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Standard Practice for Calculating the Superimposed Load on Wood-frame Floor- Ceiling Assemblies for Standard Fire-Resistance Tests¹

This standard is issued under the fixed designation D7746; 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 practice covers procedures for calculating the superimposed load required to be applied to load-bearing wood-frame floor-ceiling assemblies throughout standard fire-resistance tests.

1.2 These calculations determine the maximum superimposed load to be applied to the floor-ceiling assembly during the fire resistance test. The maximum superimposed load, calculated in accordance with nationally-recognized structural design criteria, shall be designed to induce the maximum allowable stress in the wood floor-ceiling fire test configuration being tested.

1.3 This practice is only applicable to those wood-frame floor-ceiling assemblies for which the nationally recognized structural design criteria are contained in the NDS (National Design Specification for Wood Construction) Construction (NDS).

1.4 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.5 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this 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 limitations prior to use.~~

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1.7 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

¹ This practice is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.05 on Wood Assemblies. Current edition approved Aug. 1, 2016 July 1, 2021. Published August 2016. Original approved in 2011. Last previous edition approved in ~~2011~~2016 as D7746D7746–11(2016)–H. DOI: ~~10.1520/D7746–11R16~~10.1520/D7746-21.

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.

D9 Terminology Relating to Wood and Wood-Based Products

D6513 Practice for Calculating the Superimposed Load on Wood-frame Walls for Standard Fire-Resistance Tests

E119 Test Methods for Fire Tests of Building Construction and Materials

E176 Terminology of Fire Standards

E1529 Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies

2.2 *Other Standards:*³

~~NDS~~ANSI/AWC National Design Specification (NDS) for Wood Construction

NDS Supplement Design Values for Wood Construction

3. Terminology

3.1 *Definitions*—Definitions used in this practice are in accordance with Terminology D9 and Terminology E176, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *gross cross-sectional area, n*—section area calculated from overall actual dimensions of member.

3.2.1.1 *Discussion*—

For sawn lumber and glue laminated timber, gross cross-sectional area is based on the standard dressed size of the member as given in the NDS Supplement. For I-joists and structural composite lumber, the gross cross-sectional areas or product dimensions are given in the product literature or code evaluation report.

3.2.2 *net section area, n*—section area calculated by deducting from the gross ~~section~~cross-sectional area the projected area of all materials removed by boring, grooving, dapping, notching, or other means.

3.2.2.1 *Discussion*—

For nailed or screwed connections, the net section area equals the gross cross-sectional area.

3.2.3 *span of member, n*—distance from face to face of supports, plus half of the required bearing length at each end.

3.2.4 *superimposed load, n*—~~the additional external load needed to be applied to the assembly to result in the calculated during the test to achieve the required~~ stresses within the assembly ~~when~~after any dead load of the assembly itself is accounted for in the calculations.

4. Significance and Use

4.1 Test Methods E119, E1529, and other standard fire resistance test methods specify that throughout the fire-resistance test, a constant superimposed load shall be applied to a load-bearing test specimen to simulate a maximum allowable load condition. This superimposed load shall be the maximum load allowed by design under nationally recognized structural design criteria for the tested floor configuration (that is, joist selection, spacing, and span).

4.1.1 For this ~~Practice~~practice, the nationally recognized structural design criteria to be used to determine the maximum load condition are those for the allowable stress design (ASD) method in the NDS (National Design Specification for Wood Construction).

NOTE 1—The NDS should be used to ensure calculation of the superimposed load is in compliance with all applicable provisions of that standard. Appendix X1 describes how to calculate the superimposed load in accordance with the NDS.

4.1.2 Alternatively, the standard fire resistance test methods shall be permitted to be conducted by applying a load less than the maximum allowable load in 4.1.1 for the tested configuration; however, these tests shall be identified in the test report as being conducted under restricted loading conditions.

4.2 This practice describes procedures for calculating the superimposed load to be applied in standard fire resistance tests of wood floor-ceiling assemblies. Practice D6513 provides a similar methodology for calculating the superimposed load on wood-frame walls.

³ Available from American Wood Council (AWC), 803 Sycolin Road, 222 Catocin Circle SE, Suite 201, Leesburg, VA 20175, <http://www.awc.org>.

4.3 Statements in either the fire resistance test method standard or the nationally recognized structural design standard supersede any procedures described by this practice.

4.4 The NDS shall be reviewed to ensure calculations are in compliance with all applicable provisions of that standard.

5. Test Assumptions

5.1 ~~Floor Assembly—~~Assembly Structural Members—For design considerations, wood-frame floor-ceiling assemblies consist of horizontal structural members (that is, joists), the floor decking or sheathing, and the perimeter rim boards.

