United States
Department of
Agriculture

Forest Service

**Southeastern Forest
Experiment Station**

General Technical
Report SE-33

Performance and Quality-Control Standards for Composite Floor, Wall, and Truss Framing

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November 1985

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Performance and Quality-Control Standards for Composite Floor, Wall, and Truss Framing

Part I. Preface

1.0 Origin and Use of the Standards

These standards offer building-code authorities and consumers the assurance that composite framing will perform as intended and that manufacturers will maintain its quality at specified levels. They have been prepared by the Materials Science and Engineering for Wood-Based Composite Structural Framing Unit, USDA Forest Service, Athens, GA, where COM-PLY framing is being developed, and are intended for interim use so that manufacturers can proceed with production. Permanent uniform standards for COM-PLY framing will be developed by the manufacturers, in collaboration with building-code officials, consumer groups, and government agencies.

2.0 The Product

Composite, or COM-PLY, framing is designed for residential and light commercial building construction. It consists of wood veneer facings laminated to a flakeboard core. Two or more veneer faces are laminated to the narrow face of the framing with the grain of the veneer parallel to the long axis of the framing.

When used for truss framing, COM-PLY is connected with light-gauge metal truss plates. Manufacturers shall design trusses in accordance with the current Truss Plate Institute (TPI) Design Specifications for Wood Trusses.

3.0 Purpose of the Performance Standards

To make satisfactory and safe use of COM-PLY products, consumers must be able to determine their strength, stiffness, dimensional stability, and durability. Performance standards provide the means for measuring such attributes and for developing product specifications. Manufacturers select the specifications for any given product; specifications do not restrict the materials, methods, or processes that can be used in manufacture. Performance standards, however, do set forth the materials, methods, and processes to be used in obtaining approval for a product by a regulatory agency. An agency may accept or reject a product on the basis of one or more specified tests that measure how strong, stiff, stable, and durable it is. Moreover, the standards set forth the procedures for retesting whenever materials, methods, or processes used during production are changed. The levels of performance, the test methods, and the policies governing acceptance or rejection outlined in these standards represent the consensus of regulatory agencies and COM-PLY manufacturers.

4.0 Purpose of the Quality-Control Standards

Quality-control standards specify the tests that manufacturers shall apply regularly during production to evaluate physical and mechanical properties of COM-PLY framing. Such testing assures that acceptable quality is being maintained. Manufacturers are responsible for maintaining the quality of the product by making adjustments in materials or manufacturing processes whenever necessary. The quality levels set forth in this standard have the agreement of regulatory agencies and manufacturers who will be using the standard. Because some tests must be performed daily, they are designed to be relatively inexpensive and easy to perform. Testing may be done by the manufacturer, provided that records are kept by an inspection agency, or for audit by such an agency. Manufacturers may trademark production COM-PLY framing only after it has been checked according to procedures set forth in this standard and has been shown to meet specifications. Manufacturers may not trademark COM-PLY framing that falls below accepted standards.

COM-PLY® is a registered trademark of the American Plywood Association.

Part II. Policies Governing the Use and Enforcement of the Standards

1.0 Products to Which the Standards Apply

Standards apply only to composite framing intended for use in residential, farm, or commercial floor, wall, and truss framing that uses light-gauge metal plate connectors. The material manufactured under these standards is not intended for use with full exterior exposure to weather. Throughout service life, COM-PLY should be in a protected location without direct exposure to weathering.

2.0 Definition of a Qualified Inspection and Testing Agency

All tests shall be performed by a qualified inspection and testing agency (hereafter referred to as the auditor), which is defined as one that:

- Operates an inspection system that evaluates the quality-control system of its contracting plants.
- Provides the facilities and the personnel to perform the inspection and to verify the testing as described herein.
- Determines the individual plant's ability to produce in accordance with these standards.
- Provides periodic inspection of the plant's production operations and production quality to assure compliance with these standards.
- Enforces the proper use of the inspection agency quality marks and certificates.
- Has no financial interest in or is not financially dependent upon any single company manufacturing any portion of the product being inspected or tested.
- Is not owned, operated, or controlled by any such company.
- Provides a technical review board to advise the inspection and testing agency and to arbitrate disputes between the agency and the manufacturer. Such a review board shall include a recognized independent authority in the field of engineered structural wood products to serve as chairman, and at least one registered engineer knowledgeable in the design and use of structural glued wood products.

3.0 Policies Governing Performance Standards

3.1 Purpose and Scope

The purpose of the performance standard is to assure that composite framing will perform as intended. Such assurance is attained by testing the product for such attributes as strength, durability, and stability. These policies govern such testing, which is the basis for determining whether a manufacturer shall have the privilege of trademarking a COM-PLY product. Policies also govern tests that must be done to determine whether the privilege of trademarking is to be reinstated after having been withdrawn.

3.2 Product Markings

Each piece of composite framing that complies with this standard shall be marked with a trademark and with information as specified below, depending on the type of framing, as indicated in parentheses:

- Intended use (floor, wall, truss).
- Working stress in bending, F_b (floor, wall, truss).
- Working stress in short-column compression, F_c (wall, truss).
- Working stress in tension, F_t (truss).
- Modulus of elasticity to be used in long-column design, E_{bf} (wall, truss).

- Modulus of elasticity to be used for beam deflecting, E_b (floor).
- Modulus of elasticity to be used for short-column design, E_{cs} (wall, truss).
- Manufacturer's type number (floor, wall, truss).
- Manufacturer's name or mill number (floor, wall, truss).
- Date and shift of manufacture (floor, wall, truss).
- Name of the auditor or testing company certifying quality (floor, wall, truss).

An acceptable trademark might look like this:

Composite Truss Framing
F_b = 1850 E_{bf} = 1500000
F_c = 2000 E_{cs} = 1300000
F_t = 1000 Type 3
ABC Lumber Company 8/12/86-2
XYZ Testing Company

The trademark may include manufacturer and testing company logos. The lettering and ink used for the trademark must remain legible after 1 year of outdoor weathering.

3.3 Qualifying for Trademarking Privileges

A manufacturer may trademark a COM-PLY product when:

- All of the performance tests have been performed, the product has passed the minimum requirements, and working stresses have been established.
- The initial quality-control test has been performed and the results recorded.
- The product specification has been written and includes the values for the initial quality-control test.

3.4 Required Testing or Retesting

Testing or retesting is required:

- Whenever a new product or manufacturing type that uses new process methods and/or materials is to be produced.
- Whenever there is a major change in specifications that affects the strength, durability, or dimensional stability of an old or previously manufactured product.
- Whenever production has not restored quality above the withdrawal level for any of the daily quality-control tests after three repeat samplings within any 6-day period and a followup daily sample by the auditor verifies that quality is at the withdrawal level.
- Quarterly or semiannually to demonstrate that performance is being maintained, as set forth in the performance standard.

For cases 1 and 2 the entire performance series of tests must be performed. For case 3 only those properties that have been shown to be unacceptable need be retested; the auditor stipulates the test required. In case 4 the retesting of performance shall be limited to the type of periodic test specified in section 5.0 of the quality-control standard.

3.5 Test Records

Records of the results of all tests are the property of the manufacturer who pays for the cost of running them. The auditor shall keep on file copies of all test records and correspondence for at least 2 years and shall supply the manufacturer with the number of copies agreed upon. The auditor shall retain current copies of manufacturer's product specifications for reference but shall not divulge their contents without the manufacturer's consent.

