THE EFFECT OF CORE BLOCK LENGTH ON STRENGTH OF FACEGLUED BLOCKBOARD[1]

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ABSTRACT

Blockboard is a form of lumber core plywood, the latter a product that has for years been used in the United States and Canada in furniture and cabinet manufacture. A unique manufacturing process and the fact that gluelines in faceglued blockboard are found only between face veneers and core serve to distinguish this product from the typical lumber core panel. Blockboard panels have become increasingly popular in northern Europe in recent years, where they have found application in products such as industrial shelving, storage units, packing cases, doors and partitions, benching, worktops, and even combination subflooring/underlayment.

Earlier work has indicated that blockboard of comparable strength to plywood could be manufactured from northern hardwoods and delivered to Upper Midwestern markets at a price very close to that of structural plywood. This work identified cost of raw materials for the panel core as a key element in lowering cost of production of blockboard. This report deals with the technical feasibility of using short length core blocks (which should maximize yield from low-grade and scrap wood) in the manufacture of three-ply faceglued blockboard.

Test data indicate that it would be possible to make structural faceglued blockboard panels using short core blocks. It was concluded that if blockboard panels were manufactured to a slightly greater thickness than plywood with which it might compete, comparable strength to plywood could be obtained using core blocks as short as 8 inches (20.3 cm).

Keywords: Blockboard, lumber core, veneer, laminated panel strength.

INTRODUCTION

Blockboard is a panel product made with a core of narrow wooden strips, sandwiched between face veneers; the product is made 3- or 5-ply (Fig. 1). While some blockboard panels are made with fully laminated core layers, faceglued panels are held together only by gluelines between face veneers and top and bottom surfaces of core strips (i.e. core strips are not bonded together). Core strips are generally about 1 in. wide and 25–30 in. long, with pieces cut square on the ends. Faceglued blockboard is currently manufactured commercially in several regions of the world, including Scandinavia, where it is used in making benching and worktops, storage units, packing cases, doors and partitions, industrial shelving, and combination subfloor/underlayment.

Results of several earlier studies of the potential for faceglued blockboard made from U.S. species (Bowyer 1979a, b) have indicated that blockboard can be manufactured with properties very close to those of softwood plywood. These studies also indicated that delivered prices for ⅝-in. and thicker faceglued blockboard would be close to prices for plywood of comparable strength in several major market areas of the U.S.

Blockboard has several production-related advantages over plywood and other

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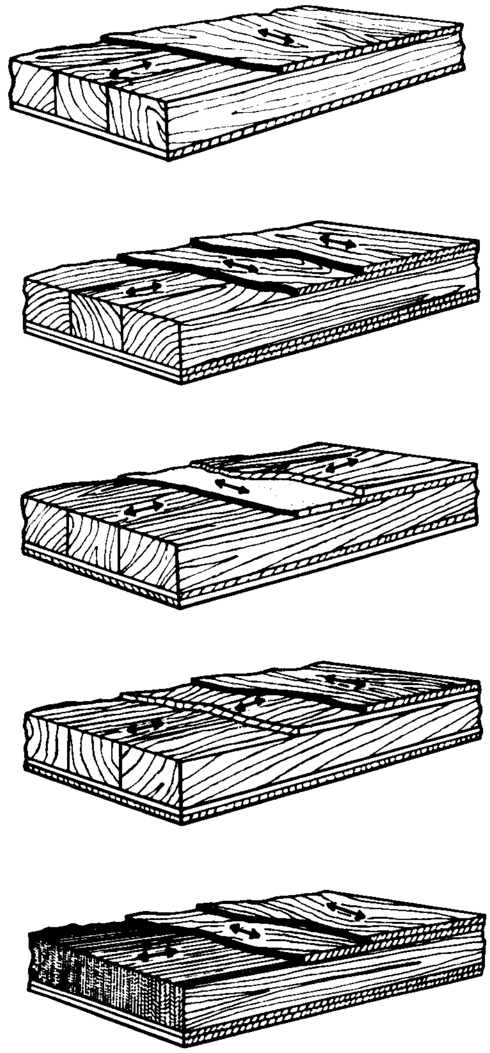

