FABRICATED WALL PANELS WITH PLYWOOD COVERINGS

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FabriCated Wall panels with Plywood Coverings

By

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Previous tests at the Forest Products Laboratory have shown that the strength and rigidity of floor and wall panels with plywood coverings may be increased enormously by gluing, instead of nailing plywood to studs, plates, and sills. Increasing interest in this type of panel, especially since its use in an experimental house recently built at the Laboratory, led to the following series of tests in which the superiority of certain details of construction were determined.

Construction of Wall Panels

Six wall panels, each 4 feet wide by 8 feet long, were used in this series of tests. Panel No. 1 had five western white pine studs each 3/4 inch thick and 1-3/8 inches wide as shown in figure 1. Panel Nos. 2, 3, and 4 were similarly constructed, but with studs 1-3/4, 2-1/4, and 3-5/8 inches wide, respectively. Panel Nos. 5 and 6 were similar in construction to Panel No. 1 except that crosswise pieces were inserted at right angles to the length (figs. 2 and 3). All studs were spaced approximately 12 inches apart. The covering was 3-ply 1/4-inch Douglas-fir plywood and was glued with casein glue (FPL Formula B-4) to the two sides of the studs. The necessary pressure during setting of the glue was provided by permanently nailing the plywood to the studs with 1-1/4-inch brads spaced 3 inches apart. The direction of the face grain was parallel to the length. A vegetable protein glue was used in the manufacture of the commercial plywood.

The rigid attachment of the coverings to the studs by means of glue give high resistance to shear between the studs and the coverings, thus causing one covering to be thrown into tension and the other covering into compression when resisting an external force. The panel acts essentially as a box girder and thus permits the use of a very thin wall to obtain the required strength.

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1Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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Method of Test

The panels were tested in static bending over a span of 7 feet 9-3/4 inches with the load applied at the third points. The rate at which the loading device descended ranged from 0.16 inch per minute for the panels 4-1/8 inches to depth to 0.30 inch per minute for the panels 1-7/8 inches in depth. Deflections were read to the nearest 0.01 inch for each 100 pounds increment of load. Figure 4 shows the method of testing.

Control specimens cut from the panels after failure were tested in accordance with standard procedure to determine their strength properties.

Discussion of Results

The results of the tests are given in the accompanying table.

In calculating the moment of inertia of the panels and the small specimens cut from them, all plies running perpendicular to the length of the panels were neglected. Because of the sanding incident to the manufacture of plywood the outer plies are often thinner than the nominal ply thickness. Such differences will materially affect the strength and therefore, the actual thicknesses of the plies were accurately determined and used in the calculations.

Panel No. 1 had a maximum strength of 118 pounds per square foot when adjusted to the basis of a uniform load. A 60-mile wind has a pressure of about 12 pounds per square foot, which is approximately 0.1, the maximum load. The corresponding deflection for a 60-mile wind would be less than 1/4 inch at the center of the panel height. Panel No. 1 is therefore amply strong, but other considerations, such as the necessary openings in walls for heating ducts, wiring, plumbing, and double-hung windows, may make desirable a thicker wall.

Panels Nos. 2, 3, and 4 had maximum loads of 134, 219, and 373 pounds per square foot when adjusted to the basis of a uniform load. These loads are greater than that for Panel No. 1 in approximately the amount expected because of the greater thickness of the panels. Lesser deflections for a given load, of course, accompany the greater thicknesses of the panels. The recorded deflections for a load of 15 pounds per square foot, assuming the load uniformly distributed, were 0.33, 0.22, 0.13, and 0.05 inch for panels with overall thicknesses of 1-7/8, 2-1/4, 2-3/4, and 4-1/8 inches, respectively. In other words, increasing the thickness of the wall by using wider studs increases the bending strength about as the section modulus is increased, or at a slightly faster rate than the stud widths are increased; and the stiffness increases about as the moment of inertia is increased, or in about the same ratio as the squares of the stud widths.

Panel Nos. 1, 2, 3, and 4 buckled at loads one-fifth to one-third maximum because of the relatively low stiffness of the plywood perpendicular to the length of the panel. Buckling of this type is shown in figure 5.
To stiffen the panel in crosswise direction pieces at right angles to the length were inserted in Panel No. 5, as illustrated in figure 2. The lengthwise and crosswise pieces are notched half way through at each intersection in forming the joints as shown in the detail of figure 2. Panel No. 5 showed considerably less tendency to buckle across the panel than did Panel No. 1. It was, however, lower in maximum load than Panel No. 1, the first failure occurring at the notches in the studs between one load point and support. The failure at the notches was caused by a high concentration of stresses, which is often several times that indicated by usual calculation. This concentration was brought about by the abrupt change in cross section. The failure at the notch occurred between a load point and a support where the shear stress is the highest. In order to overcome this difficulty and yet obtain greater stiffness than that obtained in Panel No. 1, short pieces were fitted snugly between the studs in Panel No. 6, thus leaving the studs of uniform cross section throughout their length (fig. 3). Panel No. 6 exceeded Panel No. 1 in maximum load by 25 percent and in stiffness by about 20 percent. Panel No. 6 also showed little tendency to buckle until near the maximum load.

Conclusions

The tests show that wall panels made with stressed coverings, such as plywood glued to joists to form a box girder, can be made with satisfactory strength and stiffness.

For a wall height of 8 feet, 4 by 8-foot panels consisting of five studs 3/4 inch thick and 1-3/8 inches wide spaced approximately 12 inches apart with 1/4 inch 3-ply Douglas-fir plywood covering on either side with face grain parallel to length of the panel and glued to the studs are amply strong.

Increasing the thickness of the wall by using wider studs increases the bending strength about as the section modulus is increased, or at a slightly faster rate than the stud widths are increased; and the stiffness increases about as the moment of inertia is increased or in about the same ratio as the squares of the stud widths. Wall thicknesses greater than that provided by a 1-3/8 inch stud may be desirable to provide ample space for heating ducts, wiring, plumbing, and double-hung windows.

The tendency of wall panels to buckle crosswise of the panel at from 1/5 to 1/3 the maximum load can be greatly reduced by placing stiffeners between the studs at frequent intervals. These stiffeners would also greatly reduce any tendency of wall panels to become wavy between the studs during service.
Dimensions and performance characteristics of 6 by 5-foot wall panels with stressed plywood coverings
(Span 7 ft.; g-3/4 in.; third-point loading)

<table>
<thead>
<tr>
<th>Panel Width</th>
<th>Basal</th>
<th>Studs</th>
<th>Stiff (Over)</th>
<th>Weight</th>
<th>Moment</th>
<th>Section</th>
<th>Max./Equivalent</th>
<th>Modulus</th>
<th>Deflection</th>
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<td></td>
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<td>66.2</td>
<td>67.22</td>
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</tbody>
</table>

*In calculating moment of inertia, plies which ran perpendicular to length of panel or specimen were neglected.*

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Types of Pre-Fabricated Plywood Wall Panels

Figure 1

Figure 2

Figure 3
Figure 4. --Method of testing fabricated wall panels with plywood coverings employed at Forest Products Laboratory.

Figure 5. --Appearance of plywood covering tested to destruction with apparatus shown in figure 4.