TEST METHODS FOR BASIC PROPERTIES OF WOOD-BASE PANELS: PAST EXPERIENCE, TODAY’S NEEDS

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ABSTRACT

As originally published, American Society for Testing and Materials ASTM Standard D 1037 contained small-specimen tests for fiber-based panels. By 1960 the scope of D 1037 had been expanded to cover particleboard also. These small-specimen tests are appropriate for fiber-based panels and conventional particleboard. Larger specimen tests are necessary for panels made from flakes, wafers, and strands to reduce test result variability. There are already American Society for Testing and Materials large-specimen tests for construction plywood. A joint committee of two international research organizations (International Council for Building Research Studies and Documentation and International Union of Testing and Research Laboratories for Materials and Structures) have suggested that the plywood tests are also appropriate for wood-base panels used in construction. This paper compares various D 1037 test methods with similar American Society for Testing and Materials construction plywood tests. It discusses the need for a flexural creep test. It also discusses and presents possible alternatives for some D 1037 tests which are not appropriate for wood-base construction panels for reasons other than specimen size.

INTRODUCTION


* Industry now refers to insulation board as fiberboard in response to the current understanding of the term “insulation.”
had expanded the scope of D 1037 to include particleboard, and the title became “Standard Methods of Evaluating the Properties of Wood-Base Fiber and Particle Panel Materials” [2].

Standard D 1037 is under the jurisdiction of ASTM Committee D 07 on Wood. Specifically, Subcommittee D 07.15 on Wood-Base Materials is responsible for it. The current edition of D 1037 (1978) contains more than 20 separate small specimen tests. As the title states, they are all material property tests. There are ASTM standards for panel performance in building components such as walls, roofs, and floors, but a different ASTM Committee, E 06, has jurisdiction over those standards.

D 1037 is divided into two parts:

Part A - General methods for evaluating the engineering and design properties of wood-base fiber and particle panel materials.

Part B - Acceptance and specification test methods for hardboard.

Since Part B is for procurement and acceptance testing in the hardboard industry specifically, it will not be discussed in this paper.

The introduction to D 1037 states that Part A “. . . is for use in obtaining basic properties suitable for comparison studies with other engineering materials of construction or for engineering design.” It further states that the tests apply to all wood-base panel types. These statements are no longer entirely true because the tests were developed before structural boards like waferboard and oriented strand board came on the market. Studies indicate that small-specimen testing of structural boards made from large flakes, strands, or wafers often yield results that are too variable for engineering design use [3, 4].

Subcommittee D 07.15 discussed this situation and formed a task group headed by David Fergus of International Paper Company. The task group’s objectives were to review the appropriateness of D 1037 test methods and, through contact with other interested organizations, to offer alternatives. Their report to the subcommittee [5] contained a number of test method concerns. A major concern was data variability from small-specimen tests. Other concerns included the need for a standard flexural creep test for structural boards, alternative lateral fastener performance tests, and a more reasonable accelerated aging test. Each of these concerns is discussed below. The task group also expressed other concerns which are not discussed in this paper.

### BASIC PROPERTY TESTS

#### Specimen Size vs Data Variability

Engineering data variability significantly affects a material’s allowable design value. Greater variability causes lower design values. A major factor contributing to variability is test specimen size compared to the wood particle size in the panel being evaluated. For a given specimen size, data variability increases as wood particle size increases.

Perhaps an example can better illustrate this point. Figure 1 shows an underlayment particleboard sample made from planer shavings and a waferboard sample. They represent extremes in wood particle size. The outlined area on each sample is 1 by 4 in., the standard ASTM D 1037 parallel-to-surface specimen size. The surface of the underlayment sample probably has more than 1,000 individual wood particles visible inside the outlined area. The waferboard sample has parts of only five surface wafers in the outlined area, and one wafer covers about ¼ of the area. This is close to the worst case for waferboard, but it would be possible to move the outlined area around the sample and never get more than about 10 surface wafers, or wafer fragments, to fall inside the outline. An underlayment board specimen would contain about 100 times as many individual particles as the same size waferboard specimen since both panel types are essentially homogeneous through the thickness. The result is that strength-property differences between specimens taken from different panel areas would be greater for the waferboard than for the underlayment board.

Large property variations between small specimens are not a true measure of panel performance in use. Therefore, such variations should not be a factor in design-load calculations. One way to decrease variability between specimen values is to increase test specimen sizes. The ASTM plywood subcommittee did just this some
years ago to avoid unnecessary variability caused by knots, grain deviations, core gaps, etc., in construction plywood [6-10].

Plywood vs Wood-Base Panel Specimens

Figures 2-6 clearly illustrate the size difference between ASTM construction plywood specimens and the corresponding ASTM D 1037 wood-base panel specimens. Plywood specimens are large enough to contain the maximum size defects found in sheathing panels. Cross-section areas (thickness x width) for the plywood compression and tension specimens (Figures 2 and 3) are more than six times the corresponding D 1037 specimen cross-section areas. The in-plant shear area of the plywood rolling shear specimen is nine times that of the D 1037 in-plane shear specimens (Figure 4). The plywood two-rail shear specimen cross-section area (length x thickness) is 2.4 times the D 1037 rail shear cross-section area (Figure 5). Also, the plywood width between the sets of loading rails is 8 in., whereas the D 1037 width is only 1 in. One inch is insufficient to allow the normal waferboard or oriented strand board (OSB) diagonal tension/compression failure.

