BUILDING SCIENCE perspective

FALL 2024

AUPE HEADQUARTERS FEATURES 3D DESIGN CENTERED ON HEALTH & WELLNESS

The adoption of the unvented wood roof in Alberta

Part 2 of restoring the grand old façade on the Alberta Legislature building to its original glory!

PUBLICATIONS MAIL AGREEMENT #40934510

ABECN

AN ALBERTA BUILDING ENVELOPE COUNCIL NORTH & SOUTH CHAPTERS PUBLICATION

Revolutionize your renovation or new construction project and save millions with Centra.

Due to recent successes, Centra has positioned itself as Alberta's leading authority on windows, doors, and exterior remediation. Leveraging amendments to the Building Code, the company was able to save the owners of a 22-storey Edmonton tower up to $3.3 million on renovations.

Value engineering doesn't have to mean a loss in quality or performance. Beyond unprecedented cost savings, Centra's solutions actually enhanced thermal efficiency and resident's overall comfort, redefining what is possible in our industry.

Speak to Centra's Experts to learn more about this project – and discover how they can help with yours.

Centra®

CANADA BEST MANAGED COMPANIES

403-279-2797
4705 102 Ave SE, Calgary, AB, T2C 2X7
centra.ca
info@centra.ca


We carry polyiso insulation panels for every habitat.
Just don't let bears install them. Learn more about our building envelope products at convoy-supply.com.
Convoy Supply
Construction Materials
EDMONTON, RED DEER, CALGARY, LETHBRIDGE

Alberta Construction Safety Association

Your ACSA

Training, Certification and Designation

We equip the Alberta construction industry with quality health and safety training, Certificate of Recognition (COR) programs and designations.

Training

Dive into dynamic sessions with industry experts online or in person. Or access our on-demand courses to learn at your own pace, anytime, anywhere.

Certificate of Recognition

No matter your company size, our Certificate of Recognition (COR) and Small Employer COR (SECOR) can help you build an effective health and safety management system.

Designation

Explore your career opportunities with our National Health and Safety Administrator (NHSA) and National Construction Safety Officer (NCSO) designations.

We are a uniquely member-centric, industry-funded not-for-profit organization and the largest certifying partner in Alberta,driving safety and business excellence in a high-risk industry—**where passion for safety meets expertise.**

Connect with us

1-800-661-ACSA | info@youracsa.ca | youracsa.ca

We believe in quality products, genuine service, and reliable work ethic.

With over 20 years of experience, we know how to elevate your building and make it stand out. From commercial to residential and everything else in between, we strive to create a lasting impression that will stand the test of time. We've built our reputation as being one of the best—and we intend on keeping it that way.

WESTERN CANADA'S PREMIER FABRICATOR & SUPPLIER OF CUSTOM ARCHITECTURAL PANELS

MODERN CLADDING FINISHES LTD.
ACM Fabrication Specialists

780.463.1886
estimating@moderncladding.ca
9552 26 Avenue NW, Edmonton, AB T6N 1H8
www.moderncladding.ca

The future is **FIBERGLASS**

Fort St. John Passive House
Low Hammond Rowe Architect
RENU Engineering Inc.
WCPG Construction Ltd.

- ✓ U-Values as low as 0.85 W/m²·K
- ✓ Tough frames with high wind-loading capacity
- ✓ Trusted by building envelope engineers across the prairies
- ✓ Find technical data at duxtonwindows.com/resources

DUXTON
Windows & Doors

DUXTON Windows and Doors Edmonton, AB 780.435.0649 duxtonwindows.com

TAYLOR

GENERAL CONTRACTOR SPECIALIZING IN BUILDING ENVELOPE RESTORATION

CALGARY - EDMONTON - LETHBRIDGE - CANMORE

Offering self-performed specialty services, with the focus on quality control, sequencing, and scheduling. This provides a streamlined approach and helps reduce project timelines.

Self-performed services

Hot Applied Rubberized Asphalt

The Taylor team is a Gold Seal certified applicator of Henry-Bakor 790-11 systems. This enables us to offer a Material and Workmanship warranty of up to 20 years.

Vinyl Deck Membrane

Taylor is a distributor and factory certified installer of TufDek products. We only use internally reinforced systems with PVC coated flashings to ensure the most durable watertight system available.

Concrete Repairs

Our in-house concrete repair team is ready to fix your concrete issues. From surface preparation and delamination repairs to crack injection. We are a one-stop shop for all your concrete repair needs.

Polyurethane and PMMA Coatings

Our highly skilled membrane team is ready to meet your pedestrian and vehicular coating needs. The Taylor team is certified to work with most major manufacturers including BASF, Tremco, Sika, Flexstone and more.

Landscaping

Our in-house landscaping team is ready to transform your outdoor space, build retaining walls and help to streamline the re-build process.

Carpentry

Our extensive team of carpenters will get the re-build right! Wood rot repairs, structural repairs, framing, finishing and more.

