Section 4.1. Structural Loads and Procedures

4.1.1.1. Scope

1) The scope of this Part shall be as described in Subsection 1.3.3. of Division A.

4.1.1.2. Definitions

1) Words that appear in italics in this Part are defined in Article 1.4.1.2. of Division A.

4.1.1.3. Design Requirements

1) Buildings and their structural members and connections, including formwork and falsework, shall be designed to have sufficient structural capacity and structural integrity to safely and effectively resist all loads, effects of loads and influences that may reasonably be expected, having regard to the expected service life of buildings, and shall in any case satisfy the requirements of this Section. (See Appendix A.)

2) Buildings and their structural members shall be designed for serviceability, in accordance with Articles 4.1.3.4., 4.1.3.5., and 4.1.3.6. (See Appendix A.)

3) All permanent and temporary structural members, including the formwork and falsework of a building, shall be protected against loads exceeding the specified loads during the construction period except when, as verified by analysis or test, temporary overloading of a structural member would result in no impairment of that member or any other member.

4) Falsework, scaffolding, and formwork shall be designed in conformance with
   a) CSA S269.1, “Falsework for Construction Purposes,”
   b) CAN/CSA-S269.2-M, “Access Scaffolding for Construction Purposes,” or
   c) CAN/CSA-S269.3-M, “Concrete Formwork.”
5) Precautions shall be taken during all phases of construction to ensure that the building is not damaged or distorted due to loads applied during construction.

### 4.1.1.4. Structural Drawings and Related Documents

1) Structural drawings and related documents shall conform to the appropriate requirements of Section 2.2. of Division C. (See Subsection 2.2.4. of Division C.)

### 4.1.1.5. Design Basis

1) Except as provided in Sentence (2), buildings and their structural members shall be designed in conformance with the procedures and practices provided in this Part.

2) Provided the design is carried out by a person especially qualified in the specific methods applied and provided the design demonstrates a level of safety and performance in accordance with the requirements of Part 4, buildings and their structural components falling within the scope of Part 4 that are not amenable to analysis using a generally established theory may be designed by
   a) evaluation of a full-scale structure or a prototype by a loading test, or
   b) studies of model analogues.
(See Appendix A.)

### 4.1.2. SPECIFIED LOADS AND EFFECTS

(See User’s Guide - NBC 2010, Structural Commentaries (Part 4 of Division B).)

#### 4.1.2.1. Loads and Effects

(See Appendix A.)

1) Except as provided in Article 4.1.2.2., the following categories of loads, specified loads and effects shall be taken into consideration in the design of a building and its structural members and connections:

- **Dead load** – a permanent load due to the weight of building components, as specified in Subsection 4.1.4.,
- **Earthquake load and effects** – a rare load due to an earthquake, as specified in Subsection 4.1.8.,
A permanent load due to lateral earth pressure, including groundwater,

live load – a variable load due to intended use and occupancy (including loads due to cranes and the pressure of liquids in containers), as specified in Subsection 4.1.5.,

live load exclusive of crane loads,

live load due to cranes including self weight,

Self weight of all cranes positioned for maximum effects,

crane bumper impact load,

permanent effects caused by pre-stress,

variable load due to snow, including ice and associated rain, as specified in Article 4.1.6.2., or due to rain, as specified in Article 4.1.6.4.,

effects due to contraction, expansion, or deflection caused by temperature changes, shrinkage, moisture changes, creep, ground settlement, or a combination thereof (see Appendix A), and

wind load – a variable load due to wind, as specified in Subsection 4.1.7.,

where

a) load means the imposed deformations (i.e. deflections, displacements or motions that induce deformations and forces in the structure), forces and pressures applied to the building structure,
b) permanent load is a load that changes very little once it has been applied to the structure, except during repair,
c) variable load is a load that frequently changes in magnitude, direction or location, and
d) rare load is a load that occurs infrequently and for a short time only.

2) Minimum specified values of the loads described in Sentence (1), as set forth in Subsections 4.1.4. to 4.1.8., shall be increased to account for dynamic effects where applicable.

