CHAPTER 16

STRUCTURAL DESIGN

SECTION 1601 GENERAL

1601.1 Scope. Provisions of this chapter shall govern the structural design of buildings, structures and portions thereof regulated by this code.

1601.2 Massachusetts Building Code for One- and Two Family Dwellings. Where structural design for buildings covered by the Massachusetts Building Code for One- and Two Family Dwellings is performed by a registered design professional (RDP), said RDP may follow the structural design provisions of the Massachusetts State Building Code (SBC) in lieu of those in the Building Code for One- and Two Family Dwellings, and shall follow the SBC for the structural design of components and systems not addressed in the Building Code for One- and Two Family Dwellings.

SECTION 1602 DEFINITIONS AND NOTATIONS

1602.1 Definitions. The following words and terms shall, for the purposes of this chapter, have the meanings shown herein. For definitions not contained herein, see appropriate sections of ASCE 7.

ALLOWABLE STRESS DESIGN. A method of proportioning structural members, such that elastically computed stresses produced in the members by nominal loads do not exceed specified allowable stresses (also called working stress design).

BALCONY. A floor projecting from and supported by a structure without additional independent supports.

DEAD LOADS. The weight of materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment, including the weight of cranes. All dead loads are considered permanent loads.

DECK. An exterior floor supported on at least two opposing sides by an adjacent structure, and/or posts, piers or other independent supports.

DESIGN STRENGTH. The product of the nominal strength and a resistance

factor (or strength reduction factor).

DURATION OF LOAD. The period of continuous application of a given load, or the aggregate of periods of intermittent applications of the same load.

EQUIPMENT SUPPORT. Those structural members or assemblies of members or manufactured elements, including braces, frames, lugs, snuggers, hangers or saddles, that transmit gravity load and operating load between the equipment and the structure.

ESSENTIAL FACILITIES. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow or earthquakes.

FACTORED LOAD. The product of a nominal load and a load factor.

FLEXIBLE EQUIPMENT CONNECTIONS. Those connections between equipment components that permit rotational and/or translational movement without degradation of performance.

GUARD. See Section 1002.1.

IMPACT LOAD. The load resulting from moving machinery, elevators, craneways, vehicles, and other similar forces and kinetic loads, pressure and possible surcharge from fixed or moving loads.

JOINT. A portion of a column bounded by the highest and lowest surfaces of the other members framing into it.

LATERAL FORCE-RESISTING SYSTEM. That part of the structural system that is considered in the design to provide resistance to the wind and seismic forces prescribed herein.

LIMIT STATE. A condition beyond which a structure or member becomes unfit for service and is judged to be no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state).

LIVE LOADS. Those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load or dead load.

LIVE LOADS (ROOF). Those loads produced (1) during maintenance by workers, equipment and materials; and (2) during the life of the structure by movable objects such as planters and by people.

LOAD AND RESISTANCE FACTOR DESIGN (LRFD). A method of proportioning structural members and their connections using load and resistance factors such that no applicable limit state is reached when the structure is subjected to appropriate load combinations. (Also called "strength design").

LOAD FACTOR. A factor that accounts for deviations of the actual load from the nominal load, for uncertainties in the analysis that transforms the load into a load effect, and for the probability that more than one extreme load will occur simultaneously.

LOADS. Forces or other actions that result from the weight of building materials, occupants and their possessions, environmental effects, differential movement, and restrained dimensional changes. Permanent loads are those loads in which variations over time are rare or of small magnitude, such as dead loads. All other loads are variable loads (see also "Nominal loads").

LOADS EFFECTS. Forces and deformations produced in structural members by the applied loads.

NOMINAL LOADS. The magnitudes of the loads specified in this chapter (dead, live, soil, wind, snow, rain, flood and earthquake).

NOTATIONS

D = Dead load.

E = Combined effect of horizontal and vertical earthquake- induced forces.

F = Load due to fluids.

F_a = Flood load.

H = Load due to lateral pressure of soil and water in soil.

L = Live load, except roof live load, including any permitted live load reduction.

L_r = Roof live load including any permitted live load reduction.

R = Rain load.

S = Snow load.

T = Self-straining force arising from contraction or expansion resulting from temperature change, shrinkage, moisture change, creep in component materials, movement due to differential settlement, or combinations thereof.

W = Load due to wind pressure.

P-DELTA EFFECT. The second order effect on shears, axial forces and moments of frame members induced by gravity loads on a laterally displaced building frame.

PANEL (PART OF A STRUCTURE). The section of a floor, wall or roof comprised between the supporting frame of two adjacent rows of columns and girders or column bands of floor or roof construction.

RESISTANCE FACTOR. A factor that accounts for deviations of the actual strength from the nominal strength and the manner and consequences of failure (also called strength reduction factor).

SHALLOW ANCHORS. Shallow anchors are those with embedment length-to-diameter ratios of less than 8.

SHEAR PANEL. A floor, roof or wall component sheathed to act as a shear wall or diaphragm.

SHEAR WALL. A wall designed to resist lateral forces parallel to the plane of the wall.

STRENGTH, NOMINAL. The capacity of a structure or member to resist the effects of loads, as determined by computations using specified material strengths and dimensions and formulas derived from accepted principles of structural mechanics or by field tests or laboratory tests of scaled models, allowing for modeling effects and differences between laboratory and field conditions.

STRENGTH, REQUIRED. Strength of a member, cross section or connection required to resist factored loads or related internal moments and forces in such combinations as stipulated by these provisions.

STRENGTH DESIGN. A method of proportioning structural members such that the computed forces produced in the members by factored loads do not exceed the member design strength (also called load and resistance factor design).

WALL, LOAD BEARING. Any wall meeting either of the following classifications:

1. Any metal or wood stud wall that supports more than 100 pounds per linear foot (1459 N/m) of vertical load in addition to its own weight.

2. Any masonry or concrete wall that supports more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight.

WALL, NONLOAD BEARING. Any wall that is not a load-bearing wall.

SECTION 1603 CONSTRUCTION DOCUMENTS

1603.1 General. Construction documents shall show the size, section and relative locations of structural members with floor levels, column centers and offsets fully dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.8 shall be clearly indicated on the construction documents for parts of the building or structure.

1603.1.1 Floor live load. The uniformly distributed, concentrated, and impact floor live loads used in the design and where they are applied shall be indicated. Also, whether live load reduction has been applied. shall be indicated.

1603.1.2 Roof live load. The roof live load used in the design shall be indicated (Section 1607.11).

1603.1.3 Roof snow load. The ground snow load, p_g, and the flat-roof snow load, p_f, and, if applicable, the sloped roof snow load, p_s, shall be indicated.

1603.1.4 Wind load. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral-force resisting system of the building:

1. Basic wind speed (3-second gust), miles per hour (km/hr).

2. Wind importance factor, I_W, and building category.

3. Wind exposure. If more than one wind exposure is utilized, the wind exposures and applicable wind directions shall be indicated.

1603.1.5 Earthquake design data. The following information related to seismic loads shall be shown, regardless of whether seismic loads govern the lateral design of the building:

 1. Seismic importance factor, I_E, and seismic use group.
 2. Mapped spectral response accelerations S_S and S_1.

3. Site class.
4. Spectral response coefficients S_{DS} and S_{D1}.
5. Seismic design category.
6. Basic seismic-force-resisting system(s).
7. Design base shear.
8. Seismic response coefficient(s), C_S.
9. Response modification factor(s), R.
10. Analysis procedure used.

Where the information along different horizontal axes of the building is different, the information for both orthogonal axes shall be show.

1603.1.6 Flood load. For buildings located in flood-hazard areas, the design flood elevation and whether or not the construction is subject to high-velocity wave action shall be indicated. The following information, referenced to the datum on the community's flood insurance rate map (FIRM), shall be shown, regardless of whether flood loads govern the design of the building:

1. In flood-hazard areas not subject to high-velocity wave action, the elevation of proposed lowest floor, including basement.

2. In flood-hazard areas not subject to high-velocity wave action, the elevation to which any nonresidential building will be dry floodproofed.

3. In flood-hazard areas subject to high-velocity wave action, the proposed elevation of the bottom of the lowest horizontal structural member of the lowest floor, including basement.

1603.1.7 Special loads. Special loads that are applicable to the design of the building, structure or portions thereof shall be indicated.

1603.2 Structural designs under the control of the construction contractor: When structural components, assemblies, or systems are designed by design professionals under the control of the contractor, and said designs are not included with the application for permit, said designs shall be submitted to the building official with an application for amendment of the permit.

SECTION 1604 GENERAL DESIGN REQUIREMENTS

1604.1 General. Building, structures, and parts thereof shall be designed and constructed in accordance with strength design (also known as load and resistance factor design), allowable stress design, or empirical design, as permitted by the applicable material chapters.

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 and lateral drift.

1604.3.1 Deflections. The deflections of structural members shall not exceed the limitations of Sections 1604.3.2 through 1604.3.5, as applicable; however, under no circumstance shall the deflections from gravity loads on floors or roofs exceed $1/240^{th}$ of the span, nor shall the deflections of walls due to lateral loads exceed $1/180^{th}$ of the span.

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 LRFD, AISC HSS, AISC 335, AISI -NASPEC, AISI-General, AISI-Truss, ASCE 3, ASCE 8-SSD-LRFD/ASD, and the standard specifications of SJI Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders as applicable.

1604.3.4 Masonry. The deflection of masonry structural members shall not exceed that permitted by ACI 530/ASCE 5/TMS 402.

1604.3.5 Aluminum. The deflection of aluminum structural members shall not exceed that permitted by AA-94.

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 long-term material properties.

Members that tend to accumulate residual deformations under repeated service loads shall have included in their analysis the added eccentricities 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 that are assumed not to be a part of the lateral-force-resisting system shall be permitted to be incorporated into buildings provided that their effect on the action of the system is considered and provided for in design. 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 overturning effects caused by the lateral forces specified in this chapter. See Section 1613 for earthquake, Section 1609 for wind, and Section 1610 for lateral soil loads.

1604.5 Importance factors. Importance factors shall be in accordance with ASCE 7.

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 1624.

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 material design standards listed in Chapter 35, or alternative test procedures in accordance with Section 1625, shall be load tested in accordance with Section 1626.

1604.8 Overturning, Sliding, and Anchorage.

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. Foundations shall be capable of resisting applied uplift and sliding forces.

1604.8.2 Concrete and masonry walls. Concrete and masonry walls shall be connected to floors, roofs and other structural elements that provide lateral support for the wall. Such anchorage shall provide a positive direct connection capable of resisting the horizontal forces specified in this chapter but not less

than a minimum horizontal force of 190 pounds per linear foot (2.77 kN/m) of wall for allowable stress design, and 280 pounds per lineal foot (4.09 kN/m) of wall for strength design. Walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 feet (1219 mm). Required anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall.

1604.9 Application and Posting of Live Loads

1604.9.1 Restrictions on loading. It shall be unlawful to place, or cause or permit to be placed, on any floor or roof of a building, structure, or portion thereof, a load greater than the capacity of the floor or roof determined in accordance with the requirements of this Code.

1604.9.2 Live loads posted: All buildings in Use Groups F and S shall be conspicuously posted for live loads by the owner, using durable signs. It shall be unlawful to remove or deface such notices.

1604.10 Snow, Wind, and Earthquake Design Factors: Ground snow load, p_g, basic wind speed (3 second gust speed), V, and earthquake response accelerations for the maximum considered earthquake, S_S and S_1, for each city and town in Massachusetts shall be as given in Table 1604.10.