3.6 Settlement of Disputes Between the Manufacturer and the User

Should a dispute arise between the manufacturer and a user concerning the performance of a COM-PLY product, the performance standards may be used to settle the dispute. They should agree upon a qualified independent testing laboratory to run the performance tests. The laboratory will usually be the one that certified the product in question. If the product fails to qualify for strength, durability, or stability within ± 10 percent of the trademarked or required values, it is suggested that the manufacturer pay the costs of running the test; otherwise, the user shall pay such costs.

4.0 Policies Governing Quality-Control Standards

4.1 Purpose and Scope

The purpose of the quality-control standard is to assure that the composite framing being made has the quality indicated by the trademark and original test. Such assurance is attained by collecting samples of the product daily and testing them for quality. These policies govern testing that is designed to detect whether quality has dropped to a level that requires some adjustment by the manufacturer to bring the level back up to standard. These policies also specify the procedures to follow when withdrawing trademarking privileges from a manufacturer who fails to maintain the quality of the product and when restoring trademarking priviliges to a manufacturer who raises the quality of the product to acceptable levels.

4.2 Levels of Quality

Three levels of quality--acceptable, warning, and withdrawal--are designated in the quality-control standards. The manufacturer's quality-control personnel are responsible for keeping the production superintendent informed of the current level of quality of composite framing being produced. The manufacturer is responsible for correcting unsatisfactory quality and for paying the costs of the quality-control program.

4.2.1 Acceptable quality.--Unless notified otherwise by the auditor or quality-control personnel, the manufacturer may assume that quality of a composite framing product is acceptable and may place the trademark on all pieces produced.

4.2.2 Warning levels and suspension of trademark.--Whenever quality drops below acceptable levels, quality controllers shall warn the production superintendent as soon as practically possible, providing details about the attributes of the product that have dropped to a warning level. Thereafter, testing for any attribute that has dropped to the warning level shall be done on samples taken at the intensive level. The production superintendent must correct the problem within the next three sampling units after being notified that quality has dropped or quality controllers shall issue a second warning. If quality is not corrected in the third unit after the second warning, quality-control personnel shall issue a third warning. If quality is not restored to acceptable levels by the third unit after the third warning, the quality controllers shall notify the auditor that trademarking privileges are being suspended.

The auditor shall not permit trademarking to resume until the production superintendent submits one intensive sample unit that meets the acceptable level of quality for the attribute in question. As soon as one intensive sample unit is passed as acceptable, the quality controllers shall inform the manufacturer that trademarking may be resumed and shall confirm the decision in writing.

4.2.3 Unacceptable quality and withdrawal of trademark.--Whenever quality drops to an unacceptable level, the

quality controllers shall immediately notify the production superintendent and the auditor that trademarking will cease.

When the manufacturer has made changes in production to correct the problem and the auditor has verified that quality has been restored to acceptable levels, trademarking may be resumed. As soon as one sample tested by the auditor meets the acceptable level, the auditor shall notify the manufacturer that trademarking may be resumed and shall confirm this decision in writing.

Part III. Performance Standards

1.0 Introduction

To determine how composite, or COM-PLY, floor, wall, and truss framing will perform, the manufacturer or auditor shall perform tests to evaluate working stresses, durability, and dimensional stability under certain specified conditions. This standard prescribes the test methods and materials to use to measure the strength, durability, and dimensional stability of COM-PLY. It details the physical and mechanical properties that COM-PLY must exhibit, and it describes the test methods to use or prescribes the use of procedures described elsewhere. Limitations on use of this standard are set forth, as are recommendations concerning records and materials.

2.0 Marking and Qualifying Several Types of Products

Since a mill may produce several grades of framing, the manufacturer shall stamp on each piece a type number that indicates its performance level. (The number does not rate the quality; it simply differentiates types of framing.) COM-PLY framing manufacturers may agree to limit the number of types of framing in order to avoid confusion of consumers.

Manufacturers shall qualify the performance for each type of framing except when the building-code agency waives such requirements. When a manufacturer wants to market more than one type of floor, wall, or roof truss framing and each type has distinctive design properties, the manufacturer shall qualify each type under these standards.

3.0 Strength

3.1 General Requirements and Notations

3.1.1 Requirements.--Determine the safe working stresses for composite framing according to procedures specified by this standard. Make certain that working stresses for roof truss framing are provided to design trusses as described in the current TPI method and that working stresses for floor and wall framing are provided to design joists and studs conforming to engineering requirements of building codes. Mark kay working stresses on each piece of framing. The manufacturer shall supply users with published information about all working stresses.

3.1.2 Notations.--The symbols used in this standard have the following meanings:

E_b = design value for modulus of elasticity in edgewise bending, psi

E_{bf} = design value for modulus of elasticity in flatwise bending, psi

E_{cs} = design value for modulus of elasticity for short columns, psi

E_t = design value for tensile modulus of elasticity parallel to veneer face grain, psi

F_b = design value for extreme fiber in edgewise bending, psi

F_{bf} = design value for extreme fiber in flatwise bending, psi

F_c = design value in compression parallel to veneer face grain, psi

$F_{c\perp}$ = design value in compression perpendicular to veneer face grain, psi

F_t = design value in tension parallel to veneer face grain, psi

F_v = design value in horizontal shear of the flakeboard, psi

F_1 = allowable increase for load sharing among adjacent bending members; the value is 1.15 when computing bending stresses for repetitive loading; otherwise, the value is 1.0

F_2 = safety factor; use 1.5 unless otherwise stated

F_3 = adjustment factor to account for the duration of the test load; use the average time to test for computing F_3; to find F_3, use the following equation or the graph relating duration of load; to design values in the National Design Specifications (NDS) for Wood Construction published by the National Forest Products Association: $F_3 = 1.72624/T^{0.0354831}$, where T is the average test time in minutes

F_4 = adjustment factor for the duration of the intended service load; unless otherwise stated, assume the service load is normal (10 years) and the value for F_4 is 1.0; values for F_4 are 0.9 for permanent loads, 1.0 for 10-year normal loads, 1.15 for 2-month snow loads, 1.25 for 1-week snow loads, 1.33 for 1-day wind or earthquake loads, and 2.0 for 1-second impact loads

N = number of specimens

S = standard deviation of strength or stiffness property from test

T = average test time in minutes

$t_{0.05}$ = statistical t at 0.05 confidence level for N-1 degrees of freedom

x = average strength or stiffness property from test

3.2 Number of Test Specimens

Randomly select at least 10 test specimens from production material in 10 or more loads from the press where veneer is applied to the cores of framing. Test all specimens at an equilibrium moisture content of 10 ± 2 percent, which can be attained by conditioning the specimens to a constant weight at controlled temperature and relative humidity.

Because of the relatively small number tested, the minimum sample of 10 is penalized statistically. However, there is little statistical advantage to testing more than 30 specimens.

3.3 Working Stresses

3.3.1 Strength equation.--Use the following equation to determine working stresses for strength properties:

$$\text{Working stress} = \left[x - \frac{t_{0.05}\, S}{\sqrt{N}} - t_{0.05}\, S \right] \frac{F_1}{F_2 \cdot F_3/F_4}, \quad (1)$$

Note 1: See Part III, section 3.1.2, Notations, for meaning of symbols.

