Designation: D7032 – 17

Standard Specification for Establishing Performance Ratings for Wood-Plastic Composite and Plastic Lumber Deck Boards, Stair Treads, Guards, and Handrails[1]

This standard is issued under the fixed designation D7032; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers procedures to establish a performance rating for wood-plastic composite and plastic lumber for use as exterior deck boards, stair treads, guards, and handrails. The purpose of this specification is to establish a basis for code recognition of these products or systems in exterior applications. The products addressed in this specification are considered combustible.

NOTE 1—While wood-plastic composites contain wood or other cellulosic materials, the presence of wood or other cellulosic materials in plastic lumber is not required by this specification. Due to non-wood materials in wood-plastic composites and plastic lumber the structural, physical, fire, and other attributes may not be similar to those of wood.

1.1.1 The plastic component of wood-plastic composites and plastic lumber covered by this specification shall consist primarily of thermoplastics.

1.2 Deck boards, stair treads, guards, and handrails covered by this specification are permitted to be of any code compliant shape and thickness (solid or non-solid).

1.3 Wood-plastic composites and plastic lumber are produced in a broad range of fiber and/or resin formulations. It is recognized that the performance requirements in this specification are valid for any material or combination of materials used as deck boards, stair treads, guards, or handrails.

1.4 Details of manufacturing processes are beyond the scope of this specification.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

1.7 *Table of Contents:*

[1] This specification is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.02 on Lumber and Engineered Wood Products.

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1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D9 Terminology Relating to Wood and Wood-Based Products
D198 Test Methods of Static Tests of Lumber in Structural Sizes
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D883 Terminology Relating to Plastics
D1037 Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials
D1413 Test Method for Wood Preservatives by Laboratory Soil-Block Cultures (Withdrawn 2016)[3]
D1554 Terminology Relating to Wood-Base Fiber and Particle Panel Materials
D1761 Test Methods for Mechanical Fasteners in Wood
D1929 Test Method for Determining Ignition Temperature of Plastics
D1972 Practice for Generic Marking of Plastic Products (Withdrawn 2014)[3]
D2017 Test Method of Accelerated Laboratory Test of Natural Decay Resistance of Woods (Withdrawn 2014)[3]
D2047 Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine
D2394 Test Methods for Simulated Service Testing of Wood and Wood-Base Finish Flooring
D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products
D3345 Test Method for Laboratory Evaluation of Solid Wood for Resistance to Termites
D4000 Classification System for Specifying Plastic Materials
D4092 Terminology for Plastics: Dynamic Mechanical Properties
D4761 Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material
D5764 Test Method for Evaluating Dowel-Bearing Strength of Wood and Wood-Based Products
D6109 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastic Lumber and Related Products
D6662 Specification for Polyolefin-Based Plastic Lumber Decking Boards
E84 Test Method for Surface Burning Characteristics of Building Materials
E108 Test Methods for Fire Tests of Roof Coverings
E1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter
F1679 Test Method for Using a Variable Incidence Tribometer (VIT) (Withdrawn 2006)[3]
G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

2.2 *Other References:*

AWPA Standard E1 Standard Method for Laboratory Evaluation for Determination of Resistance to Subterranean Termites[4]
AWPA Standard E10 Standard Method of Testing Wood Preservatives by Laboratory Soil-Block Cultures[4]
2009 International Building Code International Code Council, Inc.[5]
2009 International Residential Code International Code Council, Inc.[5]

3. Terminology

3.1 *Definitions*—Terminology used to describe WPCs are defined in Terminologies D9, D883, D1554, and D4092, Practice D1972, and Classification D4000.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *center-point load*—a flexure test where the load comes in contact with the test specimen at a location that is ½ the test span.

3.2.2 *guard*—a building component or a system of building components located at or near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to a lower level.

3.2.3 *handrail*—a rail intended for grasping by the hand for guidance or support.

3.2.4 *plastic lumber*—a manufactured product made primarily from plastic materials (filled or unfilled), typically used as a building material, which is usually rectangular in cross-section.

3.2.5 *quarter-point loading*—a flexure test where the load comes in contact with the test specimen at two locations, each of which is located at ¼ the span from the specimen load support.

3.2.5.1 *Discussion*—For example, quarter-point loading for a test specimen on a 24-in. (610-mm) span would have two equal loads contact the test specimen each located 6 in. in from the test specimen load support. The distance between the two points of load would be 12 in. (305 mm).

3.2.6 *span rating*—an index number that identifies the test span used in all structural load testing, which is the maximum center-to-center support spacing for the specified end use, and

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Wood-Preservers' Association (AWPA), P.O. Box 361784, Birmingham, AL 35236-1784, http://www.awpa.com.

[5] Available from International Code Council (ICC), 5203 Leesburg Pike, Suite 600, Falls Church, VA 22041-3401, http://www.intlcode.org.

allowable design capacity, in pounds per square foot (lbf/ft^2 (kN/m^2)), determined in accordance with this specification.

3.2.6.1 *Discussion*—For example, a deck span rating of 16⁄100 recognizes the deck board for installation perpendicular to the floor joists spaced a maximum of 16 in. (406 mm) on center, and for supporting the load combinations required by the applicable code, which in this case cannot exceed 100 lbf/ft^2 (4.79 kN/m^2).

