Designation: D6513 – 21

Standard Practice for Calculating the Superimposed Load on Wood-frame Walls for Standard Fire-Resistance Tests[1]

This standard is issued under the fixed designation D6513; 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 axial load required to be applied to load-bearing wood-frame walls throughout standard fire-resistance and fire and hose-stream tests.

1.2 The calculations determine the maximum load allowed by design for wood-frame wall assemblies under nationally recognized structural design criteria.

1.3 This practice is only applicable to those wood-frame assemblies for which the nationally recognized structural design criteria are contained in the *National Design Specification for Wood Construction (NDS).*[2]

1.4 The system of units to be used is that of the nationally recognized structural design criteria. For the NDS, the units are inch-pound.

1.5 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.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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:*[3]

D9 Terminology Relating to Wood and Wood-Based Products

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:*[2]

ANSI/AWC–2018 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 *effective column length, n*—unbraced length of the vertical member, adjusted for end conditions.

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

3.2.2.1 *Discussion*—For lumber, gross cross-sectional area is based on the standard dressed size of the member as given in the NDS Supplement for the nominal size member.

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

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

[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.

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[2] Available from American Wood Council, 222 Catoctin Circle SE, Suite 201, Leesburg, VA 20175

[3] 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.

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

4. Significance and Use

4.1 Test Methods E119 and E1529, and other standard fire resistance test methods specify that throughout exposures to fire and the hose stream, a constant superimposed axial load be applied to a load-bearing test specimen to simulate a maximum load condition. These test methods specify that this superimposed load shall be as nearly as practicable the maximum allowable axial design load allowed by design under nationally recognized structural design criteria. For this practice, the nationally recognized structural design criteria is the *National Design Specification (NDS) for Wood Construction*

4.1.1 Alternatively, the standard fire resistance test methods shall be conducted by applying an axial load that is less than the maximum allowable axial design load as addressed by the NDS and this practice, but these tests shall be identified in the test report as being conducted under restricted load conditions.

4.1.2 The superimposed axial load, as well as the superimposed axial load as a percentage of the maximum allowable axial design load for the stud and as a percentage of the maximum allowable design load for the plate, shall be calculated using the Allowable Stress Design (ASD) method in the NDS and this practice shall be included in the test report.

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

4.2 This practice describes procedures for calculating the superimposed axial load to be applied in standard fire resistance tests of wood-frame wall assemblies.

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.

5. Test Assumptions

5.1 Wood-frame walls consist of vertical compression members and horizontal plates.

5.1.1 Compression members support a vertical axial load.

5.1.2 Bearing ends of the compression members are supported by the horizontal plates.

5.2 *Load:*

5.2.1 The test load is determined from the vertical axial capacity of the wall.

5.2.2 The test load calculations are based on standard design conditions including normal load duration, that is, ten years load duration.

6. Design Load Calculations

6.1 For structural sawn lumber, reference design values for the grade and species of lumber are multiplied by all applicable adjustment factors to determine the allowable design values.

6.1.1 Reference design values $F_{C\perp}$, F_C, and E_{min} are given in the separate NDS Supplement.

6.1.2 Compression perpendicular to grain, $F_{C\perp}$, is multiplied by C_M, C_t, C_i and C_b.

6.1.3 Compression parallel to the grain, F_C, is multiplied by C_D, C_M, C_t, C_F, C_i, and C_P.

6.1.4 Modulus of elasticity, E_{min}, is multiplied by C_M, C_t, C_i, and C_T.

6.2 *Adjustment Factors for Design Values:*

6.2.1 If values less than those listed in this section (6.2) are used for the adjustment factors, the appropriate load restriction shall be reported in the test report.

6.2.2 Load duration factor, C_D, is 1.0.

6.2.3 Wet service factor, C_M, is 1.0.

NOTE 2—The results of testing with $C_M = 1.0$ can be conservatively applied for walls used in wet-service conditions. Where test results are limited to walls used in wet-service conditions, a reduced load consistent with the application of the wet service factor is appropriate. For both cases, wall framing is 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.

6.2.4 Temperature factor, C_t, is 1.0.

NOTE 3—The results of testing with load determined based on $C_t = 1.0$ may be conservatively applied for walls used in elevated temperature conditions.