TABLE1604.10

GROUND SNOW LOADS; BASIC WIND SPEEDS; EARTHQUAKE DESIGN FACTORS

City/Town	Ground Snow Load p_g, psf	Basic Wind Speed V, MPH	Earthquake Design Factors	
			Ss	S_1
Abington	45	110	0.26	0.064
Acton	55	100	0.29	0.071
Acushnet	45	110	0.23	0.058
Adams	65	90	0.22	0.068
Agawam	55	100	0.23	0.065
Alford	65	90	0.22	0.066
Amesbury	55	110	0.35	0.077
Amherst	55	100	0.23	0.067
Andover	55	110	0.32	0.075
Aquinnah (see Gay Head)				
Arlington	45	105	0.29	0.069

Ashburnham	65	100	0.27	0.072
Ashby	65	100	0.28	0.072
Ashfield	65	100	0.22	0.068
Ashland	55	100	0.25	0.066
Athol	65	100	0.25	0.070
Attleboro	55	110	0.24	0.062
Auburn	55	100	0.23	0.065
Avon	55	100	0.26	0.064
Ayer	65	100	0.28	0.071
Barnstable	35	120	0.20	0.054
Barre	55	100	0.24	0.068
Becket	65	90	0.22	0.066
Bedford	55	100	0.29	0.071
Belchertown	55	100	0.23	0.066
Bellingham	55	100	0.24	0.064
Belmont	45	105	0.28	0.069
Berkley	55	110	0.24	0.061
Berlin	55	100	0.26	0.068
Bernardston	65	100	0.23	0.070
Beverly	45	110	0.32	0.072
Billerica	55	100	0.30	0.072
Blackstone	65	100	0.24	0.064
Blandford	65	100	0.23	0.066
Bolton	55	100	0.26	0.069
Boston	45	105	0.29	0.068
Bourne	35	120	0.21	0.056
Boxborough	55	100	0.28	0.070
Boxford		110	0.33	0.075
Boylston	55	100	0.25	0.067
Braintree	45	105	0.27	0.066
Brewster	35	120	0.18	0.052
Bridgewater	45	110	0.24	0.062
Brimfield	55	100	0.23	0.065
Brockton	45	110	0.25	0.064
Brookfield	55	100	0.23	0.065
Brookline	45	105	0.28	0.068
Buckland	65	100	0.22	0.068
Burlington	55	105	0.30	0.071
Cambridge	45	105	0.28	0.068
Canton	55	100	0.26	0.066
Carlisle	55	100	0.29	0.071
Carver	45	110	0.24	0.060
Charlemont	65	100	0.22	0.068
Charlton	55	100	0.23	0.065
Chatham	35	120	0.17	0.050
Chelmsford	55	100	0.30	0.073

Chelsea	45	105	0.29	0.069
Cheshire	65	90	0.22	0.068
Chester	65	100	0.22	0.066
Chesterfield	65	100	0.22	0.067
Chicopee	55	100	0.23	0.066
Chilmark	35	120	0.18	0.051
Clarksburg	65	90	0.22	0.069
Clinton	55	100	0.26	0.068
Cohasset	45	110	0.27	0.066
Colrain	65	100	0.23	0.069
Concord	55	100	0.29	0.070
Conway	65	100	0.22	0.068
Cummington	65	100	0.22	0.067
Dalton	65	90	0.22	0.067
Danvers	45	110	0.32	0.073
Dartmouth	45	110	0.23	0.058
Dedham	55	100	0.26	0.066
Deerfield	65	100	0.23	0.068
Dennis	35	120	0.19	0.052
Dighton	55	110	0.24	0.061
Douglas	55	100	0.23	0.064
Dover	55	100	0.26	0.066
Dracut	55	100	0.33	0.075
Dudley	55	100	0.23	0.064
Dunstable	65	100	0.31	0.074
Duxbury	45	110	0.25	0.062
East Bridgewater	45	110	0.25	0.063
East Brookfield	55	100	0.23	0.066
East Longmeadow	55	100	0.23	0.065
Eastham	35	120	0.19	0.052
Easthampton	55	100	0.23	0.066
Easton	55	110	0.25	0.064
Edgartown	35	120	0.18	0.050
Egremont	65	90	0.23	0.066
Erving	65	100	0.23	0.069
Essex	45	110	0.33	0.073
Everett	45	105	0.29	0.069
Fairhaven	45	110	0.22	0.057
Fall River	45	110	0.23	0.059
Falmouth	35	120	0.20	0.054
Fitchburg	65	100	0.27	0.071
Florida	65	90	0.22	0.069
Foxborough	55	100	0.25	0.064
Framingham	55	100	0.26	0.067
Franklin	55	100	0.24	0.064
Freetown	45	110	0.23	0.060

Gardner	65	100	0.26	0.070
Gay Head (a.k.a Aquinnah)	35	120	0.18	0.051
Georgetown	55	110	0.34	0.075
Gill	65	100	0.23	0.069
Gloucester	45	110	0.33	0.073
Goshen	65	100	0.22	0.067
Gosnold	35	120	0.19	0.053
Grafton	55	100	0.24	0.066
Granby	55	100	0.23	0.066
Granville	65	100	0.23	0.066
Great Barrington	65	90	0.22	0.066
Greenfield	65	100	0.23	0.069
Groton	65	100	0.30	0.073
Groveland	55	110	0.34	0.076
Hadley	55	100	0.23	0.067
Halifax	45	110	0.25	0.062
Hamilton	45	110	0.33	0.074
Hampden	55	100	0.23	0.065
Hancock	65	90	0.22	0.068
Hanover	45	110	0.26	0.064
Hanson	45	110	0.25	0.063
Hardwick	55	100	0.23	0.067
Harvard	55	100	0.28	0.070
Harwich	35	120	0.18	0.051
Hatfield	55	100	0.22	0.067
Haverhill	55	110	0.35	0.077
Hawley	65	100	0.22	0.068
Heath	65	100	0.22	0.069
Hingham	45	110	0.27	0.066
Hinsdale	65	90	0.22	0.067
Holbrook	45	105	0.26	0.065
Holden	55	100	0.25	0.068
Holland	55	100	0.23	0.064
Holliston	55	100	0.25	0.066
Holyoke	55	100	0.23	0.066
Hopedale	55	100	0.24	0.065
Hopkinton	55	100	0.25	0.066
Hubbardston	65	100	0.25	0.069
Hudson	55	100	0.26	0.068
Hull	45	110	0.28	0.067
Huntington	65	100	0.22	0.066
Ipswich	45	110	0.34	0.074
Kingston	45	110	0.24	0.061
Lakeville	45	110	0.24	0.061
Lancaster	55	100	0.27	0.070

Lanesborough	65	90	0.22	0.068
Lawrence	55	110	0.33	0.075
Lee	65	90	0.22	0.066
Leicester	55	100	0.24	0.066
Lenox	65	90	0.22	0.067
Leominster	65	100	0.26	0.070
Leverett	65	100	0.23	0.068
Lexington	55	105	0.29	0.070
Leyden	65	100	0.23	0.069
Lincoln	55	100	0.28	0.069
Littleton	55	100	0.29	0.071
Longmeadow	55	100	0.23	0.065
Lowell	55	100	0.31	0.074
Ludlow	55	100	0.23	0.066
Lunenburg	65	100	0.28	0.071
Lynn	45	110	0.31	0.071
Lynnfield	45	110	0.31	0.072
Malden	45	105	0.29	0.069
Manchester	45	110	0.32	0.072
Mansfield	55	110	0.25	0.063
Marblehead	45	110	0.31	0.071
Marion	45	110	0.22	0.057
Marlborough	55	100	0.26	0.068
Marshfield	45	110	0.26	0.064
Mashpee	35	120	0.20	0.054
Mattapoisett	45	110	0.22	0.057
Maynard	55	100	0.27	0.069
Medfield	55	100	0.25	0.065
Medford	45	105	0.29	0.070
Medway	55	100	0.25	0.065
Melrose	45	105	0.30	0.070
Mendon	55	100	0.24	0.064
Merrimac	55	110	0.35	0.077
Methuen	55	110	0.34	0.076
Middleborough	45	110	0.24	0.061
Middlefield	65	100	0.22	0.066
Middleton	45	110	0.32	0.073
Milford	55	100	0.24	0.065
Millbury	55	100	0.24	0.065
Millis	55	100	0.25	0.065
Millville	55	100	0.24	0.064
Milton	45	105	0.27	0.066
Monroe	65	100	0.22	0.069
Monson	55	100	0.23	0.065
Montague	65	100	0.23	0.068
Monterey	65	90	0.22	0.066

Montgomery	65	100	0.23	0.066
Mount Washington	65	90	0.23	0.066
Nahant	45	110	0.30	0.070
Nantucket	35	120	0.15	0.047
Natick	55	100	0.26	0.067
Needham	55	100	0.27	0.067
New Ashford	65	90	0.22	0.068
New Bedford	45	110	0.23	0.058
New Braintree	55	100	0.23	0.067
New Marlborough	65	90	0.23	0.066
New Salem	65	100	0.24	0.068
Newbury	55	110	0.35	0.076
Newburyport	55	110	0.35	0.077
Newton	55	105	0.27	0.068
Norfolk	55	100	0.25	0.065
North Adams	65	90	0.22	0.069
North Andover	55	110	0.33	0.075
North Attleborough	55	110	0.24	0.063
North Brookfield	55	100	0.23	0.066
North Reading	55	105	0.32	0.073
Northampton	55	100	0.22	0.066
Northborough	55	100	0.25	0.067
Northbridge	55	100	0.24	0.065
Northfield	65	100	0.24	0.070
Norton	55	110	0.24	0.063
Norwell	45	110	0.26	0.064
Norwood	55	100	0.26	0.065
Oak Bluffs	35	120	0.18	0.051
Oakham	55	100	0.24	0.067
Orange	65	100	0.24	0.070
Orleans	35	120	0.18	0.051
Otis	65	90	0.23	0.066
Oxford	55	100	0.23	0.065
Palmer	55	100	0.23	0.066
Paxton	55	100	0.24	0.067
Peabody	45	110	0.31	0.072
Pelham	55	100	0.23	0.067
Pembroke	45	110	0.25	0.063
Pepperell	65	100	0.30	0.073
Peru	65	90	0.22	0.067
Petersham	65	100	0.24	0.068
Phillipston	65	100	0.24	0.069
Pittsfield	65	90	0.22	0.067
Plainfield	65	100	0.22	0.068
Plainville	55	100	0.24	0.063
Plymouth	45	110	0.24	0.060

Pympton	45	110	0.24	0.061
Princeton	65	100	0.25	0.069
Provincetown	35	120	0.22	0.058
Quincy	45	105	0.27	0.067
Randolph	45	105	0.26	0.065
Raynham	55	110	0.24	0.062
Reading	55	105	0.31	0.072
Rehoboth	55	110	0.24	0.062
Revere	45	105	0.30	0.070
Richmond	65	90	0.22	0.067
Rochester	45	110	0.23	0.059
Rockland	45	110	0.26	0.064
Rockport	45	110	0.33	0.073
Rowe	65	100	0.22	0.069
Rowley	55	110	0.34	0.075
Royalston	65	100	0.25	0.070
Russell	65	100	0.23	0.066
Rutland	55	100	0.24	0.068
Salem	45	110	0.31	0.071
Salisbury	55	110	0.35	0.077
Sandisfield	65	90	0.23	0.066
Sandwich	35	120	0.22	0.058
Saugus	45	110	0.30	0.070
Savoy	65	90	0.22	0.068
Scituate	45	110	0.27	0.065
Seekonk	55	110	0.24	0.062
Sharon	55	100	0.25	0.065
Sheffield	65	90	0.23	0.066
Shelburne	65	100	0.23	0.068
Sherborn	55	100	0.26	0.066
Shirley	65	100	0.28	0.072
Shrewsbury	55	100	0.25	0.067
Shutesbury	65	100	0.23	0.068
Somerset	55	110	0.23	0.060
Somerville	45	105	0.28	0.069
South Hadley	55	100	0.23	0.066
Southampton	55	100	0.23	0.066
Southborough	55	100	0.26	0.067
Southbridge	55	100	0.23	0.064
Southwick	55	100	0.23	0.065
Spencer	55	100	0.23	0.066
Springfield	55	100	0.23	0.065
Sterling	55	100	0.26	0.069
Stockbridge	65	90	0.22	0.066
Stoneham	45	105	0.30	0.071
Stoughton	55	100	0.26	0.065

