TESTS-OF CARGO FLOORING M FOR AIRCRAFT

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TESTS OF CARGO FLOORING M FOR AIRCRAFT

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Summary

This report presents the results of tests performed at the Forest Products Laboratory on aircraft floor M at the request of Air Materiel Command, Army Air Forces. These results are compared with those of tests on floors H and I, which were of similar construction.

Floor M consisted essentially of an aluminum-alloy-sheet wearing surface spot-welded to a dimpled aluminum-alloy sheet. These two sheets were spot-welded to a dimpled-sheet base formed to approximately rectangular corrugations but with webs slightly inclined to the vertical. Floor H consisted of an aluminum-alloy sheet spot-welded to a corrugated base of flat tops and webs inclined to the vertical. Floor I was of similar construction except that the corrugations were square.

Floor M weighed slightly less than either floor H or I; floor I, however, had a nonskid wearing surface that increased its weight.

Under static loading in flexure, floor M failed in horizontal shear at the spot welds between the corrugated base and the upper sheets at relatively low loads. Floor M had neither the stiffness nor load-carrying capacity of floors H and I.

Floor M was much superior to floor I in resistance to crushing over supports, but inferior in this respect to floor H. Tests conducted on floor I, however, were without benefit of the spruce filler blocks normally used in the open corrugations over the floor supports.

Under concentrated loads, floor M was inferior to floors H and I, probably because of failure at the spot welds.

In resistance to puncture by impact of a 200-pound softwood box corner, floor M was greatly inferior to floors H and I, and rupture occurred in its wearing surface from drops as low as 10 inches at midspan.

The rolling-load tests indicated that under loads less than 1,700 pounds, on the engine-cradle wheel, floor M was superior to floors H and I. As in the other test, however, the spot welds failed early in the tests.
Introduction

The Forest Products Laboratory, at the request of the Aircraft Laboratory, Air Materiel Command, Army Air Forces (Wright Field), conducted tests on cargo floor M, a new variation of the corrugated aluminum-alloy type of floor. Test methods for the evaluation of cargo floors were previously established to simulate service conditions and to compare the performance of the various floors by identical methods. Floor M was evaluated by these test methods and by comparison to aluminum-alloy floors H and I, which were of similar construction and were among a number of floors previously tested. The tests were a continuation of the program to evaluate cargo-flooring panels.

Material

Floor M

Various views of floor M are presented (figs. 1 through 4) in which figure 1 shows the upper, or wearing surface; figure 2, the lower surface; figure 3, a close-up of the lower surface; and figure 4, an end view of the floor. The panels as received were approximately 1.20 inches thick, 34 inches wide, and 36 inches long. The upper surface consisted of a flat aluminum-alloy sheet 0.032 inch thick, to which was spot-welded a dimpled aluminum-alloy sheet of the same thickness. The dimpled sheet had protrusions extending alternately above and below the plane of the sheet about 0.08 inch to form 1/2-inch squares spaced 13/16 inch from center to center. The upper two sheets were spot-welded to a similar dimpled sheet, of the same thickness, formed to nearly rectangular corrugations with the webs inclined slightly inward. The corrugations were about 1-1/8 inches deep and spaced 1-5/8 inches from center to center.

Floor H

Floor H consisted of a flat aluminum-alloy sheet 0.064 inch thick, spot-welded to a corrugated aluminum-alloy sheet 0.051 inch thick. The corrugations were 1-1/4 inches deep with flat tops 3/4 inch wide spaced 3 inches from center to center and with webs inclined to the vertical.

Floor I

Floor I consisted of a flat aluminum-alloy sheet 0.064 inch thick, spot-welded to a corrugated aluminum-alloy sheet 0.040 inch thick. The corrugations were square, 1-1/2 inches wide and deep, and spaced 3 inches from center to center.


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center to center. The open corrugations were blocked over the floor beams with Sitka spruce filler blocks. A rough wearing surface was provided on the flat sheet by an application of nonskid material.

Methods of Tests

The panels were trimmed, weighed, and measured and were then prepared, as required, for use as specimens. The following tests were made in accordance with methods specified for evaluation of this material and described in an earlier report:

- **Static Bending**: Over an 8- and 16-inch span.
- **Strip Loading**: Under a 1-1/4- by 9-inch steel bar.
- **Concentrated Loading**: Applied by a 1-inch diameter steel cylinder and by a 2-1/2-inch wide maple block shaped to a 4-inch radius.
- **Impact Loading**: Under the drop of a 200-pound softwood box corner.
- **Rolling Load**: Applied by an engine cradle wheel.

Presentation of Data

Weight

Comparative weight data for floors M, H, and I are presented graphically in figure 5.