1. 3 Ply Blockboard

2. 5 Ply Blockboard (Normal Structure)

3. 5 Ply Blockboard

4. 5 Ply Blockboard

5. Laminboard (Normal Structure)

From: Finnish Plywood Development Association Technical Publication No. 13

structural panel products. These are: 1) The investment required to begin blockboard production is far less than that associated with installation of plywood or particleboard plants. The investment needed to produce 50 $MMft^2$/yr of blockboard (⅜-in. basis) was estimated to be \$3.8 million in 1978 dollars (Bowyer 1979a); this compares to \$11–13 million for a new plywood plant of similar capacity and \$25–30 million for a waferboard mill of this size. The capital requirement differential is particularly important for the future because higher interest rates will have a greater impact on the high investment alternatives—plywood and particleboard; 2) the amount of resin needed in manufacture of thick blockboard panels is about one-half that needed for production of plywood; for example, a ¾-in. 3-ply blockboard panel would contain only two gluelines, whereas plywood of the same thickness would contain four gluelines; 3) the bulk of the wood needed for blockboard manufacture (core material) can be obtained from relatively abundant, small-diameter, low-quality, and (up to now) relatively inexpensive logs. Edgings and trim, cull lumber, and other scraps resulting from lumber manufacture can also be used as a source of core blocks. Plywood manufacture, in contrast, requires relatively high-quality logs, which have risen sharply in price in recent years.

The fact that low-grade logs, cull lumber, or edgings and trim can be used in making blockboard core represents a significant opportunity for increased use of otherwise unused material. Though this low-quality wood is relatively inexpensive, the costs can be minimized only by maximizing the yield of useable material from it. The low raw material costs for blockboard could, therefore, be likely made even lower (and therefore blockboard could be made even more competitive with plywood) by using extremely short length or random length core strips. The unknown here is the extent to which short core pieces could be used without unduly reducing panel strength; only limited work has focused upon this relationship.

STUDY OBJECTIVE

The purpose of this study was to determine the extent to which strength of faceglued blockboard is affected by core block length. The effect upon strength of butt joint configuration of core pieces was also of interest.

REVIEW OF PREVIOUS INVESTIGATIONS

As part of the most comprehensive study of blockboard properties to date, Finnish researchers dealing with birch-faced, pine core blockboard addressed the matter of butt joint occurrence vs. strength in bending (State Institute for Technical Research 1967). In this study, both commercial and laboratory-manufactured blockboards were tested in bending with results related to the presence of butt joints in core strips.

Blockboards manufactured in the laboratory were made 5-ply, and of normal construction (Fig. 1.2) using 2.5-cm-wide core strips, such that each 20 cm of width (the width measured perpendicular-to-the-grain direction of core strips) contained 8 parallel core strips. Twelve boards, 6 each of 18- and 22-mm thickness were produced, with individual boards of each thickness differing by the number of core butt joints per 20 cm of width. One board of each thickness was made with 0, 1, 2, 3, 4, and 6+ butt joints/20 cm of core width, respectively; all joints were aligned at center span. Results of static bending tests of these samples are graphically presented in Fig. 2. These results indicate a strong effect of butt joint occurrence on bending strength and stiffness parallel to strips of the blockboard core. The bending strength was found to decrease almost linearly as the number of butt joints increased from 0 to 4. When the number of butt joints reached 4 (or when every other core strip was continued fully across the span), the bending

