Part 4
Structural Design

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Section 4.1. Structural Loads and Procedures

4.1.1. General

4.1.1.1. Scope

(1) The scope of this Part shall be as described in Section 2.1.

4.1.1.2. Definitions

(1) Reserved.

4.1.1.3. Design Requirements

(1) *Buildings* and their structural members including formwork and falsework shall be designed to have sufficient structural capacity and structural integrity to resist safely and effectively all loads and 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) All permanent and temporary structural members, including 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.

(3) Reserved.

(4) Precautions shall be taken during all stages of *construction* to ensure that the *building* is not damaged or distorted due to loads applied during *construction*.

4.1.1.4. Design Basis

(1) *Buildings* and their structural members shall be designed by one of the following methods:

(a) standard design procedures and practices provided by this Part and any standards and specifications referred to therein, except in cases of conflict the provisions of the *building code* shall govern, or
(b) one of the following three bases of design,
  (i) analysis based on generally established theory,
  (ii) evaluation of a given full-scale structure or a prototype by a loading test, or
  (iii) studies of model analogues,

provided the design is carried out by a person qualified in the specific method applied and provided the design ensures a level of safety and performance at least equivalent to that provided for or implicit in design carried out by the methods referred to in Clause (a).

(2) Communications towers, dish antennas and their supporting structures shall conform to CAN/CSA-S37-M, "Antennas, Towers, and Antenna Supporting Structures".

4.1.1.5. Deflections

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

(2) Sway effects produced by vertical loads acting on the structure in its displaced configuration shall be taken into account in the design of *buildings* and their structural members.

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

(4) Except as provided in Sentence (5), the total drift per *storey* under specified 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.)

(5) The deflection limits required in Sentence (4) do not apply to industrial *buildings* or sheds if it is known by experience that greater movement will have no significantly adverse effect on the strength and function of the *building*.

4.1.1.6. Vibrations

(1) Floor systems susceptible to vibrations shall be designed so that there will be no significantly adverse effects on the intended *occupancy* of the *building* from vibrations. (See Appendix A.)

(2) Unusually flexible *buildings* and *buildings* whose ratio of height to minimum effective width exceeds 4 to 1 shall be designed so that there will be no significant adverse effects on the intended *occupancy* of the *building* from vibrations under dynamic wind load. (See Appendix A.)

4.1.1.7. Stability

(1) Provision shall be made to ensure adequate stability of a structure as a whole, and adequate lateral, torsional and local stability of all structural parts.

4.1.1.8. Reserved.

4.1.2. Specified Loads and Effects

4.1.2.1. Loads, Forces and Effects

(1) Except as provided for in Article 4.1.2.2., the following specified loads, forces and effects shall be considered in the design of a *building* and its structural members and connections:

D - *dead loads* as provided for in Subsection 4.1.5.,

E - *live load* due to earthquake as specified in Subsection 4.1.9.,

L - *live load* due to static or inertia forces arising from intended use and *occupancy* (includes vertical loads due to cranes); snow, ice and rain; earth and hydrostatic pressure,

T - effects due to contraction or expansion caused by temperature changes, shrinkage, moisture changes, creep in component materials, movement due to differential settlement or combination thereof, (See Appendix A.)

W- *live load* due to wind as specified in Subsection 4.1.8.

(2) Minimum specified values of these loads, as set forth in Subsections 4.1.5. to 4.1.10., shall be increased to account for dynamic effects where applicable.

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.

(2) If it can be shown by engineering principles, or if it is known from experience, that neglect of some or all of the effects due to **T** do not affect the structural safety and serviceability, they need not be considered in the calculations.

4.1.2.3. Structural Design

(1) Structural design shall be carried out in accordance with Subsection 4.1.4., Working Stress Design or Subsection 4.1.3., Limit States Design.

4.1.3. Limit States Design

4.1.3.1. Definitions

(1) In this Subsection, the term

(a) limit states means those conditions of a *building* structure in which the *building* ceases to fulfil the function for which it was designed,

(Those states concerning safety are called ultimate limit states and include exceeding the load carrying capacity, overturning, sliding, fracture and fatigue, while those states which restrict the intended use and *occupancy* of the *building* are called serviceability limit states, and include deflection, vibration, permanent deformation and cracking.)

(b) specified loads (**D, E, L, T** and **W**) mean those loads defined in Article 4.1.2.1. and given in this Section,

(c) load factor, α, means a factor in Sentence 4.1.3.2.(4) applied to a specified load which, for the limit states under consideration, takes into account the variability of the loads and load patterns and analysis of their effects,

(d) factored load means the product of a specified load and its load factor,

(e) load combination factor, ψ, means a factor in Sentences 4.1.3.2.(5) and (6) applied to the factored loads other than *dead load* to take into account the reduced probability of a number of loads from different sources acting simultaneously,
(f) importance factor, γ, means a factor in Sentence 4.1.3.2.(7) applied to the factored loads other than *dead load* to take into account the consequences of collapse as related to the use and *occupancy* of the *building*,
(g) resistance, **R**, of a member, connection, structure or *foundation*, is based on the dimensions and on the specified properties of the structural materials,
(h) resistance factor, ϕ, means a factor applied to a specified material property or to the resistance of a member, connection, structure or *foundation*, which for the limit state under consideration takes into account the variability of dimensions and material properties, workmanship, type of failure and uncertainty in the prediction of resistance, and
(i) factored resistance means the product of resistance and the applicable resistance factor.

4.1.3.2. Safety Check for Strength and Stability

(1) A *building* and its structural components shall be designed to have sufficient strength and stability so that the factored resistance is greater than or equal to the effect of factored loads, as required in Sentences (3) or (8).

(2) In cases of overturning, uplift and sliding, anchorage is required if the effect of loads tending to cause overturning, uplift or sliding, multiplied by load factors greater than 1.0 given in Sentence (4), is greater than the stabilizing effect of *dead load* multiplied by a load factor of 0.85 as given in Sentence (4).

(3) For load combinations not including earthquake, the effect of factored loads is the structural effect due to the specified loads multiplied by load factors, α, in Sentence (4), a load combination factor, ψ, in Sentences (5) and (6) and an importance factor, γ, in Sentence (7), and the factored load combinations shall be taken as

$$\alpha_D \mathbf{D} + \gamma\psi[\alpha_L \mathbf{L} + \alpha_W \mathbf{W} + \alpha_T \mathbf{T}]$$

(4) The load factors, α, shall be equal to
(a) $\alpha_D = 1.25$, except that when the *dead load* resists overturning, uplift or reversal of load effect, $\alpha_D = 0.85$,
(b) $\alpha_L = 1.5$,
(c) $\alpha_W = 1.5$, and
(d) $\alpha_T = 1.25$.

(5) The load combination factor, ψ, shall be equal to
(a) 1.0 when only 1 of the loads **L**, **W** and **T** in Sentence 4.1.2.1.(1) acts,
(b) 0.70 when 2 of the loads **L**, **W** and **T** in Sentence 4.1.2.1.(1) act, and
(c) 0.60 when all of the loads **L**, **W** and **T** in Sentence 4.1.2.1.(1) act.

(6) The most unfavourable effect shall be determined by considering the loads **L**, **W** and **T** in Sentence 4.1.2.1.(1) acting alone with $\psi = 1.0$ or in combination with $\psi = 0.70$ or 0.60.

(7) The importance factor, γ, shall be not less than 1.0 for all *buildings*, except that for *buildings* where it can be shown that collapse is not likely to cause injury or other serious consequences, it shall be not less than 0.8. (See Appendix A.)

(8) For load combinations including earthquake, the factored load combinations shall be taken as
(a) $1.0\mathbf{D} + \gamma(1.0\mathbf{E})$ and either,
(b) $1.0\mathbf{D} + \gamma(1.0\mathbf{L} + 1.0\mathbf{E})$ for storage and *assembly occupancies*, or
(c) $1.0\mathbf{D} + \gamma(0.5\mathbf{L} + 1.0\mathbf{E})$ for all other *occupancies*.

4.1.3.3. Serviceability and Fatigue

(1) A *building* and its structural components shall be checked for serviceability limit states as defined in Clause 4.1.4.1.(1)(a) and fatigue under the effect of the specified loads as required in the standards described in Section 4.3.

(2) Where more than one load contributes to the stress in a member, the combination of loads shall be assumed to be

$$\mathbf{D} + \psi[\mathbf{L} + \mathbf{W} + \mathbf{T}]$$

where ψ is in conformance with Sentences 4.1.3.2.(5) and (6).

4.1.4. Working Stress Design

4.1.4.1. Load Combinations

(1) In designing *buildings* and their structural members, all of the loads listed in Article 4.1.2.1. shall be considered to act in the following combinations, whichever combination produces the most unfavourable effects in the *building*, *foundation* or structural member concerned, when

appropriately reduced according to Article 4.1.4.2.:
(a) **D**
(b) **D + L**
(c) **D + (W or 2/3E)**
(d) **D + T**
(e) **D + L + (W or 2/3E)**
(f) **D + L + T**
(g) **D + (W or 2/3E) + T**
(h) **D + L + (W or 2/3E) + T**

4.1.4.2. Load Combination Factors

(1) The total of the combined load effects may be multiplied by the following load combination factors:
(a) 1.0 for the combinations in Clauses 4.1.4.1.(1)(a) to (d),
(b) 0.75 for the combinations in Clauses 4.1.4.1.(1)(e) to (g), and
(c) 0.66 for the combination in Clause 4.1.4.1.(1)(h).

