but the base consists of flat-topped corrugations formed from metal of heavier gage and to which is spot welded a continuous flat sheet.

Under static loading in flexure, floor H proved to be considerably superior to the portions of floor L with tread plates and further superior to the portions without tread plates.

Floor H was much superior to floor L in resistance to crushing over supports, except at positions in floor L where the tread plate was supported by spool-shaped aluminum struts seated in the valleys of the corrugated sheet. After a small amount of crushing, the slope of the load-deformation curve for such points was much steeper than for floor H, and the load required for a serious amount of crushing was much higher. The results of these tests seem to show that "flat" corrugations are superior to the "rounded" in resistance to crushing. The thickness of the metal, however, was 0.051 inch for the flat as compared to 0.040 inch for the rounded corrugations.

In resistance to puncture by the impact of the corner of a 200-pound softwood box, floor H was somewhat superior to the tread-plate-covered portion of floor L and much superior to other portions.

The tests indicate that the rolling loads for floor H are somewhat less than for the tread-plate portions of floor L — 950 and 750 pounds for 500 and 1,000 trips respectively as compared to 990 and 875 pounds. These differences are not large, and it should be noted that the path of rolling loads on floor H is unrestricted, whereas with floor L the tread plates must be used. Hence, it is possible that the usable life of floor H as limited by the effect of rolling loads may be no shorter than for floor L. It is indicated also that for trips fewer than about 400 the limiting rolling load may be greater for H than for L.

The principal inferiority of floor H as compared to floor L is its greater weight.

Introduction

The Forest Products Laboratory, at the request of Technical Subcommittee on Air Cargo Transport (Joint Aircraft Committee) has conducted tests on cargo floor L. This flooring is made for service in the same airplane as flooring H, which was among a number of floors previously tested. Flooring H was of a new design on which there was little service experience. Flooring L, on which considerable experience data are available, was accordingly obtained and tested. These tests form the subject of this report.

Material

Flooring L

Flooring L (fig. 1) consists of a corrugated aluminum alloy (rounded corrugations) 0.040 inch thick, to the upper side of which are spot welded, as tread plates, strips of 0.064 inch thick sheet aluminum alloy. The 6 inch wide tread plate is along the longitudinal centerline of the plane, and the 12-inch strip is adjacent to the inner edge of each of two side panels. The remainder of the corrugated portion of the floor is without cover. The corrugations are 1-1/4 inches deep and spaced at 3-inch centers. Two spool-shaped aluminum struts standing in the corrugated valleys are riveted to the corrugated sheet and the central tread plate at each point where the tread plate crosses a transverse support. Between these supports aluminum-alloy reinforcing strips 0.040 inch thick and 4 inches wide extend crosswise along the under side of the portion of the side panels not covered by tread plates and are welded to the corrugations.
The specimens of flooring L tested consisted of two center and two edge sections. Panels Nos. 1 and 2, figure 1, are edge sections and Nos. 3 and 4 are center sections. Figure 1 shows the location of all test specimens.

Flooring H

Flooring H consists of a corrugated aluminum alloy sheet 1-1/4 inches deep and 0.051 inch thick with flat-topped corrugations 3/4 inch wide spaced 3 inches on centers and webs inclined to the vertical, to the upper surface of which is spot welded an aluminum-alloy sheet 0.063 inch thick. Floor H data were taken from report No. 15501.

Description of Tests and Presentation of Data

Weight

Each panel of flooring L was weighed in the condition received. One center section was weighed with and without the tie-down fittings.

The weight of floor H is 1.93 pounds per square foot.

The weights of floor L are:

- Center panel with tie-down fittings -- 1.90 pounds per square foot.
- Center panel without tie-down fittings -- 1.36 pounds per square foot.
- Side panel -- 1.26 pounds per square foot.

Averages for two side panels (each 31-1/4 inches wide) and one center panel (16 inches wide):

- Panels with tie-down fittings -- 1.39 pounds per square foot.
- Panels without tie-down fittings -- 1.29 pounds per square foot.

These weights and that of floor H are shown in figure 2.
Static Bending

Tests of ultimate flexural strength and work performed up to the point of maximum load were made on specimens shown in figure 1 over a 16-inch span. The specimens were simply supported on knife edges equipped with roller bearing blocks. Deflections were measured at the bottom of the two central corrugations by means of a dial gage graduated to 0.001 inch. Load was applied at a machine speed of 0.05 inch per minute to the center of the span through a maple block shaped to a 4-inch radius.

Figure 3 presents typical load-deflection curves for floors H and L, and figure 4 shows the work to maximum load for these floors.

Strip Loading

The effect of strip loading, simulating the action of a floor beam, was investigated. Specimens were of width and length as shown in figure 1 and were supported top down on the platen of the testing machine and loaded by means of a metal bar 1-1/4 inches wide by 16 inches long. The bar was placed across the specimen in the same position as would be occupied by a supporting floor beam. Load was applied at a rate of 0.01 inch of head travel per minute. Deformation of the flooring was measured by two dial gages reading to 0.0001 inch mounted on each side of the bar and touching the flooring outside the deformed area.

Typical load deformation curves are shown in figure 5. The results of the tests expressed in terms of the load that was sustained at a deformation of 0.05 inch appear in figure 6.

Impact Loading

The impact loading tests investigated the effect of dropping on the flooring from various heights a 200-pound softwood box corner. A description of the apparatus used is contained in a previous report. Tests were made by dropping the box corner both on the tread plate and on the open corrugations of the side panels and on the tread plate of the center panel. When the box corner was dropped on open corrugations, the deflection and permanent deformation were measured directly below the point of impact. When it was dropped on the wearing surface, the deflection and permanent deformation were measured at the point of impact and at points on the lower part of the corrugation at either side of the point of impact.