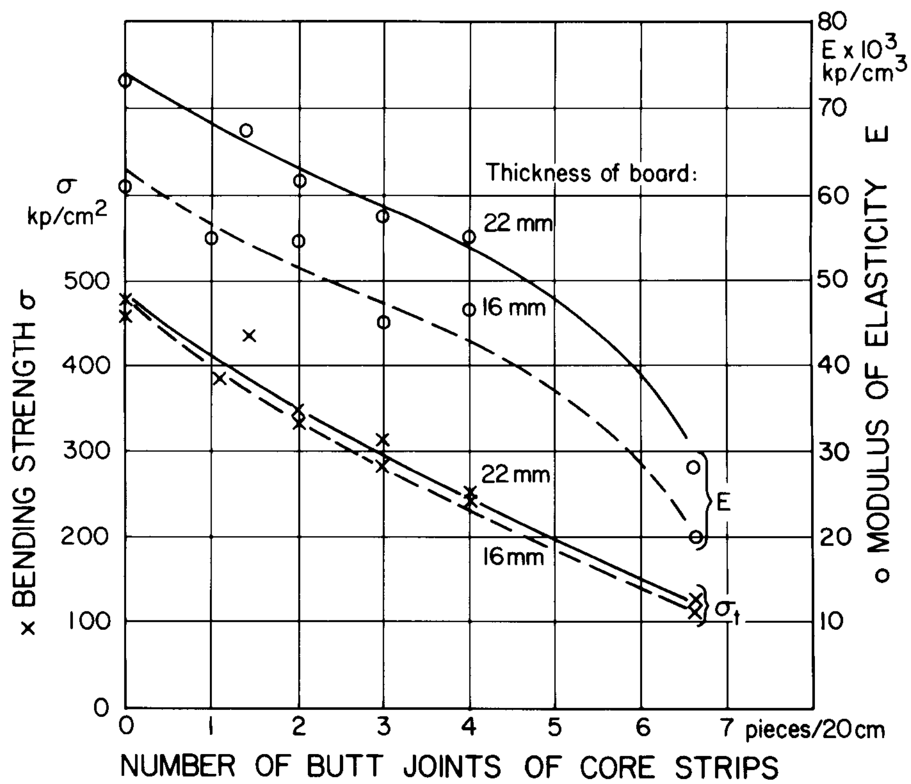

FIG. 2. Effect of the number of butt joints in the core on the bending strength and modulus of elasticity parallel with the core strips of 5-ply laboratory manufactured blockboard (State Institute for Technical Research 1967).

strength was about half of the value obtained in boards made without core joints. The modulus of elasticity was also found to decrease linearly as the number of butt joints in the center span increased from 0 to 4, although the rate of stiffness loss was less than the rate of loss noted in bending strength. With the number of butt joints at 4, MOE was determined to be approximately two-thirds of the value obtained in joint-free controls. An increase in joint occurrence to 5 or 6 or more was noted to result in sharply lower MOE values.

A second part of the Finnish study involved tests of commercially manufactured blockboards, with subsequent determination of core joint placement. Both 3- and 5-ply panels were tested. Results of tests relating the number of core joints to bending properties are presented in Fig. 3. Other data from this study were published as part of a previous article (Bowyer 1979b). Reductions in bending strength and MOE with increasing numbers of core joints were again noted, though the effect of core joints was less severe than in laboratory-manufactured panels. Referring to Fig. 3, 3-ply panels exhibited a loss in bending strength of approximately 20% as the number of core joints increased from 0 to 4. A bending strength loss of nearly 50% is shown for 5-ply panels. The 5-ply data, however, are averaged data for 16-, 18-, 22-, and 25-mm-thick panels; and 16-mm panel