4.1.4.3. Stress Reversal

(1) When loads other than **D** counteract **D** in a structural member or joint, special caution shall be exercised by the *designer* to ensure adequate safety for possible stress reversal. (See Appendix A.)

4.1.4.4. Overturning and Sliding

(1) A *building* shall be proportioned to resist an overturning moment and sliding force of not less than twice that due to the loads acting on the structure when the structure is considered as an entire unit acting on or anchored to its bearing stratum or supporting structure.

(2) The resistance to overturning shall be calculated as the sum of the stabilizing moment of the *dead load* only, plus the ultimate resistance of any anchoring devices.

4.1.5. Dead Loads

4.1.5.1. 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 *building* to be supported permanently by the member,
(c) the weight of *partitions*,
(d) the weight of permanent equipment, and
(e) forces due to prestressing.

(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 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 (20 psf) over the area of floor being considered.

(4) *Partition* loads used in design shall be shown on the drawings in sufficient detail to enable the loads due to materials of *construction* incorporated in the *building* to be determined.

(5) In cases where the *dead load* is counteractive, the load allowances as provided in Sentences (2) and (3) shall not be included in the design calculations.

4.1.6. Live Loads Due to Use and Occupancy

4.1.6.1. Loads Due to Use of Floors and Roofs

(1) The specified *live load* on an area of floor or roof depends on the intended use and *occupancy*, and shall not be less than the uniformly distributed load patterns in Article 4.1.6.3., the loads resulting from the intended use or the concentrated loads in Article 4.1.6.10., whichever produces the most critical effect.

4.1.6.2. Uses Not Stipulated

(1) Where the use of an area of floor or roof is not provided for in Article 4.1.6.3., the specified *live loads* due to the use and *occupancy* of the area shall be determined from an analysis of the loads resulting from
(a) the weight of the probable assembly of persons,
(b) the weight of the probable accumulation of equipment and furnishings, and
(c) the weight of the probable storage of materials.

4.1.6.3. Full and Partial Loading

(1) The uniformly distributed load shall be not less than the value listed in Table 4.1.6.3., reduced as may be provided for in Article 4.1.6.9., applied uniformly over the entire area, or on any portions of the area, whichever produces the most critical effects in the members concerned.

Table 4.1.6.3.
Specified Uniformly Distributed Live Loads on an Area of Floor or Roof
Forming Part of Sentence 4.1.6.3.(1)

Use of Area of Floor or Roof	Minimum Specified Load, kPa (psf)
Assembly Areas	
(a) Except for those areas listed under (b) and (c),assemble areas with or without fixed seats including	
Arenas	
Auditoria	
Churches	
Dance floors	
Dining areas [1]	
Foyers and entrance halls	
Grandstands, reviewing stands and bleachers	
Gymnasia	
Museums	
Promenades	
Rinks	
Stadia	
Stages	
Theatres	
and other areas with similar uses	4.8 (100)
(b) Assembly areas with fixed seats that have backs over at least 80 percent of the assembly area for the following uses:	
Churches	
Courtrooms	
Lecture halls	
Theatres	2.4 (50)
(c) Classrooms with or without fixed seats	2.4 (50)
Attics	
Accessible by a stairway in *residential occupancies* only	1.4 (30)
Having limited accessibility so that there is no storage of equipment or materials	0.5 (10)
Balconies	
Exterior	4.8 (100)
Interior and *mezzanines* that could be used for the assembly of people as a viewing area [2]	4.8 (100)
Interior and *mezzanines* other than above	[3]
Corridors, lobbies and aisles	
Other than those listed below	4.8 (100)
Not over 1 200 mm in width and all upper floor corridors of residential areas only of apartments, hotels and motels (that can not be used for the assembly of people as viewing area) [2]	[3]
Equipment areas and *service rooms* including	
Generator rooms	
Mechanical equipment exclusive of elevators	
Machine rooms	
Pump rooms	
Transformer vaults	
Ventilating or *air-conditioning* equipment	3.6[4] (75)
Column 1	2

Table 4.1.6.3. (Cont'd)
Specified Uniformly Distributed Live Loads on an Area of Floor or Roof
Forming Part of Sentence 4.1.6.3.(1)

Use of Area of Floor or Roof	Minimum Specified Load, kPa (psf)
Exits and fire escapes	4.8 (100)
Factories	6.0[4] (125)
Footbridges	4.8 (100)
Garages for	
Passenger cars	2.4 (50)
Unloaded buses and light trucks	6.0 (125)
Loaded buses and trucks and all other trucking spaces	12.0 (250)
Kitchens (other than residential)	4.8 (100)
Libraries	
Stack rooms	7.2 (150)
Reading and study rooms	2.9 (60)
Office areas (not including record storage and computer rooms) located in	
Basement and *first storey*	4.8 (100)
Floors above *first storey*	2.4 (50)
Operating rooms and laboratories	3.6 (75)
Patients' bedrooms	1.9 (40)
Recreation areas that cannot be used for assembly purposes including	
Billiard rooms	
Bowling alleys	
Pool rooms	3.6 (75)
Residential areas (within the scope of Article 2.1.1.2.)	
Sleeping and living quarters in apartments, *hotels*, motels, boarding schools and colleges	1.9 (40)
Work areas within *live/work units*	2.4 (50)
Residential areas (within the scope of Article 2.1.1.3.)	
Bedrooms	1.4 (30)
Other areas	1.9 (40)
Stairs within *dwelling units*	1.9 (40)
Retail and wholesale areas	4.8 (100)
Roofs	1.0[5] (20)
Sidewalks and driveways over areaways and *basements*	12.0 (250)
Storage areas, including locker rooms in apartment buildings	4.8[4] (100)
Toilet areas	2.4 (50)
Underground slabs with earth cover	[4]
Warehouses	4.8[4] (100)
Column 1	2

Notes to Table 4.1.6.3.:
[1] See Article 4.1.6.6.
[2] See Appendix A.
[3] See Article 4.1.6.4.
[4] See Article 4.1.6.7.
[5] See Article 4.1.7.1.

4.1.6.4. Loads for Occupancy Served

(1) The following shall be designed to carry not less than the specified load required for the *occupancy* they serve:
(a) corridors, lobbies and aisles not over 1 200 mm (3 ft 11 in) in wide,
(b) all corridors above the *first storey* of residential areas of apartments, hotels and motels, and
(c) interior balconies and *mezzanines,*
provided they cannot be used by an assembly of people as a viewing area.

4.1.6.5. Loads on Exterior Areas

(1) Exterior areas accessible to vehicular traffic shall be designed for their intended use including the weight of fire fighting equipment, but not less than the *live loads* due to snow, ice and rain prescribed in Subsection 4.1.7.

(2) Exterior areas accessible to pedestrian traffic, but not vehicular traffic, shall be designed for their intended use, but not less than
(a) the *live load* prescribed for assembly areas in Table 4.1.6.3., and
(b) the *live loads* due to snow, ice and rain as prescribed in Subsection 4.1.7.

4.1.6.6. Loads for Dining Areas

(1) The minimum specified load in Table 4.1.6.3. for dining areas may be reduced to 2.4 kPa (50 psf) for dining areas in *buildings* that have been converted for such purposes provided that the *floor area* does not exceed 100 m^2 (1080 ft^2) and use of the dining area for other assembly purposes including dancing is precluded.

4.1.6.7. Floor Loads Due to Intended Use

(1) Equipment areas and *service rooms*, factories, storage areas and warehouses shall be designed for the loads due to their intended use but not less than the specified loads listed in Table 4.1.6.3.

4.1.6.8. More Than One Occupancy

(1) Where an area of floor or roof is intended for 2 or more *occupancies* at different times, the value to be used from Table 4.1.6.3. shall be the greatest value for any of the *occupancies* concerned.

4.1.6.9. Variation with Tributary Area

(1) An area used for *assembly occupancies* designed for a *live load* of less than 4.8 kPa (100 psf) shall have no reduction for tributary area.

(2) Where a structural member supports a tributary area of floor, roof or combination thereof greater than 80 m^2 (861 ft^2) used for *assembly occupancies* designed for a *live load* of 4.8 kPa (100 psf) or more, or for storage, manufacturing, retail stores, garages or as a footbridge, the specified *live load* due to use and *occupancy*, excluding snow, is the load provided for in Article 4.1.6.3. multiplied by

$$0.5 + \sqrt{(20/A)}$$

where A is the tributary area in square metres for this type of use and *occupancy*, excluding the area supporting snow.

(3) Where a structural member supports a tributary area of floor, roof or combination of these greater than 20 m^2 (215 ft^2) for any use or *occupancy* other than *assembly occupancies* and those indicated in Sentences (1) and (2), the specified *live load* due to use and *occupancy*, excluding snow, is the load provided for in Article 4.1.6.3. multiplied by

$$0.3 + \sqrt{(9.8/B)}$$

where B is the tributary area in square metres for this type of use and *occupancy*, excluding the area supporting snow.

(See Appendix A.)

4.1.6.10. Concentrated Loads

(1) The specified load due to possible concentrations of load resulting from the use of an area of floor or roof shall not be less than that listed in Table 4.1.6.10. applied over an area of 750 mm (2 ft 6 in) by 750 mm (2 ft 6 in) located so as to cause maximum effects, except that for *occupancies* not listed in Table 4.1.6.10. the concentrations of load shall be determined in accordance with Article 4.1.6.2.