5.2 ~~Loading Conditions~~—Horizontal framing members support a vertical load that is ~~uniformly distributed~~ placed on the floor assembly. ~~It is assumed that load application system for the test distributes load between and along framing members in a manner consistent with a uniform load assumption and provides load distribution to members that is representative of the end-use application.~~ assembly to approximate the effects of a uniformly distributed load on the joists. Loading shall be applied to joists without relying on floor sheathing to distribute load. Load effects on joists shall be determined based on the actual load distribution.

5.2.1 The calculation procedure in this standard is not appropriate for a test that uses a load application system that incorporates discrete point load distribution beams or frames with spanning capabilities that serve to artificially re-distribute load from a failing member to the adjacent framing. Such a system would require a higher load to be applied that considers the enhanced load-sharing between members provided by the load frame and the departure from a uniform load condition.

NOTE 2—~~The calculation procedure in this standard is not appropriate for a test that uses a load application system that incorporates discrete point load distribution beams or frames with spanning capabilities that serve to artificially re-distribute load from a failing member to the adjacent framing. Such a system would require a higher load to be applied that considers the enhanced load-sharing between members provided by the load frame and the departure from a uniform load condition.~~ intent is to simulate uniform loading conditions as reasonably as possible within typical laboratory constraints. However, loads are commonly applied with discrete loading elements, such as dead weight packs, water barrels, hydraulic cylinders, pneumatic cylinders, etc. An example of a system that conforms to the calculation assumption would be one in which each discrete load element (that is, dead weight pack, water barrel, hydraulic cylinder, pneumatic cylinder, etc.) is applied to the floor at not more than two locations along the length of the framing. Multiple discrete load elements are provided along the floor assembly joists to approximate a uniform surface load. Load for each discrete load element is applied to the floor joists by distribution beams that span across not more than three framing members, adjacent floor joists. No more than two distribution beams should be used for each discrete load element and the distribution beams should be centered below the load element to ensure equal load distribution. While the barrels or tanks may be evenly spaced, the distribution beams may not be evenly spaced along the joists, and loads on adjacent joists may need to be offset slightly along the joist length to prevent interference between distribution beams. These constraints result in differences between the load effects from a true uniform load distribution and the load effects due to a series of point loads. Where loading consists of a series of point loads applied to each joist, the difference in structural actions between the assumed uniform loading and the actual load configuration should be considered.

5.3 Lateral or torsional end support, including but not limited to bridging, blocking, or bracing, shall be provided at points of bearing to prevent rotation. When additional lateral or torsional support is used away from the ends to enhance performance of the floor-ceiling assembly, description and locations of the support shall be reported

5.4 Where required to ensure that bearing capacity does not limit the test load, stiffeners or an increased bearing length shall be permitted at the bearing locations to increase capacity.

6. Design Load Calculations

6.1 *Design Values*—Reference design values: $F_b, F_v, F_{c\perp}, E$ and E_{min} for rectangular sections are given in the NDS Supplement, product literature, or code evaluation report. Reference design values: M, V, R_r, E_f, EI_{min} , and K for I-joists are given in the product literature, or code evaluation report.

6.2 *Design Value Adjustments*—Reference design values shall be multiplied by all applicable adjustment factors to determine the adjusted design values. ~~Additional adjustments may be~~ adjustments, required to address special design considerations for the specific member type, shall be applied. Not all factors may be are applicable to all product types.

6.2.1 *Bending*— F_b for rectangular sections and M for I-joists shall be multiplied by all applicable NDS adjustment factors including: $C_D, C_M, C_t, C_L, C_F, C_V, C_{fu}, C_i, C_r, C_c$.

6.2.2 *Compression parallel to the grain*, F_c , shall be multiplied by all applicable NDS adjustment factors including: C_D, C_M, C_t, C_F, C_i , and C_P .

6.2.3 *Shear parallel to grain*— F_v for rectangular sections and V for I-joists shall be multiplied by all applicable NDS adjustment factors including: C_D, C_M, C_t, C_i .

6.2.4 Tension parallel to grain, F_t , shall be multiplied by all applicable NDS adjustment factors including: C_D, C_M, C_t, C_F, C_i .

6.2.5 *Bearing*:

6.2.5.1 *Compression perpendicular-to-grain*— $F_{c\perp}$ for rectangular sections shall be multiplied by all applicable NDS adjustment factors including: C_M, C_t, C_i, C_b .

6.2.5.2 *I-joist Reference Design Reaction*— R_r , shall be multiplied by all applicable NDS adjustment factors including: C_D, C_M, C_t .

6.2.6 *Modulus of elasticity*— E or E_{min} for rectangular sections and E_I and EI_{min} for I-joists shall be multiplied by all applicable NDS adjustment factors including: C_M, C_t, C_i, C_T .

