How Much Snow is Too Much?

by Robert Daigle, P.E.

Winter is here and we have to face all of those dreadful problems associated with the cold, ice and snow again.

In years past we have had bad winters and good winters. Depending on whether you ski or not the term good or bad may take on a different meaning. Being a structural engineer, I have been faced with many varying conditions related to snow loads on buildings. Excluding the southern states, which are blessed with mild or non-existent winters, the northern states have widely varying conditions, some of which can develop into serious problems if not handled correctly.

A few years ago, New England was hit by a series of snow storms one after another. In fact, it was a record breaking season for snow accumulation. The region ended up with a number of heavily loaded roofs, along with a proportional number of concerned building owners. A weather advisory was broadcast on TV alerting people to beware of heavy snow on roofs; that a number of collapses had occurred. As the snow kept falling, the number of calls to our office increased. The common question we were asked was: “Is my roof Okay?” Obviously, this was an impossible question to answer over the phone, especially if the call was from a new client for whom we had no information or knowledge about their building. At least if we knew the building in question, we would have a feel for its strength and condition. However, even knowing the condition of the building, we still did not know how much snow was on the roof.

In order to provide the services that the callers were requesting, our office developed a method to determine the actual weight of snow on a roof. We wanted a method that was easy to deal with in the cold, even when it was dark and windy. The equipment had to be light and easy to carry because we usually have to climb a ladder to get on the roof. We came up with a solution that works very well, and it’s nothing high tech either. To start we took a couple of two foot sections of standard 4" diameter aluminum vent pipe. These two sections of pipe were interconnected by means of inserting one swaged end into the other. We found it best to hold the two sections together with duct tape so they would not fall apart when climbing a ladder. We procured a scale having a 10 pound capacity along with a plastic clip board, to hold the sample from dropping out of the sampling pipe. The above equipment was found to suffice for weighing snow samples from the majority of snow packs on open roofs.

Here’s the procedure:

Shovel a small area near where you would like to know the snow weight. This will give you a flat area to work in. Take the sample pipe and push it down into the snow pack directly adjacent to where you are standing. Try to reach away from any area which has been trampled or where snow was thrown.

Once the pipe hits resistance, gently twist it to cut into the ice or packed snow base, but be careful not to damage the roofing. Once this step is complete, without moving the pipe, take a shovel or the clip board and pull the snow from around the pipe at the front and sides. Then, taking the clip board in one hand, push the board under the sample pipe to keep the snow from falling out when you pick it up. Before hand you want to "zero-out" the scale with the sample pipe and clip board on it. That way the weight you read on the scale will be that of the snow sample only. Next, pick up the sample pipe with the clip board underneath and place it on the scale. The weight you read is what you will use on the following chart to determine the roof load (per square foot) resulting from the snow.

Conversion chart for 4" diameter sample:

Weight of Sample (lbs.)	Roof Snow Load in (lb/ft^2)
0.25	3
0.5	6
0.75	9
1	12
1.25	15
1.5	17
1.75	20
2	23
2.25	25
2.5	28
2.75	31
3	34
3.25	37
3.5	40
3.75	43
4	46
4.25	49
4.5	52
4.75	55
5	57

Cut this chart out and tape it to the sample pipe for easy reference in the field. It would be best if this were laminated first to keep it dry.

This chart merely converts the weight of the specimen from the 12.6 square inches which is the cross sectional area of the 4" sample pipe, to the 144 square inches in a square foot. Therefore, a 3.0 pound sample specimen in the pipe is the same as 34 psf (pounds per square foot) of snow weight on the roof.

Now that the actual snow weight on the roof is known, a rational decision on how to proceed can be made. If you know the snow load capacity of the roof, this will be easier. For example: If you know that your roof has a snow load capacity of 25 psf, and you take sample readings which on the conversion chart show an equivalent snow load of 17 psf, you might decide to postpone snow removal pending further snow accumulation. If you do not know the roof's capacity, contact your structural engineer. As you may suspect, the snow load requirements vary dramatically from the north to south. Snow loads can range from 0 psf (although by code, roofs must be designed to support minimum live load) to a maximum of over 60 psf on an unobstructed roof area.

Snow drifting is another issue which requires much attention. Building Codes require that engineers design for this drifting effect where roofs abut a higher building or piece of equipment such as a large roof top unit. This drifting condition also develops along parapets. Believe me when I say that snow loads can drift to over eighteen feet tall on a roof. I've seen it once in Buffalo, New York and once in Watertown, Connecticut. In both situations, it was on a low roof of an office which abutted a high bay storage warehouse. The snow load was calculated to weigh upwards of 180 psf. Fortunately, the Buffalo building had a non-bearing masonry wall running below the joists perpendicular to the span near midspan of the members. This saved the roof from collapse. The roof structure did not have provisions for drifting because it was designed prior to the code requirement increasing the design snow load in such areas. At the Watertown job, the roof did not collapse because, fortunately, it was designed for the Code required snow drift load for that specific area, which was 120 psf. Although the 180 psf snow pack exceeded this load, the factor of safety proved to be the saving grace. The roof deflected 4" under the load but did not exceed the elastic limit of the long span joists; therefore, once the load was removed, the roof rebounded to its original shape. A word of caution though - provisions for snow drift-

ing are not always properly addressed, or may be missed entirely. Do not assume that your building is properly designed.

Another issue that makes this “weigh the snow routine” a good thing to do is that if you find the snow doesn’t have to be removed, you can:

1. Save a tremendous amount of money on a large roof;
2. Eliminate the potential damage to the roofing membrane; and,
3. Eliminate the risk of someone falling off the roof when they are shoveling snow, especially at night.

One word of caution when measuring a snow pack deeper than the 48” length of pipe; always make sure that the specimen you take is the full depth of the snow pack. If it is 54” deep I would recommend getting another section of pipe to add on to the other two. Otherwise you would have to take much care in measuring the weight in multiple lifts, being careful not to disturb the different levels.

On roofs that we have inspected, a number of weight measurements were taken around the roof. At each measurement, we also measured the depth of snow for our reference. This would give us a feel for weight versus depth. However, this relationship could vary significantly from day to day. For example: a 22” depth of powdery snow might weigh 15 psf.; however, a rain storm could increase the snow density by a factor of 3. The snow also restricts the flow of snow melt and rain runoff toward the roof drains.

Horror Stories:
We have heard a few stories that make us shudder:

1. Helicopter Blow Off Method - One municipality hired a helicopter to blow the snow off their roof. This might work well with the light, powdery type of snow that would blow off easily. What happens though if the roof is loaded to its limit with snow and then a helicopter hovers overhead. Could the down blast cause a collapse? It’s possible.

2. ”Bob Cat" Method - One municipality had the great idea to lift a small "Bob Cat" type tractor onto the roof to remove the snow. They were fortunate that the machine did not punch through the deck as this is a highly concentrated load for a roof system. I am sure the abrasion from the unit turning and running back and forth didn’t help the roof warranty either.

3. Wave Method - One common method is to use snow blowers on the roof. One word of caution though, the snow blower can become a Gatling gun if the roof has stone ballast on it. Get ready to take cover! The technique used by the unknowing is to start in the center and keep moving the snow toward the edge of the roof. The only problem with this is that the snow depth and density keeps building up on every pass. This could be catastrophic.

Snow Removal Methods:

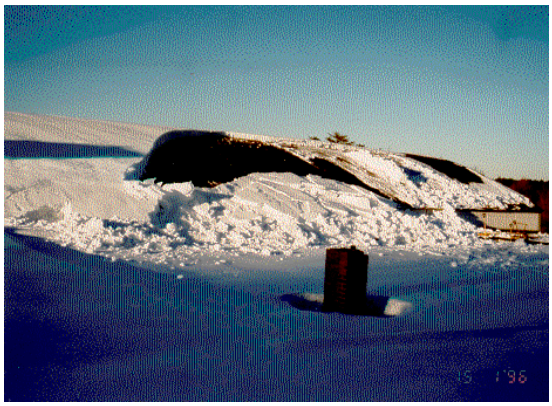
One innovative way to clear a large roof is to have a crane and dumpster available. The crane holds the dumpster above the roof for workers to fill with snow. That way areas of roof can be cleared without having to carry the snow across a large distance. This also reduces the wear and tear on the roof

roof membrane. As you probably suspect, we recommend against lowering the dumpster onto the roof. The added weight could cause a problem.

One suggestion we make, when we find that a roof is over loaded, is how much weight should be removed. Many times we have seen an owner remove all of the snow when in actuality all they needed to do was reduce the loading, not remove it entirely. If it is determined that 30% of the snow must be removed, we might recommend that 3'-0" wide lanes be cleared every 9'-0" on center. These lanes would preferably be oriented parallel with the roof slope to help facilitate water migration to the drains. If the roof has isolated interior drains, these lanes should radiate outward from each drain. Our recommendations could vary depending on actual conditions.

The other method mentioned earlier about clearing snow from aisles radiating from drains is a desirable method. In all cases plastic tipped shovels are recommended as well as minimizing worker loading until an adequate area is cleared to compensate for their added weight.

One word of caution; when digging out a roof which abuts a higher sloped roof make sure to shovel the upper roof first, if the low roof snow is up to the eave of the upper roof. The drift on the low roof might be holding back the snow from sliding off of the sloped roof. This was learned first hand when a low roof was cleared of a drift only to have the snow on the sloped roof come crashing down. Fortunately, there was no damage or injury from this oversight.



There's an old saying, "If it ain't broke, don't fix it". In this case, if you don't have to shovel your roof, don't do it. Stay inside were its warm.

.....

About the author
Robert K. Daigle, P.E.

Mr. Daigle is a structural engineer and president of Daigle Engineers Inc., a consulting firm with 8 employees. Daigle Engineers was founded by Mr. Daigle in 1979 and has provided structural engineering services to facilities throughout the northeast. A 1971 graduate of Lowell Technological Institute, Mr. Daigle is a past president of the Massachusetts Society of Professional Engineers and has given numerous talks to many groups of Building Inspectors and Officials in New England. Mr. Daigle is also an active member of the Boston Association of Structural Engineers. Along with serving on many other boards, he recently completed a two years position on the Designer Selection Board for MassPort/ Logan Airport.

He can be reached at 978-682-1748 ext. 115 or email at rdaigle@daiglepe.com