3.2.7 *third-point loading*—a flexure test where the load comes in contact with the test specimen at two locations, each of which is located at ⅓ the span from the specimen load support.

3.2.7.1 *Discussion*—For example, third-point loading for a test specimen on a 24-in. (610-mm) span would have two equal loads contact the test specimen each located 8 in. in from the test specimen load support. The distance between the two points of load would also be 8 in. (205 mm).

3.2.8 *wood-plastic composite (WPC)*—a composite made primarily from wood- or cellulose-based materials and plastic(s).

4. General Requirements

4.1 *Sampling*—Samples for testing shall be representative of the population being evaluated. Sampling shall be representative of the possible variations due to changes in raw materials and process variables over time. It is essential to consider batch-to-batch and shift-to-shift variability when sampling actual production. Test specimens shall be selected from several production runs of a given item. Products shall be sampled at the manufacturing site by an accredited third party inspection agency or testing laboratory. Exceptions to sampling at the manufacturing site, such as at a warehouse or distribution center, shall be documented in the test report.

4.2 *Sample Size*—Selection of a sample size depends upon the property to be estimated, the actual variation in the property occurring in the population, and the precision with which the property is to be estimated. The principles of Practice D2915 shall be followed. The minimum sample size shall provide estimation of mean values within 5 % in accordance with 3.4.2 of Practice D2915.

4.3 *Conditioning*—Prior to testing, all specimens shall be conditioned to environmental conditions appropriate for the intended end use of the product. Alternatively, test specimens shall be conditioned for a minimum of 40 h at 68°F ± 4°F (20°C ± 2°C) and 50 ± 5 % RH. If data show that product properties are not affected by extreme moisture conditions, such as submersion, the material shall be permitted to be tested without special conditioning. When the product is to be subjected to a water soak environment, the test specimens shall be tested within 30 min upon removal from the treatment.

4.4 *Flexural Tests*—Flexural strength and stiffness shall be determined in accordance with principles of Test Methods D4761 or D6109. Alternatively, to assess compliance with performance requirements in its intended installed configuration, the deck boards shall be tested according to the two-span method defined in Annex A1. The test specimen cross section shall be the minimum anticipated structural size for the intended end use. The test span shall be that for which code recognition is desired. The specimens shall be loaded at a constant strain rate of 1 % per minute (±10 %). Average time to failure for each test configuration shall be recorded (see Commentary, X1.2). A constant strain rate of 1 % per minute is achieved by using a constant rate of test machine crosshead motion, R, (inches/minute) computed in terms of the test span, L, and the member depth, d, by the following equation:

$$R = 0.00185 \times L^2/d \tag{1}$$

For members where the depth (vertical dimension) is varying along the member length, the depth (d) shall be taken as the gross member depth at the point of maximum moment.

NOTE 2—Eq 1 is based on the maximum extreme fiber strain at midspan of a horizontally symmetric simple span member. For a product that is symmetric about its horizontal axis, Eq 1 yields the target strain rate at both the extreme tensile and extreme compressive faces. For a product that is not symmetric about its horizontal axis, the Eq 1 strain rate is the average of the strains at these faces. See Commentary for additional information.

NOTE 3—Some wood-plastic composites and plastic lumber exhibit exceptionally large deformations prior to failure in bending. Users are cautioned to take particular care in test machine set-up to accommodate large deflections, both in terms of deflection-measuring devices and support conditions.

4.4.1 *Flexural Strength*—Modulus of rupture (*MOR*) or moment capacity shall be reported for each specimen. Flexural strength shall be calculated from the maximum load achieved or the load at 3 % strain, whichever occurs first.

4.4.2 *Flexural Stiffness*—Apparent modulus of elasticity (*MOE*) or *EI* shall be reported for each specimen. Flexural stiffness shall be calculated from a linear least squares fit of the stress-strain curve over the range of 10 to 40 % of ultimate stress.

4.4.3 The flexural strength and stiffness for deck board, guard, and handrail materials shall be determined in accordance with 4.4 and shall be used to establish a standard baseline performance level for comparison with future production during the required quality control audits.

4.5 *Temperature and Moisture Effects:*

4.5.1 *Temperature Effect*—Testing shall be conducted to verify that allowable span and load ratings are applicable at a range of temperatures expected in service. For purposes of this specification, the lower and upper temperatures shall be -20 ± 4°F (-29 ± 2°C) and 125 ± 4°F (52 ± 2°C), respectively. Flexure tests shall be conducted to failure at the desired span. A minimum of 10 specimens shall be tested at each temperature. The flexural strength and stiffness shall be determined in accordance with 4.4 and the average change in properties between the flexural strength and stiffness of the control flexural specimens and the specimens tested at low and high temperatures shall be calculated as a percentage and reported. The average change in flexural strength and stiffness properties shall be calculated by determining the difference between the control and conditioned values and dividing that difference by the control value.

4.5.2 *Moisture Effect*—Testing shall be conducted to verify that allowable span and load ratings are applicable at moisture conditions expected in service. Flexure tests shall be conducted to failure at the desired span. A minimum of 10 specimens shall be tested at moisture conditions anticipated in service (for example, high humidity, submerged). The average maximum flexural strength and stiffness shall be determined in accordance with 4.4. The average change in properties between the control specimens and those tested at the in-service moisture condition of interest shall be calculated as a percentage and reported. The average change in flexural strength and stiffness properties shall be calculated by determining the difference between the control and conditioned values and dividing that difference by the control value.