3.3.2 Stiffness equation.--Use the following equation to determine working stress for stiffness properties:

$$\text{Stiffness} = x - \frac{t_{0.05}\, S}{\sqrt{N}} \quad (2)$$

Note 2: See Part III, section 3.1.2, Notations, for meaning of symbols.

3.4 Tests for Strength and Stiffness Performance

3.4.1 Bending working stress (edgewise).--Determine the average modulus of rupture (MOR) and standard deviation for a specimen having a test span of not less than 20 times the depth of the beam and using quarter-point loads following the procedures in American Society for Testing and Materials (ASTM) D 198-84, ¶4 to ¶9. Record the time required to perform each test and compute the average time to test. Use the midspan width and depth to compute the MOR of each specimen. Use the average MOR for the value of x (eq. 1) to compute the working stress in bending, F_b. Compute two values for working stress in bending: one for repetitive bending using F_1 = 1.15 and one for single-member loading using F_1 = 1.0.

3.4.2 Bending modulus of elasticity (edgewise).--Determine the average modulus of elasticity (MOE) and standard deviation for the same specimens used to compute F_b, and by the same ASTM procedure (see section 3.4.1). Use the midspan width and depth to compute the MOE of each specimen. Use the average MOE for the value of x (eq. 2) to compute the working value for E_b in bending.

3.4.3 Bending working stress and modulus of elasticity (flatwise).--Determine the F_{bf} and E_{bf} in the flatwise direction using the same procedures used for F_b and E_b edgewise. (Note: flatwise F_{bf} and E_{bf} values may be needed for certain column designs or where framing material is to be used for plank, purlin, deck board, and the like.) This test is not required for framing marked only for use as joists or studs.

3.4.4 Compression parallel to face grain of veneer.--Determine the average short-column ultimate compressive strength (F_c) and standard deviation for specimens 8-1/2 inches long (with grain of veneer) following procedures in ASTM D 198-84, ¶12 to ¶18. Specimens may be cut from remnants of the bending test. If butt joints are used in both the veneer and core, then test a double set of specimens, one set with core joints and one with veneer joints. Use the set with the lower average ultimate strength for determining working stresses in compression. If only one component (veneer or core) contains butt joints, then only one set of specimens that contains the butt joint need be tested. If no butt joints are used but other joints such as scarf joints are used in the components, then half the specimens shall contain core joints and half contain veneer joints. Record the time to perform each test and compute the average time to test. Use the midlength width and depth to compute the short-column compressive stress of each specimen. Use the average ultimate short-column stress for the value of x (eq. 1) to compute the working stress (F_c) for short-column compression. This test is not required for framing marked only for use as joists.

3.4.5 Compressive modulus of elasticity.--Determine the MOE in compression for the same specimens used to compute F_c by using the procedures in ASTM D 198-84, ¶12 to ¶18. Use the midlength width and depth to compute the short-column MOE values for each specimen. Use the average short-column MOE for the value of x (eq. 2) to compute the working stress (E_{cs}) for column design. This test is not required for framing marked only for use as joists.

3.4.6 Tension working stress.--Determine the average ultimate tensile strength and standard deviation for all specimens following the procedures in ASTM D 198-84, ¶28 to ¶34. The length of the specimen shall be the sum of the grip lengths and the test length between grips. The test length between grips shall not be less than 48 inches but shall be long enough to include the maximum number and minimum spacing of joints that typically occur in the veneer and flakeboard core. All test specimens shall contain a typical core joint and a veneer joint in each veneer laminate. Record the time required to perform each test and record the average time to test.

Use the average time to test for computing F_3 (eq. 1). The value of F_1 is 1.0 and the value of F_2 is 1.5. Use the width and depth at the midtest length to compute the ultimate tensile strength of each specimen. Use the average ultimate tensile strength for the value of x (eq. 1) to compute the working tension stress (F_t). This test is not required for framing marked only for use as joists or studs.

3.4.7 Tension modulus of elasticity.--Determine the average tensile MOE and standard deviation for the same specimens used to compute the working tension stress (F_t) following the procedures in ASTM D 198-84, ¶28 to ¶34. Use the width and depth at midtest length to compute the MOE of each specimen. Use the average MOE for the value of x (eq. 2) to compute the working value for E_t in tension. This test is not required for framing marked only for use as joists or studs.

3.4.8 Bearing working stress (edges).--Determine the average ultimate edge-bearing stress ($F_{c\perp}$) and standard deviation for a 6-inch-long specimen following the procedures in ASTM D 143-83, ¶79 to ¶84. Specimens may be cut from an undamaged section from the bending test. The test-bearing area shall be the thickness of the framing across the veneer grain (approximately 1.5 inches) by 2.0 inches with the veneer grain. Record the time required to perform each test and compute the average time to test. Use the average ultimate edge-bearing stress for the value of x (eq. 1) to compute the working stress in edge-bearing ($F_{c\perp}$). This test is not required for framing marked only for use as studs.

An alternative to this test may be used to determine the allowable working stress in compression perpendicular to grain ($F_{c\perp}$). See the Natural Design Specification for Wood Construction (NDS) by the National Forest Products Association for the species that corresponds to the face veneer of the composite member.

3.4.9 Shear working stress.--Determine the average ultimate shear stress and standard deviation for a block-shear specimen cut from the flakeboard core following the procedures in ASTM D 143-83, ¶90 to ¶94. Specimens may be cut from end trimmings of specimens used for bending or tension tests, or may be taken from randomly selected end trimmings of production material. Record the time to perform each test and compute the average time to test. Use the average ultimate shear stress for the value of x (eq. 1) to compute the working stress for horizontal shear (F_v). This test is not required for framing marked only for use as truss or stud framing.

3.4.10 Lateral load resistance for nails driven into veneer facing.--Test an equal number of specimens for both 6d and 8d common wire nails driven into the narrow edge of the framing so the nail shank is imbedded in the flakeboard core. Determine the average ultimate lateral load and standard deviation for specimens with a 1/2-inch-thick plywood cleat following the procedures in ASTM D 1761-77, ¶12 to ¶18. Record the load that occurs at 0.015 inch of joint slip. Record the time required to perform each test and compute the average time to test. Assume the service load to be wind or earthquake with a duration of load factor (F_4) equal to 1.33. Use the average ultimate lateral nail load for the value of x (eq. 1) to compute the safe lateral load per nail. The load per nail must not be less than 68 pounds. (Note: 68 pounds is the safe lateral wind load for 6d nails in Group III woods and 8d nails in Group IV woods, according to NDS.) The average load at 0.015 inch of joint slip must not be less than 51 pounds per nail. (Note: the NDS value for normal load is 51 pounds for 6d nails in Group III woods and 8d nails in Group IV woods.)

This test is not mandatory but may be requested by the manufacturer or building-code official.

3.4.11 Lateral load resistance for end and toe-nailed joints.--Test stud-to-plate joint nail strength and joist-to-header joint nail strength. For studs, follow procedures to test for loads as specified in USDA Forest Service Research Paper SE-155, the section on strength of nailed joints, with one exception: allow lateral deformations up to 0.015 inch. For joists, follow procedures to test for loads as specified in USDA Forest Service Research Paper SE-222, the section on joists supported by nails.

This performance test is not mandatory but may be requested by the manufacturer or building-code official.