3) For the purpose of determining specified loads S, W or E in Subsections 4.1.6., 4.1.7. and 4.1.8., buildings shall be assigned an Importance Category based on intended use and occupancy, in accordance with Table 4.1.2.1. (See Appendix A.)
Table 4.1.2.1.
Importance Categories for Buildings
Forming part of Sentence 4.1.2.1.(3)

<table>
<thead>
<tr>
<th>Use and Occupancy</th>
<th>Importance Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings that represent a low direct or indirect hazard to human life in the event of failure, including: low human-occupancy buildings, where it can be shown that collapse is not likely to cause injury or other serious consequences minor storage buildings</td>
<td>Low&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>All buildings except those listed in Importance Categories Low, High and Post-disaster</td>
<td>Normal</td>
</tr>
<tr>
<td>Buildings that are likely to be used as post-disaster shelters, including buildings whose primary use is: as an elementary, middle or secondary school as a community centre</td>
<td>High</td>
</tr>
</tbody>
</table>
Manufacturing and storage facilities containing toxic, explosive or other hazardous substances in sufficient quantities to be dangerous to the public if released[^1]

*Post-disaster buildings* are *buildings* that are essential to the provision of services in the event of a disaster, and include:

- hospitals, emergency treatment facilities and blood banks
- telephone exchanges
- power generating stations and electrical substations
- control centres for air, land and marine transportation
- public water treatment and storage facilities, and pumping stations
- sewage treatment facilities
- *buildings* having critical national defence functions
**Notes to Table 4.1.2.1.:**

---

(1) See [Appendix A](#).

(2) See [A-1.1.2.(1)](#), Post-disaster Buildings, in Appendix A of Division A.
4.1.2.2. Loads Not Listed

1) Where a building or structural member can be expected to be subjected to loads, forces or other effects not listed in Article 4.1.2.1., such effects shall be taken into account in the design based on the most appropriate information available.

4.1.3. LIMIT STATES DESIGN

(See Appendix A.)

4.1.3.1. Definitions

1) In this Subsection, the term
   a) limit states means those conditions of a building structure that result in the building ceasing to fulfill the function for which it was designed (those limit states concerning safety are called ultimate limit states (ULS) and include exceeding the load-carrying capacity, overturning, sliding and fracture; those limit states that restrict the intended use and occupancy of the building are called serviceability limit states (SLS) and include deflection, vibration, permanent deformation and local structural damage such as cracking; and those limit states that represent failure under repeated loading are called fatigue limit states),

4.1.3.3. Fatigue

1) A building and its structural components, including connections, shall be checked for fatigue failure under the effect of cyclical loads, as required in the standards listed in Section 4.3. (See Appendix A.)

2) Where vibration effects, such as resonance and fatigue resulting from machinery and equipment, are likely to be significant, a dynamic analysis shall be carried out. (See Appendix A.)

4.1.3.4. Serviceability
1) A building and its structural components shall be checked for serviceability limit states as defined in Clause 4.1.3.1.(1)(a) under the effect of service loads for serviceability criteria specified or recommended in Articles 4.1.3.5. and 4.1.3.6. and in the standards listed in Section 4.3. (See Appendix A.)

4.1.3.5. Deflection

1) In proportioning structural members to limit serviceability problems resulting from deflections, consideration shall be given to
a) the intended use of the building or member,
b) limiting damage to non-structural members made of materials whose physical properties are known at the time of design,
c) limiting damage to the structure itself, and
d) creep, shrinkage, temperature changes and pre-stress. (See Appendix A.)

2) The lateral deflection of buildings due to service wind and gravity loads shall be checked to ensure that structural elements and non-structural elements whose nature is known at the time the structural design is carried out will not be damaged.

3) Except as provided in Sentence (4), the total drift per storey under service wind and gravity loads shall not exceed 1/500 of the storey height unless other drift limits are specified in the design standards referenced in Section 4.3. (See Appendix A.)

4) The deflection limits required in Sentence (3) do not apply to industrial buildings or sheds if experience has proven that greater movement will have no significant adverse effects on the strength and function of the building.

5) The building structure shall be designed for lateral deflection due to E, in accordance with Article 4.1.8.13.

4.1.3.6. Vibration

1) Floor systems susceptible to vibration shall be designed so that vibrations will have no significant adverse effects on the intended occupancy of the building. (See Appendix A.)

2) Where the fundamental vibration frequency of a structural system supporting an assembly occupancy used for rhythmic activities, such as dancing, concerts, jumping
exercises or gymnastics, is less than 6 Hz, the effects of resonance shall be investigated by means of a dynamic analysis. (See Appendix A.)