**Static Bending**

Static-bending tests to determine ultimate flexural strengths were made on specimens 8 inches wide and 10 or 16 inches long over spans of 8 and 16 inches, respectively. Typical load-deflection curves for floors H, I, and M, tested over 8- and 16-inch spans, are presented in figures 6 and 7.

The energy absorbed to maximum load (work) in bending over a 16-inch span, was averaged for seven specimens of cargo floor M, and this average value is shown in figure 8, together with similar average values for floors H and I.

**Strip Loading**

Typical load deformation curves from strip-loading compression tests on floors H, M, and I are shown in figure 9. The results of the tests, expressed in terms of the load that was sustained at a deformation of 0.05 inch, appear in figure 10.

Additional tests were conducted on floor M by compressing the corrugations beyond 0.05-inch deformation, so that additional data could be obtained.
and a more complete failure of the corrugations observed. Typical results of these tests are shown in figure 11.

**Concentrated Loads**

The place of application of the concentrated loads and the visual evidence of damage may be seen in figures 12 and 13. The results of the test may be evaluated in terms of visual damage and by means of load-deflection curves as shown in figures 14 and 15 for floors I, H, and M. Results of tests on floor M are plotted and curves drawn for concentrated loads in both the interior (4 inches from unsupported edge) and exterior (12 inches from unsupported edge) load positions and with the maple cradle wheel both parallel and perpendicular to the length of the panel.

**Impact Loading**

In figure 16 are presented the results of several tests made by dropping a 200-pound box corner from various heights on the middle of the span at several positions on its wearing surface across the panel, and by measuring the resultant deflection and permanent deformation directly below the point of impact. Tests were conducted both over and between corrugations. Several drop tests were also made to observe the resistance to impact of the floor near the center support (fig. 16). No deflection measurements were made at these locations.

The relation of height of drop to deflection and to permanent deformation is shown in figures 17 and 18, respectively.

**Rolling Load -- Engine Cradle**

Wheel loads of several magnitudes were used (each on a new panel), and for each magnitude the number of repetitions of load, or trips required to cause failure, were recorded. Three specimens were tested under a wheel load of 1,400 pounds in an attempt to measure the variability under heavy loads, and also because failure of the first specimen at this load did not appear typical.

Results from all of the tests, along with typical curves from tests on floors H and I showing relationship between wheel load and number of trips, appear in figure 19, with a trip being defined as a single passage of the load.

At the beginning of each rolling-load test, a cracking, snapping sound was heard as the load was moved across the panel. This cracking sound seemed to indicate that the spot welds were failing. This phenomenon was studied by conducting two rolling-load tests, each on a new panel, 12 inches from the edge, over an area 5 inches wide and the length of the panel. The first panel was tested under a 1,400-pound load rolled over the 5-inch width in such manner that it was covered by 10 trips; the second was tested under a 1,000-pound load, using the same number of trips and covering an area of similar

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size. These panels were then cut longitudinally along the edge of the area covered by the wheel, and the failures were observed (figs. 20 and 21).

Analysis of Results

Weight

The weight per square foot of floor M was slightly less than that of floors H or I, as shown in figure 5. The greater weight of floor I, however, was due in part to the nonskid wearing material covering the surface of this floor and in part to the spruce filler blocks between the open corrugations, that the other floors did not have.

Static Bending

Static-bending specimens tested over both an 8- and a 16-inch span failed first in horizontal shear at the spot welds between the second layer of metal and the corrugated base. These spot-weld failures began to occur at loads of about 150 and 200 pounds per inch of width for specimens tested over 16- and 8-inch spans, respectively. As the bending failure progressed all the spot welds between the second layer and corrugated base failed in horizontal shear, and the dimples that had been nested began sliding over one another with the result that the two top layers acted somewhat independently of the corrugated base over one-half of the span length, as shown in figure 22. This type of failure placed the corrugated base in compression on its upper side, and a fold developed across the specimen between the dimples.

It is evident from figure 6 that floor M had about the same stiffness as floors H and I up to a load of 250 pounds per inch of width, tested over an 8-inch span. When additional load was applied, however, floor M had neither the stiffness nor load-carrying capacity. The ultimate load sustained by floor M was about one-half that of floor H.

Similar analysis of data obtained on static-bending specimens tested on a 16-inch span and presented in figure 7, reveal that floor M had neither the stiffness nor the strength of floors H or I.

The energy absorbed to maximum load (work) served as an indication of the resistance of the floors to shock loading when the load was distributed over a considerable area. The average test results plotted in figure 8 indicated that cargo floor M was decidedly weak in this respect as compared to the other floors.