Stow	55	100	0.27	0.069
Sturbridge	55	100	0.23	0.065
Sudbury	55	100	0.27	0.069
Sunderland	65	100	0.23	0.068
Sutton	55	100	0.24	0.065
Swampscott	45	110	0.30	0.070
Swansea	55	110	0.24	0.061
Taunton	55	110	0.24	0.062
Templeton	65	100	0.25	0.070
Tewksbury	55	100	0.31	0.073
Tisbury	35	120	0.18	0.052
Tolland	65	100	0.23	0.066
Topsfield	45	110	0.33	0.074
Townsend	65	100	0.28	0.072
Truro	35	120	0.22	0.057
Tyngsborough	55	100	0.31	0.074
Tyringham	65	90	0.22	0.066
Upton	55	100	0.24	0.065
Uxbridge	55	100	0.24	0.064
Wakefield	45	105	0.31	0.071
Wales	55	100	0.23	0.065
Walpole	55	100	0.25	0.065
Waltham	55	105	0.28	0.069
Ware	55	100	0.23	0.066
Wareham	45	110	0.23	0.058
Warren	55	100	0.23	0.066
Warwick	65	100	0.24	0.070
Washington	65	90	0.22	0.067
Watertown	45	105	0.28	0.068
Wayland	55	100	0.27	0.068
Webster	55	100	0.23	0.064
Wellesley	55	100	0.27	0.067
Wellfleet	35	120	0.20	0.054
Wendell	65	100	0.23	0.069
Wenham	45	110	0.32	0.073
West Boylston	55	100	0.25	0.067
West Bridgewater	45	110	0.25	0.063
West Brookfield	55	100	0.23	0.066
West Newbury	55	110	0.35	0.077
West Springfield	55	100	0.23	0.065
West Stockbridge	65	90	0.22	0.066
West Tisbury	35	120	0.18	0.052
Westborough	55	100	0.25	0.067
Westfield	55	100	0.23	0.066
Westford	55	100	0.30	0.073
Westhampton	65	100	0.22	0.066

Westminster	65	100	0.26	0.071
Weston	55	100	0.27	0.068
Westport	45	110	0.23	0.058
Westwood	55	100	0.26	0.066
Weymouth	45	105	0.27	0.066
Whately	65	100	0.22	0.067
Whitman	45	110	0.25	0.063
Wilbraham	55	100	0.23	0.065
Willamsburg	65	100	0.22	0.067
Williamstown	65	90	0.23	0.069
Wilmington	55	105	0.31	0.073
Winchendon	65	100	0.26	0.071
Winchester	55	105	0.29	0.070
Windsor	65	90	0.22	0.067
Winthrop	45	105	0.29	0.068
Woburn	55	105	0.30	0.071
Worcester	55	100	0.24	0.067
Worthington	65	100	0.22	0.067
Wrentham	55	100	0.24	0.064
Yarmouth	35	120	0.19	0.052

SECTION 1605 LOAD COMBINATIONS

1605.1 General. Buildings and other structures and portions thereof shall be designed to resist the load combinations specified in Section 1605.2 or 1605.3 and Chapters 18 through 23, and load combinations which include the special seismic load of Section 9.5.2.7.1 of ASCE 7, where required by Section 9.5.2.6.2.11 or 9.5.2.6.3.1 of ASCE 7. Applicable loads shall be considered, including both earthquake and wind, in accordance with the specified load combinations. Each load combination shall also be investigated with one or more of the variable loads set to zero.

1605.2 Load combinations using strength design or load and resistance factor design.

1605.2.1 Basic load combinations. Where strength design or load and resistance factor design is used, structures and portions thereof shall resist the most critical effects from the following combinations of factored loads:

$1.4\,(D+F)$ **(Equation 16-1)**

$1.2(D+F) + 1.6(L+H) + 0.5(L_r \text{ or } S \text{ or } R)$ **(Equation 16-2)**

$1.2(D+F) + 1.6(L_r \text{ or } S \text{ or } R) + (f_1 L \text{ or } 0.8W) + 1.6H$ **(Equation 16-3)**

$$1.2D + 1.6W + f_1 L + 0.5(L_r \text{ or } S \text{ or } R) + 1.6H \qquad \textbf{(Equation 16-4)}$$

$$1.2D + 1.0E + f_1L + 0.5S + 1.6H \qquad \textbf{(Equation 16-5)}$$

$$0.9D + (1.0E \text{ or } 1.6W) + 1.6H \qquad \textbf{(Equation 16-6)}$$

where:

f_1 = 1.0 for floors in places of public assembly, for live loads in excess of 100 pounds per square foot (4.79 kN/m^2), and for parking garage live load.

f_1 = 0.5 for other live loads.

Where lateral soil pressure provides resistance to structural actions from other forces, it shall not be included in H, but shall be included in the design resistance.

Exception: Where other factored load combinations are specifically required by the provisions of this code, such combinations shall take precedence.

1605.2.2 Other loads.

1605.2.2.1 Load combinations including flood load. When a structure is included in a flood zone (see Section 1612), the following load combinations shall be considered:

1. In areas subject to high velocity wave action, 1.6W in Equations 16-4 and 16-6 shall be replaced with 1.6W + 2.0 F_a, where F_a is the flood load.

2. In other areas, 1.6W in Equations 16-4 and 16-6 shall be replaced with 0.8W + 1.0 F_a:

Said load combinations are in addition to and shall not replace those of Equations 16-4 and 16-6.

1605.2.2.2 Effects of temperature and ponding. The forces and stresses generated by the effects of temperature and ponding shall be considered.

1605.2.2.3 Load combinations including crane load. 1.6 times the effects of vertical and horizontal crane loads shall be added to Equations 16-2, 16-3, 16-4, and 16-6. When combined with crane loads in these equations :

0.75S may be substituted for S;

0.5W may be substituted for W;

L_r may be taken as 0; and

E may be taken as 0.

(The substituted values shall then be multiplied by the numerical coefficients given in the equations).

1605.3 Load combinations using allowable stress design.

1605.3.1 Basic load combinations. Where allowable stress design (working stress design), as permitted by this code, is used, structures and portions thereof shall resist the most critical effects resulting from the following combinations of loads:

$$D + F \qquad \textbf{(Equation 16-7)}$$

$$D + H + F + L \qquad \textbf{(Equation 16-8)}$$

$$D + H + F + L + (L_r \text{ or } S \text{ or } R) \qquad \textbf{(Equation 16-9)}$$

$$2/3\, [1.2D + (1.6W \text{ or } 1.0E) + f_1\, L + 0.5(L_r \text{ or } S \text{ or } R) + 1.6H] \quad \textbf{(Equation 16-10)}$$

$$0.6D + W + H \qquad \textbf{(Equation 16-11)}$$

$$0.6D + 0.7E + H \qquad \textbf{(Equation 16-12)}$$

where f_1 is defined in Section 1605.2.1.

Increases in allowable stresses allowed in the various materials standards referenced by the materials chapters of this code shall not be used, except that a duration of load increase shall be permitted in accordance with Chapter 23.

Where lateral soil pressure provides resistance to structural actions from other forces, it shall not be included in H, but shall be included in the design resistance.

1605.3.2 Other loads

1605.3.2.1 Load combinations including flood load. When a structure is included in a flood zone (see Section 1612), the following load combinations shall be considered:

1. In areas subject to high velocity wave action, 1.5 F_a shall be added to other loads in Equations 16-10 and 16-11, where F_a is the flood load, and E shall be set to zero in Equation 16-10.

2. In other areas, 0.75 F_a shall be added to other loads in Equations 16-10 and 16-11, and E shall be set to zero in Equation 16-10.

Said load combinations are in addition to and shall not replace those of Equations

16-10 and 16-11.

1605.3.2.2 Effects of temperature and ponding. The forces and stresses generated by the effects of temperature and ponding shall be considered.

1605.3.2.3 Load combinations including crane load. 1.0 times the effects of vertical and horizontal crane loads shall be added to Equations 16-8, 16-9, 16-10, and 16-12. When combined with crane loads in these equations :

0.75S may be substituted for S;

0.5W may be substituted for W;

L_r may be taken as 0; and

E may be taken as 0.

(The substituted values shall then be multiplied by the numerical coefficients, if any, given in the equations).

1605.4 Heliports and helistops. Heliport and helistop landing or touchdown areas shall be designed for the following loads, combined in accordance with Section 1605:

1. Dead load, *D*, plus the gross weight of the helicopter, D_h, plus snow load, *S*.

2. Dead load, *D*, plus two single concentrated impact loads, *L*, approximately 8 feet (2438 mm) apart applied anywhere on the touchdown pad (representing each of the helicopter's two main landing gear, whether skid type or wheeled type), having a magnitude of 0.75 times the gross weight of the helicopter. Both loads acting together total 1.5 times the gross weight of the helicopter.

3. Dead load, *D*, plus a uniform live load, *L*, of 100 pounds per square foot (4.79 kN/m^2).

SECTION 1606 DEAD LOADS

1606.1 Weights of materials and construction. In determining dead loads for purposes of design, the actual weights of materials and construction shall be used but not less than the applicable minimum design dead loads given in Table C3-1 of ASCE 7. In the absence of definite information, values used shall be subject to the approval of the building official.

1606.2 Weights of fixed service equipment. In determining dead loads for

purposes of design, the weight of fixed service equipment, such as plumbing stacks and risers, electrical feeders, heating, ventilating and air conditioning systems and fire sprinkler systems, shall be included.

1606.3 Weight of concrete due to deflection: Account shall be taken of the additional weight of concrete resulting from the deflection of the supporting deck and framing when placing concrete.

1606.4 Weight of ceilings: Provision shall me made for the weight of ceilings, lights, ducts, and pipes which can be supported within or under the framing of floors or roofs, whether they are presently installed or whether they can be subsequently installed.

SECTION 1607 LIVE LOADS

1607.1 General. Live loads are those loads defined in Section 1602.1.

1607.2 Loads not specified. For occupancies or uses not designated in Table 1607.1, the live load shall be determined in accordance with a method approved by the building official.

1607.3 Uniform live loads. The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall in no case be less than the minimum uniformly distributed unit loads required by Table 1607.1.

[Insert Table 1607.1 here].

Notes to Table 1607.1

For SI: 1 square inch = 645.16 mm2, 1 pound per square foot = 0.0479 kN/m2,   1 pound = 0.004448 kN.

a. Floors in garages or portions of buildings used for the storage of motor vehicles shall be designed for the uniformly distributed live loads of Table 1607.1 or the following concentrated load: (1) for passenger cars accommodating not more than nine passengers, 3,000 pounds acting on an area of 4.5 inches by 4.5 inches; (2) for mechanical parking structures without slab or deck which are used for storing passenger vehicles only, 2,250 pounds per wheel.

b. The weight of books and shelving shall be computed using an assumed density of 65 pounds per cubic foot and converted to a uniformly distributed load; this load shall be used if it exceeds 150 pounds per square foot. The 150 psf load requirement does not apply to libraries that are incidental to other uses.

c. Design in accordance with the ICC *Standard on Bleachers, Folding and Telescopic Seating and Grandstands*.

d. Other uniform loads in accordance with an approved method which contains provisions for truck loadings shall also be considered where appropriate.

e. The concentrated wheel load shall be applied on an area of 20 square inches.

f. Minimum concentrated load on stair treads (on area of 4 square inches) is 300 pounds.

g. Where snow loads occur that are in excess of the design conditions, the structure shall be designed to support the loads due to the increased loads caused by drift buildup or a greater snow design determined by the building official. See Section 1608. For special-purpose roofs, see Section 1607.11.2.2.

1607.4 Concentrated loads. Floors and other similar surfaces shall be designed to support the uniformly distributed live loads prescribed in Section 1607.2 or the concentrated load, in pounds (kilonewtons), given in Table 1607.1, whichever produces the greater load effects. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed on a floor or roof over an area of 2.5 feet square [6.25 ft^2 (0.58 m^2)] and shall be located so as to produce the maximum load effects in the structural members. The aforementioned distribution of concentrated load does not apply for concentrated load applied to framing members, scuttles, skylight ribs, hung ceiling supports, cornices, and similar elements for which there is no deck to distribute load.

1607.5 Partition loads. In office buildings and in other buildings where partition locations are subject to change, provision for partition weight shall be made, whether or not partitions are shown on the construction documents, unless the specified live load exceeds 80 pounds per square foot (3.83 kN/m^2). Such partition load shall not be less than a uniformly distributed live load of 20 pounds per square foot (0.96kN/m^2). Partition loads are non-reducible live load.

1607.6 Truck and bus garages. Minimum live loads for garages having trucks or buses shall be as specified in AASHTO Standard for H20-44 and HS20-44 Truck loadings, and for lane loads, but shall not be less than 100 pounds per square foot (4.80 kN/m^2), unless other loads are specifically justified. Actual loads shall be used where they are greater than the above specified loads.

1607.6.1 Truck and bus garage live load application. Lane loads shall be applied in aisles and ramps, as specified in AASHTO Standard. Truck loads shall be applied in aisles, ramps, in parking spaces, and berths, in positions that will maximize load effects.

