Snow loads for building - NBCC 2015

This document analyzes the snow loads for buildings according to NBCC (National Building Code of Canada) 2015. And, the design example is based on CSSBI B15-17 (NBCC 2015 : Design Load Criteria for Steel Building Systems).

References:
- NBCC (National Building Code of Canada) 2015
- CSSBI (Canadian Sheel Steel Building Institute) resouces for Steel Building systems
  - CSSBI B15-17: NBCC 2015 Design Load Criteria for Steel Building Systems

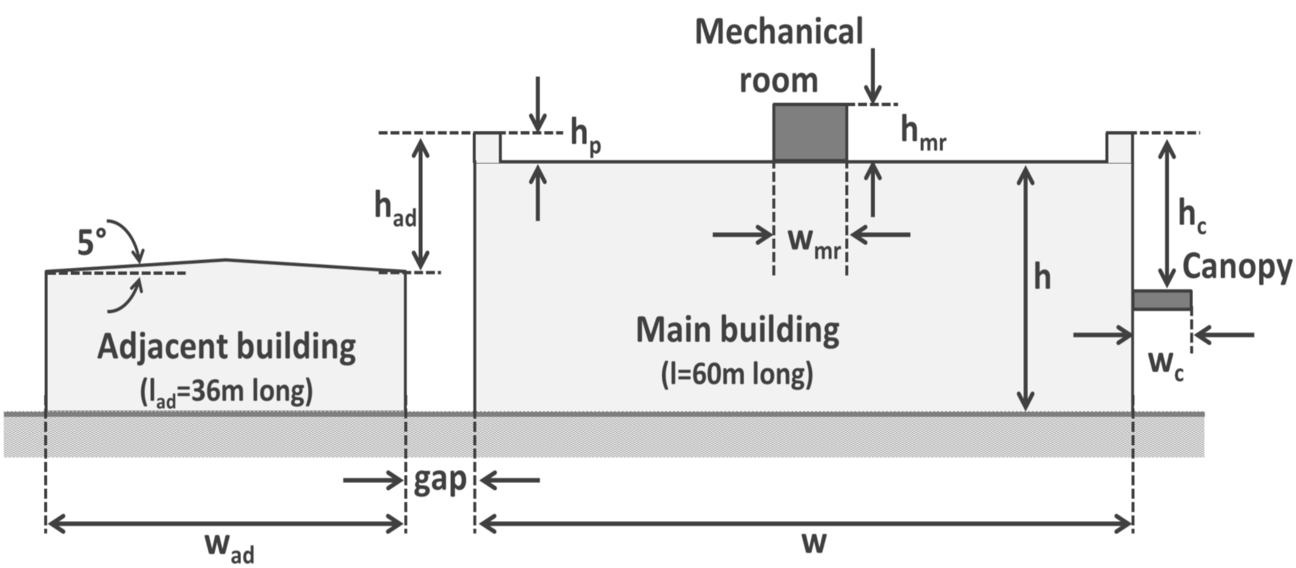

Figure 1 : Building geometry

1. Design conditions and geometries

Design conditions

Ground show load $S_s := 2.0\ \text{kPa}$

Rain load $S_r := 0.4\ \text{kPa}$

Importance Factor for Snow (Importance category : Normal) $I_s := 1.0$

Snow density $\gamma_s := \left(0.43 \cdot \frac{1}{m}\right) \cdot S_s + 2.2 \cdot \frac{kN}{m^3}$ $\gamma_s = 3.060\ \frac{kN}{m^3}$

Geometrical parameters

Building

Length	$l := 60\ \mathbf{m}$
Width	$w := 40\ \mathbf{m}$

Parapet

Height	$h_p := 0.5\ \mathbf{m}$

Canopy

Width	$w_c := 2.5\ \mathbf{m}$
Height	$h_c := 5\ \mathbf{m}$

Mechanical room

Width	$w_{mr} := 3\ \mathbf{m}$
Height	$h_{mr} := 2\ \mathbf{m}$

Adjacent building

Length	$l_{ad} := 36\ \mathbf{m}$
Width	$w_{ad} := 22\ \mathbf{m}$
Height difference to Main building	$h_{ad} := 3.5\ \mathbf{m}$
Gap between Main and Adjacent	$gap := 3.0\ \mathbf{m}$

2. Main roof

Load factors

Wind exposure factor $C_w := 0.75$
- Importance category : Normal
- Based on NBCC 4.1.6.2 (4)

Slope factor $C_s := 1.0$
- Flat roof
- Based on NBCC 4.1.6.2 (5)(6)(7)

Basic roof snow load factor

Characeristic length of the upper roof

$$l_{cs} := 2 \cdot w - \frac{w^2}{l} = 53.333\ \mathbf{m}$$

Basic roof snow load factor

$$C_b := \begin{cases} 0.8 & \left(\frac{l_{cs}}{\mathbf{m}}\right) \le \frac{70}{C_w^{\ 2}} \\ \frac{1}{C_w} \cdot \left(1 - \left(1 - 0.8 \cdot C_w\right) \cdot e^{-\frac{\left(\frac{l_{cs}}{\mathbf{m}}\right) \cdot C_w^{\ 2} - 70}{100}}\right) & \text{otherwise} \end{cases}$$

$C_b = 0.800$

Accumulation factor based on snow drifting at parapet

Height of parapet $h_p = 0.500\ \mathbf{m}$

Depth of the snow over the roof area $\frac{C_b \cdot S_s}{\gamma_s} = 0.523\ \mathbf{m}$

So, the accumulation factor can be defined as follow because drifting is not a concern at the parapet. (Depth of the snow > Height of parapet)

$C_a := 1.0$

Specified snow load

$$S := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_a + S_r \right) = 1.600 \ \mathbf{kPa}$$

2. Canopy loading

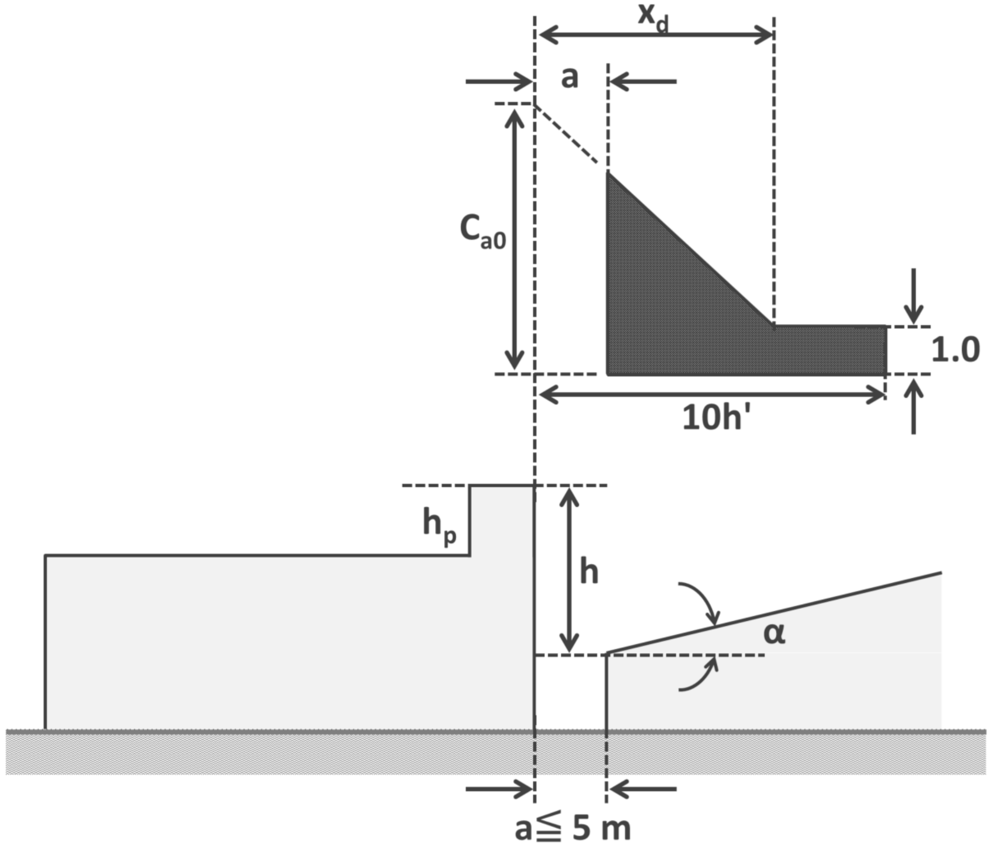

Figure 2 : Shape factor C_a **for sliding snow**

Load factors

Basic snow load factor $C_b = 0.800$

Wind exposure factor $C_w := 1.0$
- Importance category : Normal
- Based on NBCC 4.1.6.2 (4)

Slope factor $C_s := 1.0$
- Flat roof
- Based on NBCC 4.1.6.2 (5)(6)(7)

Characeristic length of the upper roof $l_{cs} = 53.333 \ \mathbf{m}$

Parameter
- Based on NBCC 4.1.6.5. Case I

$$\beta := 1.0$$

Parameter h_{d_p}

$$h_{d\_p} := h_p - \frac{C_b \cdot C_w \cdot S_s}{\gamma_s} = -0.023\ \mathbf{m}$$

Parameter F_c

$$F_c := 0.35 \cdot \beta \cdot \left(\frac{\gamma_s \cdot l_{cs}}{S_s} - 5 \cdot \frac{\gamma_s \cdot h_{d\_p}}{S_s} \right)^{0.5} + C_b = 3.965$$

Maximum accumulation factor

$$C_{a0} := \min\left(\frac{F_c}{C_b}, \frac{\beta \cdot \gamma_s \cdot h_c}{C_b \cdot S_s} \right) = 4.956$$

Maximum snow load

$$S_{max} := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_{a0} + S_r \right) = 8.330\ \mathbf{kPa}$$

Length of the snowdrift

$$x_d := 5 \cdot \frac{C_b \cdot S_s}{\gamma_s} \cdot \left(C_{a0} - 1 \right) = 10.343\ \mathbf{m}$$

Snow load at the canopy edge

$$x := w_c$$

$$C_a := C_{a0} - \left(C_{a0} - 1 \right) \cdot \left(\frac{x}{x_d} \right) = 4.000$$

$$S_{edge} := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_a + S_r \right) = 6.800\ \mathbf{kPa}$$

3. Roof area adjacent to Mechanical room

Maximum accumulation factor

$$C_{a0} := \min\left(\frac{0.67 \cdot \gamma_s \cdot h_{mr}}{C_b \cdot S_s}, \frac{\gamma_s \cdot w_{mr}}{7.5 \cdot C_b \cdot S_s} + 1\right) = 1.765$$

Maximum snow load

$$S_{max} := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_{a0} + S_r\right) = 3.224 \, \mathbf{kPa}$$

Length of the snowdrift

$$x_d := \min\left(3.35 \cdot h_{mr}, \frac{2}{3} \cdot w_{mr}\right) = 2 \, \mathbf{m}$$

Length of the affected zone

$$h_{d\_mr} := h_{mr} - \frac{C_b \cdot C_w \cdot S_s}{\gamma_s} = 1.477 \, \mathbf{m}$$

So, at $10 \cdot h_{d\_mr} = 14.771 \, \mathbf{m}$ away from the mechanical room, C_w can be reduced to 0.75

Specified snow load

$$C_a := 1.0$$

Within $10 \cdot h_{d\_mr} = 14.771 \, \mathbf{m}$ from the mechanical room

$$S := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_a + S_r\right) = 2.000 \, \mathbf{kPa}$$

Beyond $10 \cdot h_{d\_mr} = 14.771 \, \mathbf{m}$ from the mechanical room

$$C_w := 0.75$$

$$S := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_a + S_r\right) = 1.600 \, \mathbf{kPa}$$

4. Lower roof (Roof of adjacent building)

Load factors

Basic snow load factor $C_b = 0.800$

Wind exposure factor $C_w := 1.0$ (If allowed, use $C_w = 0.75$)
- Importance category : Normal
- Based on NBCC 4.1.6.2 (4)

Slope factor $C_s := 1.0$
- Flat roof
- Based on NBCC 4.1.6.2 (5)(6)(7)

Characeristic length of the upper roof $l_{cs} = 53.333\ \mathbf{m}$

Parameter $\beta := 1.0$
- Based on NBCC 4.1.6.5. Case I

Parameter h_{d_p} $h_{d\_p} := h_p - \frac{C_b \cdot C_w \cdot S_s}{\gamma_s} = -0.023\ \mathbf{m}$

Basic roof snow factor

$$l_c := 2 \cdot w_{ad} - \frac{{w_{ad}}^2}{l_{ad}} = 30.556\ \mathbf{m}$$

Because the vaule of C_w doesn't make a difference for the factor, the basic roof snow factor can be obtained with $C_w = 1.0$ as follow.

$$C_b := \begin{cases} 0.8 & \left(\frac{l_c}{\mathbf{m}}\right) \le \frac{70}{{C_w}^2} \\ \frac{1}{C_w} \cdot \left(1 - \left(1 - 0.8 \cdot C_w\right) \cdot e^{-\frac{\left(\frac{l_c}{\mathbf{m}}\right) \cdot {C_w}^2 - 70}{100}}\right) & \text{otherwise} \end{cases}$$

$C_b = 0.800$

Parameter F_{ad}

$$F_{ad} := 0.35 \cdot \beta \cdot \left(\frac{\gamma_s \cdot l_{cs}}{S_s} - 5 \cdot \frac{\gamma_s \cdot h_{d\_p}}{S_s} \right)^{0.5} + C_b = 3.965$$

Maximum shape factor

$$C_{a0} := \min\left(\frac{F_{ad}}{C_b}, \frac{\beta \cdot \gamma_s \cdot h_{ad}}{C_b \cdot S_s} \right) = 4.956$$

Maximum show load

$$S_{max} := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_{a0} + S_r \right) = 8.330 \ \mathbf{kPa}$$

Length of the snowdrift

$$x_d := 5 \cdot \frac{C_b \cdot S_s}{\gamma_s} \cdot \left(C_{a0} - 1 \right) = 10.343 \ \mathbf{m}$$

Snow load at the roof eave

$$x := gap = 3.000 \ \mathbf{m}$$

$$C_a := C_{a0} - \left(C_{a0} - 1 \right) \cdot \left(\frac{x}{x_d} \right) = 3.809$$

$$S_{eave} := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_a + S_r \right) = 6.494 \ \mathbf{kPa}$$

Length of the affected zone

$$h_{d\_ad} := h_{ad} - \frac{C_b \cdot C_w \cdot S_s}{\gamma_s} = 2.977\ \mathbf{m}$$

$$10 \cdot h_{d\_ad} = 29.771\ \mathbf{m}$$

Since the width of building is $w_{ad} = 22\ \mathbf{m}$, so the following value of the wind exposure is used.

$$C_w := 1.0$$

Specified snow load

$$C_a := 1$$

$$S := I_s \cdot \left(S_s \cdot C_b \cdot C_w \cdot C_s \cdot C_a + S_r\right) = 2.000\ \mathbf{kPa}$$