4.5.3 *Criteria*—The most restrictive effect (either temperature or moisture) shall be used to adjust the performance rating of deck boards, guardrails, and handrails. For deck boards, the deck board span (or load rating) shall be reduced by the most restrictive effect determined from 4.5.1 or 4.5.2. For guards and handrails, if the most restrictive effect exceeds 25 %, the test loads for the guards or handrails shall be increased by the amount in excess of 25 %.

4.6 *Ultraviolet (UV) Resistance Test*—To determine the mechanical property degrade after UV exposure, a minimum of five (5) full-size or full-thickness specimens shall be exposed to a minimum of 2000 h accelerated weathering in accordance with Specification D6662 using Practice G154 or D2565.

4.6.1 When testing equipment does not allow either full-size or full-thickness test specimens, coupon specimens removed from the surface of the full-size cross section shall be used. However, when using data generated from coupon specimens, the user must justify the estimation of the impact on the full-size product (see X1.2).

4.6.2 A minimum of five (5) exposed and five (5) unexposed test specimens shall be tested in accordance with 4.4. The surface expected to receive UV exposure in service shall be exposed to the UV light source. The flexure test shall be conducted with the exposed surface in tension. If more than one component is being evaluated (for example, deck boards and guard rail components) and all materials are manufactured from the same materials, then UV testing of only one component is required.

4.6.3 *Acceptance Criteria*—The average change in properties between the exposed and unexposed specimens shall be calculated as a percentage and reported. The average change in flexural strength and stiffness properties shall be calculated by determining the difference between the control and conditioned values and dividing that difference by the control value. Condition of acceptance is the average flexural strength of exposed test specimens and shall be within 10 % of the average flexural strength of unexposed specimens. For deck boards, if the decrease exceeds 10 %, the deck board span (or load rating) shall be reduced by the amount in excess of 10 %. For guards or handrails, if the decrease exceeds 10 %, the test loads for the guards or handrails shall be increased by the amount in excess of 10 % (see X1.3).

4.7 *Freeze-Thaw Resistance Test*—To determine the mechanical property degrade after freeze-thaw exposure, a minimum of five (5) specimens shall be subjected to the following exposure cycle. Whenever possible the test specimens shall be prepared using the full cross section of the as-manufactured product. Test specimens shall be submerged underwater (using weights to hold them down, if necessary) for a period of 24 h. The specimens shall then be placed in a freezer at −20 ± 4°F (−29 ± 2°C) for 24 h. After being subjected to freezing, the specimens shall be returned to room temperature for a period of 24 h. This process comprises one hygrothermal cycle. The above procedure shall be repeated two more times, for a total of three cycles of water submersion, freezing, and thawing.

4.7.1 A minimum of five (5) exposed and five (5) unexposed specimens shall be tested in accordance with 4.4. If more than one component is being evaluated (for example, deck boards and guard rail components) and all materials are manufactured from the same materials, then freeze-thaw testing of only one component is required.

4.7.2 *Acceptance Criteria*—The average change in properties between the exposed and unexposed specimens shall be calculated as a percentage and reported. The average change in flexural strength and stiffness properties shall be calculated by determining the difference between the control and conditioned values and dividing that difference by the control value. Condition of acceptance is the average flexural strength of exposed test specimens and shall be within 10 % of the average flexural strength of unexposed specimens. For deck boards, if the decrease exceeds 10 %, the deck board span (or load rating) shall be reduced by the amount in excess of 10 %. For guards or handrails, if the decrease exceeds 10 %, the test loads for the guards or handrails shall be increased by the amount in excess of 10 % (see X1.3).

4.8 *Biodeterioration Tests*—Termite and decay testing shall be required for deck board, guard, and handrail products containing wood, cellulosic, or other biodegradable materials.

4.8.1 *Fungal Decay Resistance Test*—Resistance to fungal decay shall be determined in accordance with Test Methods D2017, D1413, or AWPA Standard E10.

4.8.1.1 *Criteria*—Examination of test blocks shall reveal decay resistance equivalent to that of preservative-treated or the heartwood of naturally durable wood used in identical applications, as measured by visual inspection, and average weight loss.

NOTE 4—This is an accelerated laboratory decay test. Results are subjective and comparisons between tests and materials should be used with caution. However, mean specimen weight losses greater than 5 %, or significantly greater than controls, should be cause for concern.

4.8.2 *Termites*—Test Method D3345 or AWPA Standard E1 shall be used for evaluation of resistance to termite attack.

4.8.2.1 *Criteria*—Visual inspection of the test specimens shall demonstrate resistance to termite attack equivalent to that of preservative-treated or the heartwood of naturally durable wood used in identical applications.

4.9 *Surface Burning Characteristics*—The flame-spread index of materials used to fabricate deck boards, guards, and handrails shall be determined by testing in accordance with Test Method E84.

4.9.1 *Criterion*—Materials shall have a flame-spread index no greater than 200 when tested in accordance with Test Method E84.

