

TECHNICAL NOTE: CHARACTERIZATION OF IN-PLANE COMPRESSIVE PROPERTIES OF PLYWOOD BY IITRI AND END-LOADING COMPRESSION TESTS

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Abstract. Panel compression tests can be affected by the propensity of the thin cross-section to undergo axial buckling. Tests were conducted to measure Young's modulus, proportional stress limit, and compression strength in two edgewise directions using an end-loading compression method and an alternate method developed by the Illinois Institute of Technology Research Institute (IITRI). The IITRI method mitigates the potential for buckling without explicit restraint. Young's moduli obtained by the two methods agreed well. In contrast, the test methods had differences in the measurement of proportional stress limit and compression strength.

INTRODUCTION

To evaluate variables that are expected to influence a panel under compressive loading, it is convenient to use small specimens because many can be cut from one panel. To achieve this, there is a compression test, Method A in ASTM D 3501-94 (ASTM 1994). However, it requires lateral support to prevent the specimen from undergoing buckling deformation, and there is a concern that this load could influence the measurement of compression properties. In contrast, Method B, which requires the side rails restraining the edges of the specimen instead of lateral support, is used to obtain compressive properties of full-sized panels and is recommended for developing design properties. Consequently, Method B is not usually adopted to measure compressive properties of panels from testing small specimens. Instead of using ASTM D 3501, there is a promising end-loading method using a short column specimen, the Illinois Institute of Technology Research Institute (IITRI) method in ASTM D3410/3410M-03 (ASTM 2003) (compression test of polymer matrix composites).

In this procedure, a specimen with a small slenderness ratio is used but without lateral support or restraining rails. There are several published reports of end-loading compression tests of plywood (Takami 1964; Sekino and Sasaki 2004) but no studies examining the IITRI method. In the present research, the validity of these two methods was examined using Lauan 5-ply plywood.

EXPERIMENTAL PROCEDURE

Commercial 5-ply Lauan (*Shorea* sp.) plywood was used. The thickness of surface and core veneers was 1.6 mm, whereas the thickness of the crossplies was 3.6 mm. Average overall panel thickness was 11.8 mm and the density was 480 kg/m³ at 12% MC. Figure 1 shows the specimens used for the compression tests. The specimens in which the length direction of the surface and core veneers coincided with the longitudinal and tangential directions were defined as L- and T-types, respectively. The IITRI specimen was prepared by bonding rectangular tabs of birch on both ends. For both test methods, a uniaxial strain gauge (Tokyo Sokki FLA-2-11) was bonded at the center of each surface to measure the strain in the length

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direction. Ten specimens were used for each testing condition. As shown in Fig 2, a compression load was applied at a crosshead speed of 0.3 mm/min, and the compressive stress and strains in the loading direction were obtained. From the stress–strain curve, Young’s modulus, proportional stress limit, and compression strength were obtained.

RESULTS AND DISCUSSION

Figure 3 shows typical examples of stress–strain curves from the IITRI and end-loading methods. For the L-type specimen, the stress with the IITRI method was greater than that obtained from the end-loading method in which the separation of the stress–strain curves was induced at a low stress level. In the end-loading test, bending deformation was easily induced because of the eccentricity in loading (Timoshenko 1955). Also, in the L-type specimen, the total thickness of the even plies (crossplies) was greater than the odd plies, but the stiffness was less, potentially causing bending deformation.

In contrast, bending deformation was not easily induced with the IITRI method because the eccentricity was effectively decreased by gripping both ends of the specimen. For the T-type specimen, the stress–strain curves obtained from the IITRI test separated at a low stress level, whereas those from the end-loading method coincided until reaching a high stress level. In the IITRI test, delamination of the tab occurred because of the low level of stiffness of the surface plies in the loading direction, and it enhanced the eccentricity in loading. In contrast, the end-loading specimen was free from delamination. Additionally, because the total thickness

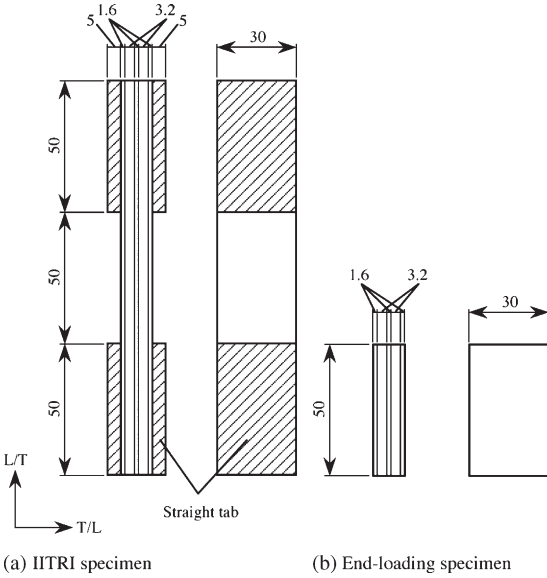


Figure 1. Diagrams of the specimens (dimensions in mm).

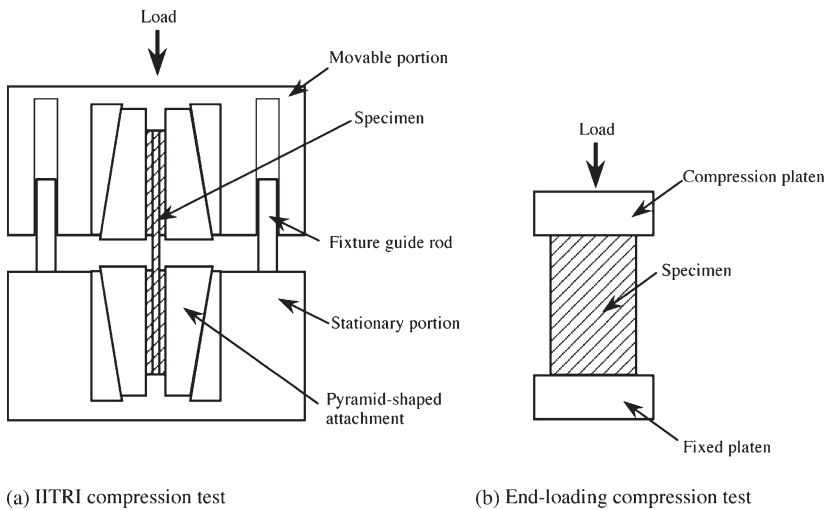


Figure 2. Compression loading techniques.

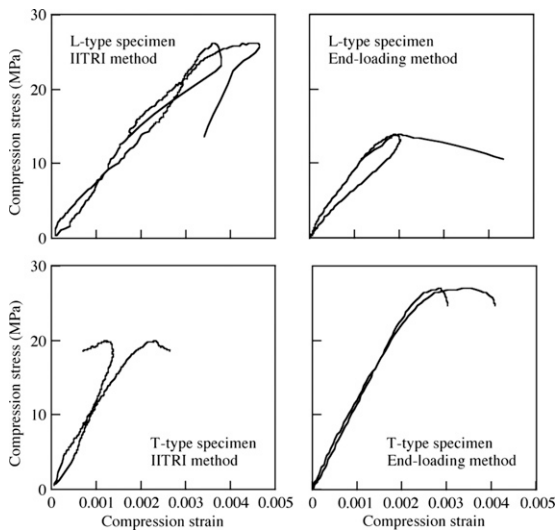


Figure 3. Typical stress–strain relations obtained using the two methods.

Table 1. Compression properties obtained by the different methods.

Loading method	Young's modulus (GPa)	Proportional limit stress (MPa)	Compression strength (MPa)
L-type			
IITRI	7.4 ± 0.4	21.4 ± 2.1	25.0 ± 2.4
End-loading	7.5 ± 0.5	13.0 ± 2.7	15.3 ± 3.6
T-type			
IITRI	11.3 ± 0.4	12.7 ± 2.0	15.8 ± 3.6
End-loading	11.8 ± 1.3	18.5 ± 3.3	24.0 ± 4.4

Results are average ± SD.

of the even plies was greater than that of the odd plies, the greater stiffness of the even layers in the loading direction could prevent the specimen from bending. Table 1 shows the compression properties obtained from each method. Both test methods were consistently able to obtain Young's modulus with little difference. However, for the

L-type specimen, the proportional limit stress and compression strength obtained with the IITRI test were greater than those obtained in the end-loading test, but this was reversed for the T-type specimen.

CONCLUSIONS

Using commercial Lauan 5-ply plywood, IITRI and end-loading compression tests were conducted to measure Young's modulus, proportional stress limit, and compression strength in two edgewise directions. The testing method had a large influence on the measurement of the in-plane compression properties of plywood. Therefore, an appropriate method for obtaining the compression properties should be selected considering the construction of the plywood and loading direction.

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