Feasibility study of a modified ASTM D 143 block shear specimen for thin material

David E. Kretschmann

Abstract

The feasibility of using a modified block shear specimen for shear tests of thin material was determined by comparing matched sections of modified and standard (ASTM D 143) clear Sitka spruce block shear specimens. The modified block shear specimen was composed of three laminated plies, 5/16, 7/8, and 13/16 inch thick. The modified specimen tended to have slightly higher shear strength values than the standard specimen, but the difference was not significant. The modified block shear specimen provides an acceptable alternative to the standard ASTM D 143 block shear specimen for evaluating the parallel-to-grain shear properties of thin material.

Background

In early November 1987, the USDA Forest Service, Forest products Laboratory (FPL), was contacted by the NASA-Langley Research Center in Hampton, Va., to conduct standard shear tests on four boards that were the remnants of material used in the manufacture of wind tunnel fan blades. NASA was concerned that some material used in the blades may have a shear strength well below the design value assumed for the blades. The standard 2-inch-thick block shear specimen could not be used to test the boards because the boards were only 7/8 inch thick. Therefore, a study was conducted at FPL to determine the feasibility of using a modified block shear specimen for shear tests.

In July 1985, the 7- by 10-foot wind tunnel fan at NASA-Langley Research Center was subjected to a massive failure that destroyed all the wooden blades in the fan and caused major damage to the structure. Replacement blades for the tunnel were constructed in England from ungraded clear Sitka spruce. In the course of testing the bond strength of the glued spruce, preliminary lap shear tests by NASA indicated that some shear strength values were approximately 25 percent below the shear strength values used in designing the blades.

The design of the NASA wind tunnel blades was based on the shear parallel-to-grain value for dry, clear Sitka spruce given in the Wood Handbook. This value is based on the ASTM D 143 block shear specimen. The eccentric loading that occurs in the ASTM test, although often ignored, is recognized as a potential source of error. Fully aware of this shortcoming, we nevertheless used the standard block shear test as the basis for comparison to ensure consistency with the clear wood design base used by NASA.

To obtain information on shear strength parallel to the grain for 7/8-inch-thick boards requires the use of a nonstandard specimen. Bendtsen and Porter demonstrated the feasibility of using a modified block shear specimen to obtain information on shear strength parallel to the grain. The purpose of their study was to compare the results of tests with a 2-inch-wide by 1-1/2-inch-thick cross section block shear specimen with the 7/8-inch-thick specimen used in the NASA study.

The author is a General Engineer, USDA Forest Serv., Forest Prod. Lab., One Gifford Pinchot Dr., Madison, WI 53705-2398. The author gratefully acknowledges Bryan River and Arnold Okkonen for their help in preparing the specimens for this study. This paper was received for publication in May 1990.

to those with the standard 2- by 2-inch block shear specimen. In our study, we used a modified version of the block shear specimen: a laminated 2- by 2-inch block shear specimen composed of three plies (Fig. 1) with the test material of interest (a 7/8-in.-thick piece of wood) placed in the center in the shear plane. This paper compares the results of tests with the modified laminated block shear specimen and the standard 2-inch block shear specimen.

**Experimental**

**Scope**

Clear Sitka spruce was processed to produce 16 matched pairs of standard and modified block shear specimens for shear tests and 8 specimens for determining specific gravity (SG) and moisture content (MC). The matched specimens were tested to obtain data on radial shear strength parallel to the grain. The shear strength values were analyzed to determine if the modified block shear specimen gave information equivalent to that given by the standard block shear specimen.