6.3 *Adjustment Factors for Design Values*—The following adjustment factors are to be assumed by default. If values less than those listed below are employed, then the appropriate load restriction shall be reported in the test report and used to adjust the design bending and shear capacity in application:

6.3.1 Load duration factor, C_D , is 1.0.

6.3.2 Wet service factor, C_M , is 1.0.

NOTE 3—The results of testing with load determined based on $C_M=1.0$ can be conservatively applied for floors used in wet-service conditions. Where test results are limited to floors used in wet-service conditions, a reduced load consistent with the application of the wet service factor is appropriate. For both cases, joists are tested in the dry condition, because in-service moisture conditions for wood designed for wet service typically vary significantly ranging from dry to wet depending on the season and application.

6.3.3 Temperature factor, C_t , is 1.0.

NOTE 4—The results of testing with load determined based on $C_t=1.0$ may be conservatively applied for floors used in elevated temperature conditions.

6.3.4 Beam stability factor, C_L , is 1.0 for a single span, sheathed fire test assembly.

6.3.5 Size factor, C_F , is the value taken from tables in the NDS Supplement for the sawn lumber joist material in the test assembly.

6.3.6 Volume factor, C_V , the value per NDS provisions for glued-laminated timber members. The value of C_V for structural composite lumber shall be defined by the product literature or code evaluation report. The value of C_V used shall be the value for the joist material in the test assembly.

6.3.7 Flat-use factor, C_{fu} , the value per NDS provisions for where the sawn lumber joist material is loaded in flat-wise bending in the test assembly.

6.3.8 Incising factor, C_i , the value per is 1.0, unless incised lumber is used for the joist framing. Where incised lumber is used, the incising factor, C_i , shall be in accordance with the NDS provisions for the sawn lumber joist material in the test assembly.

6.3.9 Repetitive member factor, C_r , the value per the NDS provisions for the joist material in the test assembly.

6.3.10 Curvature factor, C_C , the value per the NDS provisions for structural glued laminated timber.

6.3.11 Column stability factor, C_P , is calculated from equations in the NDS.

NOTE 5—When a compression member is supported throughout its length to prevent lateral displacement in all directions, $C_P = 1$.

6.3.12 Bearing area factor, C_b , is 1.0.

6.3.13 Buckling stiffness factor, C_T , is 1.0.

6.3.14 For lumber and structural glued laminated timber pressure-treated with fire-retardant chemicals, the allowable design values, including connection design values, shall be obtained from the company providing the treatment and redrying service.

6.4 *Dimensions:*

~~6.4.1 Gross cross-sectional areas are the section areas based on the standard dressed size of the member as given in the NDS for the nominal size sawn lumber or glue laminated timber member. The gross cross-sectional areas for I-joists and structural composite lumber are given in the product literature or code evaluation report.~~

~~6.4.1.1 Net section area, A , is the gross area minus the projected area of all materials that may be removed by boring, grooving, dapping, notching, or other means.~~

~~6.4.1.2 For nailed or screwed connections, the net section area equals the gross section area.~~

~~6.4.2 The span of the horizontal structural member is the distance from face to face of supports, plus half of the required bearing length at each end.~~

6.4 *Test Load:*

6.4.1 The load to be applied in the test shall be calculated in accordance with nationally recognized design criteria. The superimposed load shall be the lesser of the load calculated in accordance with [6.5.1+6.4.1.1](#) or [6.5.1+26.4.1.2](#).

6.4.1.1 A superimposed load which induces a bending moment equal to the full design capacity at the critical cross-section along the length of the horizontal structural members of the floor-ceiling configuration being tested.

6.4.1.2 A superimposed load which induces a bending shear force equal to the full design capacity at the critical cross-section along the length of the horizontal structural members of the floor-ceiling configuration being tested. Any holes or notches present in the test specimens shall be neglected for the purpose of establishing the available shear capacity of the horizontal structural members.

6.4.2 A lower superimposed load than described by [6.5+6.4.1](#) shall be permitted provided it corresponds to a stiffness limit, reaction limit, connection limit, or other alternative design criteria. However, these tests shall be identified in the test report as being conducted under restricted loading conditions. Where stiffness increases for partial composite action are permitted by design and the load is governed by the system stiffness, the maximum partial composite action between the horizontal structural member and the floor decking or sheathing permitted in application shall be included in the calculation of the stiffness for the tested floor assembly.

6.4.3 The superimposed load, as well as the superimposed load expressed as a percentage of the maximum superimposed load from [6.5+6.4.1](#) or [6.5-26.4.2](#), shall be included in the test report. Where the maximum superimposed load based on flexure and the maximum superimposed load based on shear are both less than 100 % of the full design capacity, the greater of the two percentages shall be used to reduce the design shear and bending capacities in application.

6.4.4 Actual stress in a member in [6.5+6.4.1](#) and [6.5-26.4.2](#) includes both ~~that~~ stress due to the superimposed load applied to the assembly and ~~that~~ stress due to the dead load or weight of the components being supported by the member.