1607.6.2 Horizontal Forces. Longitudinal forces and curb forces shall be as specified in AASHTO Standard. Vehicle barriers shall be designed for a concentrated 10,000 lb lateral force acting at a minimum height of 2'-0" above a floor or ramp.

1607.7 Loads on handrails, guards, grab bars and vehicle barriers. Handrails, guards, grab bars, and vehicle barriers shall be designed and constructed to the

structural loading conditions set forth in this section.

1607.7.1 Handrails and guards. Handrail assemblies and guards shall be designed to resist a load of 100 pounds per lineal foot for grandstands, stadia, arenas, and similar structures used for public assembly, and 50 pounds per linear foot (pound per foot) (0.73 kN/m) for other uses, applied in any direction at the top and to transfer this load through the supports to the structure.

Exception:

For one- and two-family dwellings, only the single, concentrated load required by Section 1607.7.1.1 shall be applied.

1607.7.1.1 Concentrated load. Handrail assemblies and guards shall be able to resist a single concentrated load of 300 pounds for grandstands, stadia, arenas, and similar structures used for public assembly, and 200 pounds (0.89 kN) for other uses, applied in any direction at any point along the top, and have attachment devices and supporting structure to transfer this loading to appropriate structural elements of the building. This load need not be assumed to act concurrently with the loads specified in the preceding paragraph.

1607.7.1.2 Components. Intermediate rails (all those except the handrail), balusters and panel fillers shall be designed to withstand a horizontally applied normal load of 200 pounds (0.88 kN) on an area equal to 1 square foot (305 mm^2) including openings and space between rails. Reactions due to this loading are not required to be superimposed with those of Section 1607.7.1 or 1607.7.1.1.

1607.7.2 Grab bars, shower seats and dressing room bench seats. Grab bars, shower seats and dressing room bench seat systems shall be designed to resist a single concentrated load of 250 pounds (1.11 kN) applied in any direction at any point.

1607.7.3 Vehicle barriers. Vehicle barrier systems for passenger cars shall be designed to resist a single load of 7,000 pounds (31.2 kN) applied horizontally in any direction to the barrier system and shall have anchorage or attachment capable of transmitting this load to the structure. For design of the system, the load shall be assumed to act at a minimum height of 1 foot, 6 inches (457 mm) above the floor or ramp surface on an area not to exceed 1 square foot (305 mm^2), and is not required to be assumed to act concurrently with any handrail or guard loadings specified in the preceding paragraphs of Section 1607.7.1. Garages accommodating trucks and buses shall be designed in accordance with an approved method that contains provision for traffic railings.

1607.8 Impact loads. The live loads specified in Section 1607.2 include allowance for impact conditions. Provision shall be made in the structural design for uses and loads that involve unusual vibration and impact forces.

1607.8.1 Elevators. Structural supports for elevators, dumbwaiters, escalators and moving walks shall be designed for the *loads* and within the limits of the deflection specified in the Massachusetts State Department of Public Safety, Board Elevator Regulations (524 CMR 1.0 through 34.0), listed in *Chapter 35*. (In accordance with the Regulations, all suspended elevator *loads* shall be increased 100% for impact).

1607.8.2 Machinery. For the purpose of design, the weight of machinery and moving loads shall be increased as follows to allow for impact: (1) elevator machinery, 100 percent; (2) light machinery, shaft- or motor-driven, 20 percent; (3) reciprocating machinery or power-driven units, 50 percent. Percentages shall be increased where specified by the manufacturer.

1607.8.3 Hangers. Live loads on hangers supporting floors, balconies, stairs, walkways, or platforms shall be multiplied by an impact factor of 1.33.

1607.9 Reduction in live loads. The minimum uniformly distributed live loads, L_o, in Table 1607.1 are permitted to be reduced according to the following provisions.

1607.9.1 General. Subject to the limitations of Section 1607.9.1.1 through 1607.9.1.7, members for which a value of $K_{LL}A_T$ is 400 square feet (37.16 m^2) or more are permitted to be designed for a reduced live load in accordance with the following equation:

$$L = L_o \left(0.25 + \frac{15}{\sqrt{K_{LL}A_T}} \right) \qquad \textbf{Equation 16-21}$$

$$\text{For SI:} \quad L = L_o \left(0.25 + \frac{4.57}{\sqrt{K_{LL}A_T}} \right)$$

where:

L = Reduced design live load per square foot (meter) of area supported by the member.

L_o = Unreduced design live load per square foot (meter) of area supported by the member (see Table 1607.1).

K_{LL} = Live load element factor (see Table 1607.9.1).

A_T = Tributary area, in square feet (square meters).

L shall not be less than 0.50*L_o* for members supporting one floor and *L* shall not be less than 0.40*L_o* for members supporting two or more floors.

TABLE 1607.9.1
LIVE LOAD ELEMENT FACTOR, K_{LL}

ELEMENT	K_{LL}
Interior columns	4
Exterior columns without cantilever slabs	4
Edge columns with cantilever slabs	3
Corner columns with cantilever slabs	2
Edge beams without cantilever slabs	2
Interior beams	2

All other members not identified above including:
   Edge beams with cantilever slabs
   Cantilever beams
   Two-way slabs
   Members without provisions for continuous
     shear transfer normal to their span
	1

1607.9.1.1 Heavy live loads. Live loads that exceed 100 pounds per foot squared (4.79 kN/m^2) shall not be reduced except the live loads for members supporting two or more floors are permitted to be reduced by a maximum of 20 percent, but the live load shall not be less than *L* as calculated in Section 1607.9.1.

1607.9.1.2 Passenger car garages. The live loads shall not be reduced in passenger vehicle garages except the live loads for members supporting two or more floors are permitted to be reduced by a maximum of 20 percent, but the live load shall not be less than *L* as calculated in Section 1607.9.1.

1607.9.1.3 Assembly occupancies. Live loads of 100 pounds per foot squared (4.79 kN/m^2) or less shall not be reduced in assembly occupancies, except that the live loads for members supporting two or more floors are permitted to be reduced by a maximum of 20 percent, but the live load shall not be less than *L* as calculated in Section 1607.9.1.

1607.9.1.4 Special structural elements. Live loads shall not be reduced for one-way slabs except as permitted in Section 1607.9.1.1. Live loads of 100 pound per foot squared (4.79 kN/m^2) or less shall not be reduced for roof members except as specified in Section 1607.11.2.

1607.9.1.5 Hangers. Live load shall not be reduced for hangers.

1607.9.1.6 Open Web Steel Joists. Live load shall not be reduced for open web steel bar joists.

1607.9.1.7 Concrete flat slabs and plates. Live load shall not be reduced for peripheral (two-way action) shear around columns, capitals, and drop panels of concrete flat slabs, flat plates, and grid slabs.

1607.10 Distribution of floor loads. Where uniform floor live loads are involved in the design of structural members arranged so as to create continuity, the minimum applied loads shall be the full dead loads on all spans in combination with the floor live loads on spans selected to produce the greatest effect at each location under consideration. It shall be permitted to reduce floor live loads in accordance with Section 1607.9.

1607.11 Roof loads. The structural supports of roofs and marquees shall be designed to resist wind and, where applicable, snow and earthquake loads, in addition to the dead load of construction and the appropriate live loads as prescribed in this section, or as set forth in Table 1607.1. The live loads acting on a sloping surface shall be assumed to act vertically on the horizontal projection of that surface.

1607.11.1 Distribution of roof loads. Where uniform roof live loads are involved in the design of structural members arranged so as to create continuity, the minimum applied loads shall be the full dead loads on all spans in combination with the roof live loads on adjacent spans or on alternate spans, whichever produces the greatest effect. See Section 1607.11.2 for minimum roof live loads and Section 7.5 of ASCE 7 for partial snow loading.

1607.11.2 Minimum roof live loads. Minimum roof loads shall be determined for the specific conditions in accordance with Sections 1607.11.2.1 through 1607.11.2.5.

1607.11.2.1 Flat, pitched and curved roofs. Ordinary flat, pitched and curved roofs shall be designed for the live loads specified in the following equation or other controlling combinations of loads in Section 1605, whichever produces the greater load. In structures, where special scaffolding is used as a work surface for workers and materials during maintenance and repair operations, a lower roof load than specified in the following equation shall not be used unless approved by the building official. Greenhouses shall be designed for a minimum roof live load of 10 pounds per square foot (0.479 kN/m^2).

$L_r = 20R_1R_2$ **(Equation 16-24)**

where: $12 \leq L_r \leq 20$

For SI: $L_r = 0.96\ R_1R_2$

where: $0.58 \leq L_r \leq 0.96$

L_r = Roof live load per square foot (m^2) of horizontal projection in pounds per square foot (kN/m^2).

The reduction factors R_1 and R_2 shall be determined as follows:

$R_1 = 1$ for $A_t \leq 200$ square feet (18.58 m^2)   **(Equation 16-25)**

$R_1 = 1.2 - 0.001A_t$ for 200 square feet $< A_t <$ 600 square feet

For SI: $1.2 - 0.011A_t$ for 18.58 square meters $< A_t <$ 55.74 square meters

(Equation 16-26)

$R_1 = 0.6$ for $A_t >$ 600 square feet (55.74 m^2)   **(Equation 16-27)**

where:

A_t = Tributary area (span length multiplied by effective width) in square feet (m^2) supported by any structural member, and

F = for a sloped roof, the number of inches of rise per foot (for SI: $F = 0.12$ slope, with slope expressed in percentage points), and

F = for an arch or dome, rise-to-span ratio multiplied by 32, and

$R_2 = 1$ for $F \leq 4$ **(Equation 16-28)**

$R_2 = 1.2 - 0.05\, F$ for $4 < F < 12$ **(Equation 16-29)**

$R_2 = 0.6$ for $F \geq 12$ **(Equation 16-30)**

1607.11.2.2 Special-purpose roofs. Roofs used for promenade purposes shall be designed for a minimum live load of 60 pounds per square foot (2.87 kN/m^2). Roofs used for roof gardens or assembly purposes shall be designed for a minimum live load of 100 pounds per square foot (4.79 kN/m^2). Roofs used for other special purposes shall be designed for appropriate loads, as directed or approved by the building official.

1607.11.2.3 Landscaped roofs. Where roofs are to be landscaped, the uniform design live load in the landscaped area shall be 20 pounds per square foot (0.958 kN/m^2). The weight of the landscaping materials shall be considered as dead load and shall be computed on the basis of saturation of the soil.

1607.11.2.4 Awnings and canopies. Awnings and canopies shall be designed for a uniform live load of 5 pounds per square foot (0.240 kN/m^2) as well as for snow loads and wind loads as specified in Sections 1608 and 1609.

1607.11.2.5 Cornices and overhanging eaves. Cornices, overhanging eaves

and other similar projections shall be designed for a minimum uniform load of 60 pounds per square foot or a load of 100 pounds per lineal foot of projection, whichever gives the most severe structural effect. The linear load shall be positioned to maximize the various structural effects.

1607.12 Crane loads. The crane live load shall be the rated capacity of the crane. Design loads for the runway beams, including connections and support brackets, of moving bridge cranes and monorail cranes shall include the maximum wheel loads of the crane and the vertical impact, lateral, and longitudinal forces induced by the moving crane.

1607.12.1 Maximum wheel load. The maximum wheel loads shall be the wheel loads produced by the weight of the bridge, as applicable, plus the sum of the rated capacity and the weight of the trolley with the trolley positioned on its runway at the location where the resulting load effect is maximum.

1607.12.2 Vertical impact force. The maximum wheel loads of the crane shall be increased by the percentages shown below to determine the induced vertical impact or vibration force:

Monorail cranes (powered) — 25 percent

Cab-operated or remotely operated bridge cranes (powered) — 25 percent

Pendant-operated bridge cranes (powered) — 10 percent

Bridge cranes or monorail cranes with hand-geared bridge, trolley and hoist — 0 percent

1607.12.3 Lateral force. The lateral force on crane runway beams with electrically powered trolleys shall be calculated as 20 percent of the sum of the rated capacity of the crane and the weight of the hoist and trolley. The lateral force shall be assumed to act horizontally at the traction surface of a runway beam, in either direction perpendicular to the beam, and shall be distributed according to the lateral stiffness of the runway beam and supporting structure.

1607.12.4 Longitudinal force. The longitudinal force on crane runway beams, except for bridge cranes with hand-geared bridges, shall be calculated as 10 percent of the maximum wheel loads of the crane. The longitudinal force shall be assumed to act horizontally at the traction surface of a runway beam, in either direction parallel to the beam.