**Specimen preparation**

Clear straight-grained 3- by 5- by 48-5/8-inch Sitka spruce with a uniform growth rate was machined from a 3-inch by 9-inch by 10-foot plank. A matching scheme was used to produce standard and modified specimens from the machined piece. Specimens were matched by cutting two 2-1/2- by 3- by 48-5/8-inch side-by-side strips (Fig. 2A). The two strips were then cut further into four pairs of matched sections (2-1/2 by 3 by 12-1/16in.) (Fig. 2B). Strip 1 of the two matched boards for each pair was planed down to 2 by 2 inches to produce a standard block shear specimen. Strip 2 of
the two matched boards for each pair was cut into three plies (Fig. 2B) (5/16 in., 7/8 in., and 13/16 in. thick) to produce the modified block shear specimen. The plies were glued together with a phenol-resorcinol adhesive to form a strip 2 by 2 inches in cross section and 12-1/16 inches long. Four block shear specimens and two MC/SG specimens were cut from each section (Fig. 2B).

**Testing**

The block shear specimens were loaded in a universal testing machine at the standard rate of 0.024 in./min. until failure. Specimens were numbered to determine if variations and trends in shear strength were related to the original position of the specimens in the wood. Measurements were taken for shear strength parallel to the grain, MC, and SG. The SG measurement was based on specimen volume at time of test and oven-dry weight.

**Results and discussion**

The results of this study are shown in Table 1. This table lists the average, high, and low values, the standard deviation values for shear strength, MC, and SG for each section, and the overall average values. The slightly higher SG values for the standard ASTM D 143 specimens may be explained by the cutting pattern used because each strip had a different series of growth rings. The shear strength data points are displayed graphically in Figure 3. One data point for the standard specimen (data point near 1,300 psi) appears to be an outlier. A likely explanation for this strange behavior is that the grain direction of the specimen was slightly inclined to the shear plane; that is, the grain angle was not parallel to the cleavage surface. The data were analyzed with and without the outlying value for this specimen and the corresponding matched specimen to determine if the outlier affected our final conclusion.

**Tukey’s test** was used with an alpha level of 0.5 to test whether boards of the same specimen type (standard or modified) were statistically different. There was no statistical difference between boards within a specimen type. Therefore, we combined the data from the four sections for each specimen type to determine differences between the two types of specimens. When all the data points were included in the analysis, the overall mean values for the modified specimen were 6 percent higher than overall means for the standard specimens. When the outlying data point and its corresponding matched data point were removed, the overall mean values for the modified specimen were 3.8 percent higher than those for the standard specimen (Table 2). An analysis of variance of the combined data with and without the outlying data point indicated no significant difference between shear strength values of the standard and modified block shear specimens (Table 3).

**Conclusion**

The feasibility of using a modified block shear specimen for shear tests of thin material was determined by comparing matched sections of the modified specimen and a standard ASTM D 143 block shear specimen. Although the modified block shear specimen tended to produce slightly higher shear strength values, perhaps as a result of the cutting pattern used, our results showed no significant difference between the standard and modified block shear specimens. Therefore, the modified block shear specimen is an acceptable alternative to the standard ASTM D 143 block shear specimen for evaluating the parallel-to-grain shear properties of material that is not thick enough to yield the standard specimen.

**TABLE 2.** Mean shear strength values for modified and standard block shear tests.

<table>
<thead>
<tr>
<th>Specimen type</th>
<th>N</th>
<th>Shear strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>16</td>
<td>924 (925)</td>
</tr>
<tr>
<td>Modified</td>
<td>16</td>
<td>980 (960)</td>
</tr>
</tbody>
</table>

*Values in parentheses do not include outlying data point.

**TABLE 3.** Analysis of variance for combined data with and without outlying data point.

<table>
<thead>
<tr>
<th>Item</th>
<th>Degree of variance</th>
<th>Mean square</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section</td>
<td>3</td>
<td>(3)</td>
<td>(1.74)</td>
<td>(0.185)</td>
</tr>
<tr>
<td>Specimen type</td>
<td>1</td>
<td>24,019.9</td>
<td>4.16</td>
<td>0.051</td>
</tr>
<tr>
<td>Error</td>
<td>27</td>
<td>159,027.6</td>
<td>3.15</td>
<td>(0.115)</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>225,112.1</td>
<td>115,675.3</td>
<td></td>
</tr>
</tbody>
</table>

*Values in parentheses do not include outlying data point.