NOTE 5—Other test procedures may be permitted for determining a flame-spread rating for the material. Depending upon material formulation, other fire performance tests may be required. Additionally, fire performance properties other than flame spread may be important. Test Methods E1354 or D1929 may be used to provide an assessment of one or more of the following properties: smoke release rate, mass loss rate, heat release rate, ignition temperatures, and spread of flame.

5. Deck Board Performance Requirements

5.1 *General*—Deck boards are a structural element and shall be tested in flexure to establish a deck board span rating. Because deck board products are often subject to a variety of outdoor environments, the effect of moisture and temperature shall be determined and used in the determination of the span (or load) rating. In addition to the structural assessments, several other performance measures shall be evaluated, which include tests to determine creep-recovery (5.4), mechanical fastener capacity (5.5), and slip resistance (5.6).

5.1.1 The unadjusted load derived in 5.3.1 shall be reduced by the adjustment factors derived in 4.5, 4.6, and 4.7.

5.1.2 The test loads specified in 5.3.2 shall be increased by the end-use adjustment factors derived in 4.5, 4.6, and 4.7. When the adjustment factors from 4.5 are required, the adjustment factor for MOR (or moment capacity) shall be used for strength criteria, and the adjustment factor for MOE (or EI) shall be used for deflection criteria.

5.2 *Flexural Performance Tests*—Flexural strength can be recorded as either modulus of rupture (*MOR*) or moment capacity. Flexural stiffness can be recorded either as apparent modulus of elasticity (*MOE*) or flexural stiffness (*EI*).

5.2.1 Flexural tests to failure at the span desired shall be conducted in accordance with 4.4. Sample size shall be a minimum of 28 specimens representative of normal production and be of the actual cross-section size for the intended end use. When a stair tread performance rating is desired, a center-point load test shall be also performed.

NOTE 6—Multiple-support conditions may be used for the flexural tests (for example, two-span continuous).

5.2.2 The maximum load, the load at the deflection at $1/180$ th of the test span, and a description of the failure mode for each test specimen shall be recorded. The average flexural strength and average apparent stiffness shall be calculated and reported in accordance with 4.4.

NOTE 7—When determining the desired span, it is important to consider whether the boards will be installed perpendicular to or at an angle to the supports (joists).

5.3 *Determination of the Unadjusted Allowable Load:*

5.3.1 The unadjusted allowable load for the test span selected shall be calculated from the lesser of the following: *(1)* the average ultimate flexural strength (from 4.4) divided by a factor of safety of 2.5, and *(2)* the average flexural strength that results in a deflection of $1/180$ th of the test span.

5.3.2 Additionally, when deck boards are to be recognized as stair treads, the boards shall also sustain a minimum concentrated load of 750 lbf (3338 N) applied over a 4 ± 0.08 in.^{2} (2580 ± 50 mm^2) area at midspan, adjacent to the edge of the deck board. The surface area of contact for the concentrated load point shall be either circular or square. The average stair tread deflection at 300 lbf (1335 N) load shall not be greater than 0.125 in. (3.1 mm).

5.3.3 *Two-Span Adjustment*—When flexural testing is conducted to failure using a simple-span condition as described in Test Methods D4761 or D6109 and the failure mode is flexural collapse or 3 % strain, two-span adjustments for flexural strength and stiffness shall be permitted. If the user intends to take the strength increases for hollow or thin-walled products, a confirming test using the two-span protocol is required to verify that the failure mode is not buckling or crushing at the support. For flexural strength (MOR or moment capacity) the increase is 23 %, and for flexural stiffness (E or EI) the increase is 39 %. The strength increase (MOR or moment capacity) is applicable to stair treads only.

NOTE 8—The increases for flexural strength and stiffness in 5.3.3 are based on engineering mechanics for a continuous beam over two spans, where the support conditions are assumed to be pinned connections. Therefore, for these increases to apply, the actual installation of the stair tread should be such that the deck board remains in contact with its supports throughout its intended lifetime.

5.4 *Creep-Recovery Test*—A minimum of three (3) specimens representative of the population being sampled shall be loaded in flexure in accordance with 4.4 to twice the design load for which approval is desired. Prior to loading, the test specimens shall be allowed to equilibrate to the test temperature conditions (for example, 68 ± 4°F (20 ± 2 °C)) and be maintained throughout the experiment. The load is applied for 24 h and the specimens are then allowed to recover with no superimposed load for 24 h. Deflection at mid-span is measured a minimum of four times: *(1)* prior to the application of load, *(2)* at 24 h with load on, *(3)* immediately after the load is removed, and *(4)* after the 24-h recovery period. Total deflection is the deflection that occurs between time zero and the end of the first 24-h loading period. The recovered deflection is the deflection at the end of the 24-h recovery period minus the total deflection. The percent recovery for each test specimen shall be defined as the recovered deflection divided by the total deflection times 100. The average percent recovery, rounded to the nearest percent, shall be 75 % or greater and reported. For products where the total deflection is less than ⅛ in. (3.2 mm), the unrecovered deflection shall be less than $1/16$ in. (1.6 mm).