1607.13 Interior walls and partitions. Interior walls and partitions, including their finish materials, shall have adequate strength to resist the loads to which they are subjected but not less than a horizontal load of 5 pounds per square foot (0.240 kN/m^2). Self-supporting portable partitions used in office furnishings are exempt from this requirement.

SECTION 1608 SNOW LOADS

This section is unique to Massachusetts

1608.1 General. Design snow loads shall be determined in accordance with Section 7 of ASCE 7, except as provided otherwise herein. The design roof load shall not be less than that determined by Section 1607.

1608.2 Ground snow Loads. Disregard Section 7.2, Figure 7.1, and Table 7-1 of ASCE 7. Ground snow loads, p_g, to be used in the determination of design snow loads for roofs and other surfaces exposed to snow shall be as set forth in Section 1604.10.

1608.3 Convex curved roofs. Section 7.4.3 of ASCE 7 applies to convex curved roofs only. See 1608.4 for concave curved roofs.

1608.4 Concave curved roofs. The effective loaded area of a concave curved roof shall be that area of the surface of the roof where the tangents to the surface have a slope of 50 degrees or less. The total uniform snow load for concave curved roofs shall be the basic snow load, P_f, multiplied by the total horizontal projected area of the roof. This total load shall be applied uniformly over the effective loaded area of the roof.

1608.5 Drifts on lower roofs.

1608.5.1 Width of windward drifts. The width of drift, w, in Figure 7-8 of ASCE 7, shall be 8 times the height of the drift (8 times h_d or h_c as applicable) for all windward drifts.

1608.5.2 Multiple level roofs. For multiple stepped roofs similar to that shown in Figure 1608.5.1, the sum of all the roof lengths upwind above the drift under consideration, l_u*, in Figure 1608.5.1, shall replace l_u in Figure 7-8 of ASCE 7. For multiple level roofs similar to that shown in Figure 1608.5.2, if the total calculated height of a drift and the underlying uniform snow layer on the upwind side of a higher roof ($h_d + h_b$) is equal to or greater than $0.7h_r$, then the length, l_u*, as shown in Figure 1608.5.2, shall be used in place of l_u in Figure 7-8 of ASCE 7.
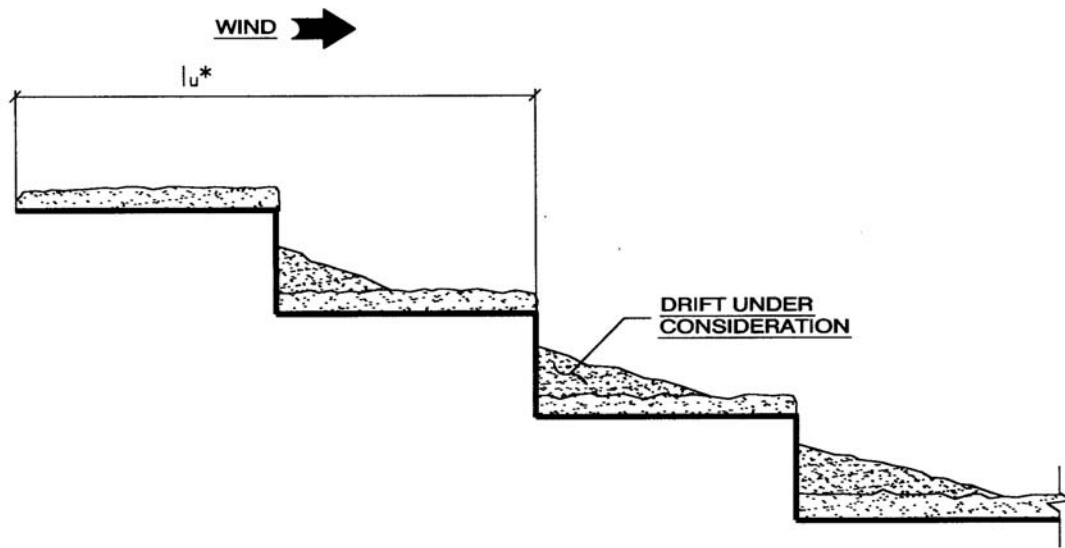
Figure 1608.5.1
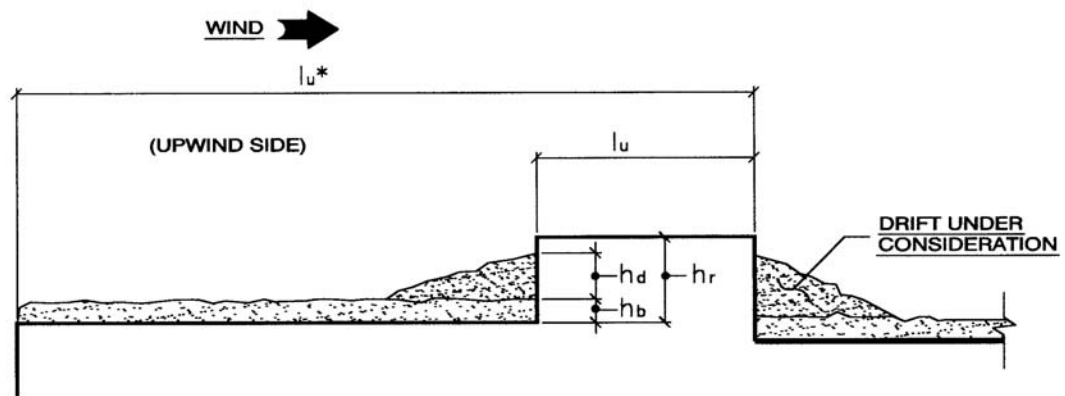**Drifting Snow At Multiple Level Roofs**

Figure 1608.5.2
Leeward Drift Affected by Upwind Windward Drift

1608.5.3 Very high roof separations. When the ratio h_r/L_T is greater than 1.0, where L_T is the dimension in feet of the upper roof perpendicular to the wind flow (perpendicular to l_u in Figure 7-8 of ASCE 7), the drift surcharge load on the lower roof due to drifting of snow from the upper roof may be reduced. The reduced height of the drift surcharge, h_{dr}, shall be not less than:

$$h_{dr} = h_r (2 - h_r/L_T)$$

except that when h_r/L_T is greater than 2.0, h_{dr} shall be equal to zero.

1608.5.4 Intersecting drifts. Where there are drifts at walls intersecting at an angle, the unit snow load at any point on the lower roof shall be not less than the greater of the unit loads from the two individual drift surcharges, plus the unit load of the balanced snow load.

1608.5.5 Snow pockets or wells. Account shall be taken of the load effects of potentially excessive snow accumulation in pockets or wells of roofs or decks.

1608.6 Roof Projections. The term roof projections used herein and In Section 7.8 of ASCE 7 shall be interpreted to include screen walls, parapets, fire wall projections, and mechanical equipment. Drift loads at roof projections shall be in accordance with Section 7.8 of ASCE 7, except that the width of drift shall be 8 times the height of the drift (8 times h_d or h_c in Figure 7-8, as applicable).

1608.7 Sliding snow. In addition to the sliding snow load on a lower roof as required in Section 7.9 of ASCE 7, the lower roof shall be designed for a windward drift surcharge at the wall separating the upper and lower roofs in accordance with 1608.5.1 and Section 7.8 of ASCE 7. The sliding snow load and the windward drift surcharge need not be considered to act concurrently.

1608.7.1 Snow guards. Sliding snow from an adjacent sloping high roof need not be considered on the low roof if snow guards, as specified herein, are provided on the high roof. In this case, the sloping roof with snow guards shall be designed for the unit snow loads required for a flat roof. Snow guards shall be designed by a registered design professional (RDP) qualified in the structural design of buildings. The design of the snow guards shall be shown on the construction documents. The RDP shall insure that there are adequate load paths from the snow guards into the supporting members and from the supporting members into the structure. The structural design of snow guards shall account for the impact of the sliding snow. The effectiveness in preventing the sliding of snow of proprietary snow guard systems shall be demonstrated by tests.

1608.8 Snow storage and collection areas: Consideration of potentially excessive snow accumulation shall be given to portions of structures designated or used as snow collection or storage areas during and after snow removal operations (e.g. temporary snow collection areas when mechanically removing snow from a roof; snow storage areas for parking structures).

SECTION 1609 WIND LOADS

This section is unique to Massachusetts

1609.1 General. Design wind loads shall be determined from Section 6 of ASCE 7, except as provide otherwise herein.

1609.2 Basic wind speed and wind directionality factor.

1609.2.1 Basic wind speed. In ASCE 7, disregard the body of the text after the section number and title of Section 6.5.4, disregard Subsection 6.5.4.1, and disregard Figure 6-1. The basic wind speed, V, used in the determination of design wind loads on buildings and other structures shall be as given in Section 1604.10, except as provide in Section 1609.2.2. V is the nominal 3-second gust wind speed in miles per hour at 33 feet (10 m) above ground for Exposure C category. The wind shall be assumed to come from any horizontal direction.

1609.2.2 Estimation of basic wind speeds from regional climatic data. In Subsection 6.5.4.2 of ASCE 7, replace "Fig. 6-1" wherever it occurs with "Section 1604.10 of the State Building Code."

1609.3 Anchorage against overturning, uplift and sliding. Structural members and systems, and components and cladding in a building or structure shall be anchored to resist wind-induced overturning, uplift and sliding and to provide continuous load paths for these forces to the foundation. Where a portion of the resistance to these forces is provided by dead load, the dead load, including the weight of soils and foundations, shall be taken as the minimum dead load likely to be in place during a design wind event.

1609.4 Wind and seismic detailing. Lateral-force-resisting systems shall meet seismic detailing requirements and limitations prescribed in this code, even when wind code prescribed load effects are greater than seismic load effects.

1609.5Enclosure classifications. Replace Section 6.5.9.3 of ASCE 7 with 1609.5.1.

1609.5.1 Protection of openings. In wind-borne debris regions, glazing in the lower 60 feet (18 288 mm) in buildings shall be assumed to be openings unless such glazing is impact resistant or protected with an impact-resistant covering meeting the requirements of an approved impact-resisting standard or ASTM E 1996 and of ASTM E 1886 referenced therein as follows:

  1. Glazed openings located within 30 feet (9144 mm) of grade shall meet the requirements of the Large Missile Test of ASTM E 1996.

2. Glazed openings located more than 30 feet (9144 mm) above grade shall meet the provisions of the Small Missile Test of ASTM E 1996.

Exceptions:

Wood structural panels with a minimum thickness of $^7/_{16}$ inch (11.1 mm) and maximum panel span of 8 feet (2438 mm) shall be permitted for opening protection in one- and two-story buildings. Panels shall be precut to cover the glazed openings with attachment hardware provided. Attachments shall be designed to resist the components and cladding loads determined in accordance with the provisions of Section 1609.6.5. Attachment in accordance with Table 1609.5.1 is permitted for buildings with a mean roof height of 33 feet (10 058 mm) or less where wind speeds (3-second gust) do not exceed 130 miles per hour.

Table 1609.5.1

WINDBORNE DEBRIS PROTECTION FASTENING SCHEDULE FOR WOOD STRUCTURAL PANELS[a,b,c]

FASTENER TYPE	FASTENER SPACING (inches)			
	Panel span ≤ 2 feet	2 feet ≤ Panel span ≤ 4 feet	4 feet < Panel span ≤ 6 feet	6 feet < Panel span ≤ 8 feet
2 $^1/_2$ # 6 Wood Screws	16	16	12	9
2 $^1/_2$ # 8 Wood Screws	16	16	16	12

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 0.454 kg, 1 mile per hour = 0.44 m/s.

a. This table is based on a maximum wind speed (3-second gust) of 130 mph and mean roof height of 33 feet or less.

b. Fasteners shall be installed at opposing ends of the wood structural panel.

c. Where screws are attached to masonry or masonry/stucco, they shall be attached utilizing vibration-resistant anchors having a minimum withdrawal capacity of 490 pounds.

1609.6 Rigid tile roof coverings. Rigid tile roof coverings that are air-permeable are permitted to be designed in accordance with Section 1609.6.1

1609.6.1 Wind loads on air permeable rigid tile roof coverings may be determined in accordance with the following equation:

$M_a = q_h C_L b L L_a [1.0 - Gc_p]$ **(Equation 16-36)**

where:

b = Exposed width feet (m) of the roof tile.