GET IN TOUCH

403.244.5225
587.572.9287

office@taylorconstruction.ca
taylorconstruction.ca

#2 - 314 Exploration Ave SE
Calgary, AB
T3S 0C1

9411 27th Ave NW
Edmonton, AB
T6N 1C9

IN THIS ISSUE

Communications Inc. www.delcommunications.com

PRESIDENT / PUBLISHER
David Langstaff

MANAGING EDITOR
Shayna Wiwierski shayna@delcommunications.com

SALES MANAGER
Dayna Oulion

SALES REPRESENTATIVES
Brent Astrope | Colin James
Ross James | Mic Paterson

PRODUCTION SERVICES
S.G. Bennett Marketing Services

CREATIVE DIRECTOR / DESIGN
Kathleen Cable

PUBLICATION COMMITTEE
Bob Passmore | Ed Bushnell | Fred Edwards
Kevin McCunn | Jamie Murphy | Casie Chou

CONTRIBUTING WRITERS
Brian Breukelman | Suzanne Checkryn
Marty Deemter | Aynsley Dueck
Fred Edwards | Stephen Epp
Ka Fund Yung | Stephen Hunter
Mickel Maalouf | Rob Pacholok

Publications Mail Agreement #40934510

Return undeliverable Canadian addresses to:
DEL Communications Inc.
Suite 300, 6 Roslyn Road, Winnipeg, Manitoba R3L 0G5
Email: david@delcommunications.com

PRINTED IN CANADA | 11/2024

Hardie® Artisan Siding

Enjoy trusted protection and long-lasting beauty with Hardie® siding that's Engineered for Climate®.

Hardie® fiber cement products are specifically engineered to resist moisture, cracking, shrinking and swelling, giving your home a look you'll love with added peace of mind.

Fire Resistant | Water Resistant | Pest Resistant | Low Maintenance

Shiplap Siding

V-Groove Siding

Square Channel Siding

Choosing Hardie® fiber cement siding gives you the added peace of mind of a noncombustible home exterior.

Scan to watch a Fire Demo video

jameshardie.com/hardie-architectural-collection

Edward Bushnell
President, ABEC (South)

Message from the ABEC South president

As we move into the fall season, I am both honoured and excited to lead ABEC South into another year of growth and collaboration. I would like to take a moment to recognize our dedicated board members, volunteers, and partners whose commitment allows us to offer valuable educational opportunities, host engaging events, and publish this informative magazine. A special thank you to our speakers and event hosts for their incredible contributions so far this year.

At ABEC South, we continue to see rapid advancements in the building envelope industry, with new technologies and products reshaping how we work. While the fundamentals of construction remain, the details are becoming more intricate, and our ability to stay informed and adapt will ensure we keep moving forward. It's critical that we not only embrace these advancements but also strive for higher efficiency and understanding through education. Our partnerships with industry leaders and educational institutes are key to ensuring that we are at the forefront of these changes, helping us provide the tools and training needed to thrive in a rapidly evolving field.

Sustainability remains a guiding principle in everything we do. As we continue to focus on energy-efficient and environmentally conscious building practices, we are building a foundation for future generations to succeed. I am proud that ABEC South plays a role in promoting these ideals, and that we work together as a community to create positive and lasting change within our industry.

Looking ahead, we are excited to bring more opportunities for learning and networking to our members. We will continue hosting our monthly luncheons providing connections with industry peers, knowledge sharing, and exploring the latest trends and innovations in building envelope science. Stay tuned for more details on future events and initiatives.

Thank you for your continued support and participation. Let’s embrace the opportunities ahead, and I look forward to another year of success and collaboration.

Edward Bushnell

Christa van Dyk, C.E.T.
President, ABEC (North)

Message from the ABEC North president

As 2024 winds down and we prepare to welcome 2025, I'm inspired by the advancements ABECN has made over the past several months. Our growing membership base, solidified financial standing, and expanded offerings are all achievements that our board and members should celebrate with pride. Personally, these accomplishments fill me with pride, too.

I feel fortunate to lead ABECN during this dynamic period filled with unfolding initiatives, made possible due to the unwavering efforts of our board and committee members, authors, speakers, sponsors, and the community of members. Our collective success underscores the fervent dedication that is at the heart of our community. Moreover, I extend my gratitude to previous board members and volunteers whose contributions have helped evolve ABECN to its current stature. This association has been crafted by passionate individuals devoted to sharing their expert knowledge in building science, thereby creating a legacy for the next generation of industry professionals.

Our community has thrived through engaging and educational events, such as our luncheons and casual night series. These gatherings have been more than just meetings; they have been opportunities to share thought-provoking ideas, engage in meaningful debates, and strengthen our connections. Whether rolling yard Yahtzee dice at our summer barbecue or listening to insightful guest speakers, we have grown both individually and collectively as a society.

Looking towards 2025, we aim to build on this momentum. Our focus will be on further increasing memberships and enhancing our financial stability to diversify our offerings. We plan to continue hosting events that foster learning and camaraderie, ensuring that ABECN remains at the forefront of the building envelope community.

I encourage each of you to deepen your involvement with ABECN. Consider inviting a colleague to join our growing membership, attend our presentations to stay informed and inspired, and renew your commitment to our shared goals. Together, we can continue to make significant contributions to our industry.

On behalf of the board, we bid farewell and a big thank you to Bereket Alazar for his enthusiasm, commitment, and dedication to ABECN. Alazar resigned his seat on the board as of September 2024.

In closing, I extend my heartfelt thanks to each member of our community for their dedication and support. Your involvement is what drives our success and keeps ABECN thriving. Here's to a promising 2025, filled with growth, learning, and the continued strength of our community.

