National Farm Building Code of Canada 1995

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Preface

This edition of the National Farm Building Code[†] is published by the National Research Council through its Canadian Commission on Building and Fire Codes. It comprises a model set of minimum requirements for farm buildings in matters affecting human health, fire safety and structural sufficiency.

The edition of the Canadian Farm Building Code published in 1977 contained a considerable amount of useful farm information. However, much of the material from that edition was outside the scope of traditional building code requirements, which are normally concerned with matters affecting fire safety, health and structural sufficiency.

The 1983 edition of the Canadian Farm Building Code was, therefore, completely rewritten by a special task group established for this purpose. It was presented in a format that permitted its legal adoption by an authority having jurisdiction either directly or by reference. The 1995 edition is an updated version of this format.

The rationale for having special requirements for farm buildings, as distinct from other buildings, is based on the low human occupancy load, the remote location of typical farm structures or the special nature of the occupancies involved. Farm buildings that do not qualify as having "low human occupancy," that is, an occupant load of not more than one person for each 40 m^2, are required to conform to the National Building Code in all respects. Dwelling units located on a farm are also required to conform to the National Building Code.

Material from the 1977 edition of this Code not related to health, fire safety or structural sufficiency is available in the Canadian Farm Buildings Handbook, available from Canada Communications Group, Publishing, 45 Sacre Coeur Blvd., Hull, Québec, Canada KlA 0S9.

All values in the Code are given in metric (SI) units. A table to convert SI units to imperial units can be found at the end of this document.

Comments on the use of this Code and suggestions for its improvement are welcomed and should be submitted to the Secretary, Canadian Commission on Building and Fire Codes, National Research Council of Canada, Ottawa, Ontario K1A 0R6.

[†] Ce document est également publié en français

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Part 1
Application and Definition

Section 1.1. Application

1.1.1. General

1.1.1.1. Scope

1) This Code covers structural sufficiency, fire safety and health requirements for the protection of persons in *farm buildings*.

1.1.1.2. Administrative Requirements

1) This Code shall be administered in conformance with the appropriate provincial, territorial or municipal regulations or, in the absence of such regulations, in conformance with the "Administrative Requirements for Use with the National Building Code 1995."

1.1.1.3. Conformance to National Building Code

1) *Farm buildings* shall conform to the appropriate requirements in the National Building Code of Canada 1995 except as specifically amended or exempted by the provisions of this Code. (See Appendix A.)

Section 1.2. Definition and Abbreviations

1.2.1. Definition

1.2.1.1. Non-Define Words and Phrases

1) Words and phrases used in this Code which are not included in Article 1.2.1.2. shall have the meanings which are commonly assigned to them in the context in which they are used, taking into account the specialized use of terms with the various trades and professions to which the terminology applies.

1.2.1.2. Define Words and Phrases

1) The words and terms in italics in this Code have the following meanings:

Access to exit means that part of a *means of egress* within a *floor area* that provides access to an *exit* serving the *floor area*.

Appliance means a device to convert fuel into energy and includes all components, controls, wiring and piping required to be part of the device by the applicable standard referred to in this Code.

Building means any structure used or intended for supporting or sheltering any use or *occupancy*.

Building area means the greatest horizontal area of a *building* above *grade* within the outside surface of exterior walls or within the outside surface of exterior walls and the centre line of *firewalls*.

Building height (in *storeys*) means the number of *storeys* contained between the roof and the floor of the *first storey*.

Business and personal services occupancy means the *occupancy* or use of a *building* or part thereof for the transaction of business or the rendering or receiving of professional or personal services.

Combustible construction means that type of construction that does not meet the requirements for *noncombustible construction*.

Dead load means the weight of all permanent structural and nonstructural components of a *building*.

Dwelling unit means a *suite* operated as a housekeeping unit, used or intended to be used as a domicile by one or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.

Exit means that part of a *means of egress*, including doorways, that leads from the *floor area* it serves, to a separate *building*, an open public thoroughfare, or an exterior open space protected from fire exposure from the *building* and having access to an open public thoroughfare.

Exposing building face means that part of the exterior wall of a *building* which faces one direction and is located between ground level and the ceiling of its top *storey*, or where a *building* is divided into *fire compartments*, the exterior wall of a *fire compartment* which faces one direction. (See Appendix A, Sentence 3.1.2.1.(1).)

Farm building means a *building* or part thereof which does not contain a *residential occupancy* and which is associated with and located on land devoted to the practice of farming, and used essentially for the housing of equipment or livestock, or the production, storage or processing of agricultural and horticultural produce or feeds. (See Appendix A.)

Fire compartment means an enclosed space in a *building* that is separated from all other parts of the *building* by enclosing construction providing a *fire separation* having a required *fire-resistance rating*.

Fire-resistance rating means the time in hours or fraction thereof that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria, or as determined by extension or interpretation of information derived therefrom as prescribed in this Code.

Fire separation means a construction assembly that acts as a barrier against the spread of fire.

Firewall means a type of *fire separation* of *noncombustible construction* which subdivides a *building* or separates adjoining *buildings* to resist the spread of fire and which has a *fire-resistance rating* as prescribed in this Code and has structural stability to remain intact under fire conditions for the required fire-rated time.

First storey means the uppermost *storey* having its floor level not more than 2 m above *grade*.

Floor area means the space on any *storey* of a *building* between exterior walls and required *firewalls*, including the space occupied by interior walls and *partitions*, but not including *exits*, vertical *service spaces*, and their enclosing assemblies.

Foundation means a system or arrangement of *foundation units* through which the loads from a *building* are transferred to supporting *soil* or *rock*.

Foundation unit means one of the structural members of the *foundation* of a *building* such as a footing, raft or pile.

Grade (as applying to the determination of *building height*) means the lowest of the average levels of finished ground adjoining each exterior wall of a *building*, except that localized depressions such as for vehicle or pedestrian entrances need not be considered in the determination of average levels of finished ground. (See *First storey*.)

High hazard industrial occupancy (Group F, Division 1) means an *industrial occupancy* containing sufficient quantities of highly combustible and flammable or explosive materials which, because of their inherent characteristics, constitute a special fire hazard.

Industrial occupancy means the *occupancy* or use of a *building* or part thereof for the assembling, fabricating, manufacturing, processing, repairing or storing of goods and materials.

Live load means the load other than *dead load* to be assumed in the design of the structural members of a *building*. It includes loads resulting from snow, rain, wind, earthquake and those due to *occupancy*.

Loadbearing (as applying to a building element) means su bjected to or designed to carry loads in addition to its own *dead load*, excepting a wall element subjected only to wind or earthquake loads in addition to its own *dead load*.

Low human occupancy (as applying to *farm buildings*) means an *occupancy* having an *occupant load* of not more than one person per 40 m^2 of *floor area* during normal use.

Means of egress means a continuous path of travel provided for the escape of persons from any point in a *building* or contained open space to a separate *building*, an open public thoroughfare, or an exterior open space protected from fire exposure from the *building* and having access to an open public thoroughfare. *Means of egress* includes *exits* and *access to exits*.

Medium hazard industrial occupancy (Group F, Division 2) means an *industrial occupancy* in which the combustible content is more than 50 kg/m^2 or 1 200 MJ/m^2 of *floor area* and not classified as *high hazard industrial occupancy*.

Noncombustible means that a material meets the acceptance criteria of CAN4-S114, "Standard Method of Test for Determination of Non-Combustibility in Building Materials."

Noncombustible construction means that type of construction in which a degree of fire safety is attained by the use of *noncombustible* materials for structural members and other building assemblies.

Occupancy means the use or intended use of a *building* or part thereof for the shelter or support of persons, animals or property.

Occupant load means the number of persons for which a *building* or part thereof is designed.

Partition means an interior wall 1 *storey* or part-*storey* in height that is not *loadbearing*.

Residential occupancy means the *occupancy* or use of a *building* or part thereof by persons for whom sleeping accommodation is provided but who are not harboured or detained to receive medical care or treatment or are not involuntarily detained.

Rock means that portion of the earth's crust which is consolidated, coherent and relatively hard and is a naturally formed, solidly bonded, mass of mineral matter which cannot readily be broken by hand.

Service room means a room provided in a *building* to contain equipment associated with *building* services.

Service space means space provided in a *building* to facilitate or conceal the installation of *building* service facilities such as chutes, ducts, pipes, shafts or wires.

Soil means that portion of the earth's crust which is fragmentary, or such that some individual particles of a dried sample may be readily separated by agitation in water; it includes boulders, cobbles, gravel, sand, silt, clay and organic matter.

Storey means that portion of a *building* which is situated between the top of any floor and the top of the floor next above it, and if there is no floor above it, that portion between the top of such floor and the ceiling above it.

Suite means a single room or series of rooms of complementary use, operated under a single tenancy, and includes *dwelling units*, individual guest rooms in motels, hotels, boarding houses, rooming houses and dormitories as well as individual stores and individual or complementary rooms for *business and personal services occupancies.*

1.2.2. Abbreviations

1.2.2.1. Organizations and Authorities

1) Abbreviations for the names of organizations or authorities in this Code have the following meanings:

ASAE .... American Society of Agricultural Engineers (2950 Niles Road, St. Joseph, Michigan 49085-9659 USA)

CCBFC .... Canadian Commission on Building and Fire Codes (National Research Council of Canada, Ottawa, Ontario K1A 0R6)

CSA .... Canadian Standards Association (178 Rexdale Boulevard, Etobicoke, Ontario M9W 1R3)

NBC .... National Building Code of Canada (National Research Council of Canada, Ottawa, Ontario K1A 0R6)

1.2.2.2. Symbols and Other Abbreviations

1) Symbols and other abbreviations in this Code have the following meanings unless otherwise defined:

°C .... degree(s) Celsius
° .... degree(s)
g .... gram(s)
h .... hour(s)
kg .... kilogram(s)
kN .... kilonewton(s)
kPa .... kilopascal(s)
L .... litre(s)
m .... metre(s)
min .... minute(s)
mm .... millimetres
o.c. .... on centre
OSB .... oriented strandboard
s .... second(s)

Part 2
Structural Design

Section 2.1. General

2.1.1. Materials

2.1.1.1. Pressure Treatment of Wood

1) Structural wood members in long-term contact with earth, manure or damp poultry litter shall be pressure-treated with a wood preservative in conformance with CAN/CSA-O80-M89, "Wood Preservation."