C_L = Lift coefficient. The lift coefficient for concrete and clay tile shall be 0.2 or shall be determined by test in accordance with Section 1715.2.

G_{cp} = Roof pressure coefficient for each applicable roof zone determined from Section 6 of ASCE 7. Roof coefficients shall not be adjusted for internal pressure.

L = Length feet (m) of the roof tile.

L_a = Moment arm feet (m) from the axis of rotation to the point of uplift on the roof tile. The point of uplift shall be taken at 0.76L from the head of the tile and the middle of the exposed width. For roof tiles with nails or screws (with or without a tail clip), the axis of rotation shall be taken as the head of the tile for direct deck application or as the top edge of the batten for battened applications. For roof tiles fastened only by a nail or screw along the side of the tile, the axis of rotation shall be determined by testing. For roof tiles installed with battens and fastened only by a clip near the tail of the tile, the moment arm shall be determined about the top edge of the batten with consideration given for the point of rotation of the tiles based on straight bond or broken bond and the tile profile.

M_a = Aerodynamic uplift moment feet-pounds (kN-m) acting to raise the tail of the tile.

q_h = Wind velocity pressure psf (kN/m^2) determined from Section 6.5.10 of ASCE 7.

Concrete and clay roof tiles complying with the following limitations shall be designed to withstand the aerodynamic uplift moment as determined by this section.

1. The roof tiles shall be either loose laid on battens, mechanically fastened, mortar set or adhesive set.

2. The roof tiles shall be installed on solid sheathing which has been designed as components and cladding.

3. An underlayment shall be installed in accordance with Chapter 15.

4. The tile shall be single lapped interlocking with a minimum head lap of not less than 2 inches (51 mm).

5. The length of the tile shall be between 1.0 and 1.75 feet (305 mm and 533 mm).

6. The exposed width of the tile shall be between 0.67 and 1.25 feet (204 mm

and 381 mm).

7. The maximum thickness of the tail of the tile shall not exceed 1.3 inches (33 mm).

8. Roof tiles using mortar set or adhesive set systems shall have at least two-thirds of the tile's area free of mortar or adhesive contact.

SECTION 1610 LATERAL SOIL AND HYDROSTATIC LOADS

[This section is unique to Massachusetts]

1610.1 General. Basement, foundation, and retaining walls shall be designed to resist lateral loads due to soil and water pressure. Lateral soil pressure on said walls shall be determined in accordance with the principles of soil mechanics and as provided in Chapter 18. Floors or similar elements below the water table shall be designed to resist the upward pressure of the water.

Exception: Uninhabitable spaces with concrete floors on the ground with an under-slab drainage system, including sump pits and sump pumps, designed to keep the water level a minimum of 1 foot below the bottom of the floor slab need not be designed to resist water pressure.

SECTION 1611 RAIN LOADS

1611.1 Design rain loads. Each portion of a roof shall be designed to sustain the load of rainwater that will accumulate on it if the primary drainage system for that portion is blocked plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow.

$R = 5.2 \, (d_s + d_h)$ **(Equation 16-37)**

For SI: $R = 0.0098 \, (d_s + d_h)$

where:

d_h = Additional depth of water on the undeflected roof above the inlet of secondary drainage system at its design flow (i.e., the hydraulic head), in inches (mm).

d_s = Depth of water on the undeflected roof up to the inlet of secondary drainage system when the primary drainage system is blocked (i.e., the static head), in inches (mm).

R = Rain load on the undeflected roof, in pounds per square foot (kN/m^2). When the phrase "undeflected roof" is used, deflections from loads (including dead

loads) shall not be considered when determining the amount of rain on the roof.

1611.2 Ponding instability. Ponding refers to the retention of water due solely to the deflection of relatively flat roofs. Roofs with a slope less than one-fourth unit vertical in 12 units horizontal (2-percent slope) shall be investigated by structural analysis to ensure that they possess adequate stiffness to preclude progressive deflection (i.e., instability) as rain falls on them or meltwater is created from snow on them. The larger of snow load or rain load shall be used in this analysis. The primary drainage system within an area subjected to ponding shall be considered to be blocked in this analysis.

1611.3 Controlled drainage. Roofs equipped with hardware to control the rate of drainage shall be equipped with a secondary drainage system at a higher elevation that limits accumulation of water on the roof above that elevation. Such roofs shall be designed to sustain the load of rainwater that will accumulate on them to the elevation of the secondary drainage system plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow determined from Section 1611.1. Such roofs shall also be checked for ponding instability in accordance with Section 1611.2.

SECTION 1612 FLOOD LOADS

[This section is unique to Massachusetts]

1612.1 General. Flood loads shall be determined in accordance with Section 5.3 of ASCE 7. Design and construction in flood zones shall be in accordance with ASCE 24 and 780 CMR 120.G and the more stringent design and construction requirements of ASCE 24 or 780 CMR 120.G , as applicable, shall be expressly identified at the building permit application stage and the more stringent requirements of either reference shall govern, except that flood loads shall be in accordance with the issue of ASCE 7 cited in Chapter 100 and "right-to construct" and structure-allowed elevations shall be governed by 780 CMR 120.G, MGL c.131 §40 and any bylaws or ordinances that have legal standing in a community.

SECTION 1613.0

EARTHQUAKE LOADS - PURPOSE

Sections 1613 through 1615 present criteria for the design and construction of buildings and non-building structures subject to earthquake ground motion. The specified earthquake loads rely on post-elastic energy dissipation in the structure, and because of this fact, the provisions for design, detailing and construction shall be satisfied even for structures and members for which load combinations containing earthquake load produce lesser effects than other load combinations.

The purposes of Sections 1613 through 1615 are to minimize the hazard to life of occupants of all buildings and non-building structures, to increase the expected performance of high occupancy assembly and education buildings as compared to ordinary buildings, and to improve the capability of essential facilities to function during and after an earthquake. Because of the complexity of and the great number of variables involved in seismic design (e.g. variability in ground motion, soil types, dynamic characteristics of the structure, material strength properties and construction practices), Sections 1613 through 1615 present only minimum criteria in general terms. These minimum criteria are considered to be prudent and economically justified for the protection of life safety in buildings subject to earthquakes and for improved capability of essential facilities to function immediately following an earthquake.

Absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, cannot be achieved economically for most buildings. The "design earthquake" ground motion levels specified herein may result in both structural and non-structural damage. For most buildings designed and constructed according to Sections 1613 through 1615, it is expected that structural damage from a major earthquake may be repairable but the repair may not be economically feasible. For ground motions larger than the design levels, the intent of Sections 1613 through 1615 is that there be a low likelihood of building collapse.

SECTION 1614

EARTHQUAKE LOADS — GENERAL

1614.1 Scope   Every building and portion thereof, and certain non-building structures as provided herein, shall as a minimum be designed and constructed to resist the effects of earthquake motions and assigned a seismic design category as set forth in these provisions. Except as noted below in Exceptions, structures shall be designed in accordance with the provisions of ASCE 7 Sections 9.1.2.4, 9.1.2.5, 9.1.3, 9.1.4, 9.2 through 9.6, 9.13 and 9.14, as modified below. ASCE 7 Appendix A.9 and B.0 are not applicable. All references to ASCE 7 Sections 9.7 through 9.12 shall be revised as follows.

ASCE 7	*MASS STATE BUILDING CODE*
9.7 Foundation Design Requirements	*Ch.18 Soils and Foundations*
9.8 Steel	*Ch. 22 Steel*
9.9 Structural Concrete	*Ch. 19 Concrete*
9.10 Composite Structure	*(not applicable)*
9.11 Masonry	*Chapter 21 Masonry*
9.12 Wood	*Chapter 23 Wood*

Exceptions:

1. *Detached one- and two-family dwellings are exempt from the requirements of these provisions.*
2. *Agricultural storage buildings that are intended only for incidental human occupancy are exempt from the requirements of these provisions.*

3. *Additions to existing buildings: An addition that is attached to an existing*

building shall be designed and constructed in accordance with the requirements of Chapter 34. Structurally separate additions shall be designed and constructed in accordance with Chapter 16.

4. *Change of occupancy: Where a change of occupancy occurs in an existing building, the building shall conform to the provisions of Chapter 34.*

5. *Alterations: Where alterations are made to an existing building, the building shall conform to the provisions of Chapter 34.*

6. *Special structures including, but not limited to, vehicular bridges, transmission towers, hydraulic structures, and nuclear power generating facilities shall be designed to resist earthquake loads, but require special consideration of their response characteristics and environment that is beyond the scope of these provisions.*

1614.2 Additions to existing buildings. *See provisions of Chapter 34, except that Chapter 16 applies to structurally separate additions.*

1614.3 Quality assurance. *A Quality Assurance Plan shall be provided where required by Chapter 17.*

SECTION 1615 EARTHQUAKE LOADS — MODIFICATIONS TO APPLICABLE PROVISIONS OF ASCE 7 *(Note that the following subsections, commencing with the prefix number "9" are referring to applicable sections of ASCE 7).*

Section 1615.1 Applicable ASCE 7 Sections. *The provisions of ASCE 7 Sections 9.1.2.4, 9.1.2.5, 9.1.3, 9.1.4, 9.2 through 9.6, 9.13 and 9.14 shall apply except as modified herein.*

9.1.2.4.1 New Buildings. *Delete the text of this section in its entirety and substitute the following: "New buildings and structures shall be designed and constructed in accordance with the quality assurance requirements of Chapter 17. The analysis and design of structural systems and components, including foundations, frames, walls, floors and roofs shall be in accordance with the applicable requirements of Section 9.5. The additional foundation requirements of Chapter 18 of the Massachusetts State Building Code shall be followed. Materials used in construction and components made of these materials shall be designed and constructed to meet the requirements of Chapters 19 through 23 of the Massachusetts State Building Code. Architectural, electrical and mechanical systems and components including tenant improvements shall be designed in accordance with Section 9.6."*

9.2.1 Definitions. *Delete the first paragraph and substitute the following: "The definitions presented in this Section provide the meaning of the terms used in these provisions. Definitions of terms that have a specific meaning relative to the use of concrete, masonry, steel or wood are presented in the Chapter devoted to the material (Chapters 19, 21, 22 and 23, respectively of the Massachusetts State Building Code). Disregard ASCE 7 references to non-applicable Sections and Appendix A9."*

9.2.2 Symbols. *Delete the second sentence and substitute the following: "The symbols and definitions presented in this Section apply to these provisions as indicated, except that references to 'A9.8' apply to Chapter 22 of the Massachusetts State Building Code and references to 'A9.9' apply to Chapter 19 of the Massachusetts State Building Code."*

SECTION 9.4 –*Seismic Design Criteria*

Section 9.4.1 Procedures for Determining Maximum Considered Earthquake and Design Earthquake Ground Motion Accelerations and Response Spectra. *Delete the second sentence and substitute the following:" The general procedure in which spectral response acceleration parameters for the maximum considered earthquake ground motions are derived using Table 1604.10 of the Massachusetts State Building Code, modified by site coefficients to include local site effects and scaled to design values, are permitted to be used for any structure except as specifically indicated in these provisions."*

Section 9.4.1.1 Maximum Considered Earthquake Ground Motions. *Delete the first sentence and substitute the following: "The maximum considered earthquake ground motions shall be as represented by the spectral response acceleration at short periods , S_S, and at 1-sec, S_1, obtained from Table 1604.10 of the Massachusetts State Building Code and adjusted for Site Class effects using the site coefficients of Section 9.4.1.2.4."*

Section 9.4.1.2 General Procedure for Determining Maximum Considered Earthquake and Design Spectral Response Accelerations. *Delete the first sentence and substitute the following: "The maximum considered earthquake spectral response acceleration at short periods, S_S, and at 1-sec, S_1, shall be determined from Table 1604.10 of the Massachusetts State Building Code based on the municipality in which the site is located. Where a site is located in more than one municipality, the higher spectral response acceleration values shall be used."*

Section 9.4.1.2.1 Site Class Definitions. *At the end of sub-paragraph 1, add the following sentence: "Potential for liquefaction shall be evaluated in accordance with Section 1804.6 Liquefaction of the Massachusetts State Building Code." Also, delete: "Exception: For Structures….9.4.1.2.4b." At the end of sub-paragraph 4, delete: "Exception: When the soil…geotechnical data."*

Section 9.4.1.2.2 Steps for Classifying a Site. *At the end of Step 1 add the following: "Exception: Refer to exception in Note a in Table 9.4.1.2.4a and in Table 9.4.1.2.4b." At the end of Step 3, paragraph a., delete the last sentence: "The rock categories, Site Classes A and B…or mat foundation." Add to Step 3 the following two paragraphs:*

> d. *When soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the building official determines that soils of Site Class E or Site Class F are likely to be present at the site.*
> e. *The rock categories, Site Classes A and B, shall not be assigned to a site if there is more than 10 ft (3m) of soil between the rock surface and the bottom of the spread footing or mat foundation.*

Section 9.4.1.2.3 Definitions of Site Class Parameters. *In the second sentence, replace "…soil layers…" with "…soil and/or rock layers…" Also, in the paragraph that begins with "N_i is the Standard…" Add the following sentence to the end of the paragraph: "When refusal is met for a rock layer, N_i shall be taken as 100 blows/foot." Following Equation EQ. 9.4.1.2-2, insert the following text: "where N_i and d_i in Eq. 9.4.1.2-2 are for cohesionless soil, cohesive soil, and rock layers."*

Delete **Figures 9.4.1.1(a)** *through* **9.4.1.1(j)** *of ASCE 7 in their entirety. All references*

to these figures must be replaced with a reference to Table 1604.10 of the Massachusetts State Building Code.