3) A building susceptible to lateral vibration under wind load shall be designed in accordance with Article 4.1.7.2, so that the vibrations will have no significant adverse effects on the intended use and occupancy of the building. (See Appendix A.)

4.1.4. DEAD LOADS

4.1.4.1. Dead Loads

1) The specified dead load for a structural member consists of
   a) the weight of the member itself,
   b) the weight of all materials of construction incorporated into the building to be supported permanently by the member,
   c) the weight of partitions,
   d) the weight of permanent equipment, and
   e) the vertical load due to earth, plants and trees.

2) Except as provided in Sentence (5), in areas of a building where partitions other than permanent partitions are shown on the drawings, or where partitions might be added in the future, allowance shall be made for the weight of such partitions.

3) The partition weight allowance referred to in Sentence (2) shall be determined from the actual or anticipated weight of the partitions placed in any probable position, but shall be not less than 1 kPa over the area of floor being considered.

4) Partition loads used in design shall be shown on the drawings as provided in Clause 2.2.4.3.(1)(d) of Division C.

5) In cases where the dead load of the partition is counteractive, the load allowances referred to in Sentences (2) and (3) shall not be included in the design calculations.

6) Except for structures where the dead load of soil is part of the load-resisting system, where the dead load due to soil, superimposed earth, plants and trees is counteractive, it shall not be included in the design calculations. (See Appendix A.)

4.1.5. LIVE LOADS DUE TO USE AND OCCUPANCY
4.1.5.1. Loads Due to Use of Floors and Roofs

1) Except as provided in Sentence (2), the specified live load on an area of floor or roof depends on the intended use and occupancy, and shall not be less than either the uniformly distributed load patterns listed in Article 4.1.5.3., the loads due to the intended use and occupancy, or the concentrated loads listed in Article 4.1.5.9., whichever produces the most critical effect. (See Appendix A.)

2) For buildings in the Low Importance Category as described in Table 4.1.2.1., a factor of 0.8 may be applied to the live load.

4.1.5.2. Uses Not Stipulated

1) Except as provided in Sentence (2), where the use of an area of floor or roof is not provided for in Article 4.1.5.3., the specified live loads due to the use and occupancy of the area shall be determined from an analysis of the loads resulting from the weight of:
   a) the probable assembly of persons,
   b) the probable accumulation of equipment and furnishings, and
   c) the probable storage of materials.

2) For buildings in the Low Importance Category as described in Table 4.1.2.1., a factor of 0.8 may be applied to the live load.

4.1.5.3. Full and Partial Loading

1) The uniformly distributed live load shall be not less than the value listed in Table 4.1.5.3., which may be reduced as provided in Article 4.1.5.8., applied uniformly over the entire area or on any portions of the area, whichever produces the most critical effects in the members concerned.

<table>
<thead>
<tr>
<th>Table 4.1.5.3.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specified Uniformly Distributed Live Loads on an Area of Floor or Roof</td>
</tr>
<tr>
<td>Forming part of Sentence 4.1.5.3.(1)</td>
</tr>
<tr>
<td>Use of Area of Floor or Roof</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Assembly Areas</strong></td>
</tr>
<tr>
<td>a) Except for the areas listed under b), c), d) and e), assembly areas with or without fixed seats including</td>
</tr>
<tr>
<td>Arenas (areas without fixed seats that have backs)</td>
</tr>
<tr>
<td>Auditoria</td>
</tr>
<tr>
<td>Churches (areas without fixed seats that have backs)</td>
</tr>
<tr>
<td>Dance floors</td>
</tr>
<tr>
<td>Dining areas</td>
</tr>
<tr>
<td>Foyers and entrance halls</td>
</tr>
<tr>
<td>Grandstands (areas without fixed seats that have backs), reviewing stands and bleachers</td>
</tr>
<tr>
<td>Gymnasia</td>
</tr>
<tr>
<td>Lecture halls (areas without fixed seats that have backs)</td>
</tr>
<tr>
<td>Museums</td>
</tr>
<tr>
<td>Promenades</td>
</tr>
<tr>
<td>Rinks</td>
</tr>
<tr>
<td>Stadia (areas without fixed seats that have backs)</td>
</tr>
<tr>
<td><strong>Theatres</strong> (areas without fixed seats that have backs)</td>
</tr>
<tr>
<td>Other areas with similar uses</td>
</tr>
<tr>
<td>b) Classrooms and courtrooms with or without fixed seats</td>
</tr>
<tr>
<td>Office areas (not including record storage and computer rooms) located in</td>
</tr>
<tr>
<td><strong>Basement</strong> and the <strong>first storey</strong></td>
</tr>
<tr>
<td>Floors above the <strong>first storey</strong></td>
</tr>
<tr>
<td>Residential areas (within the scope of <strong>Article 1.3.3.3. of Division A</strong>)</td>
</tr>
<tr>
<td>Bedrooms</td>
</tr>
</tbody>
</table>
### Other areas