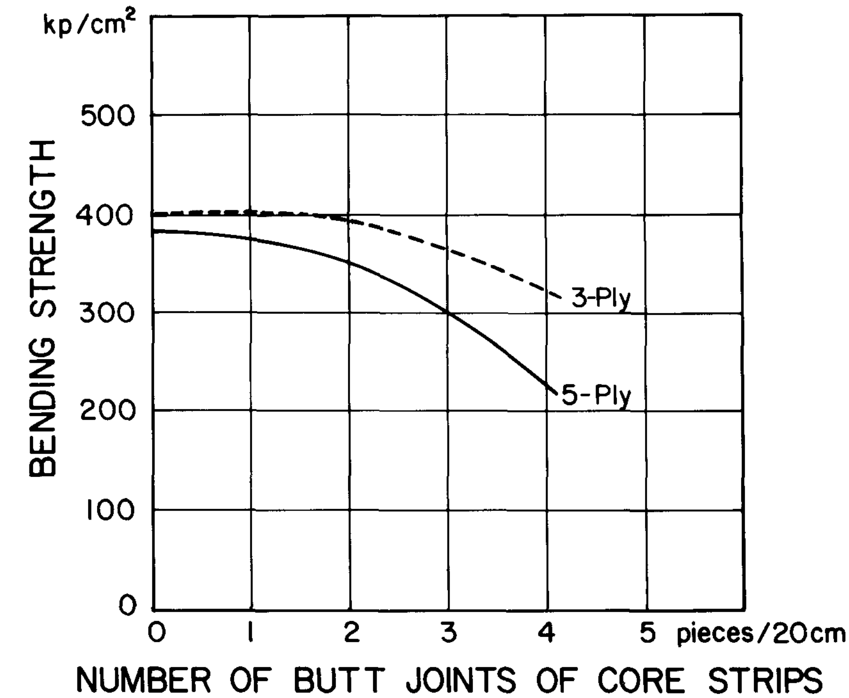

FIG. 3. Effect of the number of butt joints in the core on bending strength parallel with the strips of commercially manufactured 3- and 5-ply blockboard of normal structure as means of different thicknesses (State Institute for Technical Research 1967).

data that went into this average were, for some reason, quite low. When the 16-mm panel data are removed, results are similar to those obtained in tests of 3-ply panels. Losses in bending strength of 16–25% were found in 18- to 25-mm thick, 5-ply panels as the number of core joints increased from 0 to 4 per 20 cm of test strip width. Reductions of 6–11% were noted in MOE values. The reason for modest core joint related strength reductions in commercial boards was said to be that core joints were not aligned across the panel width as they were in those produced in the laboratory. It was concluded that "even a small terracing (of core joint placement) obviously reduced the adverse effect of joints upon strength." In 3-ply commercial panels, it was suggested that the manner of glue spread could have also affected strength, since in these panels glue was spread directly onto core strips, allowing some penetration into cracks between the strips.

Limited tests of laboratory-manufactured 3-ply elm-faced, aspen core panels made with nonaligned core joints (across the width) yielded results similar to those obtained in the tests of commercial panels described above (Bowyer 1979b). In the elm/aspen panels, the presence of as many as 5 joints over a 16-in. span and 12-in. panel width resulted in reductions of about 14% for both stiffness and maximum load-carrying capacity compared to specimens having full length core pieces. An increase to 7–8 joints per 16-in. span brought EI and maximum load capacity down from original values 24% and 38%, respectively.