6.2.5 Size factor, C_F, is taken from tables in the NDS.

6.2.5.1 Size factor for F_C and the appropriate table within NDS depends on the width, species, and grade of the lumber.

6.2.6 Incising factor, C_i, is 1.0, unless incised lumber is used for the wall framing. Where incised lumber is used, the incising factor, C_i, shall be in accordance with the NDS.

6.2.7 Column stability factor, C_P.

6.2.7.1 Buckling of compression member in plane of wall is prevented by the sheathing which normally provides support throughout its length and C_P equals 1.0.

6.2.7.2 For buckling of compression member perpendicular to plane of wall, C_P depends on the slenderness ratio of the columns. The equation for C_P is given in the NDS. The effective column length shall be the actual length of the vertical member for calculating the slenderness ratio and C_P.

NOTE 4—The effective column length used for the buckling calculation is the stud length (exclusive of the top and bottom plates) and is determined assuming a column pinned at both ends, which is consistent with typical design assumptions for loadbearing wall studs.

6.2.8 Buckling stiffness factor, C_T, is 1.0.

6.2.9 Bearing area factor, C_b, is 1.0.

NOTE 5—The NDS provides for a bearing area factor of 1.25 for a bearing length of 1.5 in. when the bearings are not nearer than 3 in. to the end of a member. Due to the random layup of platform framing, the location of butt joints in top and bottom plates cannot be specified. For this reason, the bearing area increase is not generally taken in the design of wood frame walls. Historically, a bearing area factor of one has been used in the calculations of the load for fire resistance tests of wood-frame walls.

6.2.10 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.

6.2.11 For load duration factor, C_D, equal to 1.0, there is no additional reduction for wood products pressure treated by an approved process and preservative.

6.3 For vertical compression members of simple solid wood columns, the load per vertical compression member is the maximum superimposed load that satisfies the following:

6.3.1 Actual compression stress parallel to grain based on minimum net section area does not exceed the reference compression design value parallel to grain multiplied by all applicable adjustment factors except the column stability factor, C_P.

6.3.2 Actual compression stress parallel to grain based on gross cross-sectional area at critical part of column length that is most subject to potential buckling of compression member perpendicular to plane of wall does not exceed the allowable compression design value parallel to grain (that is, reference design value multiplied by all applicable adjustment factors).

6.3.3 Actual compression stress perpendicular to grain in horizontal plates does not exceed the allowable compression design value perpendicular to grain which includes the adjustment factor for bearing area, C_b, and the other applicable adjustment factors.

6.4 Actual stress in a member in 6.3 includes both that due to the superimposed load applied to the assembly and that due to the dead load or weight of the components being supported by the member.

6.5 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 vertical compression members in the assembly.

7. Report

7.1 Report the following information:

7.1.1 Grade, species, and nominal dimensions of studs and plates;

7.1.2 Stud reference and adjusted design values;

7.1.3 Plate reference and adjusted design values;

7.1.4 Sheathing type, thickness, and density;

7.1.5 Number of studs, stud spacing, and stud placement;

7.1.6 Stud length and gross cross-sectional area;

7.1.7 Effective column length assumed;

7.1.8 Sheathing placement and attachment;

7.1.9 Dead load calculations for the wall assembly;

7.1.10 Superimposed load on the wall assembly;

7.1.11 Stud axial capacity per stud, plate bearing capacity per stud, and total load on assembly;

7.1.12 Total load as a percentage of maximum design load based on stud axial capacity and as a percentage of maximum design load based on plate bearing capacity;

7.1.13 Details of loading procedure;

7.1.14 Required reporting in Test Method E119.

8. Keywords

8.1 fire resistance; superimposed load; wall assembly; wood studs

APPENDIXES

(Nonmandatory Information)

X1. CALCULATING THE SUPERIMPOSED LOAD TO BE APPLIED TO WOOD-FRAME WALLS FOR STANDARD FIRE-RESISTANCE TESTS IN ACCORDANCE WITH TEST METHOD E119

X1.1 Scope

X1.1.1 During a standard fire resistance wall test conducted in accordance with Test Method E119, the wall assembly is required to be subjected to a superimposed load to simulate a maximum allowable axial design load condition per nationally recognized structural design criteria.