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stairs within dwelling units</td>
<td>1.9</td>
</tr>
<tr>
<td>Retail and wholesale areas</td>
<td>4.8</td>
</tr>
<tr>
<td>Roofs</td>
<td>1.0 (1) (5)</td>
</tr>
<tr>
<td>Sidewalks and driveways over areaways and basements</td>
<td>12.0 (1)(5)</td>
</tr>
<tr>
<td>Storage areas</td>
<td>4.8(4)</td>
</tr>
<tr>
<td>Toilet areas</td>
<td>2.4</td>
</tr>
<tr>
<td>Underground slabs with earth cover</td>
<td>(5)</td>
</tr>
<tr>
<td>Warehouses</td>
<td>4.8(4)</td>
</tr>
</tbody>
</table>

### Notes to Table 4.1.5.3:

1. See Appendix A.
2. See Article 4.1.5.6.
3. See Article 4.1.5.4.
4. See Sentence 4.1.5.1.(1).
5. See Article 4.1.5.5.

### 4.1.7. WIND LOAD

(See User's Guide - NBC 2010, Structural Commentaries (Part 4 of Division B).)

#### 4.1.7.1. Specified Wind Load

1) The specified external pressure or suction due to wind on part or all of a surface of a building shall be calculated using the formula

\[
p = \text{specified external pressure acting statically and in a direction normal to the surface, either as a pressure directed towards the surface or as a suction directed away from the surface,}
\]

where

\[
p = \text{specified external pressure acting statically and in a direction normal to the surface, either as a pressure directed towards the surface or as a suction directed away from the surface,}
\]

\[
I_w = \text{importance factor for wind load, as provided in Table 4.1.7.1.}
\]
q= reference velocity pressure, as provided in Sentence (4),
C_e= exposure factor, as provided in Sentence (5),
C_g= gust effect factor, as provided in Sentence (6), and
C_p= external pressure coefficient, averaged over the area of the surface considered.
(See Appendix A.)

<table>
<thead>
<tr>
<th>Importance Category</th>
<th>Importance Factor, I_W</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ULS</td>
</tr>
<tr>
<td>Low</td>
<td>0.8</td>
</tr>
<tr>
<td>Normal</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>1.15</td>
</tr>
<tr>
<td>Post-disaster</td>
<td>1.25</td>
</tr>
</tbody>
</table>

2) The net wind load for the building as a whole shall be the algebraic difference of the loads on the windward and leeward surfaces, and in some cases, may be calculated as the sum of the products of the external pressures or suctions and the areas of the surfaces over which they are averaged as provided in Sentence (1). (See Appendix A.)

3) The net specified pressure due to wind on part or all of a surface of a building shall be the algebraic difference of the external pressure or suction as provided in Sentence (1) and the specified internal pressure or suction due to wind calculated using the following formula:

where
p_i= specified internal pressure acting statically and in a direction normal to the surface, either as a pressure directed towards the surface or as a suction directed away from the surface,
I_w= importance factor for wind load, as provided in Table 4.1.7.1.,
q= reference velocity pressure, as provided in Table 4.1.7.1.,
C_e= exposure factor, as provided in Sentence (4),
C_g= gust effect factor, as provided in Sentence (5),
C_p= internal gust effect factor, as provided in Sentence (6), and
C_p= internal pressure coefficient.
(See Appendix A.)
4) The reference velocity pressure, \( q \), shall be the appropriate value determined in conformance with Subsection 1.1.3., based on a probability of being exceeded in any one year of 1 in 50.