4.1.6.11. Bleacher Seats

(1) Bleacher seats shall be designed for a uniformly distributed load of 1.75 kN (400 lb) for each linear metre or for a concentrated load of 2.2 kN (500 lb) distributed over a length of 750 mm (2 ft 6 in), whichever produces the greatest effect on the supporting members.

4.1.6.12. Helicopter Landing Areas

(1) Helicopter landing areas on roofs shall be constructed in conformance with "Heliport and Helideck

Standards and Recommended Practices", third edition, 1985, published by Transport Canada.

4.1.6.13. Roof Parking Decks

(1) Roof parking decks shall be designed for the uniformly distributed loads in Table 4.1.6.3., the concentrated loads in Table 4.1.6.10. or the roof snow load, whichever produces the greatest effect in the members concerned.

Table 4.1.6.10.
Specified Concentrated Live Loads on an Area of Floor or Roof
Forming Part of Sentence 4.1.6.10.(1)

Area of Floor or Roof	Minimum Specified Concentrated Load, kN (lb)
Roof surfaces	1.3 (300)
Floors of classrooms	4.5 (1000)
Floors of offices, manufacturing *buildings*, hospital wards and *stages*	9.0 (2000)
Floors and areas used by passenger cars	11 (2500)
Floors and areas used by vehicles	
not exceeding 3600 kg gross weight	18 (4000)
exceeding 3600 kg but not exceeding 9000 kg gross weight	36 (8000)
Floors and areas used by vehicles exceeding 9000 kg gross weight	54 (12,000)
Driveways and sidewalks over areaways and *basements*	54 (12,000)
Column 1	2

Notes to Table 4.1.6.10.
(1) See Appendix A.

4.1.7. Live Loads Due to Snow, Ice and Rain (See Appendix A.)

4.1.7.1. Specified Snow Loading

(1) The specified loading, S, due to snow accumulation on a roof or any other *building* surface subject to snow accumulation shall be calculated from the formula

$$S = S_s(C_b \cdot C_w \cdot C_s \cdot C_a) + S_r$$

where S_s is the ground snow load in kPa, determined in accordance with Subsection 2.5.1.,
S_r is the associated rain load in kPa determined in accordance with Subsection 2.5.1., but not greater than $S_s(C_b \cdot C_w \cdot C_s \cdot C_a)$,
C_b is the basic roof snow load factor of 0.8,
C_w is the wind exposure factor in Sentences (2) and (3),
C_s is the slope factor in Sentences (4), (5) and (6), and
C_a is the accumulation factor in Sentence (7).

(2) Except as provided for in Sentence (3), the wind exposure factor, C_w, shall be 1.0.

(3) The wind exposure factor in Sentence (2) may be reduced to 0.75, or in exposed areas north of the treeline to 0.5, where
(a) the *building* is in an exposed location, so that the roof is exposed to the winds on all sides, with no obstructions higher than the roof located closer to the *building* than a distance equal to 10 times the height of the obstruction above the roof,
(b) the area of roof under consideration is exposed to the wind on all sides with no significant obstructions on the roof, such as parapet walls, within a distance of at least 10 times the difference between the height of the obstruction and $C_b \cdot C_w \cdot S_s/\gamma$ metres, where γ is the unit weight of snow on roofs, and
(c) the loading does not involve accumulation of snow due to drifting from adjacent surfaces.

(4) Except as provided for in Sentences (5) and (6), the slope factor, C_s, shall be
(a) 1.0 when the roof slope, α, is equal to or less than 30°,
(b) $(70° - \alpha)/40°$ when α is greater than 30°, but not greater than 70°, and
(c) 0 when α exceeds 70°, and

(5) The slope factor, C_s, for unobstructed slippery roofs where snow and ice can slide completely off the roof shall be
(a) 1.0 when the roof slope, α, is equal to or less than 15°,
(b) $(60° - \alpha)/45°$ when α is greater than 15°, but not greater than 60°, and
(c) 0 when α exceeds 60°.

(6) The slope factor, C_s, shall be 1.0 when used in conjunction with accumulation factors for increased snow load as given in Subclauses (7)(c)(ii) and (7)(c)(v).

(7) The accumulation factor, C_a,
(a) shall be 1.0, except that

(b) for large flat upper or lower roofs it shall be
   (i) $1.2 [1 - (30/l^*)^2]$ but not less than 1.0, for roofs with $C_w = 1.0$, or
   (ii) $1.6 [1 - (120/l^*)^2]$ but not less than 1.0, for roofs with $C_w = 0.75$ or 0.5

where
- l^* = the characteristic length of the upper or lower roof defined as $l^* = 2w - w^2/l$, in metres,
- w = the smaller plan dimension of the roof, in meters,
- l = the larger plan dimension of the roof, in metres,

and

(c) where appropriate for the shape of the roof, shall be assigned other values which account for
   (i) non-uniform snow loads on gable, arched or curved roofs and domes,
   (ii) increased snow loads in valleys,
   (iii) increased non-uniform snow loads due to snow drifting onto a roof which is at a level lower than other parts of the same *building* or at a level lower than another *building* within 5 m (16 ft 5 in) of it,
   (iv) increased non-uniform snow loads on areas adjacent to roof projections, such as penthouses, large *chimneys* and equipment, and
   (v) increased snow or ice loads due to snow sliding or drainage of meltwater from adjacent roofs.

(See Appendix A.)

4.1.7.2. Full and Partial Loading

(1) A roof or other *building* surface and its structural members subject to loads due to snow accumulation shall be designed for the specified load in Sentence 4.1.7.1.(1), distributed over the entire loaded area.

★ **(2)** In addition to the distribution in Sentence (1), flat roofs and shed roofs, gable roofs of 15° slope or less and arched or curved roofs shall be designed for the specified uniform snow load in Sentence 4.1.7.1.(1), computed using Ca = 1.0, distributed on any one portion of the loaded area, and half of this load on the remainder of the loaded area, in such a way as to produce the greatest effects on the member concerned. (See Appendix A.)

4.1.7.3. Specified Rain Load

(1) The specified load due to the accumulation of rain water on a surface, whose position and shape and deflection under load is such as to make such an accumulation possible, is that resulting from the 24 h rainfall determined in conformance with Subsection 2.5.1. over the horizontal projection of the surface and all tributary surfaces. (See Appendix A.)

(2) The provisions of Sentence (1) apply whether or not the surface is provided with drainage, such as rain water leaders.

(3) Except as provided for in Sentence 4.1.7.1.(1) and except where a roof is intended to provide rain water retention, loads due to rain need not be considered to act simultaneously with loads due to snow.

4.1.8. Live Loads Due to Wind

4.1.8.1. Specified Wind Loading

(1) The specified external pressure or suction due to wind on part or all of a surface of a *building* shall be calculated from

$$p = qC_eC_gC_p$$

where
- p = the 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,
- q = the reference velocity pressure as provided for in Sentence (4),
- C_e = the exposure factor as provided for in Sentence (5),
- C_g = the gust effect factor as provided for in Sentence (6), and
- C_p = the external pressure coefficient averaged over the area of the surface considered. (See Appendix A.)

(2) The net wind load for the *building* as a whole shall be the algebraic difference of the loads on the windward and the leeward surfaces, and in some cases may be calculated as 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 for in Sentence (1) and the specified internal pressure or suction due to wind calculated from

$$p_i = qC_eC_gC_{pi}$$

where p_i = the specified internal pressure acting statically and in a direction normal to the surface either as a pressure (directed outwards) or as a suction (directed inwards),

q = the reference velocity pressure, as provided for in Sentence 4,

C_e = the exposure factor, as provided for in Sentence 5, evaluated at the building mid-height instead of the height of the element considered,

C_g = the gust effect factor, as provided for in Sentence (6), and

C_{pi} = the internal pressure coefficient.

(4) The reference velocity pressure, q, is the appropriate value determined in conformance with Subsection 2.5.1. for the following conditions:

(a) the reference velocity pressure, q, for the design of cladding shall be based on a probability of being exceeded in any one year of 1 in 10,

(b) the reference velocity pressure, q, for the design of structural members for deflection and vibration shall be based on a probability of being exceeded in any one year of 1 in 10,

(c) for all *buildings*, except those listed in Clause (d), the reference velocity pressure, q, for the design of structural members for strength shall be based on a probability of being exceeded in any one year of 1 in 30, and

(d) the reference velocity pressure, q, for the design of structural members for strength for *post-disaster buildings* shall be based on a probability of being exceeded in any one year of 1 in 100.

(5) The exposure factor C_e shall be

(a) the value shown in Table 4.1.8.1. for the appropriate reference height for the surface or part of the surface,

(b) the value of the function $(h/10)^{1/5}$ but not less than 0.9 where h is the reference height above *grade* in metres for the surface or part of the surface, or

(c) 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 is one of the following values:

(a) 1.0 or 2.0 for internal pressures as appropriate, (See Appendix A.)

(b) 2.0 for the *building* as a whole and main structural members,

(c) 2.5 for small elements including cladding, or

(d) if a dynamic approach to the action of wind gusts is used, an appropriate value depending on the turbulence of the wind and the size and natural frequency of the structure. (See Appendix A.)

