EFFECT OF NUMBER OF FASTENERS ON THE STRENGTH OF CORNER JOINTS FOR CASES

WAN-QIAN LIU
C.A. ECKELMAN

ABSTRACT

Tests were carried out in order to determine the bending strength of 457-mm-(18-in.-) wide case joints constructed with multiple fasteners. Both dowels and screws were included in the tests. Results indicated that bending strengths increase rapidly until the “zones of influence” of the fasteners overlap. No increase in strength was obtained beyond that point. Screw length was found to have a greater effect on strength than diameter. In the case of dowel joints, it was found that because of the adhesive added to the joint area, joints could be constructed that exceeded the bending strength of the board itself.

An important consideration in the product engineering of cases is the specification of the number of fasteners that should be used in joining the sides to the bottom and top of the case. In the past, various rules of thumb were used in making such decisions, but few definitive guidelines existed. More recently, the work of Ho, 1 Rajak, 2 and Zhang 3 has helped to clarify the relationships between number of fasteners used and joint strength by defining what has been termed the “zone of influence” or “zone of failure” of the fastener. What this term signifies is that an individual fastener is supported for a finite distance by the material on either side of it. As a result, when a fastener connection such as a screw in the side of a case fails, it causes a portion of the side wall on either side of it to fracture. In his work on the bending strength of case joints constructed with large screws, Rajak 2 obtained “zones of failure” that extended from 40 to 50 mm (1-1/2 to 2 in.) on either side of the fastener. Similarly, in his work on the performance testing of cases, Ho 1 obtained a value of a little more than 40 mm (1-1/2 in.) on either side. In the case of dowels in similar material, Zhang 3 found that the “zone of failure” extended about 40 mm (1-1/2 in.) on either side of the dowel.

These studies are of particular value in that they provide fundamental insights into the nature of failure of corner joints. In addition, they define the minimum fastener spacings that will yield maximum fastener strengths. Because of the limits of the studies, however, they do not provide a complete picture of expected increases in strength once the “zones of influence” of the fasteners overlap. Specifically, they do not provide a comprehensive view of the reduction in strength per fastener that must be expected when one fastener is located within the “zone of influence” of another.

To obtain such information, the authors constructed 457-mm- (18-in.-) wide joints with up to 36 fasteners. These joints were tested in compression in order to determine their ultimate bending strength. Results of the tests are given in this paper.

DESCRIPTION OF SPECIMENS

The configuration of the specimens used in the tests is shown in Figure 1. In general, each specimen consisted of two “legs” that were joined together with from 1 to 32 fasteners to form symmetrical corner joints. All joints measured


The authors are, respectively, Professor, Northeast Forestry Univ., Harbin, China, and Professor, Dept. of Forestry and Natural Resources, Purdue Univ., West Lafayette, Ind. This paper was received for publication in August 1996. Reprint No. 8557. ©Forest Products Society 1998.
Forest Prod. J. 48(1):93-95
Figure 1. — Diagram of specimens used in the study. The width of each specimen (W) was 457 mm (18 in.); length of the legs (L) was 203 mm (8 in.); thickness (t) of the particleboard was 19 mm (0.75 in.); thickness of the MDF was 22.2 mm (0.875 in.).

TABLE 1. — Summary of physical properties data for boards used in the tests.

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (mm (in.))</th>
<th>Moisture content (%)</th>
<th>Internal bond (kPa (psig))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particleboard</td>
<td>19.0</td>
<td>7.0</td>
<td>543.3 (78.8)</td>
</tr>
<tr>
<td></td>
<td>(0.75)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium density fiberboard</td>
<td>22.2</td>
<td>6.0</td>
<td>657.1 (95.3)</td>
</tr>
<tr>
<td></td>
<td>(0.875)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. — Diagram of the method used to apply loads to the specimens. One length of I-beam was attached to the upper crosshead of the testing machine and another length to the lower crosshead. Use of these beams allowed the specimens to be uniformly loaded along their entire length.

about 457 mm (18 in.) wide with 203-mm (8-in.) long legs. Four different fasteners were used: screw-type connectors that were either 5 by 50 mm, 7 by 50 mm, or 7 by 70 mm, and 9.5-mm (3/8-in.) diameter wood dowels. Depth of penetration of the dowels in the side walls was 12.5 mm (1/2 in.); corresponding depth of penetration in the ends of the members was 25.4 mm (1 in.). All of the fasteners were evenly spaced in the joints.

The screw-type specimens were constructed of medium density fiberboard (MDF) that conformed to ANSI A208.1 M-2. Selected properties of the boards are given in Table 1.

Only one sample of each configuration was constructed; e.g., only one sample was constructed with 5 dowels, only one sample with 10 dowels, etc.

DESCRIPTION OF TEST

All tests were carried out in a Tinius-Olsen universal testing machine. Specimens were loaded for testing as shown in Figure 2. The bottom leg of each specimen rested on a surfaced I-beam that in turn rested on the bed of the testing machine. Loads were applied to the top leg of a specimen through a second surfaced I-beam. The purpose of the I-beams was to ensure that loads were applied uniformly along the width of a specimen.

Rate of loading was 6.5 mm (0.25 in.) per minute. Loading was continued until a joint fractured with accompanying major drop in applied load. Maximum load was used to represent ultimate joint strength.

TEST RESULTS

Results of the tests are shown graphically in Figure 3. Since there were no replications of tests, there were no estimates of experimental error. Bending moment was calculated at the center of the joint (Fig. 2).

The mode of failure was identical for all of the joints constructed of MDF. In each case, the end of the board into which the screw-type connectors were threaded split.

Overall, as can be seen in Figure 3, joint strength increased as the number of fasteners increased (and fastener spacing decreased) until about eight fasteners were used. At this point, joint strength remained essentially constant even though additional fasteners were used. This amounts to a fastener spacing of 57 mm (2.25 in.).

The difference in the bending strengths of the joints is of particular interest. The 7 by 50 mm and the 5 by 50 mm

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connectors produced about the same bending strength, which indicates that diameter is not an important factor. The 7 by 70 mm connector, however, produced substantially higher bending strengths than the 7 by 50 mm connector; this result indicates that fastener length is quite important.

The mode of failure of the joints constructed of particleboard with dowel con-

nectors differed from that for the mechanical fasteners. In joints with up to and including six dowels, each dowel pulled a "plug" of material free from the side of the board in which it was embedded. In joints with 7 to 23 dowels, the dowels caused the end of the side board to split, and in those joints with 24 or more dowels, the strength of the joint was sufficient to cause the side leg itself to fail in bending. The most apparent explanation for this phenomenon is that the adhesive strengthened the board in the joint region so that failure occurred outside this area. Nonetheless, it is an interesting phenomenon that the joint was stronger than the board itself with a dowel spacing of 3/4 inches or less.

**Conclusions**

Results of the tests clearly indicate that the ultimate bending strength of fasteners used in corner joint construction decreases as their "zones of influence" begin to overlap. For the fasteners included in this study, bending strength per fastener began to drop as the spacing between fasteners decreased to less than about 57 mm (2.25 in.). Of related interest, screw length was found to have a greater effect on joint bending strength than diameter. Also, presumably because of the adhesive added to the joint area, corner joints constructed with dowels can exceed the bending strength of the board itself.