NOTE X1.1—In the United States, the nationally recognized structural design procedures for wood construction are contained in the *National Design Specification for Wood Construction® (NDS®)*. In accordance with these standard design procedures, the superimposed load applied to wood stud wall assemblies is typically limited by the adjusted allowable compression design stress parallel to grain of the wood stud.

X1.1.2 The maximum superimposed load for a wall being tested in accordance with Test Method E119 is the sum of the maximum allowable design loads for each stud in the wall assembly.

X1.1.3 As an alternative, Test Method E119 permits testing at less than the maximum allowable design load, however, these tests must be reported as being conducted under restricted load conditions.

X1.2 Design Example

X1.2.1 The following example calculations are based on the ASD method in 2018 *National Design Specification for Wood Construction (NDS-2018)* design procedures and the requirements of this standard.

X1.2.2 Example Construction (See Fig. X1.1):

Studs: Douglas fir – Larch (DFL) Select Structural (SS) grade 2 × 4 lumber (1.5 in. × 3.5 in.) @ 16 in. on center, 115.5 in. long

Plates: DFL SS grade 2 × 4 lumber (1.5 in. × 3.5 in.): one bottom plate 120 in. long, two top plates 120 in. long

Configuration: nine studs arranged symmetrically with the last two stud spacings at 11.25 in. on center

Insulation: 3.5 in. thick Mineral Wool Insulation

Sheathing: 5/8 in. Type X gypsum wallboard each side

X1.2.3 Compressive resistance of the example wood stud wall loaded parallel to grain, P_r, determined in accordance with the *NDS* using Allowable Stress Design (ASD) procedures:

F_c = reference compression design value parallel to grain = 1700 psi

F_c* = reference compression design value multiplied by all applicable adjustment factors except C_P

= $F_c\ C_D\ C_M\ C_t\ C_F\ C_i$ (Table 4.3.1, *NDS-2018*)

= (1700 psi)(1.0)(1.0)(1.0)(1.15)(1.0) = 1955 psi

where:

F_c = reference compression design value parallel to grain = 1700 psi

C_D = load duration factor = 1.0

C_M = wet service factor = 1.0

C_t = temperature factor = 1.0

C_F = size factor = 1.15 (for 1.5 in. × 3.5 in. studs, SS grade DFL)

C_i = incising factor = 1.0

C_P = column stability factor

A_m = gross cross-sectional area = (3.5 in.)(1.5 in.) = 5.25 in.^{2}

Due to the slenderness of the studs, the adjusted compression design stress parallel to grain is affected by the buckling resistance of each stud. For strong-axis buckling of the stud (perpendicular to the plane of wall):

$$C_P = \frac{1+(F_{cE}/F_c^*)}{2c} - \sqrt{\left[\frac{1+(F_{cE}/F_c^*)}{2c}\right]^2 - \frac{F_{cE}/F_c^*}{c}} = \frac{1+(521/1955)}{(2)(0.8)} - \sqrt{\left[\frac{1+(521/1955)}{(2)(0.8)}\right]^2 - \frac{521/1955}{0.8}} \quad \text{(X1.1)}$$

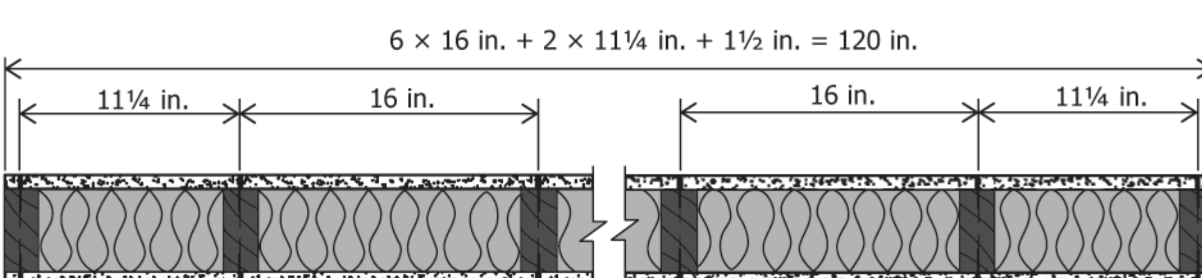

FIG. X1.1 Example Construction