2) Wood treated with toxic chemicals shall not be used in such a manner that the chemicals can come into contact with food products or animal feeds either directly or by dripping of contaminated condensation unless permitted under the Pest Control Products Act of Agriculture Canada.

Section 2.2. Structural Loads and Procedures

2.2.1. Loads Due to Use

2.2.1.1. Loads Supported on a Floor or Suspended from a Ceiling

1) Except as provided for in Article 2.2.1.9., the specified *live load* supported on a floor or suspended from a ceiling shall be not less than the values listed in Table 2.2.1.1.

2.2.1.2. Floor under a Bulk Milk Tank

1) A floor under a bulk milk tank shall be designed to support the load from the tank plus its contents.

2.2.1.3. Accumulation of Poultry Manure

1) Spaces designed for the accumulation of poultry manure, such as dropping pits under wire floors, slotted floors or cages, shall have a minimum specified *live load* of not less than 1 kPa for each 100 mm depth of manure.

Table 2.2.1.1.
Minimum Specified Live Loads due to Use
Forming Part of Article 2.2.1.1.

Type of Load	Minimum Specified Load	
	kPa	Load between Adjacent Aisles, kN/m length of aisle
Cattle		
tie stall		
cow platforms, feed alleys	3.5	—
cow traffic alleys (e.g., litter alleys)	5.0	—
loose housing	5.0	—
holding areas	5.0	—
milking parlours	3.5	—
milking rooms and milk houses	2.5[1]	—
Sheep	1.5	—
Swine		
solid floors	2.5	—
Horses	5.0	—
Turkeys[2]	2.0	—
Greenhouses	2.5	—
Chickens		
housed without cages (including manure)	2.0	—
housed in cages[2][3]		
2 levels of cage equipment		
with dropping boards	—	1.7
without dropping boards[3]	—	1.4
3 levels of cage equipment		
with dropping deflectors	—	2.7
with dropping boards[3]	—	3.0
4 levels of cage equipment		
with dropping deflectors	—	3.0

Notes to Table 2.2.1.1.:
(1) See Article 2.2.1.2.
(2) See Article 2.2.1.3.
(3) See Appendix A.

2.2.1.4. Equipment Used for Manure Cleanout in a Poultry Barn

1) Where equipment up to 700 kg including operator is used for manure cleanout in a poultry barn, the floor shall be designed for a two-wheel *live load* of 4.0 kN in addition to the distributed load of 1 kPa representing 100 mm of wet litter.

2.2.1.5. Stored Products

1) Floors supporting stored products shall be designed for the loads due to their intended use, but not less than 5.0 kPa. (See Appendix A.)

2.2.1.6. Farm Machinery

1) Except as provided in Sentence (2), the uniformly distributed *live load* on an area of floor used for farm machinery traffic shall be not less than 7.0 kPa.

2) Where it is anticipated that the area will be occupied by either loaded farm trailers and trucks or farm tractors having a mass in excess of 6 000 kg, including the mass of mounted equipment, the *live load* shall be not less than 10 kPa.

3) Concentrated *live loads* due to tractors and farm machinery shall be not less than 23 kN per wheel, applied over an area of 750 mm by 750 mm, located so as to cause maximum effects.

4) Where an area serves as a place for processing or for loading or unloading of vehicles, the minimum *live loads* for such areas shall be increased by 50% to allow for impact or vibration of the machinery or equipment.

2.2.1.7. Livestock on Slotted Floors with Slats not Interconnected

1) Except as provided in Article 2.2.1.8., the specified *live load* for livestock penned in groups on slotted floors in which the individual slats are not interconnected shall be not less than the values listed in Table 2.2.1.7.

2.2.1.8. Slotted Floors with Interconnected Slats

1) Slotted floors in which the slats are interconnected in grids shall be designed for the *live loads* in both columns of Table 2.2.1.7., whichever produces the greatest effect.

2) Slats and slat grids made of reinforced concrete shall be designed for a maximum deflection of 1/360 of the span. (See Appendix A.)

Table 2.2.1.7.
Floor Loads for Groups of Animals on Slotted Floors
Forming Part of Article 2.2.1.7.

Livestock	Live Loads for Design of a Floor Slat, kN/m of slat	Distributed Live Loads for Design of Slotted Floors and Their Supports, kPa
Dairy and beef cattle	4.5	5.0
Dairy and beef calves		
up to 150 kg	2.2	2.5
Sheep	2.0	2.5
Swine		
weaners up to 25 kg(1)	0.7	1.7
feeders up to 100 kg	1.5	2.5
sows up to 225 kg(1)	2.5	3.5

Notes to Table 2.2.1.7.:
(1) See Article 2.2.1.10.

2.2.1.9. Other Loads

1) Where loads other than those due to livestock may be present, such as from self feeders, they shall be provided for in the design. (See Appendix A.)

2.2.1.10. Slotted and Perforated Floors in Weaner and Farrowing Pens

1) In addition to the loads referred to in Article 2.2.1.7., slotted and perforated floors in weaner and farrowing pens shall be designed for a concentrated load of 1.1 kN, located so as to produce the greatest effect.

2.2.1.11. Tower Silos

1) For design purposes, cylindrical top-unloading tower silos for storing whole plant silages shall be classified and permanently identified according to wall height H_b, diameter D (in metres) and maximum safe silage moisture content M (percent wet basis) as follows:

$$\text{Class I}: \ M \leq 80 - 0.5\,(H_b + D)$$
$$\text{Class II}: \ M > 80 - 0.5\,(H_b + D)$$

(See Appendix A.)

2) Class I tower silos as defined in Sentence (1) and top-unloading tower silos for high-moisture grains including whole and ground shelled corn and ground ear corn shall be designed for lateral pressure, L, interpolated linearly between the pressures at top, at depth H_m and at bottom in conformance with the following formulae:

$$L_o = 4.0\left(e^{\beta}\right)$$
$$L_m = \frac{\gamma D}{4\mu}\left(1 - e^{-4\mu k H_m/D}\right)$$
$$L_b = \frac{1.2\gamma D}{4\mu}\left(1 - e^{-4\mu k H_b/D}\right)$$

where
L_o = lateral pressure at top, kPa,
L_m = lateral pressure at depth, H_m, kPa,
L_b = lateral pressure at bottom, kPa,
ρ_{av} = average silage density, kg/m^3 (see Appendix A, Table A-2.2.1.11.A.),
g = acceleration due to gravity, 9.81 m/s^2,
γ = $\rho_{av}g/1\,000$, kN/m^3,
μ = friction coefficient between silage and wall (see Appendix A, Table A-2.2.1.11.B.),
k = ratio of lateral/vertical pressure in silage (see Appendix A, Table A-2.2.1.11.C.),
D = silo diameter, m,
H = depth from top of silo wall, m,
H_m = $H_b/2$ for whole plant silage, $H_b/3$ for high moisture grains,
H_b = full depth of silo, m.

3) Class II tower silos as defined in Sentence (1) shall be designed to resist the silage fiber lateral pressure determined in conformance with Sentence (2) down to the top of the saturated zone, plus the possible hydrostatic pressure within the saturated zone. (See Appendix A.)

4) Bottom-unloading tower silos with unloading equipment at floor level, including those for high-moisture grains and Class I silos for whole plant silage, shall be designed to resist lateral pressures in conformance with the following formulae:

a) for $0 < H < H_m$

$$L = L_o + (L_m - L_o)\frac{H}{H_m}$$

b) for $H_m < H < \left(H_b - \frac{D}{6}\right)$

$$L = L_m + (1.25H_b - L_m)\frac{(H - H_m)}{(H_b - H_m)}$$

c) for $H_b - \frac{D}{6} < H < H_b$

$$L = 1.2L_b/k$$

(See Appendix A.)

5) Except as provided for in Sentence (6), bottom unloading tower silos with flail-type unloaders shall be designed to resist lateral pressures in conformance with the following formulae:

a) for $0 < H < H_m$

$$L = L_o + \frac{(L_m - L_o)\ H}{H_m}$$

b) for $H_m < H < H_b$

$$L = L_m + (1.25\,L_b - L_m)\frac{(H - H_m)}{(H_b - H_m)}$$

6) In the vicinity of the upper chain of a flail-type unloader in a bottom unloading tower silo, the lateral pressure shall be determined using the following formula:
for $\left(H_f - \frac{D}{12}\right) < H < \left(H_f + \frac{D}{12}\right)$

$$L = 1.2L_b/k$$

where H_f is the depth (m) from the top of the silo wall to the upper chain of the unloader.

7) Walls of all tower silos shall be designed for a total vertical load comprised of *dead load* of the walls and roof, loads due to suspended equipment and vertical wall friction of the silage as determined in conformance with Sentences (8) and (9).

8) For top-unloading tower silos, the vertical wall friction force shall be determined by multiplying the total lateral wall force by the friction coefficient, μ, between silage and wall.

9) For bottom-unloading tower silos, the total load of silage shall be assumed to be supported by vertical wall friction.

10) Annular ring footings for tower silos shall be designed to support loads due to the silo roof, equipment, wall and footings and the vertical wall friction of the silage.

11) The total bearing area of *soil* under the annular ring footing plus floor shall be designed to support the load of the tower silo, *foundation* and contents.

12) Concrete footings shall be designed to resist radial and tangential bending moments due to tower silo wall and soil reaction loads.

13) Where 2 or more tower silos are built in close proximity, the *foundations* shall be designed for the combined effect of the soil pressures.

2.2.1.12. Horizontal Silos

1) Except as provided in Sentence (2), vertical walls of horizontal silos for storage of packed whole-plant silages not exceeding 80% moisture (wet basis) shall be designed to resist lateral pressures determined from the following formula:

$$L = 3.5 + 3.5H$$

where
L = lateral pressure, kPa,
H = vertical silage depth from top of wall, m.