Table 4.1.8.1.
Exposure Factors, C_e
Forming Part of Sentence 4.1.8.1.(5)

Height, m (ft-in)	Exposure Factor
> 0 to ≤ 6 (0 to 19'-8")	0.9
> 6 to ≤ 12 (19'-8" to 39'-4")	1.0
> 12 to ≤ 20 (39'-4" to 65'-7")	1.1
> 20 to ≤ 30 (65'-7" to 98'-5")	1.2
> 30 to ≤ 44 (98'-5" to 144'-4")	1.3
> 44 to ≤ 64 (144'-4" to 210'-0")	1.4
> 64 to ≤ 85 (210'-0" to 278'-10")	1.5
> 85 to ≤ 140 (278'-10" to 459'-0")	1.6
> 140 to ≤ 240 (459'-0" to 787'-0")	1.8
> 240 to ≤ 400 (787'-0" to 1312'-0")	2.0
Column 1	2

4.1.8.2. Dynamic Effects of Wind

(1) *Buildings* whose height is greater than 4 times their minimum effective width or greater than 120 m (394 ft) and other *buildings* whose light weight, low frequency and low damping properties make them susceptible to vibration shall be

(a) designed by experimental methods for the danger of dynamic overloading and vibration and the effects of fatigue, or

(b) designed using a dynamic approach to the action of wind gusts. (See Appendix A.)

4.1.8.3. Full and Partial Loading

(1) *Buildings* and structural members shall be capable of withstanding the effects of

(a) the full winds acting along each of the two principal axes considered separately,

(b) the wind loads as described in (a) but with 25% of the load removed from any portion of the area,

(c) the wind loads as in (a) but considered simultaneously at 75% of their full value, and

(d) the wind loads as described in (c) but with 25 per cent of these loads removed from any portion of the area. (See Appendix A.)

4.1.8.4. 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*, and
(c) air pressurization by the mechanical services of the *building*.

4.1.9. Live Loads Due to Earthquakes

4.1.9.1. Analysis

(1) The specified loading due to earthquake motion shall be determined by the analysis given in this Subsection.

(2) In this Subsection

A_r = response amplification to account for type of attachment of mechanical/electrical equipment, as defined in Sentence 4.1.9.1.(19),
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 4.1.9.1.(19),
C_p = seismic coefficient for mechanical/electrical equipment, as defined in Sentence 4.1.9.1.(19),
D = the dimension of the *building* in a direction parallel to the applied forces,
D_{nx} = plan dimension of the *building* at level x perpendicular to the direction of seismic loading being considered,
D_s = dimension of wall or braced frame which constitutes the main lateral-load-resisting system in a direction parallel to the applied forces,
e_x = distance measured perpendicular to the direction of seismic loading between centre of mass and centre of rigidity at the level being considered, (See Appendix A.)
F = *foundation* factor as given in Sentence 4.1.9.1.(11),
F_t = portion of V to be concentrated at the top of the structure as defined in Sentence 4.1.9.1.(13),
F_x = lateral force applied to level x,
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 that level at which the horizontal earthquake motions are considered to be imparted to the structure,
h_s = interstorey height ($h_i - h_{i-1}$),
I = seismic importance factor of the structure, as described in Sentence 4.1.9.1.(10),
J = numerical reduction coefficient for base overturning moment as defined in Sentence 4.1.9.1.(23),
J_x = numerical reduction coefficient for moment at level "x" as defined in Sentence 4.1.9.1.(24),
Level i = any level in the *building*, i = 1 for first level above the base,
Level n = that level which is uppermost in the main portion of the structure,
Level x = that level which is under design consideration,
N = total number of *storeys* above exterior *grade* to level n, (N is usually numerically equal to n.)
R = force modification factor that reflects the capacity of a structure to dissipate energy through inelastic behaviour, as given in Sentence 4.1.9.1.(8),
S = seismic response factor, for unit value of zonal velocity ratio, as defined in Sentence 4.1.9.1.(6),
S_p = horizontal force factor for part or portion of a *building* and its anchorage, as given in Table 4.1.9.1.D. and Sentences 4.1.9.1.(17) and (19),
T = fundamental period of vibration of the *building* or structure in seconds in the direction under consideration,
T_x = floor torque at level x as defined in Sentence 4.1.9.1.(28),
U = factor representing level of protection based on experience, as specified in Sentence 4.1.9.1.(4),
v = zonal velocity ratio = the specified zonal horizontal ground velocity expressed as a ratio to 1 m/s (3.3 ft/s),
V = minimum lateral seismic force at the base of the structure, to be used with a load factor $\alpha_E = 1.0$,
V_e = equivalent lateral force at the base of the structure representing elastic response, as specified in Sentence 4.1.9.1.(5),
V_p = lateral force on a part of the structure,
W = *dead load* plus 25% of the design snow load

specified in Subsection 4.1.7. plus 60% of the storage load for areas used for storage and the full contents of any tanks, (See Appendix A.)

W_i, W_x = that portion of W which is located at or is assigned to level i or x, respectively,

W_p = the weight of a part or portion of a structure, e.g. cladding, *partitions* and appendages,

Z_a = acceleration-related seismic zone,

Z_v = velocity-related seismic zone.

(3) Earthquake forces shall be assumed to act in any horizontal direction, except that independent design about each of the principal axes shall be considered to provide adequate resistance in the structure for earthquake forces applied in any direction. (See Appendix A.)

(4) The minimum lateral seismic force, V, shall be calculated in accordance with the following formula:

$$V = (V_e/R)U$$

where U = 0.6.

(5) The equivalent lateral seismic force representing elastic response, V_e, shall be calculated in accordance with the following formula:

$$V_e = v \cdot S \cdot I \cdot F \cdot W$$

where v is the zonal velocity ratio determined in conformance with Subsection 2.5.1., except when $Z_v = 0$ and $Z_a > 0$ the value of Z_v shall be taken as 1 and v as 0.05 in all requirements of Subsection 4.1.9.

Table 4.1.9.1.A.
Seismic Response Factors
Forming Part of Sentence 4.1.9.1.(6)

T	Za/Zv	S
≤ 0.25	> 1.0 1.0 < 1.0	4.2 3.0 2.1
> 0.25 but < 0.50	> 1.0 1.0 < 1.0	4.2 - 8.4(T - 0.25) 3.0 - 3.6(T - 0.25) 2.1
≥ 0.50	All values	$1.5/(T)^{1/2}$
Column 1	2	3

(6) The seismic response factor, S, shall conform to Table 4.1.9.1.A.

(7) The fundamental period, T, in Sentence (6) shall be determined by

(a) the formula 0.1 N for any moment-resisting frame, or by the formulae $0.085(h_n)^{3/4}$ for a steel moment-resisting frame or $0.075(h_n)^{3/4}$ for a concrete moment-resisting frame, where the moment-resisting system is a frame which resists 100% of the required lateral forces and the frame is not enclosed by or adjoined by more rigid elements that would tend to prevent the frame from resisting lateral forces, and where h_n is in metres,

(b) the formula $0.09\, h_n/(D_s)^{1/2}$ for other structures, where h_n and D_s are in metres, and D_s = length of wall or braced frame which constitutes the main lateral-force-resisting system in the direction parallel to the applied forces; if the main lateral-force-resisting system does not have a well-defined length, then D shall be used in lieu of D_s, or

(c) other established methods of mechanics; the value of V_e used for design shall be not less than 0.80 of the value computed using the period calculated in Clause (a) or (b).

(8) Except as provided for in Sentences 4.1.9.3.(1), (2) and (3), values of the force modification factor, R, shall conform to Table 4.1.9.1.B. (See Appendix A.)

(9) For the purpose of applying Table 4.1.9.1.B.

(a) a ductile moment-resisting frame shall mean a frame that is designed to resist the specified seismic forces and that, in addition, has adequate ductility or energy-absorptive capacity;

(b) for combinations of different types of lateral-load-resisting systems acting in the same direction, R shall be taken as the lowest value of R corresponding to these systems except as given in Clause (c);

(c) if one of the lateral-force-resisting systems of the structure is designed to take 100% of the lateral force, R can be selected as appropriate for the system; the components of the structure not considered to be part of the lateral-force-resisting system must be capable of resisting their gravity loads under seismically induced deformations calculated in accordance with Sentence 4.1.9.2.(2);

(d) if it can be demonstrated through research or experience that the seismic performance of a structural system is at least equivalent to one of Cases 1-8, 10-14, 16-18 or 20-21 in Table 4.1.9.1.B., then such a structural system will qualify for a value of R corresponding to the equivalent case in that Table.

Table 4.1.9.1.B.
Force Modification Factors
Forming Part of Sentence 4.1.9.1.(8)

Case	Type of Lateral Load Resisting System	R
	Steel Structures Designed and Detailed According to CAN/CSA-S16.1-M	
1	ductile moment-resisting frame	4.0
2	ductile eccentrically braced frame	4.0
3	ductile steel plate shear wall	4.0
4	ductile braced frame	3.0
5	moment-resisting frame with nominal ductility	3.0
6	nominally ductile steel plate shear wall	3.0
7	braced frame with nominal ductility	2.0
8	ordinary steel plate shear wall	2.0
9	other lateral-force-resisting systems not defined in Cases 1 to 8	1.5
	Reinforced Concrete Structures Designed and Detailed According to CAN/CSA-A23.3-M	
10	ductile moment-resisting frame	4.0
11	ductile coupled wall	4.0
12	other ductile wall systems	3.5
13	moment-resisting frame with nominal ductility	2.0
14	wall with nominal ductility	2.0
15	other lateral-force-resisting systems not defined in Cases 10 to 14	1.5
	Timber Structures Designed and Detailed According to CSA-O86.1	
16	nailed shear panel with plywood, waferboard or OSB	3.0
17	concentrically braced heavy timber frame with ductile connections	2.0
18	moment-resisting wood frame with ductile connections	2.0
19	other systems not included in Cases 16 to 18	1.5
	Masonry Structures Designed and Detailed According to CSA-S304.1	
20	reinforced masonry wall with nominal ductility	2.0
21	reinforced masonry	1.5
22	unreinforced masonry	1.0
23	Other Lateral-force-resisting Systems not Defined in Cases 1 to 22	1.0
Column 1	2	3

Notes to Table 4.1.9.1.B.:
(1) See Appendix A.