Refer to Table 1604.10 of the Massachusetts State Building Code in lieu of ASCE 7 Figures 9.4.1.1(a) through 9.4.1.1(j).

Section 9.4.1.2.4 Site Coefficients and Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameters. *Delete the word "mapped" from the definitions of S_1 and S_S and substitute "tabulated."*

TABLE 9.4.1.2.4a
VALUES OF F_a AS A FUNCTION OF SITE CLASS AND SHORT PERIOD MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL ACCELERATION

Site Class	Tabulated Maximum Considered Earthquake Spectral Response Acceleration at Short Periods			
	$S_S \leq 0.26$	$0.27 \leq S_S \leq 0.29$	$0.30 \leq S_S \leq 0.32$	$0.33 \leq S_S \leq 0.35$
A	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0
C	1.2	1.2	1.2	1.2
D	1.6	1.6	1.55	1.5
E	2.5	2.4	2.3	2.2
F	Note a	Note a	Note a	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_a for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of Section 9.4.1.2.2.

TABLE 9.4.1.2.4b
VALUES OF F_v AS A FUNCTION OF SITE CLASS

Site Class	Tabulated Maximum Considered Earthquake Spectral Response Acceleration at 1-Second Periods
	$S_1 \leq 0.1$
A	0.8
B	1.0
C	1.7
D	2.4
E	3.5
F	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_v for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of Section 9.4.1.2.2.

Section 9.4.2 Seismic Design Category. *Add the following sentence to the end of this section: "Seismic Design Categories A, E and F are not applicable in Massachusetts."*

Section 9.4.2.1 Determination of Seismic Design Category. *At the end of this section add the following paragraph.*

"Exception: The seismic Design Category is permitted to be determined from Table 9.4.2.1a alone when all of the following apply:

1. *In each of the two orthogonal directions, the approximate fundamental period of the structure, T_a, determined in accordance with Section 9.5.5.3.2, is less than $0.8T_s$, where T_s is determined in accordance with Section 9.4.1.2.6 and*

2. *In each of the two orthogonal directions, the fundamental period of the structure used to calculate the story drift is less than T_s and*

3. *Equation 9.5.5.2.1-1 is used to determine the seismic response coefficient, C_s and*

4. *The diaphragms are rigid or for diaphragms that are flexible, the distance between vertical elements of the seismic force-resisting system does not exceed 40 feet.*

TABLE 9.4.2.1a
SEISMIC DESIGN CATEGORY BASED UPON SHORT
PERIOD RESPONSE ACCELERATIONS

Value of S_{DS}	Seismic Use Group		
	I	II	III
$S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS}$	D	D	D

TABLE 9.4.2.1b
SEISMIC DESIGN CATEGORY BASED UPON
1-SECOND PERIOD RESPONSE ACCELERATIONS

Value of S_{D1}	Seismic Use Group		
	I	II	III
$S_{D1} < 0.133g$	B	B	C
$0.133g \leq S_{D1} < 0.20g$	C	C	D
$0.20g \leq S_{D1}$	D	D	D

Section 9.4.3 Quality Assurance. *See Section 1614.3 of the Massachusetts State Building Code.*

9.5 STRUCTURAL DESIGN CRITERIA, ANALYSIS, AND PROCEDURES

Section 9.5.2.1 Design Basis. *Add the following at the end of this section:*

"The foundation elements shall be designed to resist the forces developed and shall accommodate the movements imparted to the building by the design ground motions. The foundation design criteria shall account for the dynamic nature of the seismic forces, the design ground motions, and the design basis for strength and ductility of the structure.

Consideration shall be given to the manner in which the earthquake lateral force, computed in accordance with Section 9.5.2.5, will be transmitted from the soil or rock to the structure. Transmission of the lateral force will occur through one or more of the following foundation elements:

    a. *Lateral soil pressure against foundation walls, footings, grade beams and/or pile caps;*
    b. *Lateral soil pressure against piles, piers or caissons;*
    c. *Side or bottom friction on walls, footings or mats; or*
    d. *Batter piles.*

Bottom friction under pile caps shall be assumed to be ineffective in transmitting horizontal forces.
The horizontal force shall be distributed among the various elements of the foundation in proportion to their estimated rigidities. Any element which will participate in the transfer of horizontal forces from the soil or rock to the structure shall be designed to resist forces in such a way that its ability to sustain static load will not be impaired."

TABLE 9.5.2.2 - HERE

Section 9.5.2.6 Design and Detailing Requirements. *Delete this paragraph and substitute the following: "The design and detailing of the components of the seismic force-resisting system shall comply with the requirements of this Section. Foundation design shall conform to the applicable requirements of Chapter 18 of the Massachusetts State Building Code. The materials and the systems composed of those materials shall conform to the requirements of Chapter 19 through Chapter 23 of the Massachusetts State Building Code for the applicable category."*

9.5.2.6.1.2 Anchorage of Concrete or Masonry Walls. *In the last sentence, delete the words "…combinations of Section 2.3.2 or 2.4.1." and substitute the following: "…combinations of Sections 1605.2.1 and 1605.3.1 of the Massachusetts State Building Code. Also see Section 1604.8 of the Massachusetts State Building Code."*

9.5.2.6.2.5 Nonredundant Systems. *Delete "…Section 1.4." and substitute "…Section 1604.11 of the Massachusetts State Building Code."*

9.5.2.6.2.8 *Change the section heading to the following: "Design of Concrete or*

Masonry Walls and Their Anchorage for Out-of-Plane Forces." Delete the text of the entire section and substitute the following: "Concrete or masonry walls and their anchorage shall be designed for a force normal to the surface equal to 40% of the short period spectral response acceleration, S_{DS}, times the occupancy importance factor, I, multiplied by the weight of wall, with a minimum force of 10 % of the weight of the wall. Walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 ft. Interconnection of wall elements and connections to supporting framing systems shall have sufficient ductility, rotational capacity, or sufficient strength to resist shrinkage, thermal changes, and differential foundation settlement when combined with seismic forces."

Add a new section 9.5.2.6.2.8.1 as follows:

9.5.2.6.2.8.1 Anchorage of Concrete or Masonry Walls. The anchorage of concrete or masonry walls to floors, roofs and other structural elements that provide lateral support to the wall or are supported by the wall shall provide a positive direct connection capable of resisting the greater of the following:

1. *A force of $0.4 S_{DS} I W_c$, except that a force of $0.8 S_{DS} I W_c$ lbs/linear ft of wall shall apply for anchorage to flexible diaphragms,*

2. *A force of $400 S_{DS} I$ lbs/linear ft ($5.84 S_{DS} I$ kN/m) of wall,*

3. *280 lbs/linear ft of wall,*

4. *where I = the occupancy importance factor , per Section 9.1.4.and W_c = the weight of wall tributary to the anchor.*

9.5.2.6.3.2 Change the section title to the following: Design and Anchorage of Concrete or Masonry Walls. Delete the first two paragraphs, including the equation and the definitions that follow, and begin with the paragraph which starts: "Diaphragms shall be provided with continuous ties or struts…"

9.5.2.6.4.2 Plan or Vertical Irregularitites. Delete the first paragraph in its entirety, and begin with the paragraph which starts: "For structures having a plan structural irregularity…"

9.5.2.7 Combination of Load Effects. *Delete text of the entire section and substitute the following:*

"The effects on the structure and its components due to seismic forces shall be combined with the effects of other loads in accordance with the combinations of load effects given in Section 1605 of the Massachusetts State Building Code. For use with those combinations, the earthquake-induced force effect shall include vertical and horizontal effects as given by Eq. 9.5.2.7-1 or 9.5.2.7-2, as applicable. The vertical seismic effect term $0.2 S_{DS} D$ need not be included where S_{DS} is equal to or less than 0.125 in Eqs. 9.5.2.7-1, 9.5.2.7-2, 9.5.2.7.1-1, and 9.5.2.7.1-2. The vertical seismic effect term $0.2 S_{DS} D$ need not be included in Eq. 9.5.2.7-2 when considering foundation overturning.

For formula (16-5) in Section 1605.2.1 or formula (16-10) in Section 1605.3.1:

$$E = \rho\, Q_E + 0.2\, S_{DS}\, D \qquad\qquad (Eq.\ 9.5.2.7\text{-}1)$$

For formula (16-6) in Section 1605.2.1 or formula (16-12) in Section 1605.3.1:

$$E = \rho\, Q_E - 0.2 S_{DS}\, D \qquad\qquad (Eq.\ 9.5.2.7\text{-}2)$$

Where:

E = the effect of horizontal and vertical earthquake-induced forces

S_{DS} = the design spectral response acceleration at short periods obtained from Section 9.4.1.2.5

D = the effect of dead load, D

Q_E = the effect of horizontal seismic (earthquake-induced) forces

ρ = the reliability factor obtained from Section 9.5.2.4"

9.5.2.7.1 Special Seismic Load. Delete text of the entire section and substitute the following:

"Where specifically required by this Code, the special seismic load of Eq. 9.5.2.7.1-1 shall be used to compute E for use in formula (16-5) in Section 1605.2.1 or formula (16-10) in Section 1605.3.1 of the Massachusetts State Building Code and the special seismic load of Eq. 9.5.2.7.1-2 shall be used to compute E in formula (16-6) in Section 1605.2.1 or formula (16-12) in Section 1605.3.1 of the Massachusetts State Building Code:

$$E = \Omega_o\, Q_E + 0.2\, S_{DS}\, D \qquad (Eq.\ 9.5.2.7.1\text{-}1)$$
$$E = \Omega_o\, Q_E - 0.2\, S_{DS}\, D \qquad (Eq.\ 9.5.2.7.1\text{-}2)$$

The value of the quantity $\Omega_o\, Q_E$ in Eqs. 9.5.2.7.1-1 and 9.5.2.7.1-2 need not be taken greater than the capacity of other elements of the structure to transfer force to the component under consideration.

Where allowable stress methodologies are used with the special load of this Section applied in formulas (16-10) or (16-12) of Section 1605.3.1 of the Massachusetts State Building Code, allowable stresses are permitted to be determined using an allowable stress increase of 1.1. This increase shall not be combined with increases in allowable stresses or load combination reductions otherwise permitted by this standard or the material reference standard except that combination with the duration of load increases permitted in Chapter 23 of the Massachusetts State Building Code is permitted."

9.5.2.8 Deflection, Drift Limits, and Building Separation. Delete the third sentence,

and substitute the following: "All portions of the structure shall be designed and constructed to act as an integral unit in resisting seismic forces unless separated by a distance sufficient to avoid damaging contact under total deflection δ_x as determined in Section 9.5.5.7 and below. All structures shall be separated from adjoining structures. Separations shall allow for the displacement δ_M. Adjacent structures on the same property shall be separated by at least δ_{MT}, at all levels, where

$$\delta_{MT} = \sqrt{[(\delta_{M1})^2 + (\delta_{M2})^2]} \qquad \text{(Equation 9.5.2.8-1)}$$

and δ_{M1} and δ_{M2} are the displacements of the adjacent buildings. When a structure adjoins a property line not common to a public way, that structure shall also be set back from the property line by at least the displacement, δ_M, of that structure.

Exception: Smaller separations or property line setbacks shall be permitted when justified by engineering analyses based on maximum expected ground motions."