2) In addition to the requirements of Sentence (1), vertical walls of horizontal silos intended for tractor packing shall be designed to resist a surcharge force calculated as the greater of 30% of the maximum wheel load or 10% of the tractor total mass but in no case less than 5.0 kN,
a) applied normally to an area 0.6 m square,
b) centered 0.6 m below the silage surface, and
c) located to produce the most critical design condition.

3) For horizontal silo walls tilted outward from vertical, the lateral pressure L referred to in Sentence (1) and the tractor surcharge force referred to in Sentence (2) shall be multiplied by a factor determined by the following formula and applied normally to the wall surface:

$$T = \frac{\sin^2 a}{k} + \cos^2 a$$

where
T = factor for wall tilt,
a = tilt angle, degrees outward from vertical,
k = ratio of lateral/vertical pressure in silage (see Appendix A, Table A-2.2.1.11.C.).

2.2.1.13. Manure Tanks

1) Manure storage tank tops exposed to vehicular traffic or used as floors in *buildings* shall be designed for the loads due to the intended use.

2) Outdoor manure storage tank tops not exposed to vehicular traffic shall be designed for *dead load* plus snow load, or *dead load* plus 2.0 kPa, whichever is greater.

3) Manure storage tank walls and *partitions* shall be designed for an internal horizontal pressure based on a manure equivalent fluid density of 10 kN/m^3.

4) Vertical external walls of manure tanks below ground level shall be designed to withstand anticipated horizontal soil pressures. (See Appendix A.)

5) In addition to loads referred to in Sentence (4), where *soil* within 1.5 m of the manure tank walls is subject to vehicular loads, such as manure tankers or trucks, the walls shall be designed for a horizontal surcharge load of 5.0 kPa, applied uniformly below ground level.

6) Manure storage tank walls shall be designed to withstand anticipated horizontal ice pressures. (See Appendix A.)

7) Manure storage tank walls shall be designed and constructed to prevent leakage of the contents. (See Appendix A.)

2.2.1.14. Storage for Dry Grains

1) Pressures and loads for the design of storage for dry grains shall be determined by the analyses given in this Article. (See Appendix A.)

2) In this Article:
F = maximum vertical load per unit of wall perimeter due to friction, kN/m,
L = horizontal pressure against the bin wall, kPa,
L_b = horizontal pressure at the bottom of the vertical section of a bin wall,
V = L/k = vertical pressure on the bin floor or within the grain mass, kPa,
μ = coefficient of friction between the fill material and the bin wall (see Appendix A, Table A-2.2.1.11.B.),
k = ratio of horizontal to vertical pressure (see Appendix A, Table A-2.2.1.11.C.),
H = depth below surface of fill or where surface would be if fill was levelled, m,
D = bin diameter, m,
a = length of short side, m,
b = length of long side, m,
R = hydraulic radius,
= D/4 for circular bins
= (2ab-a^2)/4b for rectangular bins (long side)
= a/4 for rectangular bins (short side),
C = Reimbert coefficient,
β = bin wall slope measured from horizontal (see Appendix A, Figure A-2.2.1.14.A.),
ρ = bulk density, kg/m^3 (see Appendix A, Table A-2.2.1.14.A.),
g = acceleration due to gravity, 9.81 m/s^2,
γ = (1.06ρg)/1 000 = unit weight of material, kN/m^3,
ϕ = angle of internal friction,
δ = angle of friction of fill material on bin wall = arc tan μ,
e = natural log base = 2.71828,
α = hopper slope from horizontal.

3) In this Article, a deep bin is defined as having a depth greater than 0.75 times the width and a shallow bin is defined as having a depth not greater than 0.75 times the width.

4) Except as provided in Sentences (7) and (8), the horizontal wall pressure in deep bins and in shallow bins with vertical walls shall be determined using the following Janssen formula:

$$L = \frac{\gamma R}{\mu}\left[1 - e^{-k\mu H/R}\right]$$

(See Appendix A.)

5) For shallow bins which have walls sloping at angles between 50° and 120° to the horizontal, the pressure normal to the wall surface shall be determined by multiplying the horizontal wall pressure calculated in Sentence (4) by the following Reimbert coefficient:

$$C = \frac{\beta - \phi}{90 - \phi}$$

(See Appendix A.)

6) The vertical friction load of the bin contents on the bin wall shall be determined from the following formula:

$$F = \gamma R\left(H - \frac{R}{k\mu} + \frac{R}{k\mu}\,e^{-k\mu H/R}\right)$$

(See Appendix A.)

7) For bins which empty through a central discharge opening, the horizontal wall pressure during emptying shall be that determined in Sentence (4) multiplied by an overpressure factor as given in Table 2.2.1.14. with values of C corresponding to H/4R between 2.5μ and 5μ determined by linear interpolation. (See Appendix A.)

Table 2.2.1.14.
Overpressure Factors for Stored Grain
Forming Part of Sentence 2.2.1.14.(7)

Grain stored	Overpressure factor	
	$\frac{H}{4R} \leq 2.5\mu$	$\frac{H}{4R} \geq 5\mu$
Cereal grains, shelled corn, soybeans and canola	1.0	1.4
Flaxseed and canary seed	1.0	1.6

8) For a bin which discharges through an opening which is eccentric by R/6 or more, the horizontal wall pressure during emptying shall be the pressure referred to in Sentence (4) with the pressure doubled on a strip of wall of width R extending from the discharge opening to the surface of the grain. (See Appendix A.)

9) The design vertical pressure for shallow bins with floors sloped 0° to 20° to the horizontal shall be V = γH.

10) The design vertical pressure for deep bins with floors sloped 0° to 20° to the horizontal shall be determined from the following Janssen equation:

$$V = \frac{\gamma R}{k\mu}\left[1 - e^{-k\mu H/R}\right]$$

(See Appendix A.)

11) For bin bottoms sloped between 20° and 60° to the horizontal, the normal pressure which varies linearly from a maximum at the wall-hopper junction to a minimum at the projected apex of the hopper, shall be determined from the following equations:

$$P_2 = L_b\left[\sin^2\alpha + \frac{\cos^2\alpha}{k} + (\sin\alpha\,\cos\alpha)\left(1 + \frac{1}{k}\right)\right]$$

$$P_3 = \frac{L_b\cos^2\alpha}{k}$$

where P_2 is the normal pressure at the top edge of the hopper, and P_3 the normal pressure at the apex of the projected hopper bottom. (See Appendix A.)

12) Bin bottoms sloped at 60° or greater shall be designed for mass flow. (See Appendix A.)

2.2.1.15. Storage for Bulk Vegetables and Fruits

1) Pressures and loads for the design of storage for bulk vegetables and fruits shall be determined by the analysis given in this Article. (See Appendix A.)

2) In this Article, a deep bin is defined as having a depth greater than 0.75 times the width and a shallow bin is defined as having a depth not greater than 0.75 times the width.

3) In a bin with vertical walls, the horizontal wall pressure shall be determined from the following equation:

$$L = 2.0\,CH$$

where
L = horizontal pressure, kPa,
H = depth below the levelled pile surface, m,
C = bin width factor
= 1.0 for shallow bins
= $(W/0.75H)^{1/2}$ > 0.7 for deep bins,
w = bin width, m.

4) For bins which have walls sloping at angles between 50° and 120° to the horizontal, the pressure normal to the wall surface shall be determined by multiplying the horizontal wall pressure calculated in Sentence (3) by the coefficient given in Sentence 2.2.1.14.(5).

5) For carrots and parsnips the horizontal wall pressure may be 70% of that given in Sentence (3).

6) Vertical pressure on horizontal floors of shallow bins shall be determined from the following formula:

$$v = \frac{\rho g H}{1\,000}$$

where
v = vertical pressure, kPa,
ρ = bulk density of product, kg/m^3 (See Appendix A, Table A-2.2.1.14.),
g = acceleration due to gravity, 9.81 m/s^2.

2.2.2. Loads Due to Snow

2.2.2.1. General

1) Except as provided in Articles 2.2.2.2., 2.2.2.3. and 2.2.2.4., snow loads for the design of *farm buildings* shall be in conformance with Part 4 of the National Building Code of Canada 1995.

2.2.2.2. Roofs with Smooth Slippery Cladding

1) Where roofs of *farm buildings* of *low human occupancy* are sloped at greater than 15°, are covered with smooth slippery cladding such as sheet metal and glass, and where the sliding of snow is not impaired by obstructions, the roof slope factor, C_s, as defined in NBC Sentence 4.1.7.1.(4) may be calculated as follows:
if $15° < \alpha < 60°$,

$$C_s = \frac{60° - \alpha}{53°}$$

where α = roof slope, degrees from horizontal. (See Appendix A.)

2.2.2.3. Roof Areas of Greenhouses

1) Except as provided in Article 2.2.2.4., roof areas of greenhouses of *low human occupancy* shall be designed for snow loads on the same basis as for other *farm buildings*.

2.2.2.4. Heating and Drainage Systems to Prevent Snow Accumulation

1) Where a heating and drainage system is installed to prevent the accumulation of snow and water, the supporting structure for the light-transmitting roof areas of greenhouses of *low human occupancy* shall be designed for a uniform snow load of not less than 0.7 kPa.

2.2.3. Loads Due to Wind

2.2.3.1. Reference Velocity Pressure

1) The minimum reference velocity pressure, q, for the design of structural members of *farm buildings* of *low human occupancy* shall be based on a probability of being exceeded once in 10 years.

2.2.4. Loads Due to Earthquakes

2.2.4.1. General

1) *Farm buildings* of *low human occupancy* need not be designed for loads due to earthquakes.

Section 2.3. Design Procedures

2.3.1. Allowable Stresses and Load Factors

2.3.1.1. Exceptions

1) Except as provided in Sentence (2), where *farm buildings* of *low human occupancy* are designed in conformance with Part 4 of the National Building Code of Canada 1995
a) the allowable stresses for masonry construction in working stress design are permitted to be increased by 25%, and
b) the importance factor on the effect of factored loads, other than *dead loads*, in limit states design shall be not less than 0.8.

2) Sentence (1) does not apply to
a) the design of circumferential reinforcement in cylindrical tower silos, or
b) the modulus of elasticity of materials.