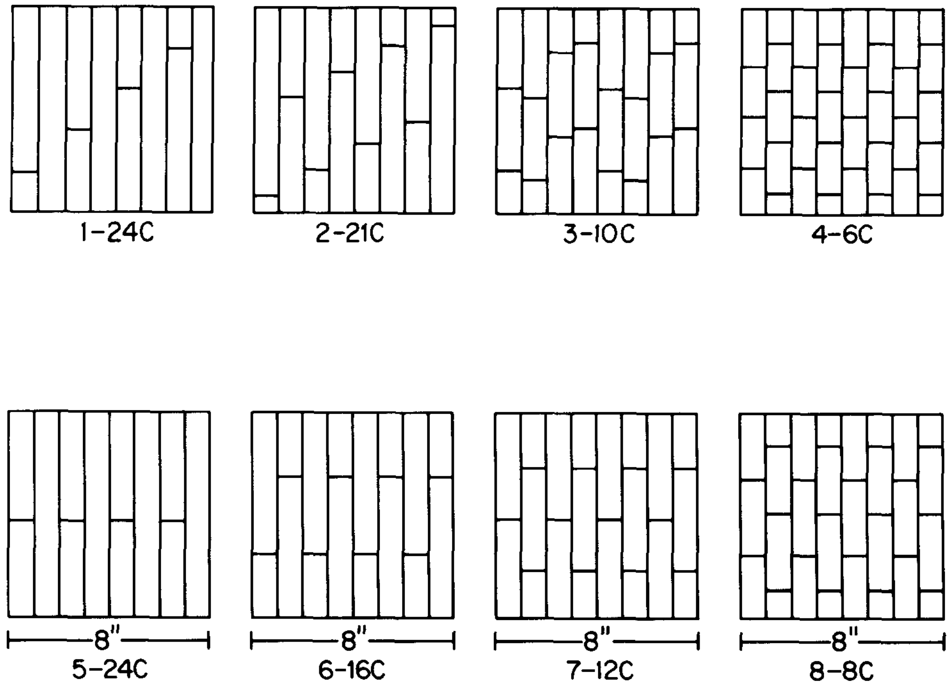

FIG. 4. Placement of butt joints in blockboard core. Only one-third of each panel is shown. The pattern illustrated was repeated twice more in constructing a 24-in. × 24-in. panel. Not drawn to scale except on vertical axis where full 24-in. dimension is shown.

PROCEDURE

Board manufacture

Eighty-one 24-in. × 24-in. 3-ply blockboards were manufactured using 0.100-in.-thick dry, white elm veneer and 4/4 rough, dry aspen lumber that had been precision ripped to form 0.7-in.-thick strips (which were thus as wide as the thickness of the rough lumber—about 1 in.). In cutting strips to desired lengths, serious defects, such as decay, large and/or unsound knots, and splits were removed and discarded. Nine replications of nine board types were produced, one made with 24-in. long, and therefore joint-free, core strips (with this then used as a 'control'), the other eight with core configurations as shown in Figs. 4 and 5. Several of the boards were designed so as to minimize alignment of core block ends, thereby achieving the kind of "terracing effect" mentioned in the Finnish study as a cause of improved strength performance in commercially manufactured blockboard. Resorcinol resin was used in making all panels, with a spread rate of 70#/M ft^2 (liquid resin). Resin was spread directly to faces of edge-to-edge crowded core strips after which face veneers were applied, with the assembly then placed between metal caul plates and cold-pressed for 5 to 10 min at approximately 20#/ft^2. Hot pressing for 10 min at 225 F and 140 psi completed the manufacturing process.

In addition to the blockboard manufactured, two 4- × 4-ft sheets of ¾-in., 5-ply, A–C exterior Douglas-fir plywood were cut into 24-in.-square panels.

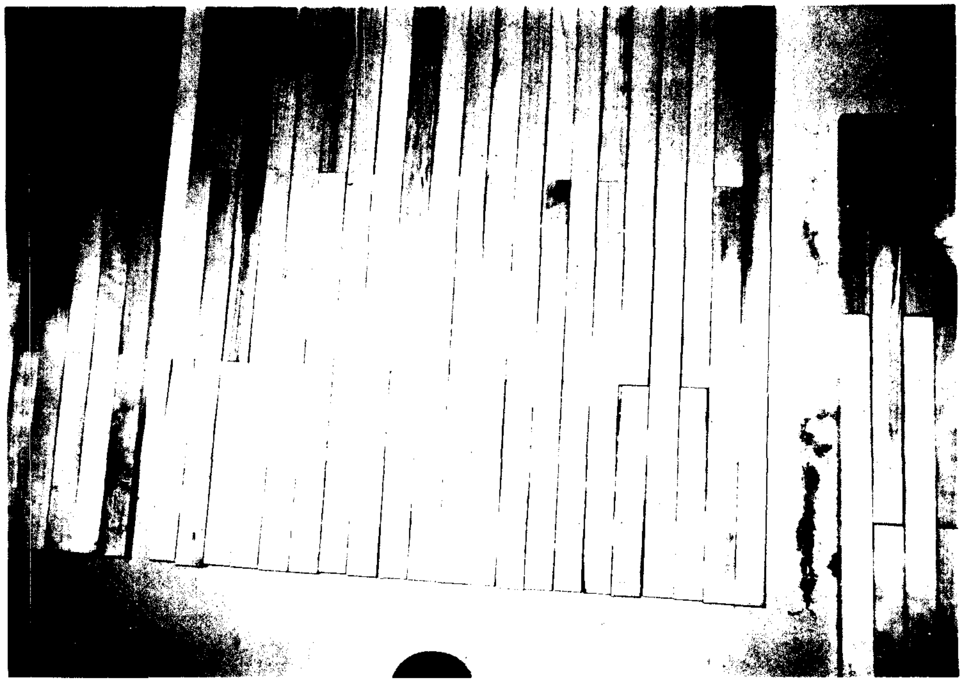

FIG. 5. Photograph of 6-16C type panel core during lay-up.