6.4.5 Total superimposed load to be applied to the test assembly during the fire test is the sum of the maximum superimposed load of each of the structural horizontal flexure members in the assembly. ~~Where the first and last horizontal floor-ceiling members are flexural members spanning the furnace, the load on these members is allowed to be reduced by half due to the reduced tributary area.~~ All spanning members in the assembly shall be loaded with their maximum allowable load.

7. Report

7.1 Report the following information:

7.1.1 Grade, species, and nominal dimensions of joists:

- 7.1.2 Reference and adjusted design values of joists;
- 7.1.3 Sheathing type, thickness, and density;
- 7.1.4 Number of joists, joist spacing, and joist placement;
- 7.1.5 Joist clear span, required bearing length, and actual bearing length;
- 7.1.6 Sheathing placement and attachment;
- 7.1.7 Dead load calculations for the floor-ceiling assembly;
- 7.1.8 Superimposed live load and loading configuration on the floor-ceiling assembly;
- 7.1.9 Bending design capacity per joist, shear design capacity per joist, bearing design capacity per joist,
- 7.1.10 Magnitude of load effects on joists due to total load including: bending moment per joist, shear force per joist, reaction force per joist;
- 7.1.11 Load effects on joists as a percentage of design capacity;
- 7.1.12 Deflection calculations;
- 7.1.13 Details of loading procedure;
- 7.1.14 Required reporting in Test Method E119.

8. Keywords

8.1 fire resistance; floor assembly; superimposed load; wood

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE CALCULATION-CALCULATIONS OF SUPERIMPOSED LOAD TO BE APPLIED TO WOOD-FRAME FLOOR-CEILING ASSEMBLIES FOR STANDARD FIRE-RESISTANCE TESTS IN ACCORDANCE WITH TEST METHOD E119 (ALLOWABLE STRESS DESIGN METHOD)

X1.1 Construction Details (see Fig. X1.1)

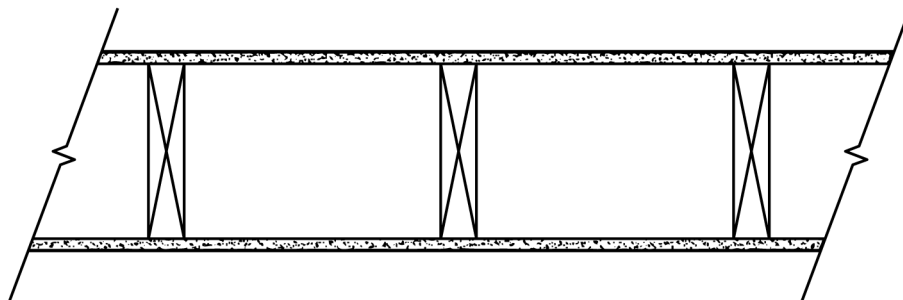


FIG. X1.1 Wood Joist Floor Assembly

X1.1.1 Joists: S-P-F (North) No. 2, 1.5 in. x 9.25 in. (nominal 2x10) @ 16 in. o.c., 12.5 ft. span
Subfloor: ½ in. thick plywood
Ceiling: 5/8 in. Type X gypsum board – direct applied

X1.2 Calculation of Test Load—Allowable bending moment of member, M_a , determined in accordance with the NDS and NDS Supplement using Allowable Stress Design (ASD) for the conditions listed above:

X1.2.1 Bending:

F_b' = adjusted bending design value, psi

$$\begin{aligned} F_b' &= F_b C_D C_M C_t C_i C_E C_u C_C \\ &= (875)(1.0)(1.0)(1.0)(1.0)(1.1)(1.0)(1.0) \\ &= (1.15) = 1107 \text{ lb/in}^2 \end{aligned}$$

(Table 4.3.1, 2018 NDS)

where:

- F_b' , reference bending design value = 875 lb/in²
- C_D , Load duration factor = 1.0
- C_M , Wet service factor = 1.0
- C_t , Temperature factor = 1.0
- C_i , Beam stability factor = 1.0
- C_E , Size factor = 1.1
- C_u , Flat use factor = 1.0
- C_C , Incising factor = 1.0
- C_p , Repetitive member factor = 1.15

$$\text{Moment } (M) = F_b' S = (1107)(21.39) = 23\,679 \text{ in.} \cdot \text{lbs}$$

where:

S , Section modulus = 21.39 in.³

$$w_{tot} = 8M/L^2 = 8(23\,679)/(150)^2 = 8.42 \text{ lb/in.} = 101.0 \text{ lb/ft}$$

where:

L , span of member = 150 in.

$$w_{tot @ 16 \text{ in. o.c.}} = 101.0/(16/12) = 75.8 \text{ lb/ft}^2$$

X1.2.2 Shear:

F_v' = adjusted shear design value, psi