Add a new section 9.5.2.9 as follows:

"9.5.2.9 Foundation Walls and Retaining Walls. Exterior foundation walls and retaining walls shall be designed to resist at least the superimposed effects of the total static lateral soil and ground water pressures, excluding the pressure caused by any temporary surcharge, plus an earthquake force, F_w , for horizontal backfill surface, equal to:

$$F_w = 0.375(S_1)(F_v)(Y_t)(H)^2$$

where S_1 is the maximum considered earthquake spectral response acceleration at a period of 1-second from Table 1604.10 of the Massachusetts State Building Code, F_v is the soil amplification factor from Table 9.4.1.2.4b, Y_t is the total unit weight of the soil, and H is the height of the wall measured as the difference in elevation of finished ground surface or floor in front of and behind the wall.

Surcharges which are applied over extended periods of time shall be included in the total static lateral soil pressure and their earthquake lateral force shall be computed and added to the force determined above. The earthquake force from the backfill shall be distributed as an inverse triangle over the height of the wall.

The point of application of the earthquake force from an extended duration surcharge shall be determined on an individual case basis. If the backfill or the existing soil behind the backfill consists of loose saturated granular soil, the potential for liquefaction of the backfill or existing soil adjacent to the wall during seismic loading shall be evaluated in accordance with the requirements of Section 1804.6 of the Massachusetts State Building Code. If the backfill or existing soil beyond the backfill is potentially subject to liquefaction, the increase in design lateral load on the foundation wall or retaining wall shall be determined by a registered professional engineer, registered in the Commonwealth of Massachusetts.

For use in wall strength design, a load factor of 1.43 times the earthquake force calculated above shall be applied."

9.5.3 *Change the section title to the following: "Effective Seismic Weight." Delete the text of the entire section and substitute the following:*

"The effective seismic weight, W, of the structure shall include the total dead load and other loads listed below:

1. *In areas used for storage, a minimum of 25 % of the floor live load (floor live load in public garages and open parking structures need not be included).*

2. *Where an allowance for partition load is included in the floor load design, the actual partition weight or a minimum weight of 10 psf (0.48 kN/m2) of floor area, whichever is greater.*

3. *Total operating weight of permanent equipment.*

4. *50 % of the roof snow load.*

9.5.5.2 Seismic Base Shear. *Delete the definition for "W" and substitute the following:*

"W = the effective seismic weight of the structure as defined in Section 9.5.3."

9.6 Architectural, Mechanical, and Electrical Components and Systems

9.6.1 General. Delete the text of Exceptions 1 through 4 and substitute the following:

1. *Not Used*
2. *Non-fireresistance rated ceilings and access floors in Seismic Design Category B and C structures which are in Seismic Use Group I.*
3. *Mechanical and Electrical components in structures assigned to Seismic Design Category B provided the Importance Factor I = 1.0.*
4. *Mechanical and Electrical components in structures assigned to Seismic Design Category C provided the Importance factor I = 1.0 and having a_p = 1.0, other than elevator components and systems in buildings more than 70 feet in height.*

9.6.1.5 Component Importance Factor. Add the following as the second item in the list: "I_p = 1.5 for stair and elevator enclosures and for non-loadbearing walls and/or partitions that form the exit from the facility and are required by other provisions of the code to provide a fire resistance rating for protection from smoke and fire for the means of egress path leading from the interior of the building to an exit discharge."

9.6.1.7 Construction Documents. Delete the text of the entire section and substitute the following: "Construction documents shall show the design and anchorage of all

architectural, mechanical and electrical components and systems to the structure, except that the construction documents may alternatively include performance specifications for the design and detailing of components and systems and their anchorage. The performance specifications shall require that the design and detailing of components and systems be prepared by a professional engineer(s), registered in the Commonwealth of Massachusetts."

Delete Table 9.6.1.7 in its entirety.

9.6.2.2 Architectural Component Forces and Displacements. Add the following sentence at the end of the section: "Anchorage forces for concrete or masonry walls shall not be less than that required by Section 9.5.2.6."

Table 9.6.2.2 Under the first item, Interior Nonstructural Walls and Partitions, substitute the following: "Plain (unreinforced) masonry walls are not permitted."

9.6.2.6.2.1 Change the section heading to the following : Seismic Design Categories B and C. Revise the first sentence to read …. "Suspended ceilings in Seismic Design Categories B and C shall be designed ….." Also, add the following sentence to end of first paragraph: "Note that design of non-fireresistance rated ceilings in Seismic Design Categories B and C which are in Seismic Use Group I need not meet these requirements."

9.13.6.2.3 Fire Resistance. Delete the text of this section and substitute the following: "Fire resistance ratings of the isolation system shall comply with Section 714.7 of the Massachusetts State Building Code."

9.14.6.6.1 General. Add the following after the first sentence: "A pier or wharf supporting a building or buildings shall be designed considering soil-structure interaction and the dynamic properties of the combined building/pier or building/wharf structure for earthquake loads specified in this code."

SECTIONS 1616 THROUGH 1623 RESERVED

SECTION 1624 IN-SITU LOAD TESTS

1624.1 General. Whenever there is a reasonable doubt as to the stability or load-bearing capacity of a completed building, structure or portion thereof for the expected loads, an engineering assessment shall be required. The engineering assessment shall involve either a structural analysis or an in-situ load test, or both. The structural analysis shall be based on actual material properties and

other as-built conditions that affect stability or load-bearing capacity, and shall be conducted in accordance with the applicable design standard. If the structural assessment determines that the load-bearing capacity is less than that required by the code, load tests shall be conducted in accordance with Section 1624.2. If the building, structure or portion thereof is found to have inadequate stability or load-bearing capacity for the expected loads, modifications to ensure structural adequacy or the removal of the inadequate construction shall be required.

1624.2 Test standards. Structural components and assemblies shall be tested in accordance with the appropriate material standards listed in Chapter 35. In the absence of a standard that contains an applicable load test procedure, the test procedure shall be developed by a registered design professional and approved. The test procedure shall simulate loads and conditions of application that the completed structure or portion thereof will be subjected to in normal use.

1624.3 In-situ load tests. In-situ load tests shall be conducted in accordance with Section 1624.3.1 or 1624.3.2 and shall be supervised by a registered design professional. The test shall simulate the applicable loading conditions specified in Chapter 16 as necessary to address the concerns regarding structural stability of the building, structure or portion thereof.

1624.3.1 Load test procedure specified. Where a standard listed in Chapter 35 contains an applicable load test procedure and acceptance criteria, the test procedure and acceptance criteria in the standard shall apply. In the absence of specific load factors or acceptance criteria, the load factors and acceptance criteria in Section 1624.3.2 shall apply.

1624.3.2 Load test procedure not specified. In the absence of applicable load test procedures contained within a standard referenced by this code or acceptance criteria for a specific material or method of construction, such existing structure shall be subjected to a test procedure developed by a registered design professional that simulates applicable loading and deformation conditions. For components that are not a part of the seismic load-resisting system, the test load shall be equal to two times the unfactored design loads. The test load shall be left in place for a period of 24 hours. The structure shall be considered to have successfully met the test requirements where the following criteria are satisfied:

1. Under the design load, the deflection shall not exceed the limitations specified in Section 1604.3.

2. Within 24 hours after removal of the test load, the structure shall have recovered not less than 75 percent of the maximum deflection.

3. During and immediately after the test, the structure shall not show evidence of failure.

SECTION 1625 ALTERNATIVE TEST PROCEDURE

1625.1 General. For materials and assemblies that are not specifically provided for in this code, the design strengths and permissible stresses shall be established by tests or a combination of tests and structural analysis.

1625.2 Tests by approved agencies. The building official shall accept duly authenticated reports from approved agencies in respect to the quality and manner of use of new materials or assemblies as provided for in Section 109.4.

1625.3 Cost of tests. The cost of all tests and other investigations required under the provisions of this code shall be borne by the permit applicant.

SECTION 1626 TEST SAFE LOAD

1626.1 Where required. Where proposed construction is not capable of being designed by approved engineering analysis, or where proposed construction design method does not comply with the applicable material design standard, the system of construction or the structural unit and the connections shall be subjected to the tests prescribed in Section 1627. The building official shall accept certified reports of such tests conducted by an approved testing agency, provided that such tests meet the requirements of this code and approved procedures.

SECTION 1627 PRECONSTRUCTION LOAD TESTS

1627.1 General. In evaluating the physical properties of materials and methods of construction that are not capable of being designed by approved engineering analysis or that do not comply with applicable material design standards listed in Chapter 35, the structural adequacy shall be predetermined based on the load test criteria established in this section.

1627.2 Load test procedures specified. Where specific load test procedures, load factors and acceptance criteria are included in the applicable design standards listed in Chapter 35, such test procedures, load factors and acceptance criteria shall apply. In the absence of specific test procedures, load factors or acceptance criteria, the corresponding provisions in Section 1627.3 shall apply.

1627.3 Load test procedures not specified. Where load test procedures are not specified in the applicable design standards listed in Chapter 35, the load-bearing and deformation capacity of structural components and assemblies shall be determined on the basis of a test procedure developed by a registered design professional that simulates applicable loading and deformation conditions. For components and assemblies that are not a part of the seismic load-resisting system, the test shall be as specified in Section 1627.3.1. Load tests shall simulate the applicable loading conditions specified in Chapter 16.

1627.3.1 Test procedure. The test assembly shall be subjected to an increasing superimposed load equal to not less than two times the superimposed design load. The test load shall be left in place for a period of 24 hours. The tested assembly shall be considered to have successfully met the test requirements if the assembly recovers not less than 75 percent of the maximum deflection within 24 hours after the removal of the test load. The test assembly shall then be reloaded and subjected to an increasing superimposed load until either structural failure occurs or the superimposed load is equal to two and one-half times the load at which the deflection limitations specified in Section 1627.3.2 were reached, or the load is equal to two and one-half times the superimposed design load. In the case of structural components and assemblies for which deflection limitations are not specified in Section 1627.3.2, the test specimen shall be subjected to an increasing superimposed load until structural failure occurs or the load is equal to two and one-half times the desired superimposed design load. The allowable superimposed design load shall be taken as the lesser of:

1. The load at the deflection limitation given in Section 1627.3.2.

2. The failure load divided by 2.5.

3. The maximum load applied divided by 2.5.

1627.3.2 Deflection. The deflection of structural members under the design load shall not exceed the limitations in Section 1604.3.

1627.4 Wall and partition assemblies. Load-bearing wall and partition assemblies shall sustain the test load both with and without window framing. The test load shall include all design load components. Wall and partition assemblies shall be tested both with and without door and window framing.

1627.5 Exterior window and door assemblies. The design pressure rating of exterior windows and doors in buildings shall be determined in accordance with Section 1627.5.1 or 1627.5.2.

Exception: Structural wind load design pressures for window units smaller than the

size tested in accordance with Section 1627.5.1 or 1627.5.2 shall be permitted to be higher than the design value of the tested unit provided such higher pressures are determined by accepted engineering analysis. All components of the small unit shall be the same as the tested unit. Where such calculated design pressures are used, they shall be validated by an additional test of the window unit having the highest allowable design pressure.

1627.5.1 Aluminum, vinyl and wood exterior windows and glass doors. Aluminum, vinyl and wood exterior windows and glass doors shall be labeled as conforming to AAMA/NWWDA 101/I.S.2 or 101/I.S.2/NAFS. The label shall state the name of the manufacturer, the approved labeling agency and the product designation as specified in AAMA/NWWDA 101/I.S.2 or 101/I.S.2/NAFS. Products tested and labeled as conforming to AAMA/NWWDA 101/I.S.2 or 101/I.S.2/NAFS shall not be subject to the requirements of Sections 2403.2 and 2403.3.

1627.5.2 Exterior windows and door assemblies not provided for in Section 1627.5.1. Exterior window and door assemblies shall be tested in accordance with ASTM E 330. Exterior window and door assemblies containing glass shall comply with Section 2403. The design pressure for testing shall be calculated in accordance with Chapter 16. Each assembly shall be tested for 10 seconds at a load equal to 1.5 times the design pressure.

1627.6 Test specimens. Test specimens and construction shall be representative of the materials, workmanship and details normally used in practice. The properties of the materials used to construct the test assembly shall be determined on the basis of tests on samples taken from the load assembly or on representative samples of the materials used to construct the load test assembly. Required tests shall be conducted or witnessed by an approved agency.