CALHOUN

Engineering Bulletin 029

RE: Snow Load Semantics

The most critical aspect of any construction project involving a roof is engineering the structure to ensure its stability and long-term safety. Of the **various** "live loads" or fluctuating forces that **affect** a roof, the load caused by snow is more **complex** than one might **expect**. Heavy snow loads have caused **significant** damage to structures in the past, prompting structural engineers to **develop** a body of design **guidelines** and historical data to ensure that roof structures can **withstand** the snow conditions that Mother Nature **presents** where buildings are erected.

Ground Snow Load

The first step in determining the design of a building's roof to carry the weight of snow is to ascertain the **"Ground Snow Load."** This is a single number that represents the weight of snowfall in a particular location with a 50-year mean recurrence interval which equates to a 2% probability of being exceeded in any given year. These values are tabulated in national standards documents (American Society of Civil Engineers (ASCE) in the US and the Nation Building Code (**NBC)** in Canada) and are the result of extreme value statistical analysis using weather records gathered near the building site.

In addition to the statistical data, the Ground Snow Load is also influenced by environmental and physical factors. For example, snow compaction (the bottom layers of snow are **denser** than the top layer); the water content of the snowfall; and the age of the various layers that make up the snowpack. It is quite a feat that these environmental factors can be combined into a single number that also accounts for the statistical variation of weather!

The key takeaway is that the Ground Snow Load value is a function of the weather at the building site. For **locations** that have too much snowfall variability to be represented with a single number (large areas of the mountainous West in North America, for example), the code requires case studies to be performed for a specific building site to determine the Ground Snow Load.

Flat Roof Snow Load

With a value for Ground Snow Load in hand, the engineer can tackle the calculation for the Flat Roof Snow Load. This value is the design snow load for a flat roof, basically separating factors that apply to any roof no matter the pitch into this calculation and leaving factors that depend on roof pitch and roof arrangement for subsequent calculations.

The Flat Roof Snow Load represents the peak snow accumulation on a roof during the winter season. For buildings in colder regions, this Flat Roof Snow Load accommodates snow deposited by multiple snow events. In between snow fall events, roofs may lose snow mass due to either wind scour or by melting from building heat loss. Since roofs have greater wind exposure than the snow on the ground, the calculation takes this fact into account as well. Finally, heat loss from a building with a "warm" roofing system causes snow melt not seen by the ground level snow. Consequently, the Flat Roof Snow Load calculation usually results in a value less than the Ground Snow Load.

In the U.S:

In the U.S., snow load design is evaluated per **ASCE 7**, which provides equations for calculating **snow loads** on roofs. Specifically, the **Flat Roof Snow Load (pf)** is the key factor for **roofs**.

The equation for **Flat Roof Snow Load**, denoted as **pf**, is expressed as:

$$pf = 0.7 \times Ce \times Ct \times Is \times pg$$

Where:

- **pf = Flat Roof Snow Load** (the design snow load for a flat roof).
- **Ce = Exposure Factor** (a site-specific factor that adjusts the snow load based on how exposed the roof is to wind and other environmental conditions).
- **Ct = Thermal Factor** (accounts for heat loss from the building that causes some of the snow on the roof to melt, which reduces the snow load).
- **Is = Importance Factor** (a factor that adjusts the snow load for the type of building; it reflects the building's importance and its ability to withstand heavy snowfalls, e.g., critical buildings like hospitals and schools have higher importance factors).
- **pg = Ground Snow Load** (the reference snow load at ground level, which is based on historical data and meteorological measurements specific to the geographic location).

In Canada:

Specified Snow Load (S) is defined in the **National Building Code of Canada (NBC)** and refers to the **design snow load** that a building's roof must be able to support due to snow and any associated rain accumulation. This value is calculated based on the **Ground Snow Load** and adjusted for several factors including **exposure**, **thermal effects**, and **importance** of the building.

The formula for calculating the **Specified Snow Load (S)** in Canada is:

$$S = I_s \times (S_s \times C_\beta \times C^w \times C_s \times C_a + S^r)$$

Where:

- **S** = Specified Snow Load (design snow load on the roof).
- I_s = Importance Factor (ranging from 0.8 to 1.25, depending on the building's criticality).
- S_s = Ground Snow Load (reference snow load at ground level).
- C_β = Basic Roof Snow Load Factor (accounts for the roof shape and geometry, between 0.8 and 1.2).
- C^w = Wind Exposure Factor (0.75 or 1).
- C_s = Roof Slope Factor (adjusts for the roof slope; 1.0 for flat roofs).
- C_a = Accumulation Factor (modifies the snow load to account for how snow accumulates on the roof)
- S^r = Rain-on-Snow Load (additional weight from rain accumulating on snow).

Please check the provided link for more information,
https://calhounsuperstructure.com/resources/blog/terrains-impact-on-design-snow-load/

The goal of these calculations is to design a roof that is both durable and cost-effective, ensuring it meets the required strength for its intended lifespan while minimizing material waste and unnecessary expenses. Achieving this, especially in the face of the variability of weather, is no simple task. This complexity requires engineers to perform careful calculations for the **Flat Roof Snow Load**.

The design process becomes more complex when factors like the slope of the roof are considered, or in the case of multi-level roof systems, where snow from an upper roof can slide down onto a lower roof, increasing the load on the lower levels**.**

Shadow drift loads occur when snow is displaced from an upper roof and accumulates on the lower roof. This additional weight must be accounted for in the structural design to ensure that the lower roof can safely support the load.

Please check the provided link for more information.
https://www.youtube.com/watch?v=KlZBptQbCVc

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