Strip Loading

Strip-loading tests revealed that floor M did not have the resistance of floor H to crushing over a floor beam, but that it was superior to floor I in this respect, as shown in figures 9 and 10. It should be noted, however,
that floor I was tested without the spruce filler blocks intended to be used between the open corrugations at points of support.

A complete load-deformation curve to maximum load and ultimate failure is shown in figure 11.

**Concentrated Loading**

Floor M had less resistance to puncture by a 1-inch diameter steel cylinder than floor I or H and deflected more under the concentrated load. In figure 14, results are shown separately for tests on floor M at an interior position, 12 inches from an unsupported edge, and for tests at an exterior position, 4 inches from an unsupported edge, while the curves for floors H and I are drawn from averaged loads. Tests conducted at interior and exterior positions on the panel produced similar results, as did loads positioned over and between corrugations.

Spot welds in floor M began failing at loads as low as 700 pounds and continued to fail in the surrounding area until ultimate rupture of the wearing surface.

Load-deflection curves obtained from loads applied through a simulated engine-cradle wheel are presented in figure 15. Two curves are shown for floor M, with the wheel oriented in a direction along the span, one of which represents a load at interior position A, and the other at exterior position B, figure 13. Load values are also shown for the wheel positioned perpendicular to the span. Average curves are plotted for floors H and I. No significant difference was found between the loads required to produce a given deflection, with the wheel parallel or perpendicular to the span or at exterior or interior positions.

Spot welds in floor M began failing at loads as low as 1,000 pounds. Although these tests were not conducted to ultimate failure, it may be assumed that floor M would never have the strength or stiffness of the other two floors.

**Impact Loading**

Impact loading produced greater deflections and more permanent deformation in floor M than in floors I or H, as shown in figures 16 and 17. The curves presented for floor M are average values of the results obtained at each height of drop, with tests located at midspan both over and between corrugations.

Cargo floor M deflected about twice as much as did floors H and I at low heights of drop of the 200-pound box corner and this ratio was increased to approximately three as the height of drop was increased. These relationships were also generally true, insofar as the permanent deformation was concerned, up to heights of drop of 12 inches, but tended to get larger above that height, as shown in figures 17 and 18.
Floor M was not considered satisfactory under impact loading, because box corners dropped from heights as low as 8 and 10 inches caused rupture of the wearing surface, evidence of which is shown in figure 18.

Rolling Load -- Engine Cradle

Results of rolling-load tests on floors H, I, and M are presented in figure 19. Under wheel loads less than 1,700 pounds, floor M was superior to floors I and H.

The first indication of failure in specimens of cargo floor M was the snapping sound made by the failing spot welds, which started with the first trip of the rolling load. All of the spot welds connecting the upper two sheets to the corrugations failed within the path of the wheel after a few trips of the rolling load. Figure 21 shows the results of passing a 1,400-pound load 10 times over specimen RO-10, of which all of the spot welds between the two upper sheets and the corrugated base failed over the 5-inch width. A load of 1,000 pounds rolled for 10 trips on specimen RO-9 produced failure in 90 percent of the spot welds at the same locations.

Conclusions

Cargo floor M was in general inferior to floors H and I to which it was compared. The performance record indicated that it was inferior to floors H and I in the impact, static-bending, and concentrated-load tests and to floor H in the strip test. This inferiority might be attributed in part to the thinness of the upper sheet, or wearing surface, which tended to rupture under impact or concentrated loads, and to the weakness of the spot welds, which failed in the static bending, concentrated-load, and rolling-load tests.

Floor M is lower in weight and superior to floors H and I in the rolling-load test and to floor I in the strip test.

APPENDIX A

COMPARATIVE RATING OF FLOORS H, I, AND M

Results of Forest Products Laboratory tests, and ratings by tentative methods A and B as described in Forest Products Laboratory Report No. 1550, are presented for floors H, I, and M in tables 1 and 2.

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Table 1.—Comparative ratings of air-cargo floors based on best results obtained from Forest Products Laboratory weight, impact, and rolling-load tests according to tentative method A.

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<th>Type of test</th>
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<th>Floor</th>
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<td></td>
<td>H</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Weight per square foot</td>
<td>Pounds</td>
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<tr>
<td>Engine-cradle rolling load sustained for 500 trips</td>
<td>Pounds</td>
<td>950</td>
</tr>
<tr>
<td>Allowable height of drop of 200-pound box</td>
<td>Inches</td>
<td>15</td>
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</table>

Criteria for satisfactory floors, based on best results:

- Weight = 1.42 pounds per square foot
- Rolling load = 1,450 pounds
- Impact = 15 inches

Percentage rating of floors based on criteria:

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<td>Weight</td>
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<td>Impact</td>
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<td>Rating</td>
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<td>81</td>
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1 Weight of nonskid surfacing included.