3.4.12 Withdrawal load resistance for nails driven into veneer facing.--Test an equal number of specimens for 6d and 8d common wire nails and 1-1/4-inch gypsum wallboard nails driven into the narrow edge of the framing so the nailhead is one-half inch from the face of the framing. Determine the average ultimate withdrawal load and standard deviation for each set of specimens following procedures in ASTM D 1761-77, ¶1 to ¶11. Record the time required to perform each test and compute the average time to test. Assume the service load to be wind for the 6d and 8d nails and permanent load for the 1-1/4-inch gypsum wallboard nails. The service duration of load factor (F_4) is 1.33 for test of 6d and 8d nails and 0.9 for test of the 1-1/4-inch gypsum wallboard nails. Use the average ultimate withdrawal load for the value of x (eq. 1) to compute the safe withdrawal load per nail. The safe withdrawal load per nail must not be less than 37 pounds for 6d nails, 56 pounds for 8d nails, and 15 pounds for 1-1/4-inch gypsum wallboard nails. (Note: the safe withdrawal loads for 6d and 8d nails are equivalent to the withdrawal loads in NDS for such nails that have been driven in wood having a specific gravity of 0.42 and with 1-1/2 and 2 inches, respectively, of shank penetration. The safe load for the 1-1/4-inch gypsum wallboard nail is equal to the dead load of 1/2-inch gypsum board and a deep fill of attic insulation supported on nails spaced 7 inches on center and for trusses spaced 2 feet on center.) The withdrawal test for the 1-1/4-inch gypsum wallboard nail is not required for framing marked for use only as joists or studs.

These tests are not mandatory but may be requested by the manufacturer or building-code official.

3.4.13 Truss plate lateral fastener resistance.--The truss plate manufacturer shall be responsible for testing the lateral fastener resistance of light-gauge metal truss plates per tooth, nail, plug, square inch, or other unit unless the manufacturer of composite truss framing volunteers to make such tests. The truss plate manufacturer shall test lateral plate resistance by using each plate type on each type of composite truss framing. The tests should follow procedures in TPI Appendix C, Design Specification for Metal Plate Connected Wood Trusses, TPI-85, except as follows:

- Test only control specimens that have a veneer moisture content of 10 ± 2 percent. (Note: composite truss framing is fabricated dry (4 to 6 percent moisture content), eliminating some potential hazards associated with wet fabrication. As a result, the TPI moisture response test has been altered somewhat.)
- Test a minimum of 10 specimens.
- Test plate that is rectangular, with a length approximately twice the width.
- Do not allow the plate to fail in net section of the metal during the test.
- Determine the allowable design load based upon ultimate load by using 1 and not by dividing by 3 as shown in paragraph 104.1(c) of the TPI standard. In computing normal

loads, use the average ultimate load value per tooth, nail, plug, or square inch of plate for the value of x (eq. 1). Assign F_4 a value of 1.0 to compute normal loads. Compute the value of F_3 on the basis of the average time it takes to perform the load test.

Use the results of this test on composite truss framing as the basis for the engineering design of truss connectors.

4.0 Durability

4.1 General Requirements

Evaluate the durability of composite framing according to methods specified by this standard. Composite framing should be able to withstand both the outdoor weathering that occurs on the job site and the changes in the moisture and temperature that occur after the framing is installed. Because composite framing is a glued wood product, testing the durability of the bonds in it is particularly important. (Resin bonds are used to make the flakeboard core and adhesive bonds are used in laminating the veneers to the core.)

4.2 Tests for Durability

To test the durability of composite framing, follow the procedures of the ASTM D 1037-78, ¶118 to ¶124, or the French Standard NFB51 293, V313 accelerated aging test. The effect of aging on composite framing must not cancel out its bending, tensile, or compressive strength and stiffness. However, testing only for bending strength and stiffness is sufficient.

Use the same number of test specimens and the same methods for selecting and conditioning specimens as those prescribed for strength performance, with the following exceptions. Select a specimen only 2 x 4 or 2 x 6 inches wide and no longer than 8 feet; longer specimens cannot fit into most freezers, and wider specimens of that length would not have a proper depth-span ratio for the bending test. For controls, use the specimens from the test for bending working stress (edgewise) that were bent to failure without aging. Using methods described above, obtain a control value for bending MOE (edgewise) before aging on specimens selected for test of aging.

Age all specimens in accordance with ASTM D 1037-78, ¶120. For aging by the V313 test method, soak the specimens in water at 20 °C (68 °F) for 3 days, then freeze them in air at -12 °C (10 °F) for 1 day, and dry them in air at 60 °C (158 °F) for 3 days; repeat the cycle twice. After aging, test the specimens for bending stiffness and MOR using procedures described above (see Part III, sections 3.4.1 and 3.4.2).

4.3 Performance Required

Aged specimens must retain 50 percent of the stiffness before aging and 50 percent of the MOR obtained in the bending strength tests of unaged specimens.

5.0 Dimensional Stability

5.1 Tests for Stability

Select specimens and condition them according to methods prescribed for tests of strength, except that length may be 8 feet for all specimens. Then, at quarter-points and midpoints along the length of each specimen, measure the width and thickness to the nearest 0.001 inch at the center of each face. Mark the points on the specimens. Then place each specimen in a metal frame so that one end rests against a fixed stop and the other against the stem of a dial gauge calibrated to the nearest 0.001 inch. A rod calibrated to the nearest 0.1 inch may be used to measure the distance between the fixed stop and the gauge stem when the dial gauge reads zero. Record the length of each specimen for later comparison after water soaking. Finally, measure the amount of warpage in all specimens according to the methods prescribed in the lumber-grading rules.

After measuring all specimens, immerse them in water at 68 ± 6 °F (20 ± 3 °C) for 24 hours. Separate the specimens with spacer blocks so that all surfaces touch the water. After the soaking period, remeasure all specimens at the same locations to obtain relative increase in width, thickness, and length. Then measure the amount of warpage in each specimen. Compute the average percentages of increase in width, thickness, and length for the test specimens after water soaking, as well as the average warpage in bow, twist, and crook.

5.2 Performance Required

After water soaking, average dimensional increases of all specimens must not exceed 8.0 percent for width, 10.0 percent for thickness and 0.1 percent for length. The average warpage must not exceed that described as "light" in lumber-grading rules for the length and width nearest that of the specimen size.

Part IV. Quality-Control Standards

1.0 Introduction

Quality control is the basis for assigning the stress ratings and trademarks on each piece of composite structural framing offered for sale. Consumers and building-code officials depend upon certified trademarking to design and build sound structures. Moreover, the maintenance of high quality ultimately affects the health, welfare, and safety of building occupants.

This standard prescribes a means for evaluating the quality of COM-PLY framing as it is being produced to ensure that its strength, stiffness, durability, and dimensional stability are maintained and that its stress rating and trademarking are valid. The quality of COM-PLY framing should be evaluated daily. Its strength and stiffness should be evaluated quarterly, and its durability semiannually.

The trademark on the product should indicate key design stresses, the manufacturer's product type number, the producing mill number or name, and the symbol or mark of the agency certifying the quality of the product (see Part II, section 3.2, for details). By placing this information on COM-PLY framing, the manufacturer indicates that the strength, durability, and dimensional stability required for a quality product have been established.

2.0 Responsibilities of the Manufacturer and the Auditor

2.1 Product Specification

The manufacturer shall provide the auditor with a written product specification for each type of product manufactured. The specification shall contain detailed information on the processes, methods, and materials used for manufacturing each type product.