2.3.1.2. System Factors for Sawn Lumber

1) For *farm buildings* of *low human occupancy*, specified strengths for sawn lumber members in a system of 3 or more essentially parallel members spaced not more than 1 220 mm apart and so arranged that they mutually support the applied load, may be multiplied by a Case 1 system factor as given in Clause 5.4.4.1. of CSA-O86.1-94, "Engineering Design in Wood (Limit States Design)."

2) Where sawn lumber members are used in accordance with the conditions given in Clause 5.4.4.2. of CSA-O86.1-94, "Engineering Design in Wood (Limit States Design)" specified strengths may be multiplied by a Case 2 system factor.

2.3.2. Design Based on Load Tests

2.3.2.1. Criteria

1) Where the load carrying capacity of a structural assembly for a *farm building* of *low human occupancy* is based upon load tests, at least 3 representative sample assemblies selected at random shall be capable of supporting

a) 100% of the specified *dead load* and *live load* for 1 h without exceeding allowable deflection limits as given in Sentence 4.1.1.5.(1) of the National Building Code of Canada 1995, and

b) 100% of the specified *dead load* plus 200% of the specified *live load* for 24 h without structural failure.

Part 3
Fire Safety

Section 3.1. General

3.1.1. Application

3.1.1.1. General

1) Unless specifically required, *farm buildings* of *low human occupancy* need not conform to the requirements of Parts 3 and 9 of the National Building Code of Canada 1995 with regard to fire safety or egress, but shall conform to the requirements of this Part. (See Appendix A.)

3.1.1.2. Floor Areas

1) When *farm buildings* of *low human occupancy* other than greenhouses exceed the *floor areas* shown in Table 3.1.1.2. on any one *storey*, they shall be separated into *fire compartments* by vertical *fire separations*, having a *fire-resistance rating* of at least 1 h, so that each portion so separated has a *floor area* on any one *storey* conforming to Table 3.1.1.2.

2) A *farm building* of *low human occupancy* or part thereof shall be separated from an *occupancy* conforming to Part 3 or Part 9 of the National Building Code of Canada 1995, including a *farm building* of other than *low human occupancy*, by a *fire separation* having a *fire-resistance rating* of at least 1 h.

Table 3.1.1.2.
Maximum Floor Areas for Farm Buildings of Low Human Occupancy
Forming Part of Article 3.1.1.2.

Maximum Number of *Storeys*	Maximum *Floor Area*, m^2/*Storey*
1	4 800
2	2 400
3	1 600

3.1.2. Spatial Separations
(See Appendix A.)

3.1.2.1. General

1) Except for greenhouses, where *exposing building faces* of a *farm building* of *low human occupancy* are located less than 30 m from a property line, the centreline of a public thoroughfare, a residence or a *farm building* of other than *low human occupancy* on the farm property, the appropriate requirements in Subsection 9.10.14. of the National Building Code of Canada 1995 for *medium hazard industrial occupancies* shall apply to those faces. (See Appendix A.)

3.1.3. Fire Stopping

3.1.3.1. Location

1) Fire stops shall be provided at floor, ceiling and roof levels to cut off all concealed draft openings occurring between *storeys* and between the top *storey* and roof space, including spaces filled with batt, loose fill or foamed plastic insulation. (See Appendix A.)

3.1.3.2. Concealed Spaces in Walls or Partitions

1) The maximum dimension of any concealed space in a wall or *partition* of *combustible construction* shall not exceed 3 m vertically or 6 m horizontally.

3.1.3.3. Concealed Spaces in Ceilings, Roofs or Attics

1) Every concealed space created by a suspended ceiling, roof space or unoccupied attic space shall be separated into compartments by fire stops so that no dimension of such space exceeds 30 m.

3.1.3.4. Material

1) Fire stops shall consist of not less than
a) 0.36 mm sheet steel,
b) 6 mm asbestos board,
c) 12.7 mm gypsum board,
d) 12.5 mm plywood, OSB or waferboard with joints backed with similar material,
e) 2 layers of 19 mm lumber with joints staggered, or
f) 38 mm lumber.

3.1.3.5. Penetration of Fire Stops

1) Where fire stops are pierced by pipes, ducts or other elements, the effectiveness of the fire stops shall be maintained around such elements.

3.1.4. Fuel Storage Tanks

3.1.4.1. Location

1) Except as provided in Article 3.1.4.3., fuels in liquid form in quantities exceeding 100 L shall be stored outdoors or in *buildings* used for that purpose only and

a) shall be separated from other *occupancies* and property lines by a distance of not less than 12 m or

b) such additional distance from *buildings* shall be provided as will ensure that any vehicle, equipment or container being filled directly from such tank will be not less than 12 m from any *building* or property line.

3.1.4.2. Separation in Conformance with National Fire Code

1) The minimum separation between a flammable or combustible liquid storage tank and a liquified petroleum gas cylinder or tank shall be in conformance with Part 4 of the National Fire Code of Canada 1995.

3.1.4.3. Underground

1) Underground fuel storage tanks shall be separated from *buildings* and from property lines by a distance of 1.5 m.

3.1.4.4. Tanks Serving Heating Appliances

1) Fuel storage tanks serving heating *appliances* conforming to CAN/CSA-B139-M91 "Installation Code for Oil Burning Equipment" and stationary engines under Section 6.7 of the National Fire Code of Canada 1995 are exempt from the provisions of Article 3.1.4.1.

3.1.5. Fire Separations

3.1.5.1. Fire Resistance Ratings

1) Except as provided in Articles 3.1.5.2. and 3.1.5.3., fuel-fired *appliances* in *farm buildings* of *low human occupancy* shall be

a) located in a *service room* or *service space* designed for that purpose, and

b) separated from the remainder of the *building* by a *fire separation* having a *fire-resistance rating* of not less than 30 min.

2) In *farm buildings* of *low human occupancy*, rooms used for crop drying or rooms in which farm machinery is repaired shall be separated from other *occupancies* by *fire separations* having a *fire-resistance rating* of not less than 30 min. (See Appendix A.)

3.1.5.2. Exception to Sentence 3.1.5.1.(1)

1) Fuel-fired space heating *appliances*, space-cooling *appliances* and service water heaters in a *farm building* of *low human occupancy* need not be separated from the remainder of the *building*, as required in Clause 3.1.5.1.(1)(b), where the equipment has been designed for such use, and

a) serves not more than one room or *suite*, or

b) serves a *building* having a *building area* of not more than 400 m^2 and not more than 2 *storeys* in *building height*.

3.1.5.3. Incinerators

1) *Service rooms* containing incinerators shall be separated from the remainder of the *farm building* of *low human occupancy* by a *fire separation* having a *fire-resistance rating* of not less than 1 h.

3.1.6. Exposed Foamed Plastic Insulation

3.1.6.1. Protection

1) Exposed foamed plastic material in *farm buildings* of *low human occupancy* shall be protected on the interior surfaces in conformance with Article 9.10.16.10. of the National Building Code of Canada 1995.

3.1.7. Electrical Installations

3.1.7.1. Wiring

1) Electrical wiring shall not be concealed unless it is installed in rigid conduit or otherwise protected against rodent damage. (See Appendix A.)

3.1.7.2. Heat Lamps

1) A heat lamp located over bedding materials shall be installed such that if the lamp is accidentally pulled down it will disconnect from the electrical circuit.

3.1.8. Lightning Protection

3.1.8.1. Installation

1) Lightning protection devices where used shall be installed in conformance with CAN/CSA-B72-M87, "Installation Code for Lightning Protection Systems."

Section 3.2. Egress

3.2.1. Exits

3.2.1.1. Number of Exits

1) Except as provided in Article 3.2.1.2., every *farm building* of *low human occupancy* shall be served by at least 2 *exits*, spaced remotely from each other at opposite ends of the *building*.

3.2.1.2. One Exit

1) *Farm buildings* of *low human occupancy* of not more than 200 m^2 in *floor area* and *farm buildings* storing bulk crops of low combustibility, such as silage, grain, fruit and vegetables, may be served by one *exit*.

3.2.1.3. Type of Exits

1) Except as permitted in Sentence (2), *exits* in *farm buildings* of *low human occupancy* shall consist of

a) an exterior doorway, or

b) an openable window or panel providing an opening measuring not less than 550 by 900 mm with a stair or ladder as required in Article 3.2.1.7.

2) An *exit* from a top-unloading tower silo may be an opening not less than 550 mm by 550 mm into the silo chute.

3.2.1.4. Location

1) *Exits* described in Article 3.2.1.3. shall be located and arranged so that they are clearly visible or their locations shall be clearly indicated.

2) *Exits* described in Article 3.2.1.3. shall be accessible at all times.

3.2.1.5. Travel Distance to an Exit

1) Except as provided in Sentence (2), the travel distance to an *exit* in a *farm building* of *low human occupancy* shall not exceed

a) 20 m in *buildings* used for liquid fuel storage in excess of 100 L, and

b) 45 m in other *buildings*.

2) Sentence (1) need not apply if *exits* are placed along the perimeter and are not more than 60 m apart, measured along the perimeter.

3.2.1.6. Signage

1) A warning sign clearly indicating the hazards of entrapment shall be installed at every designated, person access to a grain storage structure and bottom unloading tower silo. (See Appendix A.)

3.2.1.7. Stairs and Ladders for Exits above Ground Level

1) Except as provided in Sentence (2), a stair shall be provided where a doorway is more than 300 mm above the adjacent ground level.

2) If the bottom of a wall opening serving as an *exit* required in Article 3.2.1.3. is more than 2.5 m above ground level, a permanently installed outside ladder conforming to Subsection 3.2.2. or a stair shall be provided.

3.2.2. Ladders

3.2.2.1. Design Load

1) Permanently installed ladders and their fastenings to the *building* shall be designed for a concentrated load of 1.0 kN, applied so as to produce the most critical stress in the member concerned.

3.2.2.2. Termination above Ground Level

1) Permanently installed ladders serving as *exits* required in Sentence 3.2.1.3.(1) shall terminate not more than 1.5 m and not less than 1.0 m above ground level.