Christa van Dyk

North Board of Directors

CHRISTA VAN DYK, C.E.T. – PRESIDENT

MARLA SNODDON – PROGRAMMING

JOE MIS – DIRECTOR

KEVIN MCCUNN – TECHNICAL REVIEW

GARRATT GRENIER – WEBSITE

NICOLE MALIK – TREASURER

RYAN ASSELSTINE – EDUCATION

LINDSAY VERHELST – COMMUNICATIONS OFFICER

JAMIE MURPHY PL (ENG) – PUBLICATION

South Board of Directors

ED BUSHNELL – PRESIDENT

FRED EDWARDS - PAST PRESIDENT

ANTON VLOOSWYK – TREASURER

MIKE DIETRICH – SECRETARY

MARTY DEEMTER – EDUCATION COMMITTEE

MAIREAD WALSH – COMMUNICATIONS & MEMBERSHIP

GREG MARTINEAU – PROGRAM DIRECTOR

STEPHEN HUNTER - EDUCATION COMMITTEE

KRIS WALL – DIRECTOR

MICHAEL WEST – SOCIAL EVENT COORDINATOR

CALENDAR OF EVENTS

ABEC South Schedule of Events

Monthly Luncheons

January 22
February 26
March 26
April 23
May 28
June 25
September 24
October 22
November 26

Seminar Series

January 29th – ADEX, presented by EIFS technical session
February – IR Scanning Introductions & Principles
March- TBA
April – TBA

Golf Tournament – July 2025

Social Events

February 20, 2025
Bowling at National

Opportunities for informed networking & collaboration

BuildEx Calgary 2025

October 22 & 23

Partnership for luncheon and more!

ABEC North Schedule of Events

Monthly Luncheons

January 23
February 27
March 27
April 25
May 29
June 27
September 26
October 24
November 27

Seminar Series

TBD

Golf Tournament – June 2025

Social Events

Casual Nights (Second Tuesday of every month)

Summer Patio – TBA

Summer BBQ – TBA

Watch for more details on the topics and event venues.

INDUSTRY EXPERT Q&A
with Garratt Grenier

Garratt Grenier is a senior field advisor for Tremco Construction Products Group. He manages northern Alberta, British Columbia, and the NWT regions. When Garret is not experimenting with products in his garage, he assists consultants, engineers, and building owners with products and solutions. He is on the board of directors with Alberta Building Envelope Council - North.

How did you come to work in building science?

Garratt Grenier: I've always been interested in science and technology, but I also had an interest in historical cities, buildings, and cultures. I was initially going to study networking engineering. However, the dot-com crash changed that direction. I enrolled in business at NAIT and became employed with Tremco shortly after while working towards a degree. For most of my career, I acted in a technical role and continuously enrolled in building science courses. I received several designations, gained experience, stayed curious, and asked thousands of questions. Much like a puzzle, each piece of knowledge helps display the bigger picture. In this industry, age and the experience that comes with it can lead to wisdom if one stays humble and curious. Unlike in many technology sectors where what you learn is irreverent in five years, building science has a limited knowledge drift.

You are on the board at ABEC North, what do you do for the council?

I oversee technology and the upcoming new website.

How long have you been with Tremco?

This coming January, I will have worked for Tremco for 19 years.

What does your group do?

We are a global construction product group that offers products for all sides of the building enclosure. We focus heavily on restoration in place of replacement whenever possible.

What do you see as the best way a manufacturer can be utilized in a project?

Building science experts must be well-versed in building science processes, principles, and products. With the rapid pace of change in building materials, keeping up to date can be challenging. Manufacturers' representatives should provide product education, awareness on compatibility issues, and be honest about the pros and cons of their products. This will help building science experts solve complex problems and ensure that the right product is selected for the right application.

Are there services that you provide that more projects should utilize when they think of involving the manufacturer?

Tremco will often restore instead of replace. We offer lab and diagnostic services to building science professionals and their clients. One example is that we will complete adhesion testing on a metal roof to determine the suitability of the coating. Another example is sending existing building components to the lab to determine material properties (i.e. tensile strength, composition). This will often provide information on restorability, how close it is to failure, or help identify material compatibility issues.

What is the most innovative building envelope product you have come across?

A: Within Tremco, Alphaguard Bio for roof restorations. It is a 100 per cent solids, solvent-free, low-to-no-odour product made from 70 per cent renewable resources. Most importantly, it performs in harsh conditions, such as those in Edmonton. Overall, this product saves building owners money while helping the environment.

Outside of Tremco, exciting work is being done on vacuum-insulated panels by companies like Samsung and Kingspan, which have R-Values ranging from R28 to R66. One drawback to these panels is that they can be damaged if punctured. However, Kingspan has developed a panel with a polyurea coating to make it puncture-resistant. If costs can come down, these have many wide-ranging applications and can help the industry reach sustainability goals.

What advancement in technology has had the largest positive impact on the building envelope as well as the largest negative impact?

The advancement in lightweight building materials has helped decrease costs, decrease construction timelines, and allow for unique designs that were not possible in the past. One of the negatives is that often lightweight products are less durable and long-lasting. However,

product innovations are pushing the boundaries of being lightweight and durable.

You are a very driven individual, both in career and personal life. You have said a lot of that drive comes from some of the challenges you have had to overcome in your personal life to get here. Do you want to speak to that? What resources would you suggest if someone wanted to learn more or progress that cause?

When I turned six, I was diagnosed with cystic fibrosis and was given a life expectancy of 20. I was told from the doctors that I would not live long enough to get married or have kids. When my lung function started to decline in my teens, a medical breakthrough pushed my life expectancy to 30, so I got married.

Approaching 30, another medical advancement pushed my life expectancy to 40, so we decided to have kids.

As I approached 40, antibiotic resistance led to my lung capacity rapidly declining. With a lung capacity of 50 per cent and declining, the outbreak of COVID-19 made life more complicated. A medical breakthrough was approved in the United States, but not in Canada.

As my health reached a critical low and I was closing in on what appeared to be my final chapter, Trikafta was approved on June 18, 2021, and was approved for funding in Alberta on July 1, 2022. Within four weeks of being on medication, my lung function increased to 80 per cent.

Everything was good until it wasn't. Before going on the medication, my doctors provided a mental health assessment. I was dismissive. I thought, 'I've never had anxiety or mental health issues, why is this relevant?'