The quality of any flakeboard depends not only on the quality and type of materials used but also on every operation in the production line. For this reason, when the quality of COM-PLY framing drops below acceptable levels, the manufacturer or auditor must examine the causes in all factors--materials and methods--in seeking the cause. By keeping accurate records of the method of manufacture and specifications that are used when the board has satisfactory quality, the manufacturer provides the essential information for restoring quality if it falls below acceptable levels. Because some materials and processing methods are proprietary, auditors must take care to safeguard the manufacturer's product specifications so that manufacturing trade secrets will not be divulged.

The product specification should be as detailed as is practical and should include information about both materials and processes.

2.1.1 Materials.--Specifications should describe:

- Wood: species, moisture content, and specific gravity.

- Veneer: thickness, moisture content, and quality.

- Laminating adhesive: type, spread rate, assembly time, curing temperature, pressure applied, and clamp time.

- Resin binder and wax: types, percentage in flakeboard.

- Flakeboard: density, internal bond, MOE, MOR, thickness swelling, water absorption, and linear expansion.

2.1.2 Processes.--Specifications should describe:

- The method of conditioning veneer peeler blocks and drying veneer.

- The method of preparing flakes and the geometry of flakes produced.

- The amount of fines contained in or removed from dried flakes.

- The moisture content of dried flakes.

- The method of blending flakes with resin and wax.

- The method of forming (single or multiple heads) and orienting flakes in the mat.

- The flakeboard press times, temperature, speed of closure, pressure, and method of controlling thickness (with or without stops).

2.2 Testing Management and Records

2.2.1 Manufacturer's Responsibilities.--The manufacturer shall be responsible for the day-to-day quality of the product. The manufacturer shall employ qualified inspectors to perform the quality-control functions and to prepare records showing the results of quality-control tests. The manufacturer shall keep records of each day's production for at least 1 year.

2.2.2 Auditor's Responsibilities: Testing performed by the manufacturer.--The auditor shall review the records kept by the manufacturer to determine that quality of the product is being maintained. The auditor shall approve the qualifications of all applicants for quality-control positions with manufacturing firms; once quality controllers are hired, the auditor shall train them to perform all quality-control tests prescribed in this standard. The auditor shall make random, unannounced visits to the production facility to check quality control at least 12 times each year. During these visits the auditor shall select the quality-control samples to be tested for at least one shift of production and shall perform all of the daily quality-control tests required by this standard. The auditor shall provide a copy of the audit, which shall become part of the manufacturer's quality-control files.

2.2.3 Auditor's Responsibilities: Testing performed by the auditor.--The manufacturer has the option of contracting with the auditor to perform all quality-control functions. When the auditor rather than the manufacturer's employees performs all quality-control functions, the auditor may conduct tests either at the mill or at the auditor's laboratory, as agreed upon by the manufacturer and auditor. When testing is done in the auditor's laboratory, the manufacturer shall select the samples and ship them to the auditor's laboratory no less frequently than once a week, and the auditor shall also make random, unannounced visits to the mill to select samples for testing. The manufacturer shall hold that portion of production represented by the quality-control samples until the auditor completes the test and verifies the product's conformance to the standards.

2.2.4 Quality-controller's responsibilities.--The quality-control supervisor must notify the mill production superintendent immediately whenever quality of the product is found to be unacceptable.

3.0 Testing and Assurance: General Procedures

3.1 Principal Objective

The integrity of COM-PLY framing depends on the quality of adhesion between its components. Unsatisfactory adhesion seriously reduces the quality of the product, especially its durability and dimensional stability. A principal objective of quality control is to check daily the quality of the adhesive bonding of all components.

3.2 Sampling Unit

The basic quality-control sample for daily tests shall be a nominal 8-foot unit. The unit shall be cut as indicated in figure 1 into test specimens for monitoring the bondline, thickness swelling, joint strength, and flakeboard MOR, MOE, density, internal bond, and shear strength. Select units following the procedures prescribed for performance testing (see Part III, section 3.2), except that moisture content of the component shall be 6 ± 2 percent, the typical range immediately after fabrication.

3.3 Sample Size and Rate

Quality controllers shall monitor quality by testing at a rate of three units per shift per press line, or 0.02 percent of production, whichever is greater, for intensive sampling and one-third that rate for normal sampling. The mill shall supply the auditor with information on production volume. A normal rate of sampling is permissible if the results of daily tests indicate acceptable quality. Use the average value from daily quality tests as a basis for trademarking the product. If the quality drops below acceptable levels, quality controllers shall notify the mill production supervisor, and sampling shall proceed at the intensive rate. Average test values for a sample size of at least nine units shall be used as a basis for determining the quality levels (acceptable, warning, and unacceptable). When sampling at a normal rate, use a moving average for the nine units most recently tested for the daily average test value.

3.4 Test Unit Layout

The test specimen layout in figure 1 is arbitrary and not fixed. The location of the veneer joint (F) and core joint (G) specimens is critical because each of these specimens must contain an approximately midlength joint. Cut these specimens from the unit first. Next, the specimen for MOR, MOE, and density of the core (H) should be cut from the unit because of its critical length. Next in order are the specimens for thickness swelling and water absorption (E), veneer bond and core shear (A, B, C, D, K, and L), and, last, flakeboard internal bond (I and J).

3.5 Setting Standard Levels for Daily Tests

Use 30 units to establish the initial quality-control levels for each product as standard levels for daily tests, excepting only those for strength and durability. Incorporate the average values from these initial tests in the product specification. Randomly select the units used for determining the standard level from the same production runs used to establish product performance. Base the daily quality-control values on three consecutive shifts of production (not necessarily occurring in one day), with specimens cut from a minimum of nine basic units for intensive sampling or three basic units for normal sampling.

3.6 Quality-Control Levels

There are three levels of results for all daily quality-control tests.

3.6.1 Acceptable.--When test results are acceptable, the manufacturer is entitled to trademark the framing.

3.6.2 Warning.--When test results fall below the acceptable levels but do not drop to the unacceptable level, quality controllers shall warn the production superintendent that quality is falling below standard.

3.6.3 Unacceptable.--When test results fall to unacceptable levels,

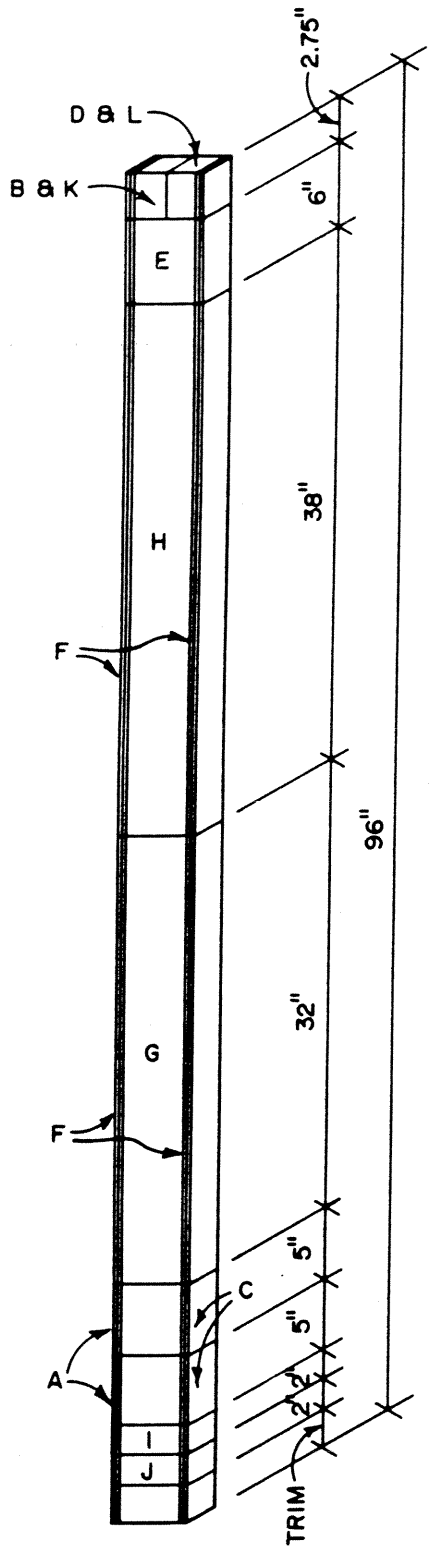

Figure 1.--Guide for cutting the basic quality-control unit.