5.5 *Mechanical Fastener Holding Tests*—Conditioning of the deck boards prior to test specimen preparation shall be conducted in accordance with 4.3. Testing of a minimum of five (5) test specimens with each fastener and load direction that the connection must resist, such as lateral, withdrawal, or pull-through, when used to fasten deck boards to the supporting structure, shall be conducted according to Test Methods D1761 or D1037 with nails, screws, or staples, and in accordance with Test Method D5764 for bolts. Connections using proprietary fasteners, which include hidden fastener systems, shall be tested in accordance with Test Methods D1761, D5764, D1037, or any other test procedure approved by the specifying authority that is appropriate for determining the allowable capacity of the connection. The allowable capacities of the fasteners shall be the average ultimate load divided by a factor of safety of three (3.0). Fastener application density for deck boards shall be based on allowable capacities of the fasteners and wind uplift pressures sought for recognition in the evaluation report.

5.6 *Slip Resistance Test*—When required, the slip resistance (coefficient of friction) shall be determined in accordance with Test Method F1679. Alternatively, Methods D2394 has long been used as a historical benchmark. Wet and dry slip resistance both parallel and perpendicular to the *L* direction shall be evaluated. A minimum of five (5) tests shall be conducted in each orientation.

NOTE 9—Other slip resistance test methods have historically been used, such as Test Method D2047, and may be justified. However, Test Method F1679 has been shown to be the most appropriate for measuring ambulatory slip performance. Test Method F1679 is usable both in the laboratory and under a range of field conditions, and is believed to provide more reliable slip resistance property estimates than historical methods. ASTM is currently coordinating slip resistance specification issues at the Society level. The results of this effort, when available, will be incorporated into this specification. See X1.4, for additional discussion.

6. Guard and Handrail Performance Requirements

6.1 *General*—Wood-plastic composite and plastic lumber guards and handrails shall comply with the general requirements in Section 4. Guards shall also comply with the structural load test requirements in accordance with 6.2; handrails shall comply with testing in accordance with 6.3.

6.1.1 The test loads specified in 6.2 and 6.3 shall be increased by the end-use adjustment factors derived in 4.5, 4.6 and 4.7. When the adjustment factors from 4.5 are required, the adjustment factor for *MOR* (or moment capacity) shall be used for strength criteria, and the adjustment factor for *MOE* (or *EI*) shall be used for deflection criteria.

6.2 *Guardrail System Test Requirements:*

6.2.1 Three complete guardrail systems shall be constructed according to the manufacturer's installation instructions. Each guard configuration, for which recognition is desired, shall be tested. However, testing a "worst-case" configuration is permitted to gain acceptance of more substantial configurations, without testing the more substantial system, provided acceptable data are submitted justifying the selection of the "worst-case" configuration. A guard test specimen shall be defined as two posts at maximum spacing, all components, and all connections used in the test specimen. Each test specimen shall be subjected to and pass the in-fill load test (6.2.2), the uniform load test (6.2.3), and the concentrated-load test (6.2.4), in that order. If a component(s) or connection(s) fails in any of the tests defined in 6.2.2, 6.2.3, or 6.2.4, a retest test shall be permitted to be performed after the failed component or connection is removed and replaced. The test series continues as defined in this section.

6.2.1.1 *One- and Two-Family Dwelling Requirements*—For compliance with the 2009 International Building Code and 2009 International Residential Code, guards and handrails intended for use for one- and two-family dwellings shall satisfactorily pass only the load tests in 6.2.2 and 6.2.4.

6.2.2 *In-Fill Load Test*—The test specimen shall be tested and shall be capable of satisfactorily resisting a load of 125 lbf (556 N) applied over a one-square foot (0.0929-m^2) area normal to the in-fill. The in-fill is considered to be the load resisting elements between posts (vertical supports), such as balusters or panel fillers. The load shall be applied at a position on the in-fill that will represent the "worst-case" loading scenario. The guard is considered to satisfactorily pass if there is no failure, nor evidence of disengagement of any component, nor visible cracks in any component.

6.2.3 *Uniform Load Test*—The top rail of the guard system test specimen shall be separately subjected to a maximum uniform load of 125 plf (1825 N/m) applied vertically and horizontally. Alternatively, a single vector load shall be applied to the top rail where the *x* and *y* components of the vector load are equal to or greater than 125 plf (1825 N). For purposes of this test, quarter-point loading shall be deemed to be equivalent to uniform loading. The guard system is considered to satisfactorily pass if there is no failure, nor any evidence of disengagement of any component, nor visible cracks in any component.

6.2.4 *Concentrated Load Test for Guards*—A 500-lbf load (2224 N) shall be applied to the guardrail system at the maximum guardrail height. The load shall be applied at critical locations (for example, top rail midspan between posts, top rail adjacent to a post, top of a single post). In each case, when the applied load reaches 200 lbf (890 N), the deflection at the point of loading shall be recorded. The allowable deflection for the top rail (6.2.4.1) and the post (6.2.4.2), at 200 lbf (890 N), shall not exceed their respective deflection limits:

6.2.4.1 *Top Rail*—The sum of the rail height, *h* (in inches), divided by 24 plus the effective rail (guard) length, *l* (in inches), between the vertical supports divided by 96, or ($h/24 + l/96$), where the effective rail length is the distance between the edges of the posts. The deflection at the midspan of the top rail is measured relative to the center of the two posts (that is, it does not include post deflection).

6.2.4.2 *Post*—The effective post height (vertical support) divided by 12, or ($h/12$). Where the effective post (vertical support) height is the distance from top-of-post to first point of support or first connector of the post to the supporting rim joist (in inches).