3.2.2.3. Clear Space behind Rungs, Steps or Cleats

1) A clear space of not less than 175 mm shall be provided behind the rungs, steps or cleats of any permanently installed ladder.

3.2.2.4. Spacing of Rungs, Steps or Cleats

1) The spacing of rungs, steps or cleats of any ladder shall be uniform and shall not exceed 300 mm.

3.2.2.5. Distance between Side Rails

1) The distance between the side rails of any ladder shall be not less than 250 mm.

3.2.2.6. Safety Cages

1) Safety cages shall be provided around permanently installed ladders of more than 6 m in height, starting not more than 3 m from the bottom of the ladder.

Part 4
Health

Section 4.1. Waste Disposal

4.1.1. Liquid Manure Storage

4.1.1.1. Covers

1) Covers providing access to liquid manure storage tanks shall be
- a) designed to prevent them from being dropped through their openings or
- b) permanently secured with safety chains.

2) Liquid manure storage tank tops shall be designed to support loads due to the use and *occupancy* of the area.

4.1.1.2. Connection to an Animal Building

1) Where a separate liquid manure storage tank is connected to an animal *building*, traps or valves shall be installed to prevent gases from the manure storage tank from entering the *building*.

4.1.1.3. Ladders

1) Ladders shall not be installed in closed liquid manure tanks.

4.1.1.4. Safety Fence or Wall

1) Liquid manure storages without fixed covers shall be enclosed with a permanent safety fence or wall extending to not less than 1.5 m above adjacent *grade* or floor level, adequately secured at ground level and having gates with latches to deter access by children and livestock.

4.1.2. Manure Hopper Openings

4.1.2.1. Safety Railings or Floor Grills

1) Manure hopper openings at or below floor level shall be fitted with a safety railing or floor grill having an opening of not more than 100 mm in width.

4.1.3. Milk Centre Wastes

4.1.3.1. Gas Traps

1) A gas trap shall be provided on the delivery pipe for milk centre wastes between the milk centre and the sediment tank or other storage.

4.1.4. Pesticide Storage

4.1.4.1. General

1) Storage facilities for pesticides shall be
- a) ventilated to the outdoors by either natural or mechanical means sufficient to prevent the accumulation of toxic or flammable vapours,
- b) accessible from the outdoors only and secured against unauthorized entry,
- c) provided with a floor of concrete or other impervious material without a floor drain and curbed around the full perimeter to provide containment for the largest container in the storage, but not less than 50 mm high,
- d) separated from all food, feed and water supplies,
- e) separated from all other *occupancies*, either by open space or by a *fire separation* having a *fire-resistance rating* of not less than 1 h,
- f) identified clearly by a sign such as, “Chemical Storage, Warning,” permanently affixed on or adjacent to the outside of each entrance leading into the storage area,
- g) provided with storage on opposite sides of a passage to permit separation of oxidizing chemicals from flammable and combustible chemicals, and
- h) provided with an insulated and heated cabinet for any chemicals that require protection from freezing.

Section 4.2. Ventilation

4.2.1. Gas Protection at Silos and Attached Feed Rooms

4.2.1.1. Powered Exhaust Ventilation

1) Where a roofed tower silo or an enclosed horizontal silo connects with an adjacent closed feed room, powered exhaust ventilation of not less than 3 air changes per hour to the exterior shall be provided from the lowest floor level of the feed room.

4.2.1.2. Airflo from Feed Room to Stable

1) Where an enclosed silo feed room connects with a stable, the ventilation system shall be designed to prevent airflow from the feed room to the stable.

4.2.1.3. Signage

1) A sign clearly indicating the danger of silo gas shall be installed adjacent to the chute or ladder on tower silos. (See A-3.2.1.6.(1) in Appendix A.)

4.2.1.4. Horizontal Silos

1) An enclosed horizontal silo shall have provision for ventilation which is either a slot at the ridge, or openings in both gable ends the total area of which is at least 1% of the *floor area* of the silo. (See Appendix A.)

4.2.2. Greenhouses

4.2.2.1. General

1) Where fuels are burned in greenhouses, separate combustion air and flue systems shall be provided except where the system is specifically designed as a generator for carbon dioxide enrichment of the greenhouse atmosphere.

4.2.3. Controlled-Atmosphere Fruit and Vegetable Storage

4.2.3.1. Signage

1) A sign clearly indicating the danger due to lack of oxygen shall be installed at the entrance of every controlled-atmosphere fruit and vegetable storage. (See A-3.2.1.6.(1) in Appendix A.)

4.2.4. Liquid Manure Storage Tanks

4.2.4.1. Signage

1) A sign clearly indicating the danger due to toxic gases shall be installed at every access to a liquid manure storage tank or under-floor manure transfer chamber. (See A-3.2.1.6.(1) in Appendix A.)

Section 4.3. Access Covers

4.3.1. General

4.3.1.1. Locking Devices

1) Manhole covers and liquid manure storage tank access covers of less than 20 kg shall be equipped with locking devices.

Section 4.4. Electrical Installations

4.4.1. Lighting Fixtures over Bulk Milk Tanks

4.4.1.1. Guarded or Offset

1) Lighting fixtures installed to illuminate the inside of bulk milk tanks shall be guarded to prevent lamp breakage or the fixtures shall be offset so that they are not installed directly over the bulk tank openings.

4.4.2. Silo Unloader Motor Controls

4.4.2.1. General

1) Silo unloader motors shall be controlled by means of a magnetic motor controller.

2) A control station shall be provided which
a) is capable of preventing the motors from being started from any other location, and
b) has a dead man switch.

3) The control station required in Sentence (2) may be on the silo unloader or on an extension cord leading from the motor controller and used with a local or remote selector switch at the controller.

Appendix A
Explanatory Material for the National Farm Building Code 1995

A-1.1.1.3.(1) Application. Notwithstanding Subsection 2.1.5. of the National Building Code of Canada 1995, farm buildings are required to conform to the appropriate requirements in the National Building Code except as specifically amended or exempted by provisions of this Code. Part 9 of the National Building Code provides detailed requirements for the construction of small buildings up to 600 m^2 per floor and 3 storeys in height which apply to all occupancies except assembly, institutional and high hazard industrial. All other buildings must be designed to satisfy the requirements in the remainder of the National Building Code of Canada 1995. Section 2.5. of the National Building Code provides for equivalent design and performance criteria. This may apply where the design of a farm building or component is supported by evidence of sound engineering principles.

The acceptance of structures which have been designed to other design standards would require the designer to prove to the appropriate authority that the structure provides the required level of safety and performance. The equivalence of safety can only be established by analyzing the structure for the loads and load factors set out in Section 4.1. of the National Building Code and demonstrating that the structure at least meets the requirements of the design standards listed in Sections 4.3. and 4.4. of the National Building Code.

A-1.2.1.2.(1) Definitio of Farm Buildings. Farm buildings as defined in Article 1.2.1.2. include but are not limited to produce storage and packing facilities, livestock and poultry housing, milking centres, manure storage facilities, grain bins, silos, feed preparation centres, farm workshops, greenhouses, farm retail centres, and horse riding, exercise and training facilities. Farm buildings may be classed as low or high human occupancy depending on the normal human occupant load.

Examples of farm buildings likely to be classed as low human occupancy as defined in Article 1.2.1.2. are livestock and poultry housing, manure and machinery storage facilities and horse exercise and training facilities where no bleachers or viewing area are provided.

Examples of buildings that would be classed as other than low human occupancy include farm retail centres for feeds, horticultural and livestock produce, auction barns and show areas where bleachers or other public facilities are provided. Farm work centres where the number of workers frequently exceeds the limit for low human occupancy will also be in this category.

It is possible to have areas of both high and low human occupancy in the same building provided that the structural safety and fire separation requirements for high human occupancy are met in the part thus designated.

A-Table 2.2.1.1. Minimum Specifie Live Loads Due to Use. Chicken cage manufacturers should be consulted for information on the type and spacing of supports (floor stand or suspended type).

Bird mass is based on eight 1.8 kg birds for each 300 mm length of deck. On this basis a 3-deck cage row has 24 birds in 300 mm of cage row length.

Dropping boards used to prevent soiling of the lower level cages are assumed to accumulate 50 mm of wet manure between cleaning operations.

A-2.2.1.5.(1) Floors Supporting Stored Products. Densities of agricultural materials are given in Table A-2.2.1.14. under the explanation for Article 2.2.1.14. in this Appendix.

A-2.2.1.8.(2) Deflectio Limitation of Reinforced Concrete Slats and Slat Grids. The deflection limitation of 1/360 has been specified to minimize cracking and thereby reduce the exposure of reinforcing steel to the corrosive effects of manure gases and solutions. Other methods of protecting the steel such as epoxy coatings may also be effective.

A-2.2.1.9.(1) Floor Loads Due to Feeding Equipment. In the absence of specific information,

The Appendix to this document is included for explanatory purposes only and does not form part of the requirements. The reference numbers that introduce each item apply to the requirements in the Code.

floors supporting feeding equipment should be designed for the following concentrated loads, located so as to produce the most critical effects:

Feeding equipment for weaner pigs — 2.5 kPa over an area of 750 mm by 300 mm.

Feeding equipment for growing and finishing pigs — 5.0 kPa over an area of 1 200 mm by 1 000 mm.

A-2.2.1.11.(1) Classificatio of Top-Unloading Tower Silos for Whole Plant Silages. Top-unloading tower silos are defined as Class I where intended for unsaturated silage and Class II for excessively wet silage. Wet silage placed in tower silos can produce enough compaction to cause near-saturation of the silage at the bottom by silage juice, which starts to drain. If the silo is made watertight and the drains are plugged, this juice is trapped in the saturated zone, producing hydrostatic pressure which is much greater than the lateral fiber pressure of unsaturated silage at equal depth. The design of Class II silos is dealt with in Sentence (3) and later in this Appendix.