Specimens for testing:

A = Bondline for veneer-to-veneer dry shear

B = Bondline for veneer-to-core dry shear

C = Bondline for veneer-to-veneer wet shear

D = Bondline for veneer-to-core wet shear

E = Thickness swelling and water absorption

F = Tensile strength of joint in veneer

G = Bending strength of joint in core

H = MOR, MOE, and specific gravity of core

I & J = Internal bond

K = Dry shear in the core

L = Wet shear in the core

Note: Unit shown is a 2 x 4 with two outer veneers on each edge.

quality controllers shall notify the production superintendent that the quality of the product is unacceptable and cannot be trademarked.

4.0 Testing and Assurance: Daily Test Procedures

4.1 Laminating Adhesive Veneer-to-Core Bond and Core Shear Strength

Cut one piece 2-3/4 inches long from the basic quality-control unit (B & K and D & L). Cut this piece further into two pieces as indicated by the "cut" line in figure 2. Then prepare block shear specimens from the left and right portions of each 2-1/2-inch-long piece cut from the unit. Place one of the block shear specimens (D & L) in a vacuum-pressure vessel and submerge in water at 70 ± 30 °F. Draw a vacuum of 25 inches of mercury on the vessel and maintain for 10 minutes. Then release the vacuum and place a pressure of 75 psi on the vessel for 50 minutes. Repeat the vacuum-pressure cycle. Use this water-soaked specimen in tests of the flakeboard and of the veneer-to-core bondline for shear strength and wood failure in the wet condition. Use the other block shear specimen in tests of the flakeboard and of the veneer-to-core bondline for shear strength and wood failure in the dry condition. For block shear tests, follow the method specified in ASTM D 905-49(81), ¶2, ¶7.

An average dry-block shear strength below 500 psi and wood failures below 80 percent are unacceptable. An average wet-block shear strength below 250 psi and wood failures below 70 percent are unacceptable. An average shear strength and wood failure values of at least 90 percent are acceptable.

4.2 Thickness Swelling and Water Absorption

Cut one specimen (E) 6 inches long from the basic quality-control unit. Test the specimen for swelling of the flakeboard core and water absorption by using the procedures in ASTM D 1037-78, ¶102 to ¶106 as a guideline. Average thickness swelling and water absorption values that are no more than 10 percent higher than the standard level are acceptable. An average more than 20 percent higher than the standard level or more than 14.4 percent, whichever is larger, is unacceptable.

4.3 Joint Strength

This test is not required if butt joints are used in both the veneer and flakeboard core components. If butt joints occur in one component but not the other, the test is required only for the component containing the glued structural joint. A glued structural joint may be a scarf, finger, stepped-scarf, tongue-and-groove, or other type joint used to improve structural performance of the product. In figure 1, specimen G is for testing joints in flakeboard cores and specimen F is for testing joints in veneer laminates that contain glue structural joints at midlength of the test specimens.

Cut away the veneer laminates on each edge of part G and either discard or use for part F. Following the procedures described in ASTM D 198-84, ¶4 to ¶9, load specimen G in flatwise bending. Use two-point loading with load points a minimum of 2 inches outside of the joint area. Check that the span-depth ratio of specimen G is at least 14 to 1 but no more than 20 to 1.

Average daily tests of flatwise bending strength (MOR) of flakeboard cores containing glued structural joints that are at least 90 percent of the standard levels are acceptable. Daily averages that drop below 80 percent of the standard are unacceptable.

Cut part F from the edge of the flakeboard core along parts G and H as shown in figure 1. Then cut end joint tension specimens from individual veneer laminates within part F as shown in figure 3. Take one specimen for each laminate glued to a single edge of a sample unit. For example, a nominal 2 x 4 having two veneer laminates glued to each