6.3 *Handrail Test Requirements (Concentrated Load)*—One handrail test specimen shall be constructed in the same manner as described in the manufacturer's installation instructions. Each handrail configuration, for which recognition is desired, shall be tested.

6.3.1 The mounting of handrails shall be such that the completed handrail and supporting structure are capable of withstanding a load of at least 200 lbf (890 N) when calculated using accepted engineering principles or 500 lbf (7300 N) when determined by test. The applied load shall be applied in any direction at any point on the handrail.

6.3.2 The handrail is considered to satisfactorily pass if there is no failure, nor any evidence of disengagement of any component, nor visible cracks in any component.

7. Report

7.1 Report the sampling plan and testing in accordance with the applicable standard used. Report the sample size and data used to make the calculations. For development of adjustment factors or other performance measures provide plots of the data and any curves fitted to the data.

7.2 *Product Description*—Report information concerning material specifications, thickness, size, and non-proprietary manufacturing process parameters.

7.3 *Installation Instructions*—Installation details and fastening methods. Where applicable, provide a description of the methods of field cutting, application, and finishing.

8. Independent Inspection

8.1 When building code listing is the objective of the investigation, the manufacturer shall employ a qualified agency for the purpose of monitoring the quality assurance process. The qualified independent agency shall establish or approve and monitor, or both, procedures for quality assurance.

8.2 *Qualified Agency*—A qualified agency is defined to be one that:

8.2.1 Is recognized by the appropriate building code organization,

8.2.2 Has trained technical personnel to verify that the workmanship and other characteristics of the products as determined by inspection, sampling, and testing comply with all applicable requirements specified in this specification,

8.2.3 Has written procedures to be followed by its personnel in performance of the inspection and testing,

8.2.4 Has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being inspected or tested, and

8.2.5 Is not owned, operated, or controlled by any such company.

9. Manufacturing Standard

9.1 A manufacturing standard for each facility shall be written and maintained by the manufacturer. The manufacturing standard shall be approved by the qualified agency, and shall include specific provisions for each product. The standard shall specify all required quality assurance procedures.

9.2 The quality assurance program shall be designed to effectively monitor daily changes in material properties of the products being produced. Due to the potential for variations in raw materials and process parameters, the properties of the WPC may change over time. In particular, the mean and variability of those properties being monitored shall be reported on a daily basis.

NOTE 10—It is common to sample material from production on an hourly basis. Statistical process control techniques are commonly used to monitor product properties over time.

9.3 *Packaging and Identification*—A description of the method of packaging and field identification of the product shall include product identification, manufacturer or mill number, the code acceptance report number (if any), and the name or logo of the quality control agency.

10. Precision and Bias

10.1 The precision and bias of the provisions in this specification are dictated by the referenced standards and are not relevant to this specification.

11. Keywords

11.1 adjustment factor; deck board; guard; handrail; independent inspection; manufacturing standard; span rating; stair tread; wood-plastic composite

ANNEX

(Mandatory Information)

A1. TWO-SPAN TEST METHOD

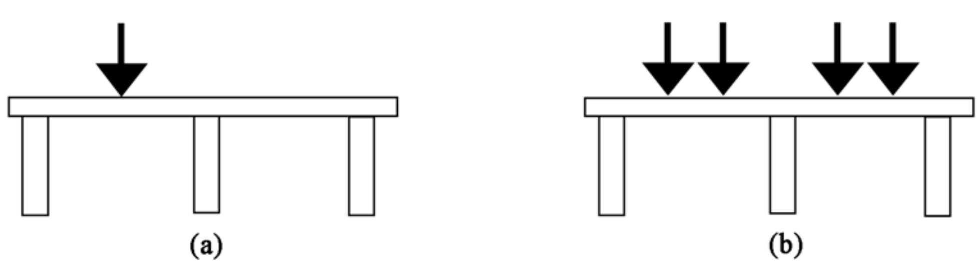

FIG. A1.1 (a) Concentrated Load Test, (b) Uniform Load Test

A1.1 *Two-Span Test Method*—The two-span test method is based on an as-installed deck board configuration. Full-size deck board specimens shall be installed in a three joist frame according to the manufacturer's recommendations (maximum joint spacing, minimum recommended fastening). The test frame shall be constructed using nominal 2 by 6 joists from a lumber species with a published specific gravity not to exceed 0.42. The test frame shall consist of three parallel joists with a center-to-center spacing equal to that for which code recognition is desired. The ends of the three joists shall be fastened to end supports to fully resist joist rotation. All test frame lumber shall have a moisture content of 15 ± 5 %. Multiple test specimens are permitted to be evaluated in a single test frame.

NOTE A1.1—To minimize extraneous variables from the test setup, when testing more than one deck board in a test frame, care should be exercised to avoid installation of fasteners within one inch of a fastener location from a previous test.

A1.2 Concentrated load and uniform load tests shall be permitted. The concentrated load test shall utilize a single concentrated load on one span with the load located at midspan adjacent to the deck board edge (Fig. A1.1a). For the purposes of simulating a uniform load, two points of loading shall be placed at the ⅓-points on each of the two spans (Fig. A1.1b).