One month in, the side effects hit me like a ton of bricks; my central nervous system was in overdrive. I was distracted and had feelings of intense anxiety, dread, and OCD. Insomnia kicked in, sleeping two hours a night. I would go for runs at 2 a.m. Running worked at first, but then it stopped.

I was relentlessly tormented mentally for five months. I pulled back from friends; I was an empty shell of what I

once was to my children and wife. I went into autopilot with work. I considered going on short-term disability, but because I run a team and I am stubborn, I refused to give up.

During this time, I tried many natural remedies and prescriptions, but nothing was helping.

I told my doctor I would try one last medication. If it failed to work, I was going to go off the very drug keeping me alive.

Fortunately, the medication worked. I was back to myself within six weeks.

Even with the struggles of cystic fibrosis, those five months were the most challenging times in my life and forever changed how I view mental health. Mental health issues create silent suffering, can hit at any age, and affect more people than you know. When I share this experience, people open up about their own struggles, people I would never imagine are suffering. It's not "in their heads" or a "bad attitude".

The next time someone is rude or distracted, a coworker's work suffers, or a friend or family member stops calling or pulls away, do not take it personally. Reach out and show love, kindness, and support. ■

If you are reading Garret's story and you are inspired to help,
please look at the resources available or
consider donating at www.cysticfibrosis.ca/ or www.mentalhealthfoundation.ca

Parkview at Terwilliger Plaza in Portland, Oregon
Passive House Multi-Family Project by
LRS Architects and Walsh Construction

View our portfolio of Passive House certified multi-fa

Windows + Doors for Passive House Projects

Innotech Windows + Doors is a Canadian manufacturer of Passive House Institute certified windows and doors. With over twenty years of dedicated experience, Innotech delivers the manufacturing expertise and product performance required for Passive House and other highly sustainable projects.

The Defender 88PH+ System is a natural evolution in a proven history of manufacturing excellence. High-quality components, expertise in manufacturing, and robust testing and quality assurance programs result in highly durable windows and doors with superior thermal performance, air and water resistance, and dimensional stability.

innotech
windows + doors

innotech-windows.com

mily projects: innotech-windows.com/passive-house

RESTORING THE GRAND OLD FAÇADE ON THE ALBERTA LEGISLATURE BUILDING TO ITS ORIGINAL GLORY!

Part two of a two-part series

By Rob Pacholok, P.Eng.

Rob Pacholok, M.Sc., P.Eng., works for Building Science Engineering and has over 40 years of experience in the field of masonry and building engineering. Historic masonry restoration projects that Pacholok has worked on include Alberta Legislature Building major and minor dome terra cotta replacement, Government House, Edmonton balcony deck clay tile replacement, and Bowker Building, Edmonton Tyndall stone cladding restoration.

Pacholok is a long-standing Technical Committee member for CSA masonry standards S304 "Design of Masonry Structures" and A371 "Masonry Construction for Buildings."

In the spring 2024 issue of *Building Science Perspective*, we presented a portion of the major restoration recently completed on the Alberta Legislature Building. This included stone interventions to address deterioration of sandstone cladding and inappropriate past repairs; cracked and displaced stones reinforced, repaired, repositioned and tied back to structure; flashings installed to manage water; wood windows and doors stripped, repaired, refinished and reglazed.

This article is the balance of the work done to maintain and preserve the province's architectural crown jewel.

North portico cracking

Major vertically oriented cracking and stone displacement had occurred within the north portico east and west elevation sandstone cladding most likely as the result of differential foundation movements arising from the construction of the 97th Avenue underpass and adjoining underground parkades to the north of the building.

Sandstone remediation included removal, repair (complete with stainless-steel dowel stitching and embedment of stainless-steel tees in the bottom of the stones) and reinstallation of cracked third and fourth floor window head stones, repositioning and stitching second and third floor ashlar, sill, frieze and window entablature stones, tying back outward displaced lower architrave stones above the fourth-floor windows, and deep repointing where required.

To monitor for future settlement and differential movements, two in-ground survey markers were installed and an initial 3D photogrammetric survey was carried out on the building exterior.

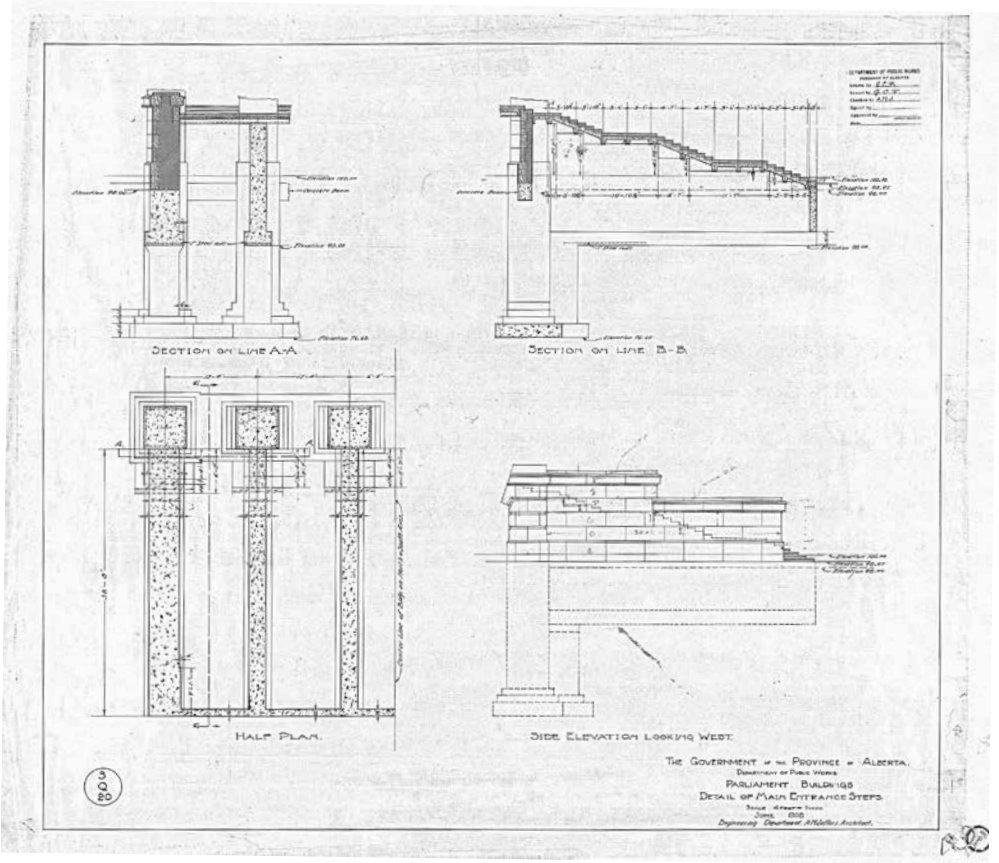
North Stairs Restoration [2020-2022]