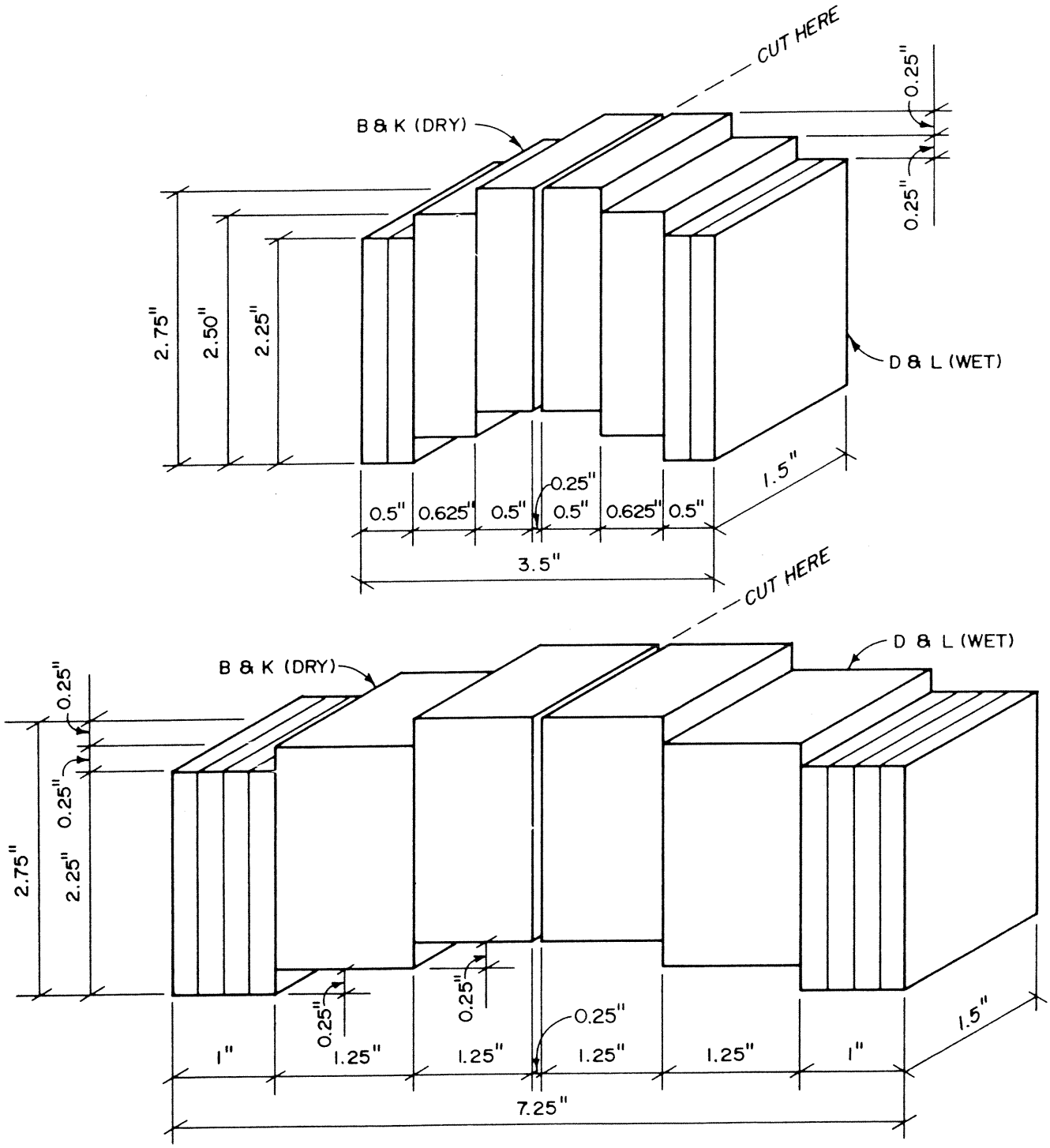

Figure 2.--Guide for cutting specimens for evaluation of dry and wet block shear strength of veneer-to-core bondline and flakeboard core. Specimen for 2 x 4 member is above, and specimen for 2 x 8 member below.

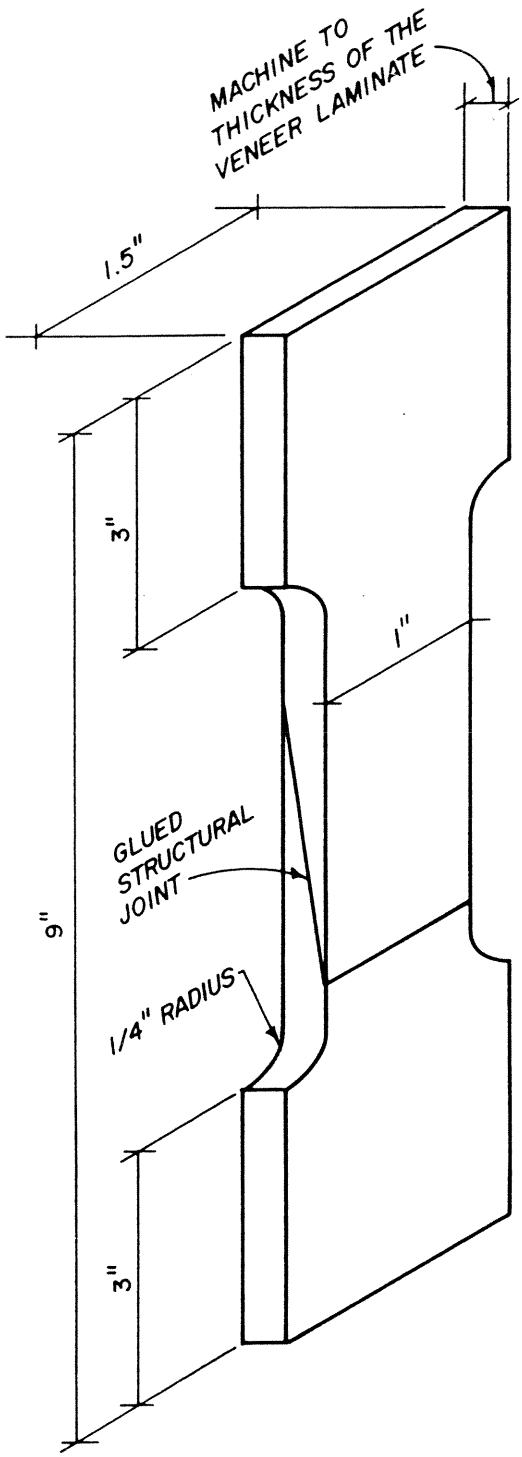

Figure 3.--Guide for cutting the specimen for evaluating dry tensile strength of joints in veneer laminates. Specimen is F in figure 1.

edge, or a total of four laminates, would require two test specimens, one from either of the two outer veneers and one from either of the two inner veneers.

Machine the specimen to a thickness of the veneer laminate, taking care to maintain a uniform thickness of specimen and to remove veneer or flakeboard on either face that would affect tensile strength of the specimen. Discard specimens containing knots, burls, extensive cross-grain, or holes that severely reduce tensile strength of the wood; be certain that in other respects the specimen is representative of production.

Test the specimen in tension by using the procedures in ASTM D 2339-82, ¶6 and ¶8. Jaws of the tension fixture should grip the specimen not closer than 0.5 inch from the necked-down portion.

To establish standard levels, make a set of 30 specimens not containing a glued structural joint, as shown in figure 3, and test in tension for each species of veneer used in the product. To establish the standard for the quality of bond for end joints in the veneer, average the ultimate tensile stress psi (g/cm^2) of the 30 specimens.

Average daily test results for ultimate tensile stress for wood failure that reach at least 80 percent of the standard values are acceptable. Daily averages that drop below 70 percent of the standard are unacceptable.

4.4 Modulus of Rupture, Elasticity, and Specific Gravity of the Flakeboard Core

Cut one piece 38 inches long (H) from the basic quality-control unit. Cut away the veneers from each side of the flakeboard core and use them for part F or discard. Next, cut the width of the piece to 3 inches (2.5 inches for nominal 2 x 4's) and the length to 24 times the depth plus 2 inches. Determine the specific gravity MOR, and MOE, and by using the procedures in ASTM D 1037-78, ¶9, ¶11 to ¶20, with these exceptions: test only conditioned specimens and none that are soaked. It is permissible to use an incremental load known to be below the proportional limit in lieu of the proportional limit load to calculate MOE. The load-deflection curve need not be plotted.

Average values of flakeboard MOR and MOE that are at least 90 percent of the standard levels are acceptable. Average values that drop below 80 percent are unacceptable.

Average values of flakeboard specific gravity that are at least 95 percent of the standard levels are acceptable. Average values that drop below 90 percent are unacceptable.

4.5 Internal Bond of Core

Cut two sections 2 inches long (I and J), from the basic quality-control unit. Reduce these two pieces from the unit width to 2 inches by removing an equal amount of veneer and flakeboard along each edge so that the final size is the thickness of the piece (approximately 1-1/2 inches) by 2 inches square. Test the specimens for internal bond using the procedures in ASTM D 1037-78, ¶28 to ¶31.

Average internal bond values that are at least 90 percent of the standard levels or 80 psi are acceptable. Average values that drop below 70 psi are unacceptable.