A-2.2.1.11.(2) Design of Class I Silos and Top-Unloading Tower Silos for High Moisture Grains. Figure A-2.2.1.11.A. shows a comparison of lateral pressure for whole-plant alfalfa silage (Class I concrete silo), versus ground shelled corn in a top-unloading concrete silo of the same size. For the high moisture ground corn the bilinear pressure curve breaks at one-third of the depth, whereas for whole-plant silages this occurs at half of the depth. This fact, together with different characteristic values of ρ_{av}, μ, and k (see Tables A-2.2.1.11.A., A-2.2.1.11.B. and A-2.2.1.11.C.), accounts for the differences between the curves for alfalfa silage and ground shelled corn.

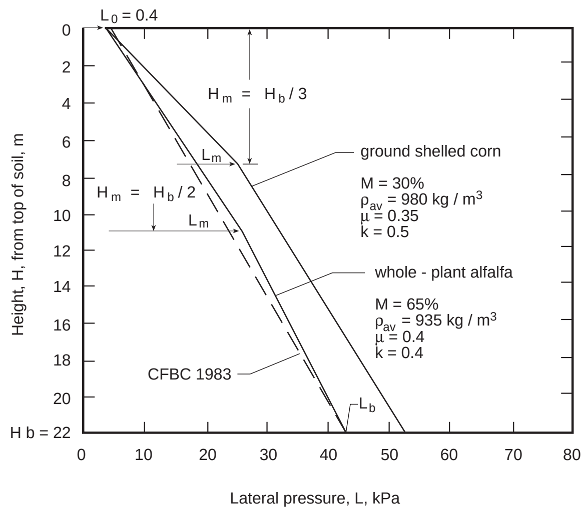

Figure A-2.2.1.11.A.

Lateral pressure in a 7.3 × 22 m top-unloading Class I concrete tower silo storing whole-plant alfalfa silage or ground shelled corn

Table A-2.2.1.11.A.
Average Silage Density in Tower Silos (ρ_{av}) at Typical Moisture Percentage (M), kg/m^3

Silo Diameter, m	Alfalfa, M (%)				Corn Silage, M (%)				Ground Shelled Corn, M (%)			Barley Silage, M (%)		
	40	50	60	70	55	60	65	70	25	30	35	40	50	60
3.7	350	440	580	840	470	540	620	740	820	910	1 030	320	350	400
4.3	370	460	620	890	500	570	660	780	830	930	1 050	360	390	420
4.9	390	490	660	950	530	600	690	810	840	950	1 070	400	420	450
5.5	410	520	690	990	550	620	710	830	850	960	1 080	420	440	460
6.1	440	550	730	1 040	580	650	730	850	860	970	1 090	460	470	480
7.3	470	590	780	1 090	600	670	750	870	870	980	1 110	490	500	510
9.1	530	650	850	1 180	640	730	830	940	890	1 000	1 130	550	560	590

Table A-2.2.1.11.B.
Coefficients of Friction for Grain and Silage

Type of Grain	Moisture Content, % (wet basis)[1]	Smooth Steel, μ	Corrugated Steel, μ	Plywood, μ	Concrete,[2] μ	Internal Friction within the Grain, tan σ[3]
Wheat and barley	11.0 13.0	0.1 0.25	0.35	0.3	0.35	0.5
Shelled corn	11.0 16.0	0.2 0.35	0.35	0.3 0.45	0.35 0.6	0.5 0.6
Soybeans	11.0	0.2		0.35	0.5	0.5
Flaxseed	9.0 11.5	0.2 0.25		0.35 0.4	0.35 0.45	0.25 0.23
Canola (rapeseed)	9.0 12.5	0.2 0.25		0.35 0.35	0.35 0.35	0.5 0.6
Whole-plant silages		0.3 – 0.4[4]			0.4 – 0.5[4]	
High-moisture ensiled grains, including ground shelled and ground ear corn		0.25 – 0.35[4]			0.35 – 0.45[4]	

Notes to Table A-2.2.1.11.B.:

(1) The moisture content of grain is the weight of water in the grain divided by the weight of the wet grain. For higher moisture contents, the friction coefficients will be appreciably higher, resulting in greater wall vertical loads, but maximum lateral pressures will occur with clean, dry grain.

(2) Values are for rough textured concrete. Where concrete is placed against smooth forms and polished by the repeated flow of grain, values will be approximately two-thirds of those shown.

(3) For horizontally corrugated or very rough surfaces, sliding may occur within the grain mass rather than on the surface, in which case the internal friction within the grain applies, if less than μ.

(4) For conservative design to resist lateral pressures, select the lower value of the range; for vertical friction force, select the higher value.

Table A-2.2.1.11.C.
Ratio of Horizontal to Vertical Pressure for Grains and Silages, k[1]

Type of Grain	Smooth Wall	Rough Wall
Cereal grains Canola (rapeseed)	0.4 0.4	0.6 0.6
Flaxseed and canary seed	0.55	0.8
Whole-plant silages	0.4	0.4
High-moisture ensiled grains, including ground shelled and ground ear corn	0.5	0.5

Notes to Table A-2.2.1.11.C.:

(1) For products not listed, k can be approximated by:

$$\frac{1 - \sin\varphi \cos 2\epsilon}{1 + \sin\varphi \cos 2\epsilon}$$

where

$$2\epsilon = \arcsin\frac{\sin\delta}{\sin\varphi} - \gamma$$

A-2.2.1.11.(3) Design of Class II Silos. When farming practices are expected to produce excessively wet silage, the silage depth, H_s, at which saturation can occur is calculated, then the unsaturated lateral pressure, L_s, at the top of the saturation zone is determined according to Sentence 2.2.1.11.(2) by interpolation. Below depth H_s, the silage fibre pressure, L_s, is assumed to be constant and the hydrostatic pressure is added to it. The depth below the top of the silo, H_s, where the saturated zone is estimated to start, can be determined as follows:

$$H_s = 160 - 2M - D \qquad (1)$$

where

H_s = depth from top of silo to saturated zone, m,
M = silage moisture content, percent wet basis, and
D = silo diameter, m.

Below depth H_s, the design lateral pressure, L, can be determined as follows:

$$L = L_s + (H - H_s)\left(11.0 - \frac{4\mu k L_s}{D}\right) \qquad (2)$$

For example, Figure A-2.2.1.11.B. shows the lateral pressure, L, in a 7.3 × 22 m top-unloading concrete silo, intended for whole-plant silages up to moisture content M = 68%. Sentence 2.2.1.11.(1) gives a limiting moisture content dividing Class I and Class II, for this size of silo, as follows:

$$\begin{aligned} M &\le 80 - 0.5\,(H_b + D) \\ &\le 80 - 0.5\,(22 + 7.3) \\ &\le 65\%. \end{aligned}$$

Therefore, this silo must be considered as Class II and designed for hydrostatic pressure in the bottom part. Formula (1) gives the depth, H_s, to the top of the saturated zone, as follows:

$$\begin{aligned} H_s &= 160 - 2\,(68) - 7.3 \\ &= 16.7\ \text{m}. \end{aligned}$$

For example, Figure A-2.2.1.11.B. shows the calculated lateral pressure. Below depth H_s, the fiber pressure, L_s, is not considered to increase further because the silage can be considered as floating in the juice, but the juice adds hydrostatic pressure in proportion to the saturated depth (H – H_s) and the effective density of the juice. This gives saturated lateral pressure, L, according to formula (2).

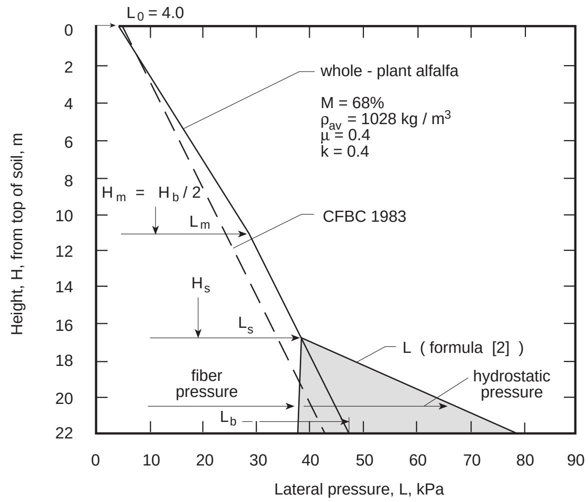

Figure A-2.2.1.11.B.

Lateral pressure in a 7.3 × 22 m, top-unloading Class II concrete tower silo storing whole-plant alfalfa silage

Between the top and depth H_s, lateral pressure is calculated from the equations in Sentence 2.2.1.11.(2), the same as for a Class I silo except that the silage density, ρ_{av}, will be greater (see Table A-2.2.1.11.A.). In Figure A-2.2.1.11.B., the pressure is plotted for alfalfa silage because it is denser than whole-plant corn silage at the same moisture content, M = 68%.

A-2.2.1.11.(4) Bottom-Unloading Silos. Bottom-unloading silos are used for whole-plant and high-moisture grain silages but not for silages over 65% moisture. Therefore, hydrostatic pressures are not a problem here. However, the unloading equipment tends to form a dome-shaped bottom cavity with a base diameter 100 – 200 mm less than the silo diameter. The development of this domed cavity coincides with increased lateral wall pressure near the bottom of the silo and is estimated to affect the walls up to a depth of D/6 above the bottom. This dome effect is dealt with by the formula in Clause 2.2.1.11.(4)(c). This equation does not apply to flail-type bottom unloaders, where the domed arch develops at a higher elevation in the silo.

In addition, there are dynamic effects when slugs of silage drop suddenly. These effects are dealt with by the 1.25 impact factor in Clause 2.2.1.11.(4)(b).

Figure A-2.2.1.11.C., for example, shows lateral pressure curves for bottom-unloading concrete and steel silos, 7.3 × 24 m, storing high moisture ground shelled corn (30% moisture). For comparison, a curve for top-unloading is also included.