The north stairs, as well as the east and west stairs, were clad with 'granite' (more accurately, granodiorite) quarried from Kelly (Granite), Hardy, Nelson, and Fox Islands in Jervis Inlet, British Columbia. Original drawings[7] show that the north stair construction included a full concrete structure supporting the granite tread and landing stones, with steel channels

Clockwise from top left: East elevation of north portico. Cracking and displacement over the east elevation fourth-floor window. Removal of east elevation fourth-floor window head stone to review as-build construction. Tie-back for displaced west elevation infill lower architrave unit. Repair of east elevation fourth-floor window head stone using stitching, Dutchman, and stainless-steel embedded tee. Cracking and movement at west elevation third-floor window head. Repair of west elevation third-floor window head using stitching, embedded stainless-steel tee, and Dutchman repairs.

and I-beams supporting the concrete deck at the colonnade.

In 1977, the original concrete support structure was replaced with a precast concrete system of raker beams and columns, which turned the granite tread and landing stones into structural members simply spanning between raker beams and supported solely by bedding mortar at their ends (there were no dowels connecting the granite to the raker beams). Circa-1983 plaza work resulted in removal of the bottom two sets of treads and the creation of a pit below the plaza deck[9] that filled with water in warm months and ice in cold months, which resulted in premature deterioration of the concrete plaza deck above and abutting raker beams. Around 2004, retrofit steel channels were installed below a number of broken granite treads to prevent catastrophic collapse.[9]



Section B-B through original stair construction as shown on original drawing 3.Q.20.[8]

Over time the mortar head joints failed, allowing rain and snow melt to flow through, resulting in significant deterioration of precast members (due to corrosion of steel reinforcement and connection plates) and bedding mortar (which turned to sand as cementitious materials were washed out). The resulting displacement of treads and landing stones further widened open head joints. In 2011, a retrofit steel support structure was added to support the failing precast structure[9], which over time also experienced corrosion due to on-going water infiltration.

The work of the north stair restoration project included removal of the existing raker beam and retrofit steel support structures, construction of a new full-support cast-in-place concrete stair structure complete with two-ply bituminous membrane waterproofing, and reinstallation of the granite tread and landing stones complete with stainless-steel dowels into the concrete stair structure to affix the granite stones in place. The new concrete stair structure incorporated raker beams to reduce the required thickness of the infill slab and minimize the overall weight of the new stair structure assembly so as not to overload the existing foundations.

During the work of the project, it was discovered that the steel structure supporting the colonnade concrete deck was severely corroded and required replacement. A new steel framing system and concrete deck slab was constructed.

The stair wall demolition and reconstruction work revealed concerning vertical cracking at the junctions of the north corridor concrete wall to freestanding column concrete pilasters and diagonal

Clockwise from top left: North stair prior to restoration. 1977 precast concrete raker beam structure and circa 2011 retrofit steel shoring. Deteriorated precast raker beam, tread bedding mortar, and concrete plaza slab at north end of stair. Retrofit channels installed beneath broken granite treads.

Clockwise from above: Forming and reinforcing steel for new c.i.p. concrete stair structure. Two-ply waterproofing membrane on top of concrete stair structure. Granite landing stones laid on grout pads complete with stainless-steel dowels.



From left to right: Severely corroded existing steel framing beneath the colonnade deck. Replacement colonnade steel structure.

cracking within the masonry portion of the east freestanding column pilaster.

Ground-penetrating radar scanning at select locations on the concrete north corridor wall did not reveal any steel embedments characteristics of actual steel reinforcing[10]. Scanning within a test pit made at the east pilaster revealed embedded steel near the bottom of the beam, however, the amount of steel reinforcing (number and size of bars) and embedment into the pilaster could not be determined.

As a result of the cracking and apparent lack of suitable tie-in of the north corridor wall to the column pilasters, a tie system was designed and installed using two rows of 1¼ inch (32 mm) diameter tension rods to connect the outer pilasters to the

Clockwise from left: Eastern freestanding columns and concrete pilasters. Cracking between concrete north corridor wall and east concrete pilaster. Diagonal cracking with masonry portion of east freestanding column pilaster. Pilaster tie system.



Clockwise from top left: Eastern freestanding columns and concrete pilasters. Cracking between concrete north corridor wall and east concrete pilaster. Diagonal cracking with masonry portion of east freestanding column pilaster. Pilaster tie system. Stainless-steel handrails, complete with integrated LED rail puck lighting, were installed along each stair wall. New stainless-steel handrailing. LED recessed through granite landing stones. North portico lighting on Canada Day 2023. Existing wood plank catwalk in north portico attic space (left) and new metal grating (right).

two adjacent pilasters.