Table 4.1.9.1.C.
Foundation Factors
Forming Part of Sentence 4.1.9.1.(11)

Categories	Type and Depth of *Rock* and *Soil* Measured from the *Foundation* or *Pile* Cap Level	F
1	*Rock*, dense and very dense coarse-grained *soils*, very stiff and hard fine-grained *soils*; compact coarse-grained *soils* and firm and stiff fine-grained *soils* from 0 to 15 m (0 to 49 ft 3 in) deep	1.0
2	Compact coarse-grained *soils*, firm and stiff fine-grained *soils* with a depth greater than 15 m; very loose and loose coarse-grained *soils* and very soft and soft fine-grained *soils* from 0 to 15 m (0 to 49 ft 3 in) deep	1.3
3	Very loose and loose coarse-grained *soils*, with depth greater than 15 m (49 ft 3 in)	1.5
4	Very soft and soft fine-grained *soils* with depth greater than 15 m (49 ft 3 in)	2.0
Column 1	2	3

Notes to Table 4.1.9.1.C.:
(1) See Appendix A.

(10) The seismic importance factor, I, shall equal 1.5 for *post-disaster buildings*, 1.3 for schools and 1.0 for all other *buildings*.

(11) The foundation factor, F, shall conform to Table 4.1.9.1.C., except that the product F·S need not exceed 3.0 where Z_a does not exceed Z_v and need not exceed 4.2 where Z_a is greater than Z_v. (See Appendix A.)

(12) The weight, W, of the *building* shall be calculated in accordance with the following formula:

$$W = \sum_{i=1}^{n} W_i$$

(13) The total lateral seismic force, V, shall be distributed as follows:

(a) a portion, F_t, shall be assumed to be concentrated at the top of the *building* and equal to 0.07 TV, except that F_t, need not exceed 0.25 V and may be considered as zero where T does not exceed 0.7 s; the remainder, V - F_t, shall be distributed along the height of the *building*, including the top level, in accordance with the formula

$$F_x = (V - F_t)\, W_x h_x \,/\, (\sum_{i=1}^{n} W_i h_i)$$

or

(b) by dynamic analysis, with the seismic effects scaled such that the base shear from the dynamic analysis equals V as given in Sentence 4.1.9.1.(4). (See Appendix A.)

(14) The total shear in any horizontal plane shall be distributed to the various elements of the lateral-force-resisting system in proportion to their rigidities according to rational analysis, with due regard to the capacities and stiffnesses of the nonstructural elements and to the effects of torsion as required by Sentence 4.1.9.1.(28).

(15) Except as provided for in Sentence (16), parts of *buildings* as described in Tables 4.1.9.1.D. and 4.1.9.1.E. and their anchorage shall be designed to accommodate the deflections defined in Article 4.1.9.2., and for a lateral force, V_p, equal to $v \cdot I \cdot S_p \cdot W_p$, distributed according to the distribution of mass of the element under consideration, where v is determined in conformance with Subsection 2.5.1., and I is the same importance factor as used for the *building*.

(16) For non *post-disaster buildings* in zones where Z_a and Z_v are equal to or less than 1.0 and F is equal to or less than 1.3, the requirements of Sentence (15) shall not apply to Table 4.1.9.1.E. or to cases 7, 8, and 9 of Table 4.1.9.1.D.

(17) Except as provided for in Sentence (21), the values of S_p in Sentences (15) and (16) for architectural components shall conform to Table 4.1.9.1.D. ★

Table 4.1.9.1.D.
Values of S_p for Architectural Parts or Portions of Buildings
Forming Part of Sentence 4.1.9.1.(15)

Category	Architectural Part or Portion of *Building*	Direction of Force	Value of S_p
1	All exterior and interior walls except those of Categories 2 and 3	Normal to flat surface	1.5
2	Cantilever parapet and other cantilever walls except retaining walls;	Normal to flat surface	6.5
3	Exterior and interior ornamentations and appendages	Any direction	6.5
4	Connections/attachments for Categories 1, 2 and 3		
	The body of ductile connections/attachments	Any direction	2.5
	All fasteners and anchors in the ductile connection, such as bolts, inserts, welds or dowels	Any direction	(1)
	Non-ductile connections/attachments	Any direction	15.0
5	Floors and roofs acting as diaphragms[3]	Any direction	0.7
6	Towers, *chimneys*, smokestacks and penthouses when connected to or forming part of a *building*[2]	Any direction	4.5
7	Horizontally cantilevered floors balconies, beams, etc.	Vertical	4.5
8	Suspended ceilings, light fixtures and other attachments to ceilings with independent vertical support	Any direction	2.0
9	Masonry veneer connections	Normal to flat surface	5.0
Col. 1	2	3	4

Notes to Table 4.1.9.1.D.:
(1) See Sentence 4.1.9.1.(18).
(2) See Sentence 4.1.9.1.(21).
(3) See Appendix A.

Table 4.1.9.1.E.
Values of C_p for Mechanical/Electrical Parts or Portions of Buildings
Forming Part of Sentence 4.1.9.1.(15)

Category	Mechanical/Electrical Part or Portion of *Building*	Direction of Force	Value of C_p
1	Machinery, fixtures, equipment, ducts, tanks and pipes (including contents) except as noted elsewhere in this table[1]	Any direction	1.0
2	Machinery, fixtures, equipment, ducts, tanks and pipes (including contents) containing toxic or explosive materials, materials having a *flash point* below 38°C (100°F) or fire fighting fluids.	Any direction	1.5
3	Flat bottom tanks (including contents) attached directly to a floor at or below *grade* within a *building.*	Any direction	0.7
4	Flat bottom tanks (including contents) attached directly to a floor at or below *grade* within a *building* containing toxic or explosive materials having a *flash point* below 38°C (100°F) or fire fighting fluids.	Any direction	1.0
Column 1	2	3	4

Notes to Table 4.1.9.1.E.:
[1] See Appendix A.

(18) All fasteners and anchors in a ductile connection, such as bolts, inserts, welds, or dowels, shall be capable of developing 3 times the yield load of the body of the connection.

(19) The values of S_p in Sentences (15) and (16) for mechanical/electrical components shall be equal to:

$$S_p = C_p \cdot A_r \cdot A_x$$

where:

C_p = seismic coefficient for components of mechanical and electrical equipment as given Table 4.1.9.1.E.

A_r = 1.0 for components that are both rigid and rigidly connected and for non-brittle pipes and ducts,
= 1.5 for components located on the ground that are flexible or flexibly connected except for non-brittle pipes and ducts,
= 3.0 for all other cases,

A_x = $1.0 + (h_x/h_n)$.

(20) For the purpose of applying Sentence (19)
(a) components that are both rigid and rigidly connected are defined as those having a fundamental period for the component and connection less than or equal to 0.06 s, and
(b) flexible components or connections are defined as those having a fundamental period greater than 0.06 s.

(21) Floors and roofs acting as diaphragms shall be designed for a minimum force corresponding to a value of S_p equal to 0.7 applied to loads tributary from that *storey*, unless a greater force F_x is assigned to the level under consideration as in Sentences (13) and (14).

(22) When the mass of a tank plus contents is greater than 10% of the mass of the supporting floor, the lateral forces shall be determined by rational analysis.

(23) The overturning moment, M, at the base of the structure shall be multiplied by a reduction coefficient, J, where
(a) J = 1 where T is less than 0.5,
(b) J = (1.1 - 0.2T) where T is not less than 0.5, but not more than 1.5, and
(c) J = 0.8 where T is greater than 1.5.

(24) The overturning moment M_x at any level x shall be
(a) multiplied by J_x where

$$J_x = J + (1 - J)(h_x/h_n)^3, \text{ and}$$

(b) distributed as required in Sentences (25), (26) and (27).

(25) The incremental changes in the design overturning moments, in the *storey* under consideration, shall be distributed to the various resisting elements in the same proportion as the distribution of shears in the resisting system.

(26) Where other vertical members are provided which are capable of partially resisting the overturning moments, a redistribution may be made to these members if framing members of sufficient strength and stiffness to transmit the required loads are provided.

(27) Where a vertical-resisting element is discontinuous, the overturning moment carried by the lowest *storey* of that element shall be carried down as loads to the *foundation*.