Bending tests illustrate the greatest relative size difference between ASTM plywood and wood-base specimens (Figure 6). The 3 in. wide wood-base specimen is loaded at the center of a 12 in. span (for 1/2 in. thick panels). Minimum recommended test panel width for the plywood pure-moment bending test is 24 in. [10, Sec. 7.2]. The plywood standard does not specify overall panel length. A common plywood test panel size is 4 by 4 ft in order to measure bending strength in both panel directions from the same 4 by 8 ft sheet. Sometimes full-size 4 by 8 ft sheets are tested in pure-moment bending.

The plywood plate shear test (Figure 7) in ASTM Standard D 3044 [11] does not have an equivalent test for wood-base panels. It is a type of nondestructive torsional shear test used to measure modulus of rigidity (shear modulus) associated with in-plane shear deformations. Dimensions of the square specimen range from 25-40 times panel thickness. Researchers have found the test to be appropriate for measuring modulus of rigidity for a variety of wood-base panels [12-15].
Figure 2. Relative size of ASTM compression specimens: A. Construction plywood, 7 1/2 by 15 in. B. Wood-base panels, 1 by 4 in.

Figure 3. Relative size of ASTM tension specimens: A. Construction plywood, 10 by 48 in. B. Wood-base panels, 2 by 10 in., necked down to 1 1/2 in. Shaded areas are covered by grips.

Figure 4. Relative size of ASTM in-plane shear specimens: A. Construction plywood, 6 by 18 in. B. Wood-base panels, 2 by 6 in.

Figure 5. Relative size of ASTM shear through-the-thickness (two-rail shear) specimens: A. Construction plywood, 17 by 24 in. B. Wood-base panels, 3 1/2 by 10 in. Shaded areas are covered by loading rails.
Figure 6. Relative size of ASTM bending specimens: A. Construction plywood, pure moment test, 24 in. width. B. Wood-base panels, 3 by 14 in. (12 in. span)

Figure 7. ASTM D 3044 plywood plate shear test
Large Panel vs Small-Specimen Data

All the large panel plywood tests discussed above have been suggested as methods for determining engineering data on structural wood-base panels [3, 16, 17]. However, two factors must be considered:

1. Large panel tests are unsuitable for routine plant quality control. Therefore, small specimen tests are still needed.
2. Large panel and small-specimen test results do not always agree.

Post [17] stated that large panels give higher or lower values depending upon the property being measured. Several studies, summarized by McNatt [3], reported large-panel and small-specimen bending strength and stiffness. Materials tested included waferboard, OSB, flakeboard, and composite plywood. Large-panel modulus of elasticity (MOE) averaged about 20% greater than small-specimen MOE. Szabo [4] concluded that the greater stiffness of larger specimens was related to edge effects. By contrast, large-panel modulus of rupture (MOR) averaged about 20% less than small-specimen MOR. In a related study, Szabo [18] compared results from 2 by 4 ft and 4 by 4 ft waferboard panels tested by the pure-moment bending method. He found that average MOR and MOE were about equal for the two panel sizes, but the smaller panel data were more variable.

McNatt and Superfesky [19] compared strength and elastic properties from Standard ASTM D 1037 and modified tension and compression specimens. Doubling dimensions of the standard 1 by 4 in. compression specimen resulted in higher compressive strength and MOE. Bonding together two thicknesses probably resulted in load sharing. Increasing the necked-down portion of the standard tension specimen (Figure 3) from 2 to 6 in. lowered tensile strength due to higher probability of weaker “links,” but did not affect MOE.

INTERNATIONAL TEST DEVELOPMENT

ASTM is not the only organization considering large-specimen tests for structural wood-base panels. Two international groups are jointly developing such tests: International Council for Building Research Studies and Documentation (CIB) and International Union of Testing and Research Laboratories for Materials and Structures (RILEM) (the acronyms CIB and RILEM come from the organizations’ French language titles).

The stated purpose of the CIB Timber Structures Committee, W 18, is [20]:

To study and highlight the major differences between relevant national design codes and standards and suggest ways in which the future development of these codes and standards might take place in order to minimize or eliminate these differences.

One of their goals, then, is more uniformity in the ways wood materials are tested in different countries. The committee is drafting an international timber design code and needs supporting test methods for wood materials, including plywood and structural wood-base panels. W 18 asked a joint committee, 3TT, of RILEM/CIB to develop acceptable structural plywood tests. The result was RILEM Recommendation TT2, Testing Methods for Plywood in Structural Grades for Use in Load-Bearing Structures.