Test sample preparation

Blockboard panels were cut parallel-to-the-grain direction of core strips to form 7.4-in.-wide test strips. The 24-in.-square plywood panels were also cut into 7.4-in.-wide strips; half were cut parallel-to-the-grain direction of face veneers, with the rest sawn perpendicular-to-the-grain of face plies. All samples were then equilibrated at 68 F and 50% RH.

Testing

The 7.4- × 24-in. test samples supported across the width 1 in. from each end, producing a 22-in. span. Samples were then subjected to an increasing load applied to the center of the span; the loading head was designed such that the load was applied across the full unsupported width. With a span of 22 in., the span/depth ratio was 24.4:1 for blockboard and 29:1 for plywood. The rate of loading and design of the test apparatus were as specified in ASTM D-3043-76.

RESULTS AND DISCUSSION

EI and maximum load at failure values for each panel type are shown in Figs. 6 and 7. Significant differences between panel types are also indicated, these based upon a sequential "Q-test" (Snedecor and Cochran 1967). Note that 0.9-in.-thick blockboard panels with core block lengths as short as 6–8 in. had EI values as high as ¾-in. Douglas-fir plywood in its strongest orientation. With respect to maximum load, only those blockboard panels made with 6-in. core blocks exhibited significantly less strength than did the strongest orientation of