5) The exposure factor, \( C_e \), shall be
   a) \((h/10)^{0.2}\) but not less than 0.9 for open terrain, where open terrain is level terrain with only scattered buildings, trees or other obstructions, open water or shorelines thereof, \( h \) being the reference height above grade in metres for the surface or part of the surface (see Appendix A),
   b) \(0.7(h/12)^{0.3}\) but not less than 0.7 for rough terrain, where rough terrain is suburban, urban or wooded terrain extending upwind from the building uninterrupted for at least 1 km or 20 times the height of the building, whichever is greater, \( h \) being the reference height above grade in metres for the surface or part of the surface (see Appendix A),
   c) an intermediate value between the two exposures defined in Clauses (a) and (b) in cases where the site is less than 1 km or 20 times the height of the building from a change in terrain conditions, whichever is greater, provided an appropriate interpolation method is used (see Appendix A), or
   d) if a dynamic approach to the action of wind gusts is used, an appropriate value depending on both height and shielding (see Appendix A).

6) The gust effect factor, \( C_g \), shall be one of the following values:
   a) for the building as a whole and main structural members, \( C_g = 2.0 \) (see Appendix A),
   b) for external pressures and suctions on small elements including cladding, \( C_g = 2.5 \),
   c) for internal pressures, \( C_{gi} = 2.0 \) or a value determined by detailed calculation that takes into account the sizes of the openings in the building envelope, the internal volume and the flexibility of the building envelope (see Appendix A), or
   d) if a dynamic approach to wind action is used, \( C_g \) is a value that is appropriate for the turbulence of the wind and the size and natural frequency of the structure (see Appendix A).

4.1.7.2. Dynamic Effects of Wind

1) Except as provided in Sentence (2), buildings whose height is greater than 4 times their minimum effective width, which is defined in Sentence (3), or greater than 60
m, and buildings whose lowest natural frequency is less than 1 Hz, as determined by rational analysis (see Appendix A), shall be designed
a) by experimental methods for the danger of dynamic overloading, vibration and the effects of fatigue, or
b) by using a dynamic approach to the action of wind gusts (see Appendix A).

2) Buildings whose lowest natural frequency is less than ¼ Hz, as determined by rational analysis, shall be designed by experimental methods in accordance with Clause (1)(a).

(See Appendix A.)

3) The effective width, w, of a building shall be calculated using

where the summations are over the height of the building for a given wind direction, \( h_i \) is the height above grade to level \( i \), as defined in Sentence 4.1.7.1.(5), and \( w_i \) is the width normal to the wind direction at height \( h_i \); the minimum effective width is the lowest value of the effective width considering all possible wind directions.

4.1.7.3. Full and Partial Loading

1) Buildings and structural members shall be capable of withstanding the effects of
a) the full wind loads acting along each of the 2 principal horizontal axes considered separately,
b) the wind loads as described in Clause (a) but with 100% of the load removed from any portion of the area,
c) the wind loads as described in Clause (a) but considered simultaneously at 75% of their full value, and
d) the wind loads as described in Clause (c) but with 50% of these loads removed from any portion of the area.

(See Appendix A.)

4.1.7.4. Interior Walls and Partitions

1) In the design of interior walls and partitions, due consideration shall be given to differences in air pressure on opposite sides of the wall or partition which may result from
a) pressure differences between the windward and leeward sides of a building,
b) stack effects due to a difference in air temperature between the exterior and interior of the building,
c) air pressurization by the mechanical services of the building.

4.1.8. EARTHQUAKE LOAD AND EFFECTS

(See User's Guide - NBC 2010, Structural Commentaries (Part 4 of Division B).)

4.1.8.1. Analysis

1) The deflections and specified loading due to earthquake motions shall be determined according to the requirements in this Subsection, except that the requirements in this Subsection need not be considered in design if $S(0.2)$, as defined in Sentence 4.1.8.4.(7), is less than or equal to 0.12.