APPENDIX

(Nonmandatory Information)

X1. COMMENTARY

X1.1 *Commentary to Section 1, Scope*—Because a composite is a mixture of materials, whereby the properties are defined by the components of the mixture, it stands to reason that a wide range of performance attributes will result. This specification makes no attempt to exclude any composite. It is written to address " fitness-for-use" for a specific structural application (that is, deck boards and guardrails).

X1.1.1 Over the past several years, numerous lumber substitute materials have emerged in the marketplace. Of particular note have been decking products, which include deck boards and guardrail systems. When structural performance is an issue (that is, when building code recognition is required), it is critical that uniform criteria are available to assess fitness for use. This specification has been designed to be used to establish the basis for code recognition of deck board span ratings and guardrail system performance (guards and handrails). In particular, this specification has followed the guidelines provided by all major model codes in North America and specifically the 2009 International Building Code (IBC), and the 2009 International Residential Code (IRC).

X1.1.2 Because WPC deck boards and guardrail systems rely on a similar set of test methods and code requirements, it was deemed appropriate to place both product applications within a single specification. The Table of Contents was added to assist users of the standard in finding the portions pertinent to the application of interest.

X1.1.3 This specification draws on historical test methods for wood-based products, as well as from standards activity involving polyolefin lumber substitutes and wood-plastic composite products. Several test methods and Specification D6662, developed by ASTM Committee on Plastics D20, provide guidance in this area.

X1.2 *Commentary to 4.4—Flexural Tests*—A wide variety of flexural test methods exist within ASTM standards. In particular, Test Methods D790, traditionally for small specimen (coupon) testing of plastics, was considered for inclusion in this specification. The Committee noted that this WPC standard is a performance specification designed to evaluate a manufactured product according to code-prescribed performance levels. Using small specimens to assess the effect of various environmental impacts may result in property reductions not representative of the manufactured product. It was recommended that full-size or full-thickness test specimens be used wherever possible. It was further noted that there was no restriction to the utilization of coupon specimens for some tests if the intent was to establish a "worst-case" performance level.

X1.2.1 When reporting of product stiffness properties (apparent *MOE* or *EI*) is to be used, the method of calculating stiffness is very important. Numerous options to assess stiffness are available; these include a variety of secant methods, tangent methods, or data-fit methods. The consensus of the committee was that a stiffness of the product somewhere near the design stress was appropriate; therefore, it was agreed to continue to use a linear least squares fit of the load-deflection (or stress-strain) data over the range of 10 to 40 % of ultimate load.

X1.2.2 The rate of test specimen loading has been discussed many times in the D20 and D07 forums. The traditional plastic test methods use a constant strain rate. The traditional wood test methods use a constant time to failure. When comparing products with very high ductility (strain at failure), such as all-plastic products, against products with less ductility, a constant strain rate results in differing failure times; conversely, mandating a constant time to failure results in differing strain rates. While to understand time to failure is important for load duration calibration purposes, it is also important to provide a consistent basis for comparison between the material properties of the various products being evaluated. Loading at a constant strain rate attempts to provide that consistency. The Committee, therefore, recommended that a constant strain rate be used when performing the flexure tests required in this specification. It was also recommended that time to failure be recorded for each test specimen. The magnitude of the strain rate is a second question. For the current version of this specification, a 1 % rate of strain was chosen.

X1.2.2.1 As stated in Note 2 in the standard, the equation for testing speed is based on elementary engineering mechanics for a simple span member and is strictly applicable only within its specific assumptions (that is, plane sections remain plane, homogeneous linear elastic material, small deflections, and so forth). These underlying assumptions are violated in varying degrees for various properties and applications. For example: (*1*) For members that are not horizontally symmetric, the strain at one face is significantly higher than the strain at the opposite face. (*2*) For configurations other than simple span, ⅓-point loading, the relationship between testing speed and strain rate is somewhat different. (*3*) For two-span testing as specified in Annex A1.1, the strain rates (in both the positive and negative moment regions) are somewhat different. After consideration of all of these effects, it was the Committee's judgment that these multitudinous effects cannot be addressed without adding significant complexity to the testing speed equations. Since application of Eq 1 in its current form will already yield test failures in a relatively narrow range of failure times (approximately 1 to 3 min), it was determined that additional complexity was not warranted.

X1.2.2.2 For unusual product configurations (that is, varying depth where the maximum depth does not correspond to the zone of maximum moment; members in which the neutral axis is significantly different from mid-depth), the user may wish to establish testing speed using principles of engineering mechanics for the specific case being examined. In some of these cases, preliminary testing may assist the user in determining the critical failure section of interest. On this basis, the testing speed would then be established in accordance with 4.4 (target strain rate at the location of maximum fiber stress equal to 1 % per minute with a tolerance of ±0.1 % per minute).

X1.2.3 And finally, because the procedures provided in this specification relate to a performance rating, it was recommended that either *MOR* and *MOE* or moment capacity and stiffness (*EI*) be reported.

X1.3 *Commentary to 4.6—Ultraviolet (UV) Resistance, and 4.7—Freeze-Thaw Resistance*—In these two paragraphs (4.6 and 4.7) the condition of acceptance is the following: the average flexural strength of exposed test specimens shall be within 10 % of the average flexural strength of unexposed test specimens. If decreases exceed 10 %, the deck board span (or load rating) shall be reduced by the amount in excess of 10 %; and for the case of guards or handrails, the minimum test loads shall be increased by the amount in excess of 10 %.