(28) Torsional moments about a vertical axis of the *building* shall be calculated as:

(a) for an analysis carried out in accordance with Clause 4.1.9.1.(13)(a), the torsional moments applied at each level throughout the *building* shall be derived for each of the following load cases considered separately
   (i) $T_x = F_x(1.5e_x + 0.1\ D_{nx})$
   (ii) $T_x = F_x(1.5e_x - 0.1\ D_{nx})$
   (iii) $T_x = F_x(0.5e_x + 0.1\ D_{nx})$
   (iv) $T_x = F_x(0.5e_x - 0.1\ D_{nx})$

   where F_x is the lateral floor force at each level as given by Clause 4.1.9.1.(13)(a) and the term $0.1\ D_{nx} \cdot F_x$ represents the accidental torsional moment applied at each level and where each element in the *building* is designed for the most severe effect of the above load cases, or

(b) the effects of accidental torsional moments applied at each level throughout the *building* shall be derived for each of the following load cases considered separately and shall be added to the effects of a three dimensional dynamic analysis
   (i) $T_x = +0.1\ D_{nx} \cdot F_x$
   (ii) $T_x = -0.1\ D_{nx} \cdot F_x$

and where each element in the *building* is designed for the most severe effect of the above load cases and F_x is the lateral floor force at each level as given by Clause 4.1.9.1.(13)(a). (See Appendix A.)

(29) The *building* design shall take full account of the possible effects of setbacks. (See Appendix A.)

4.1.9.2. Deflections

(1) Lateral deflections of a structure shall be calculated in accordance with accepted practice and based on the loads and requirements defined in this Section.

(2) Lateral deflections obtained from an elastic analysis using the loads given in Sentences 4.1.9.1.(13) and (14) and incorporating the effects of torsion shall be multiplied by R to give realistic values of anticipated deflections.

(3) The interstorey deflections based on the lateral deflections as calculated in Sentence (2) shall be limited to $0.01h_s$ for *post-disaster buildings* and $0.02h_s$ for all other *buildings*.

(4) All portions of the structure shall be designed to act as integral units in resisting horizontal forces, unless separated by adequate clearances which permit horizontal deflections of the structure consistent with values of deflections calculated in accordance with Sentence (2).

(5) The nonstructural components shall be designed so as not to transfer to the structural system any forces unaccounted for in the design, and any interaction of rigid elements such as walls and the structural system shall be designed so that the capacity of the structural system is not impaired by the action or failure of the rigid elements.

(6) Adjacent structures shall either be separated by the sum of their individual deflections as calculated in Sentence (2), or shall be connected to each other.

(7) The method of connection in Sentence (6) shall take into account the mass, stiffness, strength, ductility and anticipated motion of the connected *buildings* and the character of the connection.

(8) The deflections as calculated in Sentence (2) shall be used to account for sway effects due to seismic loading as required by Sentence 4.1.1.5.(2).

(9) The connected *buildings* in Sentence (6) shall be assumed to have the lowest R value of the *buildings* connected, unless the use of a higher value can be justified by rational analysis.

4.1.9.3. Special Provisions

(1) *Buildings* more than 3 *storeys* in *building height* in velocity- or acceleration-related seismic zones of 2 and higher shall have a structural system as described in Cases 1-8, 10-14, 16-18 or 20-21 in Table 4.1.9.1.B.

(2) For *buildings* more than 60 m in height with a structural system having R = 2.0 or R = 1.5 as determined from Table 4.1.9.1.B. or as determined from Clause 4.1.9.1.(9)(b), the value of V shall be increased by 50% in velocity-related seismic zones of 4 and higher.

(3) Elevated tanks plus full contents not supported by a *building*, shall be designed using R = 1 in the formula in Sentence 4.1.9.1.(4), with the conditions

(a) the minimum and maximum value of the product S·I

shall be taken as 1.5 and 3.0, respectively,
(b) the overturning moment reduction coefficient, J, as set forth in Sentence 4.1.9.1.(2) shall be 1.0, and
(c) the torsional requirements of Sentence 4.1.9.1.(28) shall apply.

(4) For *buildings* in velocity- or acceleration-related seismic zones of 2 and higher in which discontinuities in columns or shear walls occur, special design provisions shall be made to ensure that failure at the point of discontinuity will not occur before the capacity of the remaining portion of the structure has been realized.

(5) In velocity- or acceleration-related seismic zones of 2 and higher, reinforcement conforming to Clause 6.3.3. of CSA-S304.1, "Masonry Design for Buildings (Limit States Design)" shall be provided for masonry *construction* in
(a) *loadbearing* and lateral load-resisting masonry,
(b) masonry enclosing elevator shafts and stairways, or used as *exterior cladding*, and
(c) masonry *partitions*, except for *partitions* which,
   (i) do not exceed 200 kg/m² (40 lb/ft²) in weight, and
   (ii) do not exceed 3 m (9 ft 10 in) in height and are laterally supported at the top.

4.1.9.4. Foundation Provisions

(1) *Foundations* shall be designed so that yielding will occur first in the superstructure and not the *foundations*, unless the design specifically provides otherwise.

(2) Except in velocity-related seismic Zone 0, individual *pile* footings, drilled piers and caissons shall be interconnected by ties in at least 2 directions.

(3) Ties in Sentence (2) shall be designed to carry by tension or compression a horizontal force equal to the greatest factored *pile* cap loading multiplied by a factor 0.5 v, but not exceeding 10% of the greatest factored *pile* cap load, unless it can be demonstrated that equivalent restraints can be provided by other means.

(4) Except in velocity-related seismic Zone 0, *piles* shall be connected to the *pile* cap or structure by reinforcement having sufficient anchorage to develop the yield strength of the reinforcement, and the top of the *piles* (below the *pile* cap) shall be reinforced to allow ductile behaviour if the design depends upon such action.

(5) Except in velocity-related seismic Zones 0 and 1, *basement* walls shall be designed to resist seismic lateral pressures from backfill or natural ground.

(See Appendix A.)

4.1.10. Other Effects

4.1.10.1. Loads on Guards (See Appendix A.)

(1) The minimum specified horizontal load applied inward or outward at the top of every required *guard* shall be
(a) 3.0 kN/m (200 lb/ft) for *means of egress* in grandstands, stadia, bleachers and arenas,
(b) a concentrated load of 1.0 kN (225 lb) applied at any point for access walkways to equipment platforms, contiguous stairs and similar areas where the gathering of many people is improbable, and
(c) 0.75 kN/m (50 lb/ft) or a concentrated load of 1.0 kN (225 lb) applied at any point, whichever governs, for locations other than described in Clauses (a) and (b).

(2) Individual elements within the *guard*, including solid panels and pickets, shall be designed for a concentrated load of 0.5 kN (113 lb) at any point in the element.

(3) The loads required in Sentence (2) need not be considered to act simultaneously with the loads provided for in Sentences (1) and (4).

(4) The minimum specified load applied vertically at the top of every required *guard* shall be 1.5 kN/m (100 lb/ft) and need not be considered to act simultaneously with the horizontal load provided for in Sentence (1).

4.1.10.2. Loads on Vehicle Guardrails

(1) Vehicle guardrails for parking garages shall be designed for a concentrated load of 22 kN (5000 lb) applied horizontally outward at any point 500 mm (19¾ in) above the floor surface. (See Appendix A.)

4.1.10.3. Loads on Walls Acting As Guards

(1) Where the floor elevation on one side of a wall, including a wall around a shaft, is more than 600 mm (23⅝ in) higher than the elevation of the floor or ground on the other side, the wall shall be designed to resist the appropriate lateral design loads prescribed elsewhere in this Section or 0.5 kPa (10 psf), whichever produces the greatest effect.

4.1.10.4. Firewalls

(1) *Firewalls* shall be designed to resist the maximum

effect due to:
(a) the appropriate lateral design loads prescribed elsewhere in this Section, or
(b) a factored lateral load of 0.5 kPa (10 psf) under fire conditions as described in Sentence (2).

(2) Under fire conditions, when the *fire-resistance rating* of the structure is less than that of the *firewall*,
(a) lateral support shall be assumed to be provided by the structure on one side only, or
(b) another structural support system capable of resisting the loads imposed by a fire on either side of the *firewall* shall be provided.
(See Appendix A.)

4.1.10.5. Vibrations and Impact of Machinery and Equipment

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

(2) The minimum specified load due to equipment, machinery or other objects that may produce impact shall be the sum of the weight of the equipment or machinery and its maximum lifting capacity, multiplied by an appropriate factor listed in Table 4.1.10.5.

Table 4.1.10.5.
Factors for the Calculation of Impact Loads
Forming Part of Sentence 4.1.10.5.(2)

Impact Due to	Factor
Operation of cab or radio operated cranes	1.25
Operation of pendant or hand operated cranes	1.10
Operation of elevators	(1)
Supports for light machinery, shaft or motor driven	1.20
Supports for reciprocating machinery (e.g. compressors)	1.50
Supports for power driven units (e.g. piston engines)	1.50
Column 1	2

Notes to Table 4.1.10.5.
(1) See CAN/CSA-B44-M, Clauses 2.6.2. and 2.10.3.

(3) Crane runway structures shall be designed to resist a horizontal force applied normal to the top of the rails equal to not less than 20% of the sum of the weights of the lifted load and the crane trolley (excluding other parts of the crane).

(4) The force described in Sentence (3) shall be equally distributed on each side of the runway and shall be assumed to act in either direction.

(5) Crane runway structures shall be designed to resist a horizontal force applied parallel to the top of the rail equal to not less than 10% of the maximum wheel loads of the crane.

4.1.10.6. Resonances and Sway Forces

(1) 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.)

(2) The floor assembly and other structural elements that support fixed seats in any *building* used for *assembly occupancies* to accommodate large numbers of people at one time, such as grandstands, stadia and *theatre* balconies, shall be designed to resist a horizontal force equal to not less than 0.3 kN (70 lb) for each metre length of seats acting parallel to each row of seats, and not less than 0.15 kN (35 lb) for each metre length of seat acting at right angles to each row of seats, assuming such forces to be acting independently of each other.