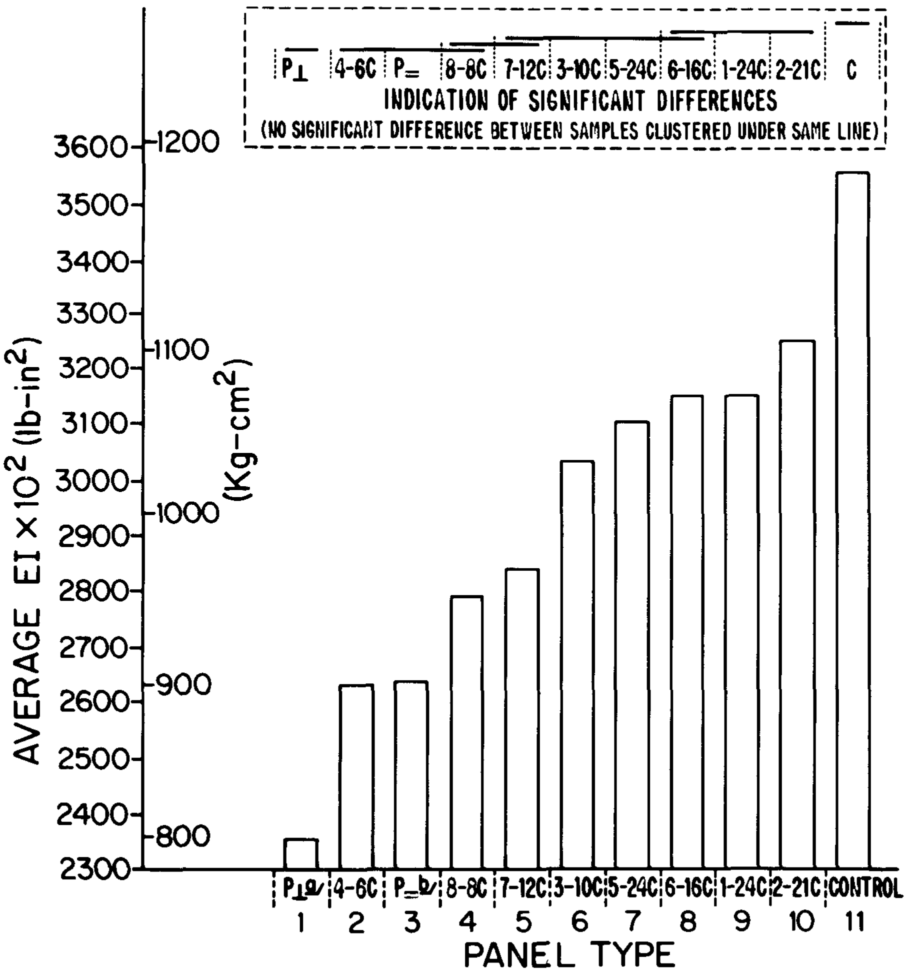

FIG. 6. EI for various panel types based upon static bending of 7.4-in. × 24-in. samples. a. Plywood tested perpendicular-to-the-grain direction in face plies. b. Plywood tested parallel-to-the-grain direction in face plies.

plywood. Control panels—blockboard made with full width (or joint-free) core strips—exhibited the greatest stiffness and load carrying ability in bending.

In comparing panel types, both on the basis on EI and maximum load, a consistent correlation of strength to core block length was not found. For example, maximum load figures for panel types 12C and 5-24C (which were made with 12-in. and 24-in.-long core pieces, respectively), were significantly less than for the 10C type (made with 10-in. core blocks) or to the 1-24C type (also made with 24-in. core blocks). This is thought due to the confounding effect of end joint placement. Examination of Fig. 6 shows that panel types 12C and 5-24C both had an alignment of core block butt joints at center span, a location corresponding to the location of the greatest bending moment during loading. Butt joints in panel types 10C and 1-24C, in contrast, were not aligned at center span. Failures in