The relation of height of drop to deflection and to permanent deformation is shown in figures 7 and 8, respectively. These figures show also the positions of points of impact and points of deflection measurement relative to the corrugations.
Rolling Load -- Engine Cradle

The rolling load test was made to determine the effect of a load rolled along a panel of the flooring on a cast wheel 8 inches in diameter and 2-1/2 inches wide. The specimens for this test were as wide as the panel and 34 inches long extending over three supports (two spans). The 1-1/4 inch wide flanged supports to which the panel was fastened were on 16-inch centers. Wheel loads of several magnitudes were used and for each the number of repetitions of load, or trips, required to cause failure was recorded. For panels of both types (edge and center) the load was moved along the center of the tread plate. The relation between wheel loads and number of trips is shown in figure 9, a trip being defined as a single passage of the load.

Analysis of Results

Weight

The weight per square foot of floor H is practically the same as the center section of floor L with the tie-down fittings. Floor H is heavier than floor L with two edge sections and the one center section with or without the tie-downs.

Static Bending

It is evident from figure 3 that the corrugated section of floor L without the wearing surface tread plates (1-B-2) could not carry the loads that the section covered with wearing surface could support. Floor L, in general, has neither the stiffness nor the load-carrying capacity of floor H. For even that portion with tread plates the ultimate strength of floor L is only about one-half that of H.

Specimens 1-B-2 and 2-B-2 were tested with the transverse reinforcing strip on the bottom of the corrugations at the center of the span. These specimens failed at the spot welds that connected the transverse reinforcing strip to the corrugations by transverse splitting of the corrugated aluminum sheet but carried the same load as specimens 1-B-3 and 1-B-4, which had no reinforcing strip.
Strip Loading

The edge panels of flooring L showed little resistance to crushing at the floor beams. The center section with the spool-shaped struts over the floor beams carried the largest load at 0.05 inch deformation. This section, however, was not as stiff as floor H below 375 pounds per square inch (figs. 5 and 6).

It may be noted in figure 5 that the curve for specimen 4-ST-1 is unusual in that the rate of deformation decreases with increasing load. This is undoubtedly due to the presence of the aluminum spools or struts. At low loads the resistance to deformation of the floor is low, but the spools coming into bearing with increased load change the characteristics and account for the decrease in the rate at which the deformation increases.

Impact Loading

Because the edge sections of floor L are used in service with the corrugations exposed to loads without a wearing surface, impact tests were made on this part of the panel as well as on the part with the wearing surface. The greatest deflection and permanent deformation occurred when the box corner was dropped on the upper part of a corrugation (ridge); the next in magnitude occurred when the box corner was dropped between corrugations, although it did not then strike the bottom (valley) of the corrugation. When the box corner was dropped on the wearing surface, the impact produced a greater deflection and permanent set in the center panel than in the edge panel. There was little difference between floor H and L for the same type of deflection and deformation measurement when the box corner was dropped on the wearing surface as shown in figures 7 and 8.

Rolling Load -- Engine Cradle

Figure 9 presents the results of rolling load tests. These tests reveal that the tie-down fittings and the spool-shaped aluminum struts or separators over the floor beams caused the rolling load to bounce over these points resulting in some impact on the panel thereby reducing its serviceability or life (figs. 10 and 11). Cracks first occurred at spot welds between the wearing surface and the corrugation. At failure, the wearing surface was torn; the corrugations were crushed over the supports, and the smaller tie-down fittings torn from the corrugations. The tie-down cross beam remained intact.

The edge panels showed evidence of failure, first, at the spot-welded lap joint in the corrugated sheet, which joint was located beneath and along the centerline of the wearing surface; and second, at the spot welds between the wearing surface and the corrugated sheet. Later, the tread plate or wearing surface sheared along the edge of the wheel track (figs. 12 and 13).
Conclusions

Stress-deflection and impact characteristics of floor H are shown to be superior to similar characteristics of floor L; rolling load tests, however, show a slight superiority for floor L at the 1,000 trip level. The principal inferiority of floor H as compared to floor L is its greater weight.
Figure 1.—Location of test specimen from cargo flooring L.
Panels Nos. 1 and 2 are edge and Nos. 3 and 4 are center floor sections.

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Figure 2.--Weight per square foot of floors H and L.
Figure 3.—Typical load-deflection curves from static-bending tests of floors H and L over a 16-inch span.
Figure 4.--Results of bending tests of floors H and L showing the work-to-maximum load per inch of floor width when supported on a 16-inch span.
Figure 5.--Typical load-deformation curves from compression tests simulating the crushing effect of floor beams on floors H and L.
Figure 6.—Results of tests of floors H and L under strip loading simulating the effect of crushing over floor beams. Load per square inch corresponding to a deformation of 0.05 inch.
Figure 7.—Relation between height of drop of a 200-pound softwood box corner and the deflection of floor panels H and L.
Figure 8.—Relation between height of drop of a 200-pound softwood box corner and the permanent deformation of floor H and L.
Figure 9.--Relation of wheel load to number of trips required to produce failure of floors H and L.
Figure 10.—Top surface of rolling load specimen from panel No. 3. Floor subjected to 1,044 trips with a weight of 800 pounds on engine cradle wheel.

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Figure 11.--Bottom surface of rolling-load specimen shown in figure 10. Note tearing of the corrugated sheet around the tie-down fitting.
Figure 12.--Top surface of the rolling load specimen from panel No. 2. Floor subjected to 510 trips with a weight of 1,200 pounds on the engine cradle wheel.
Figure 13.—Bottom surface of rolling-load specimen shown in figure 12.

Note failure of spot-welded lap seam along centerline of wheel track. This was the first evidence of failure.