4.1.8.2. Notation

1) In this Subsection

- $A_r$ = response amplification factor to account for type of attachment of mechanical/electrical equipment, as defined in Sentence 4.1.8.18.(1),
- $A_x$ = amplification factor at level $x$ to account for variation of response of mechanical/electrical equipment with elevation within the building, as defined in Sentence 4.1.8.18.(1),
- $B_x$ = ratio at level $x$ used to determine torsional sensitivity, as defined in Sentence 4.1.8.11.(9),
- $B$ = maximum value of $B_x$, as defined in Sentence 4.1.8.11.(9),
- $C_p$ = seismic coefficient for mechanical/electrical equipment, as defined in Sentence 4.1.8.18.(1),
- $D_{mx}$ = plan dimension of the building at level $x$ perpendicular to the direction of seismic loading being considered,
- $e_x$ = distance measured perpendicular to the direction of earthquake loading between centre of mass and centre of rigidity at the level being considered (see Appendix A),
- $F_a$ = acceleration-based site coefficient, as defined in Sentence 4.1.8.4.(4),
- $F_t$ = portion of $V$ to be concentrated at the top of the structure, as defined in Sentence 4.1.8.11.(6),
- $F_v$ = velocity-based site coefficient, as defined in Sentence 4.1.8.4.(4),
- $F_x$ = lateral force applied to level $x$, as defined in Sentence 4.1.8.11.(6),
h_i, h_n, h_x = the height above the base (i = 0) to level i, n, or x respectively, where the base of the structure is the level at which horizontal earthquake motions are considered to be imparted to the structure,  
h_x = interstorey height (h_i - h_{i-1}),  
I_e = earthquake importance factor of the structure, as described in Sentence 4.1.8.5.(1),  
J = numerical reduction coefficient for base overturning moment, as defined in Sentence 4.1.8.11.(5),  
J_x = numerical reduction coefficient for overturning moment at level x, as defined in Sentence 4.1.8.11.(7),  
Level i= any level in the building, i = 1 for first level above the base,  
Level n= level that is uppermost in the main portion of the structure,  
Level x= level that is under design consideration,  
M_v= factor to account for higher mode effect on base shear, as defined in Sentence 4.1.8.11.(5),  
M_x = overturning moment at level x, as defined in Sentence 4.1.8.11.(7),  
N= total number of storeys above exterior grade to level n,  
= Average Standard Penetration Resistance for the top 30 m, corrected to a rod energy efficiency of 60% of the theoretical maximum,  
P_GA= Peak Ground Acceleration expressed as a ratio to gravitational acceleration, as defined in Sentence 4.1.8.4.(1),  
PI= plasticity index for clays,  
R_d= ductility-related force modification factor reflecting the capability of a structure to dissipate energy through reversed cyclic inelastic behaviour, as given in Article 4.1.8.9.,  
R_o= overstrength-related force modification factor accounting for the dependable portion of reserve strength in a structure designed according to these provisions, as defined in Article 4.1.8.9.,  
S_p= horizontal force factor for part or portion of a building and its anchorage, as given in Sentence 4.1.8.18.(1) ,  
S(T)= design spectral response acceleration, expressed as a ratio to gravitational acceleration, for a period of T, as defined in Sentence 4.1.8.4.(7) ,  
S_a(T)= 5% damped spectral response acceleration, expressed as a ratio to gravitational acceleration, for a period of T, as defined in Sentence 4.1.8.4.(1),
SFRS= Seismic Force Resisting System(s) is that part of the structural system that has been considered in the design to provide the required resistance to the earthquake forces and effects defined in Subsection 4.1.8.,
s\text{u}= \text{average undrained shear strength in the top 30 m of soil},
T= \text{period in seconds},
T_s= \text{fundamental lateral period of vibration of the building or structure in seconds in the direction under consideration, as defined in Sentence 4.1.8.11.(3)},
T_x= \text{floor torque at level } x, \text{ as defined in Sentence 4.1.8.11.(10)},
V= \text{lateral earthquake design force at the base of the structure, as determined by Article 4.1.8.11.},
V_e= \text{lateral earthquake design force at the base of the structure, as determined by Article 4.1.8.12.},
V_e= \text{lateral earthquake elastic force at the base of the structure, as determined by Article 4.1.8.12.},
V_{ed}= \text{lateral earthquake design elastic force at the base of the structure, as determined by Article 4.1.8.12.},
V_p= \text{lateral force on a part of the structure, as determined by Article 4.1.8.18.},
V_{ave}= \text{average shear wave velocity in the top 30 m of soil or rock},
W= \text{dead load, as defined in Article 4.1.4.1.}, \text{ except that the minimum partition load as defined in Sentence 4.1.4.1.(3) need not exceed 0.5 kPa, plus 25\% of the design snow load specified in Subsection 4.1.6., plus 60\% of the storage load for areas used for storage, except that storage garages need not be considered storage areas, and the full contents of any tanks (see Appendix A)},
W_i, \ W_x= \text{portion of } W \text{ that is located at or is assigned to level } i \text{ or } x \text{ respectively},
W_p= \text{weight of a part or portion of a structure, e.g., cladding, partitions and appendages},
\delta_{ave}= \text{average displacement of the structure at level } x, \text{ as defined in Sentence 4.1.8.11.(9)}, \text{ and}
\delta_{max}= \text{maximum displacement of the structure at level } x, \text{ as defined in Sentence 4.1.8.11.(9)}.

