A WINTER PERSPECTIVE ON DESIGN

Presented by:

Note: Photographs within this presentation are intended as examples only and are not a reflection of building performance.

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The Credibility Statement

Career Experience

Over 18 years of Microclimate Consulting

- Design Reviews and Analysis
- Cold Room Testing and Validation
- Mt. Washington High Elevation Icing Research
- Incident Investigations
- Wind Tunnel & Water Flume Analyses
- Highway Snow Drift Field Review and Analyses

Membership Organizations

- ASTM International – Subcommittee E06.55 on Performance of Building Enclosures
- Council on Tall Buildings and Urban Habitat (CTBUH)
- The American Institute of Architects (AIA) – National Allied Member
- The Ontario Association of Certified Engineering Technicians & Technologists (OACETT)
Recent Publications


- **Snow Engineering VII, Fukui, Japan (2012)**, Caution: Falling Ice and Snow – What is an acceptable risk?


What is “A Winter Perspective on Design?”

Falling Ice & Snow Prediction
- Slippery Roof Surfaces (Large & Small)
- Wind Blown from Roof Edges, Canopies, etc.
- Falling from Facades, Sills, Shades, etc.

Obstructed Views
- Skylights & Clearstories

Mitigation Development

High Elevation Icing

Melt Water Control (Icicles)

Curtain Wall Cladding Options

Slip & Fall Hazards

Challenging Geometries

Protocols & Procedures

Assist Structural Design

Criteria Development & Due Diligence Documentation

Damage & leakage

Snow Infiltration

Severe Weather Exposure

Noise & Vibration (Snow Movement)

Snow Infiltration

Mitigation Development

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Buildings and Structure Types

- Bridges
- Works of Art
- Historical
- Educational
- Museums
- Super Tall
- Large Roof
- Health Care
- Airports
- Corporate Headquarters
- Monuments
- Office Buildings
- Communications
- Stadiums

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Cities Big and Small
Mitigation Methods

- Design Modifications
- Integrated Mitigation Strategies
- Add-on Devices
- Melt Water Control

Size
Surface Texture
Shape
Material
Thermal Properties
Coating

Colour
Mitigation Methods

- Design Modifications
- Integrated Mitigation Strategies
- Add-on Devices
- Melt Water Control

Integrated...

VS.

After Thought?
Mitigation Methods

- Design Modifications
- Integrated Mitigation Strategies
- Add-on Devices
- Melt Water Control

- Barriers
- Buttons / Pins
- Guards
- Surface Roughness
- Protrusions
- Diverters
- Tabs
- Fences
Mitigation Methods

- Design Modifications
- Integrated Mitigation Strategies
- Add-on Devices
- Melt Water Control
Industry Status

Building Codes

- Codes **acknowledge** the issue and prescribe action.

**Examples:**

- Massachusetts Amendment to IBC2009 -1608.9 Snow Guards
  - The designer must “Account for the impact of the sliding snow”
  - “Snow guard systems shall be demonstrated by tests”
  - "where water, snow or ice can accumulate on a building, provision shall be made to minimize the likelihood of hazardous conditions arising from such accumulation."
- ASCE7-05 Commentary on Snow Loads
- ISO 4355 Bases for Design of Structures (future)
Industry Status

Building Codes:

- However they currently do **not:**
  - offer criteria, standards or procedures to follow;
  - provide example cases for snow movement;
  - address issues beyond the roof; or,
  - stipulate aspects of proper snow guard design.

Establish project specific criteria based on building or structure type and site.
Common Approach:

- Trial & Error.
- Responsibility of Structural Engineer or Architect...?
- Incidents are Not discussed publically.
- Precedent is set in past court cases – joint responsibility of building management and designer (many incidents occur in the first or second winter of operation).
Points for Consideration:

- Reduce, not prevent.
- Once an incident has occurred, an extremely stringent solution is required.
- Client education of anticipated performance is far less onerous!
- Retro-fit costs are significantly higher than design modifications.
Lessons Learned...

The following slides contain “real events”. However, building names have been omitted and graphics have been modified to maintain anonymity.
Sloped Walls can be Problematic....

A sloped surface will collect significantly more snow than a vertical wall. This needs to be anticipated during design and managed/mitigated.

On sloped surfaces snow, ice and icicle collection and release needs consideration during design. Often mitigation is minor and consists of slight modification to design. This condition is influenced by wall thermal performance and the interaction between design and winter weather events.

Example: Snow collecting on sloped glazing

Example: Accumulated snow transforms into ice and icicles.
Snow is Not Static or Homogeneous...

A combination of wind drifted and sliding snow/ice, as well as, melt water migration scenarios needs consideration for both static and impact forces on sloped roof surfaces to avoid potentially hazardous situations.

Issues with snow movement often reveal themselves in the first or second year of operation. Any sloped roof surface is susceptible and needs consideration from the entire team during design.

This issue can be challenging to predict and solve as it is highly site and design specific. A design solution requires input from multiple disciplines and the development of criteria.

An experienced based assessment can provide direct guidance to ensure the least amount of effort is required from the design team to arrive at an appropriate and cost effective solution to reduce risk of potential issues.
Double Facades, Solar & Rain Screens can Collect Ice & Snow...

Cold exterior surfaces increase the surface area exposed to winter precipitation and can create melt and refreeze issues.

Project Example:
- Accumulated snow melts and refreezes, accumulating into larger ice masses further down the facade that can fall, slide, or wind release from facade. Icicle formation is a significant concern.
- Dripping melt water creates a significant management issue promoting slippery walking surfaces for extended periods.

Examples of:
Double facades, solar and rain screens.
Insulated/high performance glass and improved HVAC technologies and/or thermal performance promote a colder exterior, thus a greater chance that ice or snow formation will occur.

Reports of ice formations in central windows during winter storm events.

Project Example:
Ice forms due to variability in internal heating exposure.

Published 2011 in The New York Times Paper
A large sheets of ice, at least a foot across, fell from facade glazing.
Wall & Window Sills Performance is Changing...

A cold slippery sill below glazing can refreeze melt water turning accumulated snow into a ice projectile.

Project Example:
Ice formed and shed from larger ledge. Smaller ledges release slushy snow that is less hazardous.

Design solutions exist for larger sills, ledges, and curtain wall details; however, mitigation via design modifications or custom designed add-on devices require site and design evaluation and experienced based assessment.

Photograph Published 2011
charlotteobserver.com

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Solar Shade Devices can Produce Ice...

1. Exposure and neighbouring building geometries need consideration when choosing a barrier shape and style.
2. Ice, snow, and icicle formations can be compounded by the repetition of shades up a facade.

Project Example:
Snow from roof drifted onto shades which then overloaded the structure, producing a cascading failure of multiple shades down the facade.
Low Parapets & Stepped Roofs can Promote Overhanging Ice & Snow...

Wind drifted snow builds past roof or canopy edge, forming hardened snow and ice that eventually falls.
Commercially Available Products:
1. Product testing is not standardized.
2. Performance varies greatly between products.
3. Knowledge of requirements for proper layout, attachment and installation varies greatly between suppliers.
4. There are no code requirements or commentaries that instruct structural engineers regarding proper barrier design.
5. There is often limited interaction between snow retention and the structural design for the building.

Project Experience:
1. Often a designer is looking for a custom or integrated design solution.
2. A commercial product is one part of a retention strategy. A knowledgeable consultant can work with the design team to ensure that structural, roofing/cladding, drainage, and electrical (if required), aspects align with the snow retention strategy to reduce risks during all types winter weather.
Complex Facades, Materials, & Building Crowns Collect Ice & Snow...

Uniqueness of Design = Uniqueness of Performance
Complexity of shape, variable thermal profile, increase in surface area, etc.
Building heat loss or solar gain during cold temperatures can allow for the melt and refreeze of snow into ice, ice dams, and icicles.

**Project Experience:**
Complete management of the melt water drainage path is critical.
Building Renovations can Lead to a Change in Performance...

Any change to the thermal profile of a wall, roof, or window will change exterior performance possibly leading to hazardous consequences.

Wind Driven Snow

Project Experience:
20 year old building that had not experienced a significant falling ice event previously, sheds large ice pieces that damaged a glass below.
The Importance of Heat Trace Layouts

If heat trace is required, it is important to have a layout designed by a professional, otherwise the heat trace could create a greater issue than the original issue.
A Winter Operational Protocol can Reduce Risk...

Recommending that a Winter Operational Protocol be developed and implemented can significantly reduce the potential of a future call-back.

Career Experience:
1. Very few Owners/Managers have a clear understanding how a new building will perform, and even fewer have a protocol in place to prevent injury or damage.
2. If ice and snow formations are anticipated and managed through building operations the tolerance for the need for mitigation is significantly less than the tolerance after an un-managed falling ice and snow incident.

It also reduces the reliance on signs!
Take Away Points...

1. Develop a Project Specific Criteria:
   - High risk
     - Buyer Beware
     - Recommend winter operational procedures to client
     - Design/Mitigate to avoid significant damage to structure or local property
     - Adopt a program of addressing performance issues through design and recommended operational procedures
   - Low Risk

2. Design Details that Create Issues:
   - Roof that is either: large, sloped, curved, complex, close to neighbouring buildings, etc.
   - Walls that: are sloped, have projections, double facades, non-typical materials or thermal profiles.
   - Exposed features: roof top crowns/features, sun shades, low parapets, roof edges, mullions or ledges larger than 3” or 4” in projection, etc.
   - Re-freezing potential on skin surfaces (warm to cold).
   - Melt water management on roofs, walls (icicle formation), and at grade is critical.
   - Any modification/renovation to a facade or roof changes the thermal profile and impacts performance.

3. Mitigation:
   - Snow retention products are not regulated and are typically designed for the residential or low-rise commercial risk tolerances. Public buildings and urban core buildings tend to have more stringent performance requirements.
   - Heat trace requires a layout plan to ensure desired performance.
   - Any time snow or ice is held on a surface, input from the structural designer is needed.
   - Custom/Integrated snow retention is cost effective.
   - Best defence is a good offence...talk to the owner/client about the effort and thought you have put into winter performance and the need for them to develop and implement winter operational procedures to learn about their new building’s performance.
Thank You

A Winter Perspective on Design

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