The tests described in this document, published in 1981, are essentially the same as the ASTM large-specimen plywood tests [6-11]. Committee 3TT appointed a subcommittee to develop a similar document for structural grades of particleboard. This subcommittee was asked to use the above RILEM Recommendation as a base, but also to consider tests of the European Federation of Associations of Particleboard Manufacturers. This subcommittee’s work is continuing.

CREEP TESTS

Neither the ASTM nor RILEM standard includes a flexural creep test. Such a test is, however, desirable for structural wood-base panels. Two ASTM panel material creep tests could be considered. One is the simple ASTM D 2164 “sag!” test for structural fiberboard roof deck [21]. The other is ASTM C 480 flexure creep test for structural sandwich panels [22]. In D 2164, weights totaling 2.4 times design load are evenly distributed on a 10 in. wide, simply supported
panel (Figure 8). Midspan deflection is recorded immediately after loading, after 48 hours, and 1 hour after the load is removed. In C 480 the lever arm applies a midspan load to a simply supported sandwich panel (Figure 9). The standard does not specify a load amount or load duration.

Perhaps a modified version of one of these two tests could serve as a standard structural wood-base panel creep test. A literature review of structural panel creep testing might also reveal an acceptable test [23-31].

**LATERAL FASTENER TESTS**

The ASTM D 1037 lateral nail resistance test (Figure 10) is not suitable for some structural wood-base panels for reasons other than test specimen size. It was developed specifically for fiberboard sheathing. It works well for these low-density panels, but not for the higher-density hardboards and wood particle panels. The problem is that the nail bends as it is pulled toward the specimen edge (Figure 11). A fastener-bearing strength test was developed in Germany [32] to avoid the nail-bending problem. The 6d (0.113 in. diameter) nail is replaced by a 0.113-in. diameter steel rod, reinforced with a steel plate to prevent bending. This reinforced rod fits through a rounded-end slot machined in the specimen (Figure 11). The failure in this test duplicates the ASTM D 1037 test method intent.

The American Plywood Association (APA) developed a lateral nail resistance test for their structural-use panel performance standards [33]. The nail is driven through the specimen with the nailhead flush against the face (Figure 12), which is characteristic of in-use conditions. The failure mode is also similar to what happens in a wall-racking test with higher-density sheathing panels. That is, the nail head tends to be pulled through the panel thickness (Figure 11).

Professor Poo Chow, University of Illinois, used these three methods (ASTM D 1037, reinforced rod, APA) to measure lateral nail resistance of sheathing-grade plywood, composite plywood, oriented strandboard, waferboard, and

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**Figure 8** ASTM D 2164 “Sag” test for structural fiberboard roof deck panels
Figure 9. *ASTM C 480* flexure creep test for structural sandwich panels

Figure 10. *ASTM D 1037* lateral nail resistance test for wood-base panels
Figure 11. Failure characteristics of lateral fastener resistance tests

Figure 12. "Exploded" view of APA lateral nail resistance test (method S-4 [33])
QUALITY CONTROL TEST

This search for appropriate tests for structural wood-base panels does not mean that current D 1037 tests will be replaced without due consideration for other wood-base panel products. However, Subcommittee D 07.15 is always looking for ways to update, clarify, and simplify this standard.

The subcommittee is currently considering a compression-shear test (Figure 13) as an alternative to the standard internal bond test for quality control work. Researchers at the University of Minnesota developed the apparatus, so the test is also referred to as the Minnesota Shear Test. It operates on the principle that a compression force produces maximum shear at a 45° angle.

The test measures bond strength in the plane of the panel, and results correlate with the standard internal bond strength. A Technical Note in the ForestProductsJournal[43] describes the test in detail.

ASTM Standard D 1037, Standard Methods of Evaluating the Properties of Wood-Base Fiber and Particle Panel Materials, was originally published in 1949 for fiber-based products where small-specimen tests are convenient and accurate. Most D 1037 tests work well for conventional particleboards, also. However, larger size specimens are more appropriate for structural-use panels like waferboard and oriented strand board to avoid unnecessary data variability when developing engineering values. Small-specimen tests are, of course, convenient and appropriate for quality control work.

ASTM standards and at least one other international standard (RILEM TT2) for construction plywood include large-specimen tension, compression, bending, and shear tests. These could be adapted to other structural-use panels. In addition, a creep test is desirable for structural wood-base panels.

Figure 13. Compression shear test apparatus [43]
Two ASTM D 1037 tests are inappropriate for some panel types for reasons other than test specimen size, lateral nail resistance, and accelerated aging. The current lateral nail resistance test works only for the low-density fiberboards. Excessive nail bending can preclude accurate results when hardboards or wood particle panels are tested. ASTM is considering alternatives to the current test. The 6-cycle accelerated aging test is considered inappropriate because it usually takes more than two weeks to complete. An analysis of the current 6-cycle test and a review of other durability tests will lead, hopefully, to a shorter alternative test.

ASTM Subcommittee D 07.15, responsible for Standard D 1037, continually looks for ways to update, clarify, and simplify the more than 20 separate tests in this standard.

REFERENCES


McNatt, J. Dobbin Test methods for basic properties of wood-base panels: