

2021 Virginia Construction Code

CHAPTER 16 STRUCTURAL DESIGN

SECTION 1604 GENERAL DESIGN REQUIREMENTS

1604.1 General.

Building, structures and parts thereof shall be designed and constructed in accordance with *strength design*, *load and resistance factor design*, *allowable stress design*, empirical design or conventional construction methods, as permitted by the applicable material chapters and referenced standards.

1604.2 Strength.

Buildings and *other structures*, and parts thereof, shall be designed and constructed to support safely the *factored loads* in load combinations defined in this code without exceeding the appropriate strength *limit states* for the materials of construction. Alternatively, buildings and *other structures*, and parts thereof, shall be designed and constructed to support safely the *nominal loads* in load combinations defined in this code without exceeding the appropriate specified allowable stresses for the materials of construction.

Loads and forces for occupancies or uses not covered in this chapter shall be subject to the approval of the *building official*.

1604.3 Serviceability.

Structural systems and members thereof shall be designed to have adequate stiffness to limit deflections as indicated in [Table 1604.3](#).

TABLE 1604.3
DEFLECTION LIMITS^{a, b, c, h, i}

CONSTRUCTION	L or L_r	S or W^f	$D + L^{d, g}$
Roof members: ^e			
Supporting plaster or stucco ceiling	$l/360$	$l/360$	$l/240$
Supporting nonplaster ceiling	$l/240$	$l/240$	$l/180$
Not supporting ceiling	$l/180$	$l/180$	$l/120$
Floor members	$l/360$	—	$l/240$
Exterior walls:			
With plaster or stucco finishes	—	$l/360$	—
With other brittle finishes	—	$l/240$	—
With flexible finishes	—	$l/120$	—
Interior partitions: ^b			
With plaster or stucco finishes	$l/360$	—	—
With other brittle finishes	$l/240$	—	—
With flexible finishes	$l/120$	—	—
Farm buildings	—	—	$l/180$
Greenhouses	—	—	$l/120$

For SI: 1 foot = 304.8 mm.

- For structural roofing and siding made of formed metal sheets, the total load deflection shall not exceed $l/60$. For secondary roof structural members supporting formed metal roofing, the live load deflection shall not exceed $l/150$. For secondary wall members supporting formed metal siding, the design wind load deflection shall not exceed $l/90$. For roofs, this exception only applies when the metal sheets have no roof covering.
- Flexible, folding and portable partitions are not governed by the provisions of this section. The deflection criterion for interior partitions is based on the horizontal load defined in [Section 1607.16](#).
- See [Section 2403](#) for glass supports.
- The deflection limit for the $D + (L + L_r)$ load combination only applies to the

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deflection due to the creep component of long-term dead load deflection plus the short-term live load deflection. For lumber, structural glued laminated timber, prefabricated wood I-joists and structural composite lumber members that are dry at time of installation and used under dry conditions in accordance with the [ANSI/AWC NDS](#), the creep component of the long-term deflection shall be permitted to be estimated as the immediate dead load deflection resulting from $0.5D$. For lumber and glued laminated timber members installed or used at all other moisture conditions or cross laminated timber and wood structural panels that are dry at time of installation and used under dry conditions in accordance with the [ANSI/AWC NDS](#), the creep component of the long-term deflection is permitted to be estimated as the immediate dead load deflection resulting from D . The value of $0.5D$ shall not be used in combination with [ANSI/AWC NDS](#) provisions for long-term loading.

- e. The preceding deflections do not ensure against ponding. Roofs that do not have sufficient slope or camber to ensure adequate drainage shall be investigated for ponding. See Chapter 8 of [ASCE 7](#).
- f. The wind load shall be permitted to be taken as 0.42 times the “component and cladding” loads or directly calculated using the 10-year mean return interval wind speed for the purpose of determining deflection limits in [Table 1604.3](#). Where framing members support glass, the deflection limit therein shall not exceed that specified in [Section 1604.3.7](#)
- g. For steel structural members, the deflection due to creep component of long-term dead load shall be permitted to be taken as zero.
- h. For aluminum structural members or aluminum panels used in skylights and sloped glazing framing, roofs or walls of sunroom additions or patio covers not supporting edge of glass or aluminum sandwich panels, the total load deflection shall not exceed $l/60$. For continuous aluminum structural members supporting edge of glass, the total load deflection shall not exceed $l/175$ for each glass lite or $l/60$ for the entire length of the member, whichever is more stringent. For aluminum sandwich panels used in roofs or walls of sunroom additions or patio covers, the total load deflection shall not exceed $1/120$.
- i. l = Length of the member between supports. For cantilever members, l shall be taken as twice the length of the cantilever.

1604.3.1 Deflections.

The deflections of structural members shall not exceed the more restrictive of the limitations of [Sections 1604.3.2](#) through [1604.3.5](#) or that permitted by [Table 1604.3](#).

1604.3.2 Reinforced concrete.

The deflection of reinforced concrete structural members shall not exceed that permitted by [ACI 318](#).

1604.3.3 Steel.

The deflection of steel structural members shall not exceed that permitted by [AISC 360](#), [AISI S100](#), [ASCE 8](#), [SJI 100](#) or [SJI 200](#), as applicable.

1604.3.4 Masonry.

The deflection of masonry structural members shall not exceed that permitted by [TMS 402](#).

1604.3.5 Aluminum.

The deflection of aluminum structural members shall not exceed that permitted by [AA ADM](#).

1604.3.6 Limits.

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The deflection limits of [Section 1604.3.1](#) shall be used unless more restrictive deflection limits are required by a referenced standard for the element or finish material.

1604.3.7 Framing supporting glass.

The deflection of framing members supporting glass subjected to 0.6 times the “component and cladding” wind loads shall not exceed either of the following:

1. $\frac{1}{175}$ of the length of span of the framing member, for framing members having a length not more than 13 feet 6 inches (4115 mm).
2. $\frac{1}{240}$ of the length of span of the framing member $+1/4$ inch (6.4 mm), for framing members having a length greater than 13 feet 6 inches (4115 mm).

1604.4 Analysis.

Load effects on structural members and their connections shall be determined by methods of structural analysis that take into account equilibrium, general stability, geometric compatibility and both short- and longterm material properties.

Members that tend to accumulate residual deformations under repeated service *loads* shall have included in their analysis the effects of added deformations expected to occur during their service life.

Any system or method of construction to be used shall be based on a rational analysis in accordance with well-established principles of mechanics. Such analysis shall result in a system that provides a complete *load* path capable of transferring *loads* from their point of origin to the load-resisting elements.

The total lateral force shall be distributed to the various vertical elements of the lateral force-resisting system in proportion to their rigidities, considering the rigidity of the horizontal bracing system or *diaphragm*. Rigid elements assumed not to be a part of the lateral force-resisting system are permitted to be incorporated into buildings provided that their effect on the action of the system is considered and provided for in the design. A *diaphragm* is rigid for the purpose of distribution of *story* shear and torsional moment when the lateral deformation of the diaphragm is less than or equal to two times the average *story* drift. Where required by ASCE 7, provisions shall be made for the increased forces induced on resisting elements of the structural system resulting from torsion due to eccentricity between the center of application of the lateral forces and the center of rigidity of the lateral force-resisting system.

Every structure shall be designed to resist the effects caused by the forces specified in this chapter, including overturning, uplift and sliding. Where sliding is used to isolate the elements, the effects of friction between sliding elements shall be included as a force.

1604.5 Risk category.

Each building and structure shall be assigned a *risk category* in accordance with [Table 1604.5](#). Where a reference standard specifies an occupancy category, the *risk category* shall not be taken as lower than the occupancy category specified therein. Where a referenced standard specifies that the assignment of a *risk category* be in accordance with [ASCE 7](#), Table 1.5-1, [Table 1604.5](#) shall be used in lieu of [ASCE 7](#), Table 1.5-1.

Exception: The assignment of buildings and structures to Tsunami *Risk Categories* III and IV is permitted to be in accordance with Section 6.4 of [ASCE 7](#).

TABLE 1604.5
RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

RISK CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: <ul style="list-style-type: none"> • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
II	Buildings and other structures except those listed in Risk Categories I, III and IV.

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III	<p>Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to:</p> <ul style="list-style-type: none"> • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing one or more public assembly spaces, each having an occupant load greater than 300 and a cumulative occupant load of these public assembly spaces of greater than 2,500. • Buildings and other structures containing Group E or Group I-4 occupancies or combination thereof, with an occupant load greater than 250. • Buildings and other structures containing educational occupancies for students above the 12th grade with an occupant load greater than 500. • Group I-2, Condition 1 occupancies with 50 or more care recipients. • Group I-2, Condition 2 occupancies not having emergency surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000.^a • Power-generating stations, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Risk Category IV. • Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that: <ul style="list-style-type: none"> • Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1(2) or per outdoor control area in accordance with the <i>International Fire Code</i>; and • Are sufficient to pose a threat to the public if released.^b
IV	<p>Buildings and other structures designated as essential facilities, including but not limited to:</p> <ul style="list-style-type: none"> • Group I-2, Condition 2 occupancies having emergency surgery or emergency treatment facilities. • Ambulatory care facilities having emergency surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures. • Buildings and other structures containing quantities of highly toxic materials that: <ul style="list-style-type: none"> • Exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the <i>International Fire Code</i>; and • Are sufficient to pose a threat to the public if released.^b • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water storage facilities and pump structures required to maintain water pressure for fire suppression.

- a. For purposes of occupant load calculation, occupancies required by Table 1004.5 to use gross floor area calculations shall be permitted to use net floor areas to determine the total occupant load.
- b. Where approved by the building official, the classification of buildings and other structures as Risk Category III or IV based on their quantities of toxic, highly toxic or explosive materials is permitted to be reduced to Risk Category II, provided that it can be demonstrated by a hazard assessment in accordance with Section 1.5.3 of ASCE 7 that a release of the toxic, highly toxic or explosive materials is not sufficient to pose a threat to the public.

1604.5.1 Multiple occupancies.

Where a building or structure is occupied by two or more occupancies not included in the same *risk category*, it shall be assigned the classification of the highest *risk category* corresponding to the various occupancies. Where buildings or

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structures have two or more portions that are structurally separated, each portion shall be separately classified. Where a separated portion of a building or structure provides required access to, required egress from or shares life safety components with another portion having a higher *risk category*, both portions shall be assigned to the higher *risk category*.

Exception: Where a *storm shelter* designed and constructed in accordance with [ICC 500](#) is provided in a building, structure or portion thereof normally occupied for other purposes, the *risk category* for the normal occupancy of the building shall apply unless the *storm shelter* is a designated emergency shelter in accordance with [Table 1604.5](#).

1604.6 In-situ load tests.

The *building official* is authorized to require an engineering analysis or a load test, or both, of any construction whenever there is reason to question the safety of the construction for the intended occupancy. Engineering analysis and load tests shall be conducted in accordance with [Section 1708](#).

1604.7 Preconstruction load tests.

Materials and methods of construction that are not capable of being designed by *approved* engineering analysis or that do not comply with the applicable referenced standards, or alternative test procedures in accordance with [Section 1707](#), shall be load tested in accordance with [Section 1709](#).

1604.8 Anchorage.

Buildings and *other structures*, and portions thereof, shall be provided with anchorage in accordance with [Sections 1604.8.1](#) through [1604.8.3](#), as applicable.

1604.8.1 General.

Anchorage of the roof to walls and columns, and of walls and columns to foundations, shall be provided to resist the uplift and sliding forces that result from the application of the prescribed *loads*.

1604.8.2 Structural walls.

Walls that provide vertical load-bearing resistance or lateral shear resistance for a portion of the structure shall be anchored to the roof and to all floors and members that provide lateral support for the wall or that are supported by the wall. The connections shall be capable of resisting the horizontal forces specified in Section 1.4.4 of [ASCE 7](#) for walls of structures assigned to *Seismic Design Category A* and to Section 12.11 of [ASCE 7](#) for walls of structures assigned to all other *seismic design categories*. Required anchors in masonry walls of hollow units or *cavity walls* shall be embedded in a reinforced grouted structural element of the wall. See [Sections 1609](#) for wind design requirements and [1613](#) for earthquake design requirements.

1604.8.3 Decks.

Where supported by attachment to an *exterior wall*, decks shall be positively anchored to the primary structure and designed for both vertical and lateral loads as applicable. Such attachment shall not be accomplished by the use of toenails or nails subject to withdrawal. Where positive connection to the primary building structure cannot be verified during inspection, decks shall be self-supporting. Connections of decks with cantilevered framing members to *exterior walls* or other framing members shall be designed for both of the following:

1. The reactions resulting from the *dead load* and *live load* specified in [Table 1607.1](#), or the snow load specified in [Section 1608](#), in accordance with [Section 1605](#), acting on all portions of the deck.
2. The reactions resulting from the *dead load* and *live load* specified in [Table 1607.1](#), or the snow load specified in [Section 1608](#), in accordance with [Section 1605](#), acting on the cantilevered portion of the deck, and no *live load* or snow load on the remaining portion of the deck.

1604.9 Wind and seismic detailing.

Lateral force-resisting systems shall meet seismic detailing requirements and limitations prescribed in this code and [ASCE 7 Chapters 11, 12, 13, 15, 17 and 18](#) as applicable, even where wind load effects are greater than seismic load effects.

Exception: References within [ASCE 7](#) to [Chapter 14](#) shall not apply, except as specifically required herein.

1604.10 Loads on storm shelters.

Loads and load combinations on storm shelters shall be determined in accordance with [ICC 500](#).