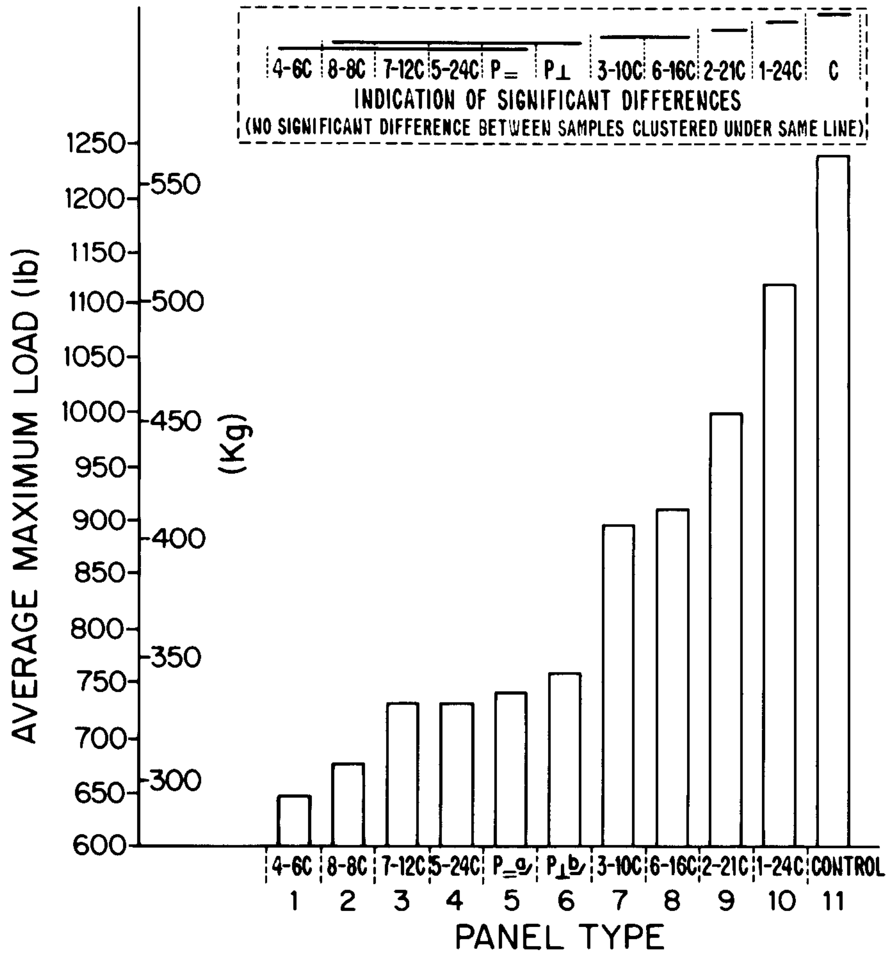

FIG. 7. Maximum load at failure for various panel types based upon static bending of 7.4-in. × 24-in. samples. a. Plywood tested parallel-to-the-grain direction in face plies. b. Plywood tested perpendicular-to-the-grain direction in face plies.

panel types 12C and 5-24C tended to be abrupt, with complete failure of the lower veneer at the point of butt joint alignment followed by shear along the grain direction within core blocks (Fig. 8). Failures in the type 10C and 1-24C panels were much less obvious and quite similar to those observed when testing plywood. Had dual head loading been used in static bending tests so as to create a uniform bending moment and zero shear over the central part of the span, observed strength values would likely have been more closely correlated with core block length (similar to the findings of the Finnish State Institute for Technical Research). On the other hand, the single head loading tests that were conducted provided a more severe test of panel performance than would have been provided by dual head loading.

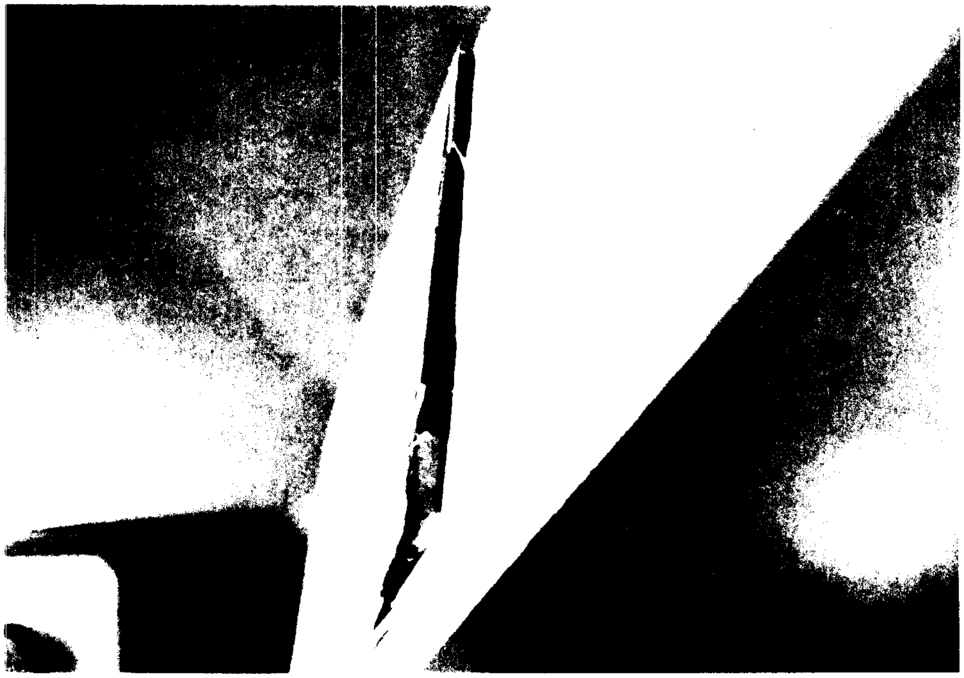

FIG. 8. Photograph of failure in panel type 7–12C showing complete failure of lower veneer and shear failure along the grain of core strips.

CONCLUSIONS

These test results indicate that it would be possible to make structural faceglued blockboard panels using short core blocks. If blockboard panels were manufactured to a slightly greater thickness than plywood with which it might compete, comparable strength to plywood could be obtained using core blocks as short as 8 in. The fact that short core blocks can be used translates to direct economic advantages in that a variety of low-cost materials, including edgings from lumber, and trim from panel products, are potential sources of core blocks.

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