Colour-changing LED lights were added to illuminate the north portico consisting of floodlights mounted on the stair walls, within the landing stones adjacent to the freestanding columns and within the north portico soffit space. In the event that the column lighting is no longer required, replicate granite landing stones for those that had floodlight openings cut into them were supplied and stored under the stairs, with the source of the granite being from one of the same quarries (Hardy Island) as the original stair granite.

As part of the floodlight work, the narrow wood plank catwalk located in the north portico attic space over the lath and plaster soffit was replaced with full-width metal grating.

Summary of Part 1

Significant deterioration of the Alberta Legislature sandstone cladding has occurred over the past 100 years. A total of 22,230 stone interventions were carried out to address these deficiencies which included past repairs that used inappropriate materials and methodologies. Metal and membrane flashings were installed over horizontally projecting stone elements to manage water. The wood windows and balcony doors were stripped, repaired, and repainted, and the windows were reglazed. The main entrance doors were stripped, repaired, and re-stained. Cracked and displaced stones on the north portico were reinforced, repaired and repositioned, and displaced lower architrave stones were tied back to the structure.

Summary of Part 2

The north stair restoration work included removal of the existing deteriorated precast concrete raker beam structure and retrofit steel shoring and replacement of the severely corroded colonnade deck steel structure. A full-stair concrete slab and raker beam structure was cast-in-place and covered with waterproofing membrane. The granite tread and landing stones were repaired and re-laid complete with stainless-steel dowels. The upper portion of the stair walls were rebuilt complete with waterproofing under the copings. A pilaster tie system was installed along the north corridor wall under the stair. Stainless-steel handrails and column lighting were added. Steel grating catwalk was installed over the north portico soffit.

References:

[1] 'Edmonton Journal' newspaper article, July 31, 1912, page 1.

[2] 'Paskapoo Formation', Wikipedia. https://en.wikipedia.org/wiki/Paskapoo_Formation

[3] 'Building Stone in Alberta - ERCB/AGS Open File Report 2010-01', C.S. Crocq, Energy Resources Conservation Board – Alberta Geological Survey, January 2010.

[4] "Report on the Building and Ornamental Stones of Canada, Vol. IV., Provinces of Manitoba, Saskatchewan and Alberta", Canada Department of Mines – Mines Branch, by Wm. A. Parks, B.A., Ph.D., Ottawa Government Printing Bureau, 1916, No. 388.

[5] 'Standards and Guidelines For The Conservation Of Historic Places In Canada', A Federal, Provincial and Territorial Collaboration, Second Edition, Her Majesty the Queen in Right of Canada, 2010.

[6] 'Paskapoo-Porcupine Hills Formation in Western Alberta: Synthesis of Regional Geology and Resource Potential', A.P. Hamblin, 'Geological Survey of Canada – Open File 4679', 2004.

[7] 'ASTM C616/C616M-15, Standard Specification for Quartz-Based Dimension Stone', ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA, United States.

[8] 'Drawing 3.Q.20 Detail of Main Entrance Steps – Parliament Buildings', The Government of the Province of Alberta, Department of Public Works, Engineering Department. A.M.Jeffers.Architect, June 1908.

[9] 'Edmonton – Legislature Building – 2015 North Stair Structural Condition Update', prepared by 'Read Jones Christoffersen Consulting Engineers (RJC)' and dated 'September 4, 2015'.

[10] 'Inspection Report No. S1', prepared by 'BPTECC Engineering' and dated 'October 15, 2021'.

PROJECT TEAM INCLUDED:

Client: Alberta Infrastructure
Prime Consultant: Building Science Engineering

Sub-Consultants
Architectural: H2 Architecture (Burgess Bredo Architect)
Structural: BPTEC Engineering
Electrical: SMP Engineering
Prime Contractor: Scorpio Masonry
Window Restoration Contractor: E.T. Fraser Construction. ■

RENOVATION AND REPAIR OF A PROVINCIAL HISTORIC RESOURCE

By Ka Fund Yung, Alberta Infrastructure project manager

For over 100 years, the Alberta Legislature building stood prominent overlooking the North Saskatchewan River and Alberta's capital city of Edmonton. Although built to last, weather and time had done their work. Repair was required for this building to serve Albertans for another 100 years.

An up-close investigation, completed by Building Science Engineering in 2016, revealed the building's sandstone cladding had significant deterioration, including: chips/spalls, failed patches/coatings, exfoliation, weather/erosion, cracks, efflorescence, displacement, detachment, discolouration, and deteriorated mortar joints.

In 2018, the finish on the existing wood windows was reviewed and identified as requiring repairing/refinishing. The window and subsequent door restoration work would be added to the sandstone cladding repairs to take advantage of the scaffold setup.

In 2019, an in-depth review of the existing north stair assembly was completed by BSE and W&R foundation specialists. The review concluded there were significant structural deficiencies including: water infiltration, drainage issues, and slab and stone deficiencies. The work on these stairs also provided an opportunity to illuminate the North Portico with columns, soffit lighting, and addition of handrails for public safety.

The Beaux-Arts architectural-style building had been designated as a Provincial Historic Resource in 2012. This brought about specific requirements for design and construction professionals to maintain the building's character-defining elements and visual historic features.

The consulting team, Building Science Engineering (BSE) Ltd., provided repair methods (interventions) in their specification package that followed the Standards and Guidelines for the Conservation of Historic Places in Canada and the Historical Resources Act (Section 20).

The proposed intervention methods included:

This September, the Alberta Masonry Council presented their 2024 Alberta Masonry Design Awards. An Award of Excellence – Platinum was given to Legislature Building Stone Cladding and Window Restoration.