4.6 Laminating Adhesive Veneer-to-Veneer Bond

Cut pieces either 4 or 5 inches long from the laminated veneer portion of the basic quality-control unit (A and C). Cut additional pieces from part F as needed. Prepare two sets of tension shear specimens from the pieces, as shown in figure 4. The larger specimen (1-1/2 inches by 5 inches) is preferable to the smaller specimen (1 inch by 4 inches) if large tension grips are available. Cut away waste veneer or flakeboard removed when preparing the specimen with a smooth cutting saw to eliminate points of stress concentration; make the cut as close as practically possible to glue lines on the outer facings of the specimen. Prepare one specimen for each glue line in a piece, one set of specimens for dry testing, and one set for wet testing. Place the tension shear specimens for wet testing in a vacuum-pressure vessel and submerge in water at 70 > 30 °F. Draw a

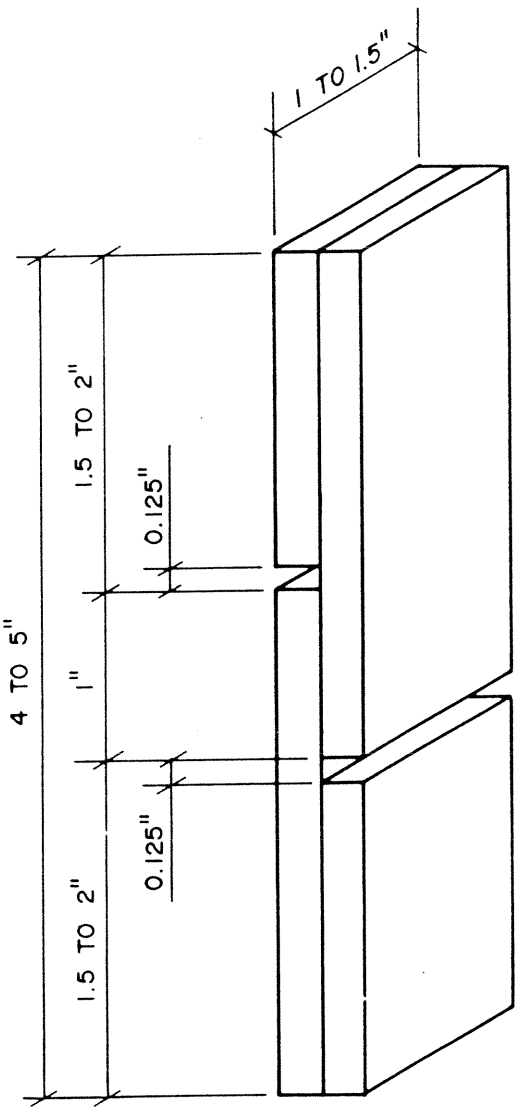

Figure 4.--Guide for cutting the tension shear specimens for testing the quality of laminated veneer-to-veneer adhesive bond. Specimens shown as A and C in figure 1.

vacuum of 25 inches of mercury on the vessel and maintain for 10 minutes. Release the vacuum and place a pressure of 75 psi on the vessel for 50 minutes. Repeat the vacuum-pressure cycle. Test these water-soaked tension shear specimens for shear strength and wood failure in the wet condition. Test the remaining tension shear specimens for shear strength in the dry condition. Follow procedures for making the tension shear test as specified in ASTM D 2339-82, ¶6, ¶8.

Average dry tension shear strength less than 800 psi and wood failures less

than 70 percent are unacceptable. Average wet tension shear strength less than 400 psi and wood failures less than 70 percent are unacceptable. Average daily shear and wood failure values that are at least 90 percent of the standard values are acceptable. Average values that drop below 80 percent are unacceptable.

4.7 Truss Plate Lateral Fastener Resistance

The manufacturer of the plates shall select one well-established brand of pressed-in-tooth-type truss plates to use as the standard for quality control. To determine the standard level for quality control for framing to be marked for use as truss framing, test 30 specimens, as required by the performance standard. Fabricate test specimens from truss framing randomly selected from production runs. Average results of tests for ultimate load per tooth, plug, or square inch of truss plate that are at least 90 percent of the average for the standard level are acceptable. Average values that drop below 80 percent are unacceptable. Apply this test only to framing marked for use in truss framing.

5.0 Testing and Assurance: Periodic Test Procedures

5.1 Quarterly Monitoring for Strength and Stiffness

Select for testing 10 specimens every quarter-year in accordance with procedures for determining edgewise bending strength and stiffness. Use the average values from these quality tests as a basis for trademarking the product, for determining that performance has dropped below acceptable levels, and for withdrawing trademarking privileges or for requiring a complete retesting.

Although it is important to check strength performance quarterly, it is not necessary to check all of the strength attributes covered in the performance standard. Only the edgewise bending strength and stiffness properties need be checked quarterly to determine if strength properties of the product are being maintained. Use a sample size of 10 pieces. Follow the procedure used in the performance standard to establish the bending stress F_b and MOE E_b (see Part III, sections 3.4.1 and 3.4.2). If the MOR and MOE of the quality-control sample are within 10 percent of the values developed in the performance evaluation that established the working stresses for bending strength and stiffness, performance is acceptable.

If either the MOR or MOE of the quality-control samples is more than 10 percent lower than the performance values used to establish working stresses, the quality controllers shall notify the superintendent that process methods or materials must be changed to ensure that working stresses marked on the product are maintained. Followup action by the production superintendent and quality controllers are described in Part II, section 4.2.2.

If either the MOR or MOE of the quality-control sample is more than 15 percent lower than the performance values used to establish working stresses, the quality controllers shall notify the production superintendent to cease trademarking the product. Reinstatement procedures are described in Part II, section 4.2.3.

5.2 Semiannual Monitoring of Durability

Check the durability of the COM-PLY product semiannually, or for each 6 months of production, using a sample size of 10 pieces. Follow the same procedure used in the performance standard for durability (see Part III, section 4.0). Aged specimens should have at least 50 percent of the strength and stiffness of the unaged specimens that were used to establish product performance. If data from the original durability performance tests are not available, use a second sample of 10 unaged specimens as controls.

Aged specimens that have retained less than 50 percent of either the unaged strength or stiffness are unacceptable.

References

American Society for Testing and Materials. Standard methods of evaluating the properties of wood-base fibers and particle panel materials. D-1037-78. Annual Book of ASTM Standards. vol. 4.09. Philadelphia, PA; 1985:225-267.

American Society for Testing and Materials. Standard methods of static test of timbers in structural sizes. D-198-84. Annual Book of ASTM Standards. vol. 4.09. Philadelphia, PA; 1985:108-134.

American Society for Testing and Materials. Standard methods of testing mechanical fasteners in wood. D-1761-77. Annual Book of ASTM Standards. vol. 4.09. Philadelphia, PA; 1985:406-442.

American Society for Testing and Materials. Standard methods of testing small clear specimens of timber. D-143-83. Annual Book of ASTM Standards. vol. 4.09. Philadelphia, PA; 1985:47-103.

American Society for Testing and Materials. Standard test method for strength properties of adhesive in two-ply wood construction in shear by tension loading. D-2339-82. Annual Book of ASTM Standards. vol. 15.06. Philadelphia, PA; 1985:98-201.

American Society for Testing and Materials. Standard test methods for strength properties of adhesive bonds in shear by compression loading. D-905-49(81). Annual Book of ASTM Standards. vol. 15.06. Philadelphia, PA; 1985:36-40.

Blomquist, Richard F.; Duff, John E.; Koenigshof, Gerald A. [and others]. Performance standards for composite studs used in exterior walls. Res. Pap. SE-155. COM-PLY Rep. 2, Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, and Washington, DC: U.S. Department of Housing and Urban Development; 1978. rev. 24 pp.

National Forest Products Association. National design specification for wood construction. Washington, DC; 1982:54-55; and Suppl. pp. 6-22.

Truss Plate Institute. Design specification for metal plate connected wood trusses. TPI-85. Madison, WI; pp. 24-25.

Wittenberg, Dick C. End bearing and joint strength of COM-PLY joists. Res. Pap. SE-222. COM-PLY Rep. 20, Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1981. 2 pp.

Koenigshof, Gerald A.
Performance and quality-control standards. Gen. Tech. Rep. SE-33. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1985. 20 pp.

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Keywords.--Strength, stiffness, dimensional stability, durability.

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