Measuring Snow Load on Flat Roofs with Low Cost Sensors

Abstract

Flat roofs in northern climates fail when accumulated snow exceeds their design load. We describe a sensor network built from commodity load cells and a small radio module that reports roof load every ten minutes. Across two winters on fourteen buildings, the system detected every load event that later required manual snow removal and produced three false alarms. Total hardware cost per roof was below 400 euros.

Introduction

Building codes specify a characteristic snow load for each region, but actual loads vary widely from roof to roof. Wind moves snow into drifts, meltwater refreezes into dense ice, and rain on snow can double the weight within hours. Property owners usually rely on visual inspection, which is slow, risky and often too late.

Commercial monitoring systems exist, yet their price limits them to large public buildings. Our goal was a system that a housing cooperative could afford and install without specialist help.

Method

Hardware

Each node consists of four load cells mounted under a steel plate of one square metre, an amplifier, a microcontroller and a long range radio. Nodes run on two lithium cells and sleep between measurements. A gateway in the building forwards readings to a central server over the mobile network.

Calibration

We calibrated every node in place by placing known weights on the plate before the first snowfall. Temperature drift was measured over a week and corrected with a linear model. After correction, the mean absolute error against a reference scale was 1.8 kilograms per square metre.

Alert rule

An alert is raised when the measured load exceeds 70 percent of the design load for two consecutive readings. Requiring two readings filters out short spikes caused by people or animals on the roof.

Results

The network recorded 1.2 million readings over two winters. Table 1 summarises the alert performance per winter.

Winter	Roofs	Load events	Detected	False alarms
2023 to 2024	9	11	11	2
2024 to 2025	14	17	17	1

Battery life exceeded one full winter on all nodes. Radio packet loss stayed below 2 percent except during one storm, when a gateway lost power for six hours.

Discussion

The main limitation is coverage. One plate measures the load at one point, while drifts can form elsewhere on the roof. In practice we placed plates where drifts were known to build up, based on the caretaker's experience. A second limitation is ice formation on the plate edges, which we solved with a simple heated rim.

Conclusion

Low cost load sensing is accurate enough to warn property owners before snow becomes dangerous. The design is open and can be built from parts available in any electronics store.