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Table 2.—Comparative ratings of air-cargo floors based on best results obtained from Forest Products Laboratory weight, impact, and rolling-load tests according to tentative method B

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<td>Weight per square foot</td>
<td>Pounds</td>
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<tr>
<td>Engine-cradle rolling load sustained for 1,000 trips</td>
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<tr>
<td>Allowable height of drop of 200-pound box</td>
<td>Inches</td>
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Criteria for satisfactory floors based on best results

Weight = 1.42 pounds per square foot  
Rolling load = 1,300 pounds  
Impact = 15 inches

Percentage rating of floors based on criteria

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<th>Units</th>
<th>B</th>
<th>I</th>
<th>M</th>
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<tr>
<td>Weight</td>
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<tr>
<td>Rolling load</td>
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<td>Impact</td>
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<tr>
<td>Sum</td>
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<tr>
<td>Rating</td>
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<td>78</td>
<td>71</td>
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1=Weight of nonskid surfacing included.
Figure 1.--Cargo floor M, upper surface of test specimen.
Figure 2.—Cargo floor M; lower surface of test specimen.
Figure 4.--Cargo floor M, end view.
Figure 5.—Weight per square foot of floors M, H, and I.
Figure 6.—Typical load-deflection curves from static-bending tests of floors H, I, and M over an 8-inch span.
Figure 7.—Typical load-deflection curves from static-bending tests of floors H, I, and M over a 16-inch span.
Figure 8.—Results of bending tests of floors M, H, and I, showing the work to maximum load per inch of floor width when supported on a 16-inch span.
Figure 9.—Typical load-deformation curves from compression tests simulating the crushing effect of floor beams on floors H, M, and I.
Figure 10.—Results of tests of floors I, M, and H under strip loading, when the load per square inch corresponded to a deformation of 0.05 inch.
Figure 11.—Typical load-deformation curve of strip-loading test of floor W condensed to failure.
Figure 12.--Cargo floor M, test specimen showing the place of application and the effect of concentrated-load tests on the panel. The concentrated loads used were a 1-inch-diameter steel cylinder and a 2 1/2-inch-wide maple block shaped to a 4-inch radius, both positioned in a direction parallel to the width of the panel. Points A and I, and C and 2 are exterior positions; B and 3, interior positions; and 4, a position just over the floor stringer.
Figure 13.--Cargo floor M, test specimen showing the place of application and the effects of concentrated-load tests on the panel. On this specimen, a load block simulating an engine-cradle wheel was positioned as for travel in a direction parallel to the length of the panel. Positions D and 1, and 3 and B are exterior positions; and 4 and A, and C and 2 are interior positions.
Figure 14.—Load-deflection curves from concentrated-load tests on floors I, H, and M. Specimens loaded at midspan with a 1-inch-diameter steel cylinder. The two curves shown for floor M are for interior and exterior load positions on the panel. The load locations may be seen in Figure 13.
Figure 15.--Load-deflection curves from concentrated-load tests on floors I, H, and M, produced by loading the floor with a maple block 2½ inches wide, shaped to a 4-inch radius, and simulating an engine-cradle wheel. Loads were applied at positions shown in figures 12 and 13. Two curves are shown for floor M, one with the maple block positioned as for travel in the direction of the panel, the other at right angles to the span. The results of loading at positions B, specimen No. CO-2, are shown but no curve has been drawn.
Figure 16.—Cargo floor M, impact-test specimen showing heights and effects of drop of a corner of a 200-pound softwood box on the panel.
Figure 17.--Relation between height of drop of a corner of a 200-pound softwood box and the deflection of floor panels FLOOR I, H, and M.
Figure 18.—Relation between height of drop of a corner of a 200-pound softwood box and the permanent deformation of floors I, H, and M.
Figure 13. Relation of wheel load to number of trips required to produce failure of floors I, M, and H.

- **Floor 1**
- **Floor H**
- **Floor M**

**Wheel Load (Pounds)**

**Number of Trips (Logarithmic Scale)**
Figure 20.--Cargo floor M, parts of specimens used in the rolling-load test, showing the location of test area (between saw kerfs) and results of tests with reference to the left edge of panel. Tests consisted of 10 trips of rolling loads with weights of 1,400 or 1,000 pounds on the engine-craddle wheel.
Figure 21.—Cargo floor M, sections of panels showing failure at spot welds after 10 trips of rolling load. Specimen on the left was subjected to a 1,400-pound rolling load and all of its spot welds failed, separating the two top layers from the corrugated base. Specimen on the right had been subjected to a 1,000-pound rolling load.
Figure 22.—Cargo floor M, static-bending specimens tested over a 16-inch span, showing the horizontal shear failures between the upper two layers and the corrugated base.