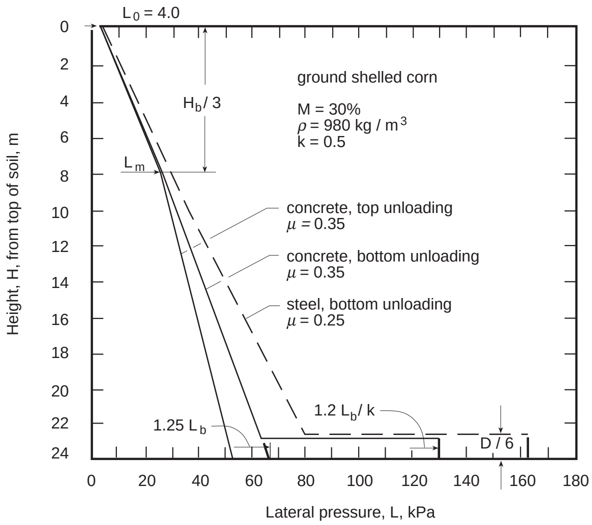

Figure A-2.2.1.11.C.

Lateral pressures in bottom-unloading concrete and steel silos, 7.3 × 24 m, storing ground shelled corn. (A curve for a top-unloading concrete silo is included for comparison.)

A-2.2.1.13.(4) Design Pressures for Walls of Manure Tanks. Vertical external walls of manure tanks below grade should be designed for external horizontal soil pressures based on the following soil equivalent fluid densities:

clean sand and gravel, well drained — 4.7 kN/m^3,
sand and gravel with fines, restricted permeability — 5.7 kN/m^3,
stiff residual silts and clays — 7.0 kN/m^3, and
soft silts and clays, poorly drained — 16.0 kN/m^3.

Horizontal soil pressures should not be used to offset the pressures exerted by the manure tank contents unless properly compacted granular backfill is used.

A-2.2.1.13.(6) Horizontal Ice Pressures in Manure Storage Tanks. Horizontal ice pressures in manure storage tanks have been found to reach values of 50 kPa acting over a height of 0.5 m at the level of the liquid in the Quebec city region. Horizontal ice pressures will vary depending on geographic location, type of manure and type of construction. Further information can be found in "Formation of Ice in Manure Tanks" by Godbout, S., A. Marquis and D. Masse in Canadian Agricultural Engineering, Vol. 34, No. 3, July/August/September 1992.

A-2.2.1.13.(7) Design of Manure Tanks to Prevent Leakage. In the design of manure tank walls and bottoms to prevent leakage of the contents, account should be taken of all additional loads which may cause cracks, such as thermal effects, shrinkage of the concrete, movement of the structure, choice of components (materials) and installation of the material. Prevention of leakage and of cracks is particularly critical to reinforced concrete structures due to subsequent corrosion of the reinforcing steel.

A-2.2.1.14.(1) Pressures and Loads for Storage of Dry Grain.

(a) Maximum lateral pressures on walls are produced by small values of μ, which occur with very dry grain. Maximum friction loads on the walls are produced by larger values of μ, which occur with higher moisture contents. The designer must investigate the worst combination of loadings by selecting appropriate values from Tables A-2.2.1.11.B. and A-2.2.1.11.C..
(b) When a deep bin is filled by spouting grain against one wall, the pressure on that wall may be double the pressure on the wall opposite. This produces bending in circular bins.
(c) Moisture added to grain while in storage causes it to swell and can produce pressures 3 to 4 times the filling pressures.

A-2.2.1.14.(2) Bulk Densities of Agricultural Materials

Table A-2.2.1.14.
Bulk Densities of Agricultural Materials

Material	Bulk Density, ρ, kg/m^3
Grains and Seeds[(1)]	
Alfalfa	750
Alsike	740
Barley	620
Beans	
castor beans	590
lima beans	720
navy beans	770
snap beans	380
Bentgrass	450
Birdsfoot Trefoil	740
Bluegrass	
Canada bluegrass	270
Kentucky bluegrass	280
rough bluegrass	270
Bromegrass	170
Buckwheat	640
Canola	640
turnip or Polish rape	640
Argentine rape	770
Clover	
red clover	750
sweet clover	780
white clover	760

Table A-2.2.1.14. (Continued)

Material	Bulk Density, ρ, kg/m^3
Corn	
ear-husked	450
shelled	720
Cottonseed	410
Cowpeas	770
Fescue	
chewings fescue	240
meadow fescue	290
red fescue	220
tall fescue	280
Flaxseed (linseed)	700
Grain sorghums	720
Lentils	770
Milkvetch	820
Millet	640
Mustard	640
Oats	420
Orchard grass	200
Peanuts	
shelled	640
unshelled	240
Peas	770
Rapeseed (see Canola)	
Red top	390
Reed canary grass	380
Rice	
hulled	770
rough	580
Russian wild rye	250
Rye	720
Ryegrass	
annual ryegrass	360
perennial ryegrass	300
Safflower seed	720
Sainfoin	360
Soybeans	770
Sunflower seed	310 – 410
Timothy	580
Wheat	770
Concentrated Feeds	
Alfalfa	
meal	250 – 350
pellets	650 – 700
Barley	
ground, meal	380 – 450
malt	500
Beet pulp, dried	180 – 250
Bone meal	800 – 960
Bran, rice-rye-wheat	260 – 320

Table A-2.2.1.14. (Continued)

Material	Bulk Density, ρ, kg/m^3
Brewer’s grain	
spent, dry	220 – 290
spent, wet	880 – 960
Corn	
cobs, ground	270
cobs, whole	190 – 240
cracked	640 – 800
Corn germ	340
Corn grits	640 – 720
Corn meal	510 – 640
Corn oil, cake	400
Crumbled ration	550
Fish meal	560 – 640
Flaxseed oil cake (linseed oil cake)	770 – 800
Flaxseed oil meal (linseed oil meal)	400 – 720
Malt	
dry, ground	320 – 480
meal	580 – 640
Meat meal	600
Oats	
crimped	300 – 420
crushed	350
rolled	300 – 420
Pelleted ration	600
Salt	1 000 – 1 100
Soya bean meal	550 – 650
Wheat, cracked	640 – 720
Wheat, germ	350 – 450
Roughage Feeds and Bedding	
Hay (air-dried)	
baled	160
chopped	160
long	80
wafered	325
Silage, 70% moisture, wet basis(2)	
tractor-packed, in horizontal silo	700
unpacked, in horizontal silo	500
Silage in tower silos(3)	
Straw	
chopped	100 – 130
field baled	130
long	60
Wood shavings, baled	320
Fruits and Vegetables	
Apples, bulk	600
Apricots	620
Beans	
shelled	800
unshelled	400
Beets	700

Table A-2.2.1.14. (Continued)

Material	Bulk Density, ρ, kg/m^3
Blackberries	610
Cabbage	500
Carrots	550
Cauliflower	320
Corn, cob	450
Cranberries	480
Cucumbers	620
Onions, dry	650
Parsnips	500
Peaches	620
Pears	640
Peas	390
Peppers	320
Plums	720
Potatoes	670
Pumpkins	600
Squash	600
Sweet potatoes	700
Tomatoes	680
Turnips	600
Miscellaneous Products	
Eggs in cases	200
Fertilizer	950 – 1 000
Tobacco	550
Wool	
compressed bales	775
uncompressed bales	200
Fresh manure (feces and urine mixed)	1 000

Notes to Table A-2.2.1.14.:

(1) Bulk densities for grain given in Table A-2.2.1.14. are test weights determined by filling a small container. When grain is dropped some distance into a bin, a 5% increase in bulk density may occur. If a grain spreader is used during filling, the bulk density will be increased further but wall pressures will be more uniform and slightly less than if filling is from a central spout. This increase has been dealt with by the 1.06 factor in the definition of γ.

(2) Bulk density at a moisture content other than 70% can be calculated as follows:

$$\rho_{\mathrm{M}} = 30\,(\rho_{70})\,/\,(100 - \mathrm{M})$$

where

ρ_{M} = bulk density at moisture content M%, kg/m^3,
ρ_{70} = bulk density at 70% (wet basis), kg/m^3,
M = moisture content, per cent (wet basis).

(3) See Table A-2.2.1.11.A.

A-2.2.1.14.(4) Lateral Wall Pressure for Shallow Bins. For shallow bins with vertical walls, horizontal wall pressures may be conservatively estimated by using an equivalent fluid density of γk.

A-2.2.1.14.(5) Shallow Bins with Sloping Walls

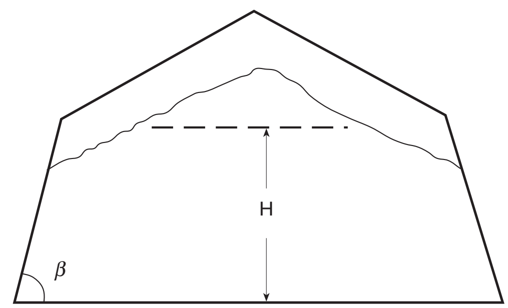

Figure A-2.2.1.14.A.

Shallow bin with wall at slope β to the horizontal; see Sentence 2.2.1.14.(2) for definition of H

A-2.2.1.14.(6) Vertical Friction Load of the Bin Contents on the Bin Wall. The equation given in this Sentence is a summation of the horizontal pressure multiplied by the wall friction coefficient. Wall friction loads may exceed this value. One example is where grain drying in the bin with heated air causes drying of the lower layers of the grain and wetting of the upper layers. Grain at the lower level shrinks; that at the upper level swells, increasing the horizontal pressure and the vertical load on the wall.

A-2.2.1.14.(7) and (8) Horizontal Wall Pressures during Emptying. Increased pressures frequently occur as bins begin to empty. The magnitude of the increase will depend on the ratio of height to diameter, wall roughness, slope of bin hopper (if any) and location of the discharge opening. Where a bin with a flat bottom or a shallow hopper empties through a central opening, the grain will form a hopper of stationary material to a depth approximately equal to the width or diameter of the bin. This hopper will cushion increased pressures in this region but in very deep bins the pressure can increase significantly above the hopper of grain. For bins with hoppers steeper than 45° to the horizontal, increased horizontal pressures will extend from the top of the hopper.

Where a bin is emptied from an opening near a wall, the cushioning effect of grain is not obtained, so the horizontal pressure increases that occur during emptying are greater than for centric emptying and they extend to near the opening.