4.1.10.7. Bleachers

(1) Bleachers shall be checked by the erector after erection to ensure that all structural members including bracing specified in the design have been installed.

(2) Telescopic bleachers shall be provided with locking devices to ensure stability while in use.

4.1.10.8. Anchor Systems on Building Exterior

(1) Where maintenance and window cleaning operations are intended to be carried out on the exterior of a *building* described in Article 2.1.1.2, anchor systems shall be provided where any portion of the roof is more than 8 m (26 ft 3 in) above adjacent ground level.

(2) Except as provided in Sentence (3), the anchor systems in Sentence (1) shall be designed, installed and tested in conformance with CSA Standard Z91, "Safety Code for Window Cleaning Operations".

(3) Other anchor systems may be used where such systems provide an equal level of safety.

(4) The anchor system material shall be made of

stainless steel, aluminum, or other corrosion resistant base material, or from steel that is hot dipped galvanised, in accordance with CSA Standard G164-M81, "Hot Dip Galvanising of Irregularly Shaped Articles".

Section 4.2. Foundations

4.2.1. General

4.2.1.1. Application

(1) This Section applies to *excavations* and *foundation* systems for *buildings*.

4.2.2. Subsurface Investigations and Reviews

4.2.2.1. Subsurface Investigation

(1) A *subsurface investigation* shall be carried out, which shall include *groundwater* conditions. (See Appendix A.)

4.2.2.2. Reserved.

4.2.2.3. Review

(1) A review shall be carried out by the *designer* or by another suitably qualified person to ascertain that the subsurface conditions are consistent with the design and that *construction* is carried out in accordance with the design and good engineering practice. (See Appendix A.)

(2) The review required in Sentence (1) shall be carried out

- (a) on a continuous basis
  - (i) during the *construction* of all *deep foundation units* with all pertinent information recorded for each unit, and
  - (ii) during the installation and removal of retaining structures and related backfilling operations, and
- (b) as required, unless otherwise directed by the *chief building official*,
  - (i) in the *construction* of all *shallow foundation units*, and
  - (ii) in excavating, dewatering and other related works.

4.2.2.4. Altered Subsurface Condition

(1) Where during *construction* the *soil*, *rock* or *groundwater* is found not to be of the type or in the condition used in design, and as indicated on the drawings, the design shall be reassessed by the *designer*.

(2) Where during *construction* climatic or any other conditions have changed the properties of the *soil*, *rock* or *groundwater*, the design shall be reassessed by the *designer*

4.2.3. Materials Used in Foundations

4.2.3.1. Wood

(1) Wood used in *foundations* or in support of *soil* or *rock* shall conform with the appropriate requirements of Subsection 4.3.1.

4.2.3.2. Preservation Treatment of Wood

(1) Wood exposed to *soil* or air above the lowest anticipated *groundwater* table shall be treated with preservative in conformance with CAN/CSA-O80-M, "Wood Preservation" and the requirements of the appropriate commodity standard as follows:

- (a) CSA-O80.2-M, "Preservative Treatment of Lumber, Timber, Bridge Ties and Mine Ties by Pressure Processes",
- (b) CSA-O80.3-M, "Preservative Treatment of Piles by Pressure Processes", or
- (c) CSA-O80.15-M, "Preservative Treatment of Wood for Building Foundation Systems, Basements and Crawl Spaces by Pressure Processes".

(2) Where timber has been treated as required in Sentence (1), it shall be cared for as provided in AWPA Standard M4, "Care of Preservative Treated Wood Products" as revised by Clause 6 of CAN/CSA-O80, "Wood Preservation".

4.2.3.3. Plain and Reinforced Masonry

(1) Plain or reinforced masonry used in *foundations* or in support of *soil* or *rock* shall conform with the requirements of Subsection 4.3.2.

4.2.3.4. Prevention of Deterioration of Masonry

(1) Where plain or reinforced masonry in *foundations* or

in structures supporting *soil* or *rock* may be subject to conditions conducive to deterioration, protection shall be provided to prevent such deterioration.

4.2.3.5. Concrete

(1) Plain, reinforced or prestressed concrete used in *foundations* or in support of *soil* or *rock* shall conform with the requirements of Subsection 4.3.3.

4.2.3.6. Chemical Attack of Concrete

(1) Where concrete in *foundations* may be subject to chemical attack, it shall be treated in conformance with the requirements in CAN3-A23.1, "Concrete Materials and Methods of Concrete Construction".

4.2.3.7. Steel

(1) Steel used in *foundations* or in support of *soil* or *rock* shall conform with the appropriate requirements of Subsections 4.3.3. or 4.3.4., unless otherwise specified in this Section.

4.2.3.8. Steel Piles

(1) Where steel piles are used in *deep foundations* and act as permanent load-carrying members, the steel shall conform with one of the following standards:
- (a) CAN3-G40.21-M, "Structural Quality Steels",
- (b) ASTM A252, "Welded and Seamless Steel Pipe Piles",
- (c) ASTM A283/A283M, "Low and Intermediate Tensile Strength Carbon Steel Plates",
- (d) ASTM A570/A570M, "Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality", or
- (e) ASTM A611, "Steel Sheet, Carbon, Cold-Rolled Sheet, Structural Quality".

4.2.3.9. High Strength Steel Tendons

(1) Where high strength steel is used for tendons in anchor systems used for the permanent support of a *foundation* or in the erection of temporary support of *soil* or *rock* adjacent to an *excavation*, it shall conform with the requirements of CAN3-A23.1, "Concrete Materials and Methods of Concrete Construction".

4.2.3.10. Corrosion of Steel

(1) Where conditions are corrosive to steel, adequate protection of exposed steel shall be provided. (See Section 2.7. for use of other materials)

4.2.4. Design Requirements

4.2.4.1. Design Basis

(1) The design of *foundations*, *excavations* and *soil*- and *rock*-retaining structures shall be based on a *subsurface investigation* carried out by a person competent in this field of work, and one of the following:
- (a) application of generally accepted geotechnical and civil engineering principles by a person especially qualified in this field of work as provided in this Section and other Sections of Part 4,
- (b) established local practice where such practice includes successful experience both with *soils* and *rocks* of similar type and condition and with a *foundation* or *excavation* of similar type, *construction* method, size and depth, or
- (c) in situ testing of *foundation units* such as the load testing of *piles*, anchors or footings carried out by a person competent in this field of work.

(See Appendix A.)

4.2.4.2. Subsurface Investigation

(1) A *subsurface investigation* shall be carried out to the depth and extent to which the *building* or *excavation* will significantly change the stress in the *soil* or *rock*, or to such a depth and extent as to provide all the necessary information for the design and *construction* of the *excavation* or the *foundations*.

4.2.4.3. Identification

(1) The identification and classification of *soil*, *rock* and *groundwater* and descriptions of their engineering and physical properties shall be in accordance with a widely accepted system.

4.2.4.4. Loads on Foundations

(1) The *foundation* of a *building* shall be capable of resisting all loads as stipulated in Section 4.1., in accordance with limit states design in Subsection 4.1.3. or working stress design in Subsection 4.1.4. (See Appendix A.)

4.2.4.5. Differential Movements

(1) The *foundation* of a *building* shall be proportioned so that the estimated total and differential movements of the *foundation* are not greater than the movements that the

building is designed to accommodate. (See Appendix A.)

4.2.4.6. Depth of Foundations

(1) Except as permitted in Sentence (2), the *bearing surface* of a *foundation* shall be below the level of potential damage, including damage resulting from *frost action*, and the *foundation* shall be designed to prevent damage resulting from *adfreezing* and frost jacking. (See Appendix A.)

(2) The *bearing surface* of a *foundation* need not be below the level of potential damage from frost where the *foundation*
(a) is designed against *frost action*, or
(b) overlies material not susceptible to *frost action*.

4.2.4.7. Sloping Ground

(1) Where a *foundation* is to rest on, in or near sloping ground, this particular condition shall be provided for in the design.

4.2.4.8. Eccentric and Inclined Loads

(1) Where there is eccentricity or inclination of loading in *foundation units*, this effect shall be fully investigated and provided for in the design.

4.2.4.9. Dynamic Loading

(1) Where dynamic loading conditions apply, the effects shall be assessed by a special investigation of these conditions and provided for in the design.

4.2.4.10. Hydrostatic Uplift

(1) Where a *foundation* or any part of a *building* is subject to hydrostatic uplift the effects shall be provided for in the design.

4.2.4.11. Groundwater Level Charge

(1) Where proposed *construction* will result in a temporary or permanent change in the *groundwater level*, the effects of this change on adjacent property shall be fully investigated and provided for in the design.

4.2.4.12. Permafrost

(1) Where conditions of permafrost are encountered or proven to exist, the design of the *foundation* shall be based upon analysis of these conditions by a person especially qualified in that field of work.

4.2.4.13. Swelling and Shrinking Soils

(1) Where swelling or shrinking *soils*, in which movements resulting from moisture content changes may be sufficient to cause damage to a structure, are encountered or known to exist, such a condition shall be fully investigated and provided for in the design.

4.2.4.14. Expanding and Deteriorating

(1) Where *rock* which expands or deteriorates when subjected to unfavourable environmental conditions or to stress release is known to exist such condition shall be fully investigated and provided for in the design.

4.2.4.15. Construction on Fill

(1) *Buildings* may be placed on *fill* if it can be shown by *subsurface investigation* that
(a) the *fill* is or can be made capable of safely supporting the *building*,
(b) detrimental movement of the *building* or services leading to the *building* will not occur, and
(c) explosive gases can be controlled or do not exist.