The awards are given every four to five years and acknowledge excellence, innovation, and design in the use of masonry in Alberta construction.

References:
https://albertamasonrycouncil.ca/masonry-design-awards/masonry-design-awards-2024/

https://albertamasonrycouncil.ca/wp-content/uploads/2024/09/Alberta-Masonry-Awards-2024-Winners-Final.pdf

1. Using minimal intervention (Standard 3)
2. Use the gentlest means possible for any intervention (Standard 7)
3. Maintain character-defining elements on an ongoing basis (Standard 8)
4. Preserve character-defining elements physically and visually compatible with the historic place (Standard 9)
5. Repair, rather than replace character-defining elements (Standard 10)
6. Make new additions physically and visually compatible with, subordinate to, and distinguishable from the historic place (Standard 11)

Alberta Culture reviewed the interventions and reported to the project team with conditions that the contractor had to demonstrate via mock-ups prior to proceeding with any work. These conditions included:

1. Clarification of the proposed replacement mortar formulation for the sandstone cladding
2. Replacement sandstone types and sources
3. Masonry cleaner products and cleaning techniques
4. Window restoration mock-up
5. Proposed paint formulations
6. Proposed masonry mortar mixes, control joints, and soft joints for the rebuilding and repointing of the north steps

As the project started, the project team collaborated with Alberta Culture, working over the course of months to clear each condition. This collaboration provided a smooth path for completing the remaining project phases. Ultimately, the work completed will allow Albertans to enjoy this designated historic resource for many generations to come. ■

AUPE HEADQUARTERS: 3D DESIGN CENTERED ON HEALTH & WELLNESS

By Aynsley Dueck, Duxton Windows & Doors
With contributions from AUPE and NEXT Architecture

Edmonton's AUPE (Alberta Union of Provincial Employees) headquarters stands as a beacon of modern office building innovation. It seamlessly integrates striking architecture with outstanding energy efficiency and occupant well-being. This pioneering structure is Edmonton's first commercial office building to incorporate NECB 2011, WELL Building Standard, and LEED v4 into its design.

Sustainable design from the start

Next Architecture was carefully selected as the prime architecture firm due to its creativity, collaborative nature, and responsiveness to the client's goals. Together, they developed the 125,000-square-foot headquarters, prioritizing sustainability and occupant health, all while pioneering the use of 3D design tools.

The Building Information Modeling (BIM) system was crucial in the planning, bidding, and construction phases. This technology allowed the architects to explore various design options, optimizing factors like floor layouts, orientation, solar heat gain, and energy use. BIM also streamlined construction by enabling the prefabrication of building components and accelerating on-site assembly.

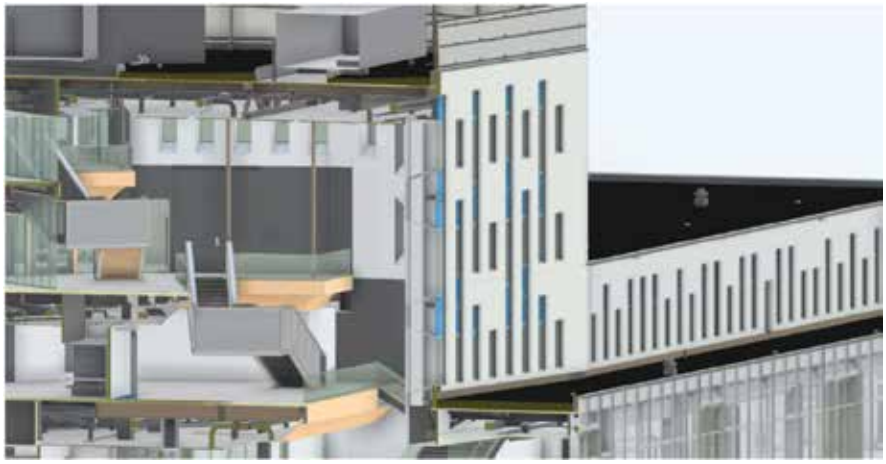
"BIM helps optimize energy usage at the design phase," says Scott Hawryluk of Next Architecture. "This is especially valuable in the long run, as the typical building owner will spend five times the construction cost on maintaining the building."

The 3D model further allowed trades to manufacture from the Revit

Watch the impressive time-lapse here: https://youtu.be/1XtbeOK9HfA?list=TLGGDrbEeXHQQG4yNDA1MjAyNA

3D renderings by NEXT Architecture.

models and prepare the mechanical, electrical, curtain wall, wall panels, plumbing, and fiberglass punched windows off-site. The modular exterior wall panels expedited construction by approximately four to six months.



From living walls to high-tech systems

From a living wall that includes over 1,000 plants to smart building systems that adjust CO_2 levels and temperature in real-time, the AUPE headquarters integrates numerous features to promote occupant well-being and environmental sustainability. The WELL Standard was particularly impactful, with thoughtful designs such as:

- The stairs are centrally located, and the elevator is hidden around the corner to encourage more active living.
- The vending machine offers healthier options.
- Water fountains are available throughout the building.
- Ample fresh air. The new building exceeded the fresh air requirement thanks to the WELL standards, which was particularly important during the COVID-19 pandemic.

"The AUPE building has an impressive operating system exclusively for controlling mechanical, lighting, CO_2, temperatures, and security, to name a few," says Mike Moskaluk of AUPE. "The dashboard is easily accessed so that any adjustments can be made remotely. The sensors in the building collect data constantly so that we can fine-tune the systems and bring down utility costs."

Living wall featuring over 1,000 plants. Image credit: Next Architecture.

