

# RiskTopics

## When to initiate a roof snow removal plan January 2018

Removing snow from a roof is a challenging task. It is important to develop a practice to manually or automatically monitor a roof so action can be implemented quickly and effectively when needed.

### Introduction

Consider developing a roof snow removal plan for any building located in a region where snow may occur.

Having a plan prepared and ready allows for the timely assessment of snow loads and the confidence to know when the costly action of snow removal is actually necessary.

### Discussion

Removing snow from a roof is an expensive activity. Workers, fall protection, and cranes are examples of some of the costs that may be associated with roof snow removal. There may also be added costs of eventual roof repairs due to the work activities taking place on cold roof surfaces.

A roof snow removal plan should compare the design snow load of a roof to the actual snow load on a roof.

The design load or total roof strength for a roof is a combination of the:

- Dead load (weight of the building materials and fixed equipment)
- Live load (loads due to workers, tools, and equipment on the roof)
- Wind load
- Snow load

These loads will be documented in the design documents for a building, or can be developed by a qualified structural engineer.

There are several methods to determining the actual snow load on a roof.

A frequently mentioned approach to determining the actual roof snow load is to collect and weigh all snow from a one square-foot area of the roof. This approach often involves a person going onto the roof to remove a heavy snow sample. The obvious concern is the unknown exposure to the person going onto the snow loaded roof to collect the sample.

Another approach to collecting a roof snow sample is offered by the National Weather Service. This alternative involves collecting a smaller sample of the roof snow from an accessible point. This may be near a roof access door, hatch, window, fixed ladder, or other safe means of approaching the roof area. See Appendix A for further information on this approach.

If faced with periodically making a decision to remove snow from a roof, it may be cost effective to install a roof deflection monitoring system that can alert you only when snow removal action is needed. Roof deflection monitoring is discussed further below.

See Appendix B for additional roof snow load insights.

## Guidance

### Roof snow removal “safe work plan”

Implement a roof snow removal “safe work plan” that includes the following elements:

- Measurement methods to determine actual roof snow loads
- Identification of the design snow loads for each roof
- Incorporation of OSHA fall protection guidelines
- Supply of tools and equipment
- Triggers to implement the plan

### Measuring actual snow loads

Select a method to measure actual roof snow loads. As discussed above, the measurement methods include:

- Weighing a one square foot snow sample from the roof
- Using the National Weather Service method discussed on Appendix A
- A roof deflection monitoring system

### Roof deflection monitoring systems

Remember, when you make a decision to clear snow from a roof, it will likely be a costly endeavor. Consider installing a roof deflection monitoring system that can provide an alert when action is needed. Examples of companies\* that can provide roof deflection monitoring systems include:

- Safe Roof Systems <http://saferoofsystems.com/>
- Sensing Systems Corporation <http://www.sensing-systems.com/>

## Design roof snow loads

Take action before a snow event to determine the design roof snow loads.

As discussed earlier, the design loads for a roof will be documented in the building design documents. If the documents are not available, the loads can be developed by a qualified structural engineer.

Snow load knowledge has been evolving in recent years. If the roof design loads are not based upon the current edition of ASCE 7 "Minimum Design Loads for Buildings and Other Structures", consider having a structural engineer re-evaluate the snow load capacities based upon the current edition.

### Design roof loads and change management

Implement a change management program to avoid uncontrolled changes that may affect roof loads.

Change may have an impact on the roof snow load in two ways:

- The snow load capacity of the roof may be reduced

Adding weight to a roof will reduce its snow load capacity. An example of adding weight is re-roofing without the removal of old roofing.

Another example of adding weight is the installation of new equipment on a roof or suspending new equipment from the underside of a roof.

- The snow loads experienced by the roof may be increased

An example of a change that may increase the snow load experienced by a roof is increasing the amount of insulation in a roof. Whenever a roof system is updated, adding insulation may be required to comply with current local energy codes. Increasing roof insulation reduces roof snow melt and increases the retained snow accumulations.

Another example of a change that may increase the snow load experienced by a roof is the addition of an attached or nearby building with a higher roof. The taller building may cause increased snow accumulations on the lower roof of the existing building.

The change management plan for roofs should include a review by a qualified structural engineer based upon the current edition of ASCE 7. The structural engineer can guide any needed structural upgrades, and help establish triggers for roof snow removal plans.

## OSHA fall protection

As roof snow removal involves working at heights, incorporate OSHA fall protection guidelines into the roof snow removal "safe work plan".

Take time to consider personnel fall protection needs. This may include the installation of permanent, engineered anchor points for use with fall protection connectors and harnesses.

## Tools and equipment

As part of planning, consider the tools and equipment needed for the safe and effective removal of snow. Select tools and equipment that promote the handling of snow one time. Once snow is picked up, provide sleds, tubs, or hoppers to receive and transport the snow off the roof.

Consider providing tools and equipment such as:

- Fall protection anchor points
- Fall protection connectors
- Fall protection harnesses
- Equipment to mark drop zones where snow is dropped off the roof
- Plastic snow shovels (plastic to help reduce potential damage to roof coverings)



*Plastic snow shovels (Photo source: Zurich)*

- Plastic sled and tubs to transport snow off the roof



*Plastic tubs for snow transport (Photo source: Zurich)*

- Cranes with hopper (needed when it is not possible to dispose of snow off a roof edge)



*Crane and hopper removing snow (Photo source: Zurich)*

### **Plan triggers**

Selecting triggers is one of the more challenging aspects of the roof snow removal “safe work plan”. After all, activating the plan will likely be costly, and there is no desire to activate a costly plan if it is not needed. When selecting triggers, consider factor such as:

- **Business impact.** Is the roof above high value equipment, high value stock, or a vital production operation? If so, consider a more conservative approach.
- **Snow drifting exposure.** Is the roof subject to drifting snow (roof height changes, parapets, or roof top equipment)?
- **Building age.** Was the building designed based upon the current edition of ASCE 7? As discussed earlier, if the building was designed to an earlier version, consider having a structural engineer re-evaluate the roof snow load capacities of the building based upon the current edition. Establish plan triggers based upon this re-evaluation.
- **Weather forecasts.** Is another rain or snow event anticipated before the current snow accumulation is gone? Sequences of storms, especially rain following snow, have led to roof collapses. Snow absorbs rain like a sponge, preventing water runoff and significantly adding to the actual roof snow load.

### **Excessive snow loads**

It is possible for a single snow event to overwhelm the design loads for a building. In these cases, a variety of audible and visual signs may be present that indicate a safe roof snow load has been exceeded. If any indicators are present, assume the roof is unsafe and subject to failure. Immediately evacuate the building. These visual and audible indicators include:

- Building steel that is visually deformed
- Wood structural members that are cracked or split
- Sprinklers pushed down below ceiling tiles

- Doors that pop open or no longer operate correctly
- Utility pipes or conduits that are bowed out of normal position
- Structural noises including creaking, cracking, or popping sounds

Secure the services of a structural engineer to evaluate the integrity of the building before allowing personnel on or under the roof.

## Roof snow removal

The activity of removing snow from a roof is an arduous task. To handle the task safely requires reasonable work conditions and careful attention to safety. It is important to understand that snow removal is not considered safe and is not recommended during a snow storm. Once a snowstorm is over and the roof snow removal plan has been initiated, begin the snow removal process.

### Remember – Handle snow one time

Once a shovel of snow has been lifted, place it in a sled, tub, or hopper for transport off the roof. Dropping snow back onto the roof leads to snow melting, snow compaction, more work, and potentially more roof damage as the snow is shoveled again.

Typically, it is not necessary to remove all snow from a roof. Note:

- The objective, at least initially, is to clear snow from the most critical areas such as drains, roof edges, drift areas, and centers of bays.
- Clear snow close to but not down to the roof surface. Some guidelines recommend leaving at least 50 mm (2 in.) of snow to avoid causing damage to roof covers.

Consider the following actions in the sequence listed:

#### 1. Increase building heat

Increasing building heat may promote roof snow melt. Most roof assemblies will allow some heat transfer from inside the building to the underside of the rooftop snow accumulation.

Some areas of a building may have suspended ceilings beneath the roof deck that effectively reduce the amount of heat reaching the underside of the roof deck. The temporary removal of a few scattered ceiling tiles during severe rooftop snow accumulations can help warm the underside of the roof deck and promote snow melt.

#### 2. Drains

This includes roof drain inlets and outlets. Clear drains help remove water from melting snow. Clogged drains can lead to ice accumulation, and ice accumulation can contribute to roof failures during later snow or rain events.

Periodically recheck drains to verify they remain clear. Ice melt may be used to maintain drains.

As a note, while temperatures may be below freezing, roof snow removal activities introduce sources of energy (such as foot traffic and shoveling) that promote snow melt.

External gutters and downspouts can quickly become obstructed by snow that melts and then re-freezes before the water can flow out of the downspouts. Early in a snow event, begin downspout outlets clear of ground snow accumulations. This includes any snow pushed near downspout outlets as parking lots and sidewalks are cleared of snow.

### 3. Around drains and along perimeters

Remove snow from the first 3 m (10 ft.) around drains and along roof perimeters.

Install flags, markers, or delineators sized to extend above the level of the snow to mark the location of roof drains.

### 4. Snow drifts

Remove drifting snow. Deeper snow drifts take longer to melt and drain from a roof. Their presence over a longer period of time increase the likelihood that another snow or rain event may add to the snow load in the drift exposed areas.

### 5. Centers of bays

Remove snow from the areas between building column lines. Specifically, clear at least one third of the snow from the center each bay.

Keep in mind the strongest sections of the roof are above the column lines. The areas above column lines should be the last areas cleared if such action is considered necessary.



*Snow removed from center of bay (Photo source: Zurich)*

Also, keep in mind that snow forms a relatively even load across a roof. As snow is removed, it should be removed in a balanced manner. For example, as snow is removed from the center of a bay one side of a peaked roof, the next action should be to remove the snow from the corresponding center of bay on the other side of the peak.

When clearing snow from a peaked roof, clear the snow from the eave towards the peak. This promotes the flow of water to drains.

As snow is removed, beware of obstacles that may be hidden beneath the snow.



*Lightning protection cable (Photo source: Zurich)*

Roofs may have equipment, piping, wiring and lightning protection equipment located close to the roof. These features may be hidden beneath the snow. Some roofs may also have skylights or other features that introduce fall hazards. In advance of the snow season:

- Prepare maps showing the locations of these features so worker may be aware of their presence
- Install flags, markers, or delineators sized to extend above the level of the snow to mark the location of these features

### **Avoid using tarps**

Avoid using tarps to collect, lift, and remove snow by crane. While the load of snow on the tarp may be no problem for the crane, it could overload the roof supporting the snow laden tarp.

### **Using qualified contractors**

Unless there are personnel on staff with experience to safely remove snow from a roof, secure the services of a qualified contractor to implement the roof snow removal "safe work plan".

Review detailed safety rules and regulations with all contractors and secure contractor signatures indicating they have received this training.

Have contractors provide Certificates of Insurance verifying adequate levels of insurance for both Workers' Compensation and General Liability. Verify coverage is provided for property damage or bodily injuries caused by contractor's employees or their operations.

## **Conclusion**

For further guidance or to discuss questions, contact your Zurich account team.

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## Appendix A - An approach to estimating roof snow loads

This approach involves collecting a core sample of roof snow from an accessible point. This may be near a roof access door, hatch, window, fixed ladder, or other safe means of approaching the roof area.

The core sample can be collected using a pipe of any diameter. An interesting element of the approach is that the pipe diameter does not impact the calculations. To keep the weight of the sample as light as possible, select the smallest diameter pipe available that will effectively collect the core sample.

To collect the snow core sample, use a capped section of clear plastic pipe having a length that exceeds the snow depth. Stick the pipe vertically down into the snow, and collect a full depth sample. When taking the sample, note the depth of the snow at the sample location. This can be accomplished by marking the sampling pipe.

Take the collected sample into a heated area and allow the snow to melt inside the pipe. Keep in mind that snow melts slowly even when indoors. Melting can be hastened with a hair dryer.

Once the snow has melted, measure the height of water in the pipe. Using the following formulas, calculate the "estimated roof snow load" and the "estimated snow density" at the sample location.

$$(1) P = 5.2H, \text{ where}$$

P = Estimated roof snow load in pounds per square foot

H = Height of water in the pipe in inches

$$(2) D = 12 P/S, \text{ where}$$

D = Estimated roof snow density in pounds per cubic foot

P = Estimated Roof snow load in pounds per square foot

S = Measures snow depth at the roof sample point

To estimate the roof snow load at another location on the roof, there is a need to identify the depth of snow at that location. This can be accomplished by using the heights of known rooftop features such as equipment parapets, and penthouses. Pre-marking walls and equipment with elevations or measuring sticks can also facilitate identifying snow depths. The overall objective is to visually identify the snow depths from a distance without traversing the roof.

Once a snow depth is identified at another location, the roof snow load at that location can be estimated using the following formula:

$$(3) P = D S/12, \text{ where:}$$

P = Estimated roof snow load in pounds per square foot

D = Estimated roof snow density in pounds per cubic foot

S = Estimated snow depth at the desired point on the roof

As a caution, any ice present under the measured snow layer may go unaccounted if care is not taken to include the ice layer if present. Each inch of ice represents an added roof load of 4.8 psf.

## Appendix B – Additional roof snow load insights

### Model building codes

The model building codes guide structural engineers to design the structure of a roof to support a roof snow load in proportion to regional or local ground snow load accumulations. The codes typically allow the roof snow load to be reduced due to; exposure factors, roof slope with slick surfaces, thermal heat loss through the building roof, and at times, the shape of the roof.

There are other conditions noted in the model building codes that should prompt the structural designers to increase the roof snow load strength, such as: unbalanced snow loads or snow drifting due to roof elevation changes, snow drifting due to changes in roof elevation or projections above the roofline, sliding snow falling onto a lower roof, rainfall surcharge on top of existing rooftop snow, and nearby buildings and terrain features that can create localized drifting on buildings.

For low-slope roof decks, the majority of snow collapse losses occur where the snow is deeper due to snow drifting due to wind. As you consider the risks and hazards of a potential collapse of a roof due to snow loading, the roof areas where snow drifting could occur should receive attention.

Other snow loading roof collapse events can sometimes be related to snow loading combinations or conditions that did not correspond to model building code parameters or the assumptions of the structural designer. Here are a few of the issues that can occur to exceed the original design snow load for a structure:

### Snow Density

The actual density of snow accumulations on a roof can vary greatly depending upon geographic region and weather conditions. A common conceptual comparison of snow to rain water weight is 10 inches unpacked snow is equivalent in weight to 1 in. depth of water on a roof (5.2 pounds per square foot – psf).

The correlation of a building's snow load strength (psf) solely in comparison to a given depth of snow may not represent the correct magnitude of the true weight on the roof structure.

For example, a densely packed "ice layer" 6 in. deep or a 2.5 ft. deep layer of powdery snow could create an identical 30 psf load on flat roof.

### Multiple severe snowfall events

Multiple severe snow fall events within a short period of time can sometimes cause snow load accumulations and snow load weight on the roof structure to exceed the original design building code assumptions. These severe snowfall events and ice storms can allow significant snow and rooftop weight accumulations before and significant snow melting can occur.

### Rain Surcharge

Depending upon the regional ground snow loads in combination with the roof slope, the snow load design for the roof structure can be increased or reduced by as much as 5 psf (0.24kN/m-m).

Rainfall on an existing layer of accumulated snow or drifted snow can increase the density and total weight of the snow load.

### **Obstructed or frozen roof drains**

Roof drains, gutters and downspouts help reduce the weight on a roof structure by removing water created by melting snow. When the roof drains becomes obstructed by ice, or when the gutters and downspouts become blocked by frozen water, the ability of a roof to shed the weight of melted rainwater is reduced. This water may re-freeze forming a very dense or heavy layer of ice beneath a layer of “fluffy” snow.

The natural sagging or deflection of the structures beams and joists can also create areas where water can accumulate without flowing toward a roof drain.

Internal equipment, piping and other collateral loads, or roof mounted equipment added to the roof structure after the original construction can create loads that reduce the available roof strength needed to support a severe roof snow load.

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