4.2.4.16. Structural Design

(1) The structural design of the *foundation* of a *building*, the procedures and *construction* practices shall conform with the appropriate Sections of this Code unless otherwise specified in this Section.

4.2.5. Excavations

4.2.5.1. Design of Excavations

(1) The design of *excavations* and of supports for the sides of *excavations* shall conform with the requirements of Subsection 4.2.4. and with this Subsection. (See Appendix A.)

4.2.5.2. Excavation Construction

(1) Every *excavation* shall be undertaken in such a manner as to prevent movement which would cause damage to adjacent property, existing structures, utilities, roads and sidewalks at all phases of *construction*.

(2) Material shall not be placed nor shall equipment be operated or placed in or adjacent to an *excavation* in a

manner that may endanger the integrity of the *excavation* or its supports.

4.2.5.3. Supported Excavations

(1) The sides of an *excavation* in *soil* or *rock* shall be supported by a retaining structure conforming with the requirements of Articles 4.2.5.1. and 4.2.5.2., except as permitted in Article 4.2.5.4.

4.2.5.4. Unsupported Excavations

(1) The sides of an *excavation* in *soil* or *rock* may be unsupported where a design is prepared by a person especially qualified in this field of work in conformance with the requirements of Articles 4.2.5.1. and 4.2.5.2.

4.2.5.5. Control of Water Around Excavations

(1) Surface water, all *groundwater*, *perched* and in particular *artesian groundwater* shall be kept under control at all phases of *excavation* and *construction*.

4.2.5.6. Loss of Ground

(1) At all phases of *excavation* and *construction*, loss of ground due to water or any other cause shall be prevented.

4.2.5.7. Protection and Maintenance at Excavations

(1) All sides of an *excavation*, supported and unsupported, shall be continuously maintained and protected from possible deterioration by *construction* activity or by the action of frost, rain and wind.

4.2.5.8. Backfilling

(1) Where an *excavation* is backfilled, the backfill shall be placed so as to
(a) provide lateral support to the *soil* adjacent to the *excavation*, and
(b) prevent detrimental movements.

(2) The material used as backfill or *fill* supporting a footing, *foundation* or a floor on *grade* shall be of a type that is not subject to detrimental volume change with changes in moisture content and temperature.

4.2.6. Shallow Foundations

4.2.6.1. Design of Shallow Foundations

(1) The design of *shallow foundations* shall be in conformance with Subsection 4.2.4. and the requirements of this Subsection. (See Appendix A.)

4.2.6.2. Support of Shallow Foundations

(1) Where a *shallow foundation* is to be placed on *soil* or *rock*, the *soil* or *rock* shall be cleaned of loose and unsound material and shall be adequate to support the *design load* taking into account temperature, precipitation, *construction* activities and other factors which may lead to changes of the properties of *soil* or *rock*.

4.2.6.3. Incorrect Placement of Shallow Foundations

(1) Where a *shallow foundation unit* has not been placed or located as indicated on the drawings
(a) the error shall be corrected, or
(b) the design of the *foundation unit* shall be recalculated for the altered conditions by the *designer*.

4.2.6.4. Damaged Shallow Foundations

(1) Where a *shallow foundation unit* is damaged,
(a) it shall be repaired, or
(b) the *design* of the *foundation unit* shall be recalculated for the damaged condition by the *designer*.

4.2.7. Deep Foundations

4.2.7.1. General

(1) A *deep foundation unit* shall provide support for a *building* by transferring loads by end-bearing to a competent stratum at considerable depth below the structure, or by mobilizing resistance by adhesion or friction, or both, in the *soil* or *rock* in which it is placed. (See Appendix A.)

4.2.7.2. Design for Deep Foundations

(1) *Deep foundation units* shall be designed in conformance with Subsection 4.2.4. and this Subsection. (See Appendix A.)

(2) Where *deep foundation units* are load tested, as required in Clause 4.2.4.1.(1)(c), the determination of the number and type of load test and the interpretation of the results shall be carried out by a person especially qualified in this field of work. (See Appendix A.)

(3) Where *deep foundation units* are not load tested as outlined in Clause 4.2.4.1.(1)(c), and where well established local practice as outlined in Clause 4.2.4.1.(1)(b) is not applicable, the design shall be carried out in conformance with Clause 4.2.4.1.(1)(a).

(4) The design of *deep foundations* shall be determined on the basis of geotechnical considerations taking into account
(a) the method of installation,
(b) the degree of inspection,
(c) the spacing of *foundation units* and group effects,
(d) other requirements of this Subsection, and
(e) the appropriate structural requirements of Section 4.1. and Subsections 4.3.1., 4.3.3. and 4.3.4.

(5) The portion of a *deep foundation unit* permanently in contact with *soil* or *rock* shall be structurally designed as a laterally supported compression member.

(6) The portion of a *deep foundation unit* which is not permanently in contact with *soil* or *rock* shall be structurally designed as a laterally unsupported compression member.

(7) The structural design of prefabricated *deep foundation units* shall allow for all stresses resulting from driving, handling and testing.

4.2.7.3. Tolerance in Alignment and Location

(1) Permissible deviations from the design alignment and the location of the top of *deep foundation units* shall be determined by design analysis, and shall be indicated on the drawings.

4.2.7.4. Incorrect Alignment and Location

(1) Where a *deep foundation unit* has not been placed within the permissible deviations referred to in Article 4.2.7.3., the condition of the *foundation* shall be assessed by the person responsible for the design, any necessary changes made and action taken as required.

4.2.7.5. Installation of Deep Foundations

(1) *Deep foundation units* shall be installed in such a manner as not to impair
(a) the strength of the *deep foundation units* and the properties of the *soil* or *rock* on or in which they are placed beyond the calculated or anticipated limits,
(b) the integrity of previously installed *deep foundation units*, or
(c) the integrity of neighbouring structures and services.

4.2.7.6. Damaged Deep Foundation Units.

(1) Where inspection shows that a *deep foundation unit* is damaged or not consistent with design or good engineering practice,
(a) such a unit shall be reassessed by the *designer*, and
(b) any necessary changes shall be made and action taken as required.

4.2.8. Special Foundations

4.2.8.1. General

(1) Where special *foundation* systems are used, such systems shall conform to Subsection 4.2.4.

4.2.8.2. Use of Existing Foundations

(1) Existing *foundations* may be used to support new or altered *buildings* provided they comply with all pertinent requirements of this Section.

Section 4.3. Design Requirements for Structural Materials

4.3.1. Wood

4.3.1.1. Design Basis for Wood

(1) *Buildings* and their structural members made of wood shall conform to CAN/CSA-O86.1-M, "Engineering Design in Wood (Limit States Design)".

4.3.1.2. Glue-Laminated Members

(1) Glued-laminated members shall be fabricated in plants conforming to CAN/CSA-O177-M, "Qualification Code for Manufacturers of Structural Glued-Laminated Timber".

4.3.1.3. Termites

(1) In areas known to be infested by termites, the

requirements in Articles 9.3.2.9., 9.12.1.1. and 9.15.5.1. shall apply.

4.3.2. Plain and Reinforced Masonry

4.3.2.1. Design Basis for Plain and Reinforced Masonry

(1) *Buildings* and their structural members made of plain and reinforced masonry shall conform to
(a) CAN3-S304-M, "Masonry Design for Buildings", or
(b) CSA-S304.1, "Masonry Design for Buildings" (Limit States Design).

4.3.3. Plain, Reinforced and Prestressed Concrete

4.3.3.1. Design Basis for Plain, Reinforced and Prestressed Concrete

(1) *Buildings* and their structural members made of plain, reinforced or prestressed concrete shall conform to CAN/CSA-A23.3-M, "Design of Concrete Structures for Buildings". (See Appendix A.)

4.3.4. Steel

4.3.4.1. Design Basis for Structural Steel

(1) *Buildings* and their structural members made of structural steel shall conform to CAN/CSA-S16.1-M, "Limit States Design of Steel Structures". (See Appendix A.)

4.3.4.2. Design Basis for Cold Formed Steel

(1) *Buildings* and their structural members made of cold formed steel shall conform to CAN/CSA-S136-M, "Cold Formed Steel Structural Members". (See Appendix A.)

4.3.5. Aluminum

4.3.5.1. Design Basis for Aluminium

(1) *Buildings* and their structural members made of aluminum shall conform to CAN3-S157-M, "Strength Design in Aluminum".

4.3.6. Glass

4.3.6.1. Design Basis for Glass

(1) Glass shall be designed in conformance with CAN/CGSB-12.20-M, "Structural Design of Glass for Buildings".

Section 4.4. Design Requirements for Special Structures

4.4.1. Air-Supported Structures

4.4.1.1. Design Basis for Air-Supported Structures

(1) The structural design of *air-supported structures* shall conform to CAN3-S367-M, "Air-Supported Structures".

4.4.2. Parking Structures

4.4.2.1. Design Basis for Parking Structures

(1) Parking structures shall be designed in conformance with CSA-S413, "Parking Structures".

4.4.3. Guards Over Retaining Walls

4.4.3.1. Guards Over Retaining Walls

(1) Every retaining wall which is a designated structure in Subsection 2.1.2. shall be protected by *guards* on all open sides where the public has access to open space at the top of the retaining wall.

Part 5
Wind, Water and Vapour Protection