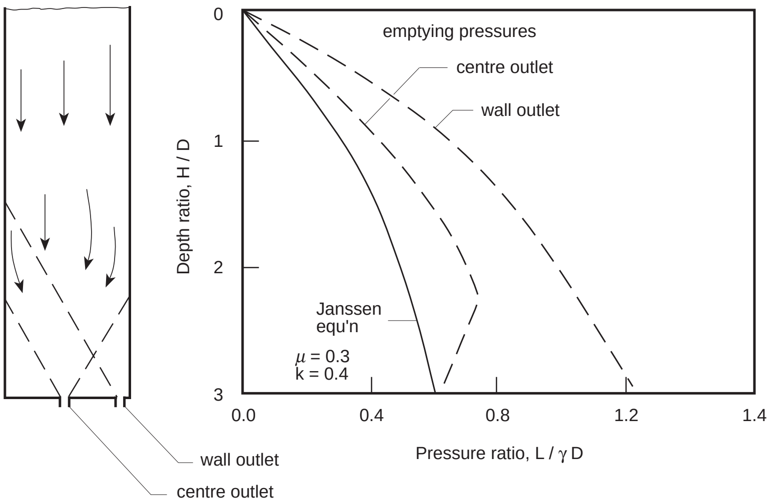

Figure A-2.2.1.14.B.

Increased horizontal pressures during emptying a deep bin with the discharge opening in the centre or near the wall

A-2.2.1.14.(10) Vertical Pressure for Deep Bins. The equation for vertical pressure assumes maximum friction on the wall. After a few hours in storage grain settles noticeably, which increases the load on the floor by approximately 25%.

A-2.2.1.14.(11) Pressures on Hoppers Sloped 20° to 60° from the Horizontal. For hoppered bins in which the vertical wall height is small relative to hopper depth, the dead and live load of the hopper and contents may produce the critical loads for design.

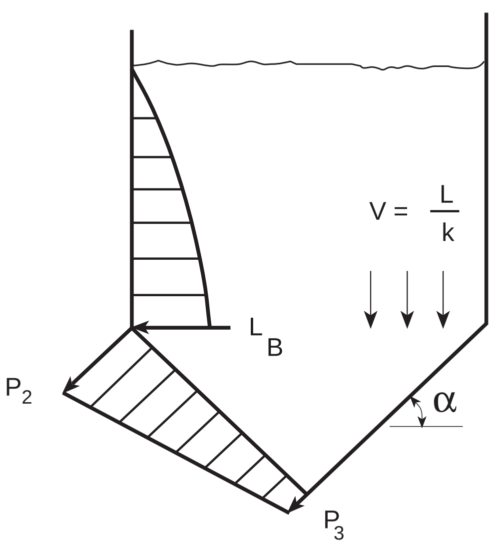

Figure A-2.2.1.14.C.

Variation in pressure on hoppers sloped 20° to 60° from the horizontal

A-2.2.1.14.(12) Pressures on Bin Bottoms Sloped at 60° or Greater. In bins having steep hoppers designed for mass flow, a large increase in pressure occurs in a localized area where the bin wall and hopper meet.

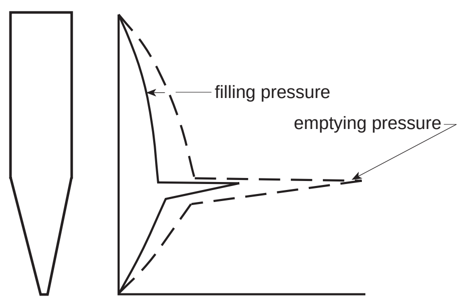

Figure A-2.2.1.14.D.

Typical pressure distribution in a conical mass flow hopper

A-2.2.1.15.(1) Design of Storages for Bulk Vegetables and Fruits. The pressures and loads for the design of storages for bulk vegetables and fruits have been based on the most critical situation, which is the storage of round, wet potatoes with an equivalent fluid density of 2.0 kN/m^3.

A-2.2.2.2.(1) Reduced Snow Loads for Smooth Slippery Roofs. Research has shown reduced snow loads on sloping roofs covered with prepainted steel, as compared to roofs covered with asphalt shingles. This Sentence allows a reduction of the slope factor, C_s, for smooth, slippery farm building roofs where snow is free to slide. Figure A-2.2.2.2. shows the shape of the C_s curve based on the National Building Code of Canada 1995 and modified by Sentence 2.2.2.2.(1)

The designer should examine a proposed roof configuration carefully to ensure that snow will be free to slide before using the reduced C_s factor. The reduced C_s factor does not apply to roof slopes terminating at grade, at a roof valley or at another roof of flatter slope because the snow mass may pile up or refuse to bend at the transition. Other obstructions may include chimneys, silos and ice guards.

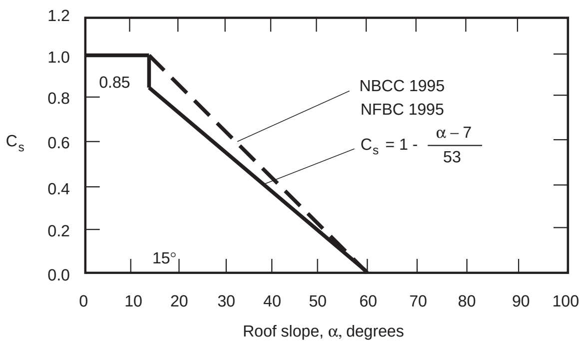

Figure A-2.2.2.2.

Roof slope snow reduction factor, C_S, versus roof slope, α, for smooth, slippery, unobstructed farm building roofs

A-3.1.1.1.(1) Fire Safety Requirements. The fire safety requirements in Part 6 of the National Building Code of Canada 1995 apply by virtue of Sentence 1.1.1.3.(1)

A-3.1.2. Spatial Separations. The requirements in this Subsection are considered adequate to provide for the safety of humans in farm buildings. However, because many farm buildings and their contents are highly combustible, spatial separations may be used to minimize property losses and provide additional safety for firefighters during fires. A guide for open-space separations to prevent the spread of fires by radiation can be found in Section 1.10 “Separation to Prevent the Spread of Fire” of the Canadian Farm Buildings Handbook. The Handbook is available from authorized bookstore agents and other bookstores or by mail from Canada Communications Group, Publishing, 45 Sacre Coeur Blvd., Hull, Quebec, Canada K1A 0S9.

A-3.1.2.1.(1) Definitio of Exposing Building Face. The National Farm Building Code 1995 regulates only the building under construction. The concern of the Code, therefore, is the exposure offered by that building (i.e., the exposing building) to an adjacent building (i.e., the exposed building) or property line.

A-3.1.3.1.(1) Fire Stopping. This requirement is not intended to prohibit concealed roof spaces being used as fresh air supply plenums for air distribution through porous ceilings or slotted inlets to rooms below.

A-3.1.5.1.(2) Fire-Resistance Rating. See Table A-3.1.5.1.(2)

Table A-3.1.5.1.(2)
Estimated Fire-Resistance Ratings for Assemblies(1)(2)

Structure	Membranes	Fire Resistance, Min
38 mm × 89 mm wood studs 400 mm o.c.	11.0 mm Douglas Fir plywood, OSB or waferboard (both faces)	30
	14.5 mm Douglas Fir plywood, OSB or 15.5 mm waferboard (both faces)	35
	4.5 mm asbestos cement board over 9.5 mm gypsum wallboard (both faces)	60
	12.7 mm gypsum wallboard (both faces)	35
	8.0 mm Douglas Fir plywood or 9.5 mm OSB or waferboard (both faces) with stud spaces filled with mineral wool batts	40
38 mm × 89 mm wood studs 600 mm o.c.	11.0 mm Douglas Fir plywood, OSB or waferboard (both faces) with stud spaces filled with mineral wool batts	30
	4.5 mm asbestos cement board over 9.5 mm gypsum wallboard (both faces)	30
	12.7 mm Type X gypsum wallboard (both faces)	35
Steel studs 400 mm o.c.	4.5 mm asbestos cement board over 9.5 mm gypsum wallboard (both faces)	50

Table A-3.1.5.1.(2) (Continued)

Structure	Membranes	Fire Resistance, Min
Wood floor and roof joists (38 mm thickness) 400 mm o.c. or Open web steel joist floors and roofs with ceiling supports 400 mm o.c.	12.7 mm Type X gypsum wallboard ceiling	35
	4.5 mm asbestos cement board on 9.5 mm gypsum wallboard ceiling	50
	26 mm portland cement and sand or lime and sand plaster on metal lath ceiling	40
90 mm hollow concrete blocks (normal weight aggregate)	—	45
140 mm hollow concrete blocks (normal weight aggregate)	—	60
190 mm hollow concrete blocks (normal weight aggregate)	—	90

Notes to Table A-3.1.5.1.(2):

(1) Additional information on fire-resistance ratings for assemblies is given in Appendix D, "Fire Performance Ratings" of the National Building Code 1995 and Article 9.10.3.1. of the National Building Code 1995.

(2) Interior walls are rated from both sides, whereas floors and roofs are rated from below.

A-3.1.7.1.(1) Rodent Damage of Electrical Wiring. In locations where rodents may damage the insulation, wiring should be surface mounted or protected by rigid PVC conduit or other approved material.

A-3.2.1.6.(1) Signage. Information on signage can be found in the American Society of Agricultural Engineers Standard ASAE S441 (SAE J115 Jan 87) "Safety Signs."

A-4.2.1.4.(1) Gas Hazards in Enclosed Horizontal Silos. Gas hazards exist in enclosed horizontal silos due to tractor operations during filling and unloading and due to gases produced during silage fermentation. This fermentation period normally extends for two to three weeks after filling. Since most of these gases are heavier than air, it is an advantage to provide at least one opening near floor level, which may be the tractor access opening.

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Conversion Factors

To Convert	To	Multiply by
°C	°F	1.8 and add 32
kg	lb	2.205
kg/m^3	lbf/ft^3	0.06243
kN	lb	224.81
kN/m	lbf/ft	68.52
kN/m^3	lbf/ft^3	6.360
kPa	lbf/in^2 (psi)	0.1450
kPa	lbf/ft^2	20.88
L	gal (imp.)	0.2200
m	ft	3.281
m^2	ft^2	10.76
mm	in.	0.03937
m/s^2	ft/s^2	3.281