4.1.8.3. General Requirements

1) The building shall be designed to meet the requirements of this Subsection and of the design standards referenced in Section 4.3.

2) Structures shall be designed with a clearly defined load path, or paths, that will transfer the inertial forces generated in an earthquake to the supporting ground.
3) The structure shall have a clearly defined Seismic Force Resisting System(s) (SFRS), as defined in Article 4.1.8.2.

4) The SFRS shall be designed to resist 100% of the earthquake loads and their effects. (See Appendix A.)

5) All structural framing elements not considered to be part of the SFRS must be investigated and shown to behave elastically or to have sufficient non-linear capacity to support their gravity loads while undergoing earthquake-induced deformations calculated from the deflections determined in Article 4.1.8.13.

6) Stiff elements that are not considered part of the SFRS, such as concrete, masonry, brick or pre-cast walls or panels, shall be
   a) separated from all structural elements of the building such that no interaction takes place as the building undergoes deflections due to earthquake effects as calculated in this Subsection, or
   b) made part of the SFRS and satisfy the requirements of this Subsection. (See Appendix A.)

7) Stiffness imparted to the structure from elements not part of the SFRS, other than those described in Sentence (6), shall not be used to resist earthquake deflections but shall be accounted for
   a) in calculating the period of the structure for determining forces if the added stiffness decreases the fundamental lateral period by more than 15%,
   b) in determining the irregularity of the structure, except the additional stiffness shall not be used to make an irregular SFRS regular or to reduce the effects of torsion (see Appendix A), and
   c) in designing the SFRS if inclusion of the elements not part of the SFRS in the analysis has an adverse effect on the SFRS (see Appendix A).

8) Structural modelling shall be representative of the magnitude and spatial distribution of the mass of the building and of the stiffness of all elements of the SFRS, including stiff elements that are not separated in accordance with Sentence (6), and shall account for
   a) the effect of cracked sections in reinforced concrete and reinforced masonry elements,
   b) the effect of the finite size of members and joints,
   c) sway effects arising from the interaction of gravity loads with the displaced configuration of the structure, and
   d) other effects that influence the lateral stiffness of the building. (See Appendix A.)
### Table 4.1.8.9.

**SFRS Ductility-Related Force Modification Factors, $R_d$, Overstrength-Related Force Modification Factors, $R_o$, and General Restrictions**

Forming part of [Sentence 4.1.8.9.(1)]

<table>
<thead>
<tr>
<th>Type of SFRS</th>
<th>$R_d$</th>
<th>$R_o$</th>
<th>Restrictions&lt;sup&gt;(2)&lt;/sup&gt;</th>
<th>Cases Where $I_E F_a S_a(0.2)$</th>
<th>Cases Where $I_E F_a S_a(1.0)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Structures Designed and Detailed According to <a href="3">CSA S16</a></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductile moment-resisting frames</td>
<td>5.0</td>
<td>1.5</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Moderately ductile moment-resisting frames</td>
<td>3.5</td>
<td>1.5</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Limited ductility moment-resisting frames</td>
<td>2.0</td>
<td>1.3</td>
<td>NL</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>Moderately ductile concentrically braced frames</td>
<td></td>
<td></td>
<td>60</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> Forming part of [Sentence 4.1.8.9.(1)]

<sup>(2)</sup> Restrictions:

- $< 0.2$
- $\geq 0.2$ to $< 0.35$
- $\geq 0.35$ to $\leq 0.75$
- $> 0.75$
- $> 0.3$

<sup>(3)</sup> Steel Structures Designed and Detailed According to [CSA S16](3)
<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
<th>Value 5</th>
<th>Value 6</th>
<th>Value 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension-compression braces</td>
<td>3.0</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Tension only braces</td>
<td>3.0</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Limited ductility concentrically braced frames</td>
<td>2.0</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Tension-compression braces</td>
<td>2.0</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Ductile buckling-restrained braced frames</td>
<td>4.0</td>
<td>1.2</td>
<td>NL</td>
<td>NL</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Ductile eccentrically braced frames</td>
<td>4.0</td>
<td>1.5</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Ductile plate walls</td>
<td>5.0</td>
<td>1.6</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Limited ductility plate walls</td>
<td>2.0</td>
<td>1.5</td>
<td>NL</td>
<td>NL</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Conventional construction of moment resisting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frames, braced frames or plate walls</td>
<td>1.5</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Assembly occupancies</td>
<td>1.5</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Other occupations</td>
<td>1.5</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>60</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Other steel SFRS(s) not defined above</td>
<td>1.0</td>
<td>1.0</td>
<td>15</td>
<td>15</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>Concrete Structures Designed and Detailed According to <a href="#">CAN/CSA-A23.3</a></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductile moment-resisting frames</td>
<td>4.0</td>
<td>1.7</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Moderately ductile moment-resisting frames</td>
<td>2.5</td>
<td>1.4</td>
<td>NL</td>
<td>NL</td>
<td>60</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Ductile coupled walls</td>
<td>4.0</td>
<td>1.7</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Ductile partially coupled walls</td>
<td>3.5</td>
<td>1.7</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Ductile shear walls</td>
<td>3.5</td>
<td>1.6</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
<tr>
<td>Moderately ductile shear walls</td>
<td>2.0</td>
<td>1.4</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Structure Type</td>
<td>1.5</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>15</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>---------------</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Conventional construction</td>
<td>Moment-resisting frames</td>
<td>1.5</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>15</td>
<td>NP</td>
</tr>
<tr>
<td></td>
<td>Shear walls</td>
<td>1.5</td>
<td>1.3</td>
<td>NL</td>
<td>NL</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Other concrete SFRS(s) not listed above</td>
<td>1.0</td>
<td>1.0</td>
<td>15</td>
<td>15</td>
<td>NP</td>
<td>NP</td>
</tr>
</tbody>
</table>

Timber Structures Designed and Detailed According to CSA **O86**

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>3.0</th>
<th>1.7</th>
<th>NL</th>
<th>NL</th>
<th>30</th>
<th>20</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear walls</td>
<td>Nailed shear walls: wood-based panel</td>
<td>3.0</td>
<td>1.7</td>
<td>NL</td>
<td>NL</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Shear walls: wood-based and gypsum panels in combination</td>
<td>2.0</td>
<td>1.7</td>
<td>NL</td>
<td>NL</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Braced or moment-resisting frames with ductile connections

| 2.0 | 1.5 | NL | NL | 20 | 20 | 20 |
| Moderately ductile | Limited ductility | 1.5 | 1.5 | NL | NL | 15 | 15 | 15 |

Other wood- or gypsum-based SFRS(s) not listed above

| 1.0 | 1.0 | 15 | 15 | NP | NP | NP |

Masonry Structures Designed and Detailed According to CSA **S304.1**
<table>
<thead>
<tr>
<th>Construction Type</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately ductile shear walls</td>
<td>2.0</td>
<td>1.5</td>
<td>NL</td>
<td>NL</td>
<td>60</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Limited ductility shear walls</td>
<td>1.5</td>
<td>1.5</td>
<td>NL</td>
<td>NL</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Conventional construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear walls</td>
<td>1.5</td>
<td>1.5</td>
<td>NL</td>
<td>60</td>
<td>30</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Moment-resisting frames</td>
<td>1.5</td>
<td>1.5</td>
<td>NL</td>
<td>30</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>Unreinforced masonry</td>
<td>1.0</td>
<td>1.0</td>
<td>30</td>
<td>15</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>Other masonry SFRS(s) not listed above</td>
<td>1.0</td>
<td>1.0</td>
<td>15</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
</tbody>
</table>

Cold-Formed Steel Structures Designed and Detailed According to [CAN/CSA-S136](https://www.canadianstandards.org/standards/can-b136)
<table>
<thead>
<tr>
<th>Combination</th>
<th>Diagonal strap concentrate braced walls</th>
<th>Limited ductility</th>
<th>Conventional construction</th>
<th>Other cold-formed SFRS(s) not defined above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.9</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
</tbody>
</table>

Notes to Table 4.1.8.9.:

(1) See Article 4.1.8.10.

(2) NP = system is not permitted.
NL = system is permitted and not limited in height as an SFRS; height may be limited in other Parts of the Code.
Numbers in this Table are maximum height limits in m.
The most stringent requirement governs.

(3) Higher design force levels are prescribed in CSA S16 for some heights of buildings.