X1.3.1 For clarity the following examples for a deck board are provided:

X1.3.1.1 *Example 1:* The ratio of the average exposed *MOR* to the average unexposed *MOR* provides the loss factor (for example, 2041/2617 = 0.78).

(1) Temperature effect = 0.78. This is a 22 % loss in property.

(2) Moisture effect = 0.85. This is a 15 % loss in property.

(3) UV effect = 0.92. This is an 8 % loss in property.

(4) Freeze-thaw effect = 0.96. This is a 4 % loss in property.

Deck Board End-Use Adjustment Factor = 0.78

Discussion—0.78 is the more restrictive of "1" and "2." Neither "3" nor "4" exceed the 10 % limit and need not be applied.

X1.3.1.2 *Example 2:*

(1) Temperature effect = 0.78. This is a 22 % loss in property.

(2) Moisture effect = 0.85. This is a 15 % loss in property.

(3) UV effect = 0.86. This is a 14 % loss in property, which is 4 % greater than the 10 % limit; therefore, use 0.96.

(4) Freeze-thaw effect = 0.88. This is a 12 % property loss, which is 2 % greater than the 10 % limit; therefore, use 0.98.Deck Board End-Use Adjustment Factor = 0.78 × 0.96 × 0.98 = 0.73.

Discussion—0.78 is the more restrictive of "1" and "2;" both "3" and "4" exceed the 10 % limit and the amount in excess of the 10 % limit must also be applied.

X1.3.1.3 The proposed treatment of end-use adjustment factors is consistent with the approach used for all structural products. This approach is characterized by first estimating a structural property; second, adjusting that property by a standard reduction factor deemed large enough to provide a safety margin under a broad range of application conditions; and third, assessing whether other potential extreme conditions should be considered to be either adequately covered by the standard reduction factor or subject to an additional reduction. The standard reduction specified in 5.3 (and also embedded in the load requirements of Section 6) is 2.5, which is consistent with typical building code requirements.

X1.3.1.4 In applying additional adjustment factors, the aforementioned judgment can be characterized for each of the four environmental effects as follows. For deck boards, the effects of temperature *or* moisture were deemed to be potentially significant enough that they should be added to the standard reduction factor. It was judged that these effects did not need to be cumulatively applied. An analogous example is for solid wood deck board where design values are not based on the hypothetical condition of being water saturated while simultaneously being subjected to an elevated temperature, such as 125°F. From a probabilistic standpoint, neither of these factors was deemed necessary for guardrails and handrails where the maximum loading event is infrequent.

X1.3.1.5 The effects of UV and freeze-thaw resistance were treated somewhat differently, primarily because the relationship between the test protocol results and long-term application exposures is unclear. On this basis, it was judged that property degradation beyond a certain small tolerance (10 % was chosen) might be an indication of potential long-term exposure problems. This formed the basis of the 10 % tolerance limit. It was judged that, if limited to a relatively small tolerance, the effects of UV or freeze-thaw degradation could be reasonably covered by the standard reduction factor. Otherwise, if the decreases exceed 10 %, the amount that exceeded the allowance must be accounted for in the calculation. This reduction is applied to deck boards, guardrails, and handrails.

X1.4 *Commentary on 4.8—Biodeterioration, and 5.6—Slip Resistance*—Committee members agreed to limit recommended test methods to those currently accepted by the model code organizations for wood-based products. The Committee further recommended that where appropriate, other complimentary wood-based standards be included as alternates. For example, to assess the effect of wood-destroying fungi, Test Method D2017 has been identified as a preferred test method with Test Method D1413 to be offered as an alternate. While the slip resistance measured in accordance with Test Method F1679 is preferred because of its broader range of applicability, the traditional James machine method will be included as an alternate.

X1.5 *Commentary to 4.9—Fire Performance Tests*—A flame spread index generated with Test Method E84 has been a traditional method used to understand the spread of flame characteristics for wood-based products such as paneling. This test method has been referenced in the model building codes for these purposes. For exterior decking products used in combustible construction, there currently exists no formal requirement to assess spread of flame with the exception found in ICC-ES AC174. The incorporation of Test Method E84 in this specification is an attempt to assure that WPCs used in decking applications perform to the level expected of traditional solid wood products. It made little sense to exclude materials that have traditionally been used in these applications. No suggestion of fire retardancy is expressed or implied.

X1.5.1 Alternate fire test methods for decking products have been under development by several institutions. As these methods emerge, they will be considered for inclusion as appropriate.

X1.6 *Commentary to 5.5—Mechanical Fastener Holding Tests*—Although code requirements for fastening of deck boards are unclear, it was considered appropriate that fastener holding tests be included in the performance specification. The data could provide guidance for installation recommendations where uplift forces must be considered. These data would allow one to establish fastener location and frequency recommendations.

X1.7 *Commentary to Section 8—Independent Inspection, and Section 9—Manufacturing Standard* —This specification will most often be used by individuals unfamiliar with the process of obtaining a code listing. It was agreed that the information contained in Sections 8 and 9 was helpful to the user unfamiliar with a code listing for a structural product.