A clever window solution for modular panels

The designers at Next Architecture had decided to pursue modular panels for the building but needed a solution for the windows. The building design features vertical strip windows spanning multiple stories, so an aluminum curtain wall would normally be specified. However, a curtain wall would have the glazing installed on-site instead of in the modular panel factory. The designers wanted to avoid extending the construction timelines and added costs associated with the curtain wall option.

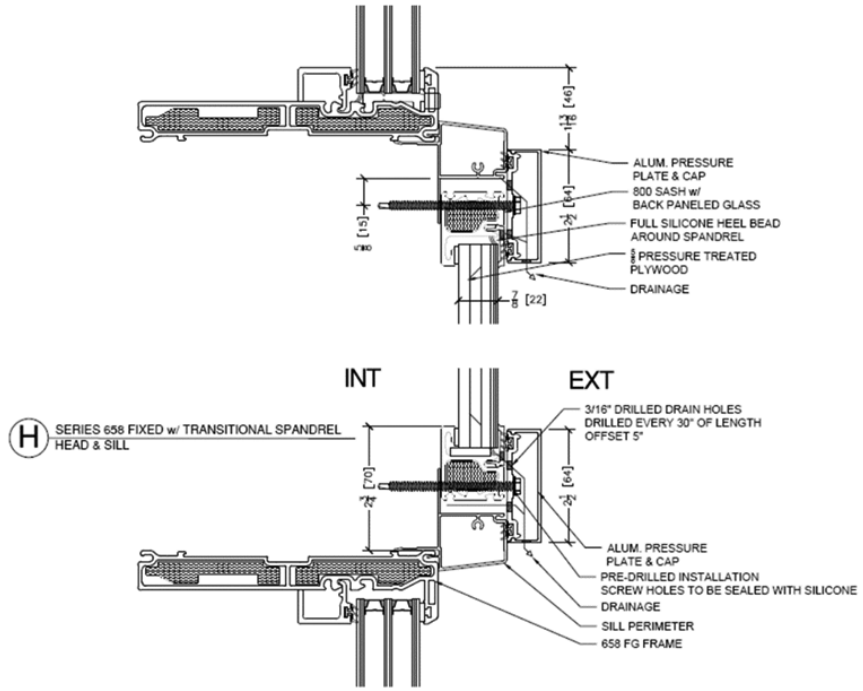
Aesthetics meet functionality

Next started looking at fiberglass frames because they are lighter and highly energy efficient. Upon approaching Duxton Windows & Doors, they communicated the goal of wanting factory-installed windows for each two-storey modular panel with minimal site work.

Duxton proposed a custom transitional spandrel to maintain the architectural integrity while achieving the construction goals. The windows were fabricated as punched openings and installed in the modular panel factory. Then, the transitional spandrel was installed on-site to create the illusion of continuous glazing. Unlike traditional stick framing, these modular panels and fiberglass windows facilitated faster assembly and installation, saving time and costs. Notably, the modular approach ensured a weather-tight building envelope much sooner, which is crucial for Edmonton's climate.

The window design featured a few

FiberWall™ Series 658 Fixed Windows with Cardinal LoE-272 Insulating Glass, Sill Perimeter, and custom transitional spandrel supplied by DUXTON Windows & Doors.



AUPE building with punched openings and transitional spandrel. Image credit: Next Architecture.

AUPE interior building with punched openings. Image credit: Next Architecture.

other clever details from NEXT Architecture:

- The narrow rectangular design helped meet the WELL standards for occupant well-being, as they push more daylight into the inner spaces.
- The deep window sills were angled at 45 degrees to reduce cleaning maintenance, as dust can't stick to the drywall at that angle.
- A beautiful blue spandrel colour was selected to reflect the sky.

Technological collaboration for a sustainable future

The AUPE headquarters exemplifies the power of technological collaboration. Duxton collaborated with Next Architecture to create Revit models of their products, enhancing drawing accuracy and coordination among different trades.

"Scott Hawryluk from Next Architecture has been a trailblazer in BIM. It takes leadership to get trades away from 2D paper drawings and encourage everyone to adopt today's 3D technology," says Aynsley Dueck, operations manager at Duxton Windows & Doors. "We were very excited to publish our window Revit models and expect the technology to continue growing in use since it produces more accurate drawings, better coordination amongst trades, and has the potential to generate energy modeling in the future."

A model for the future

Next Architecture's collaborative design process resulted in a highly thoughtful design, putting people first at every stage. Combining the 3D model and prefabricated components substantially reduced construction timelines and costs, and created a smooth construction process. The finished product is a long-lasting building that allows owners to conveniently monitor and manage energy usage. AUPE headquarters showcases a great commitment to innovation, energy efficiency, and quality. The project serves as a prototype for modern office buildings, demonstrating how clever planning and collaboration can elevate both functionality and sustainability.

For a closer look at the project's stunning visuals and insights, visit Next Architecture's project page at www.nextarchitecture.ca/work/aupe-headquarters. ■

— CASE STUDY —

INTERSTITIAL CONDENSATION DUE TO AIR FLOW THROUGH EXTERIOR WALLS INDUCED BY HVAC COUPLING

By Stephen Hunter, P.Tech. (Eng.), Senior Project Manager,
Building Science Specialist at Sense Engineering

Stephen Hunter is a building envelope specialist at Sense Engineering in Calgary. He provides building envelope engineering services for new and existing buildings

Introduction

This case study is about a failure involving air flow through exterior walls resulting in wintertime condensation at a residence located in Calgary, Alta. Coupling of the forced air heating, ventilation, and air conditioning (HVAC) system to the building enclosure contributed to the failure by creating pressure differences that induced interior air flow through the exterior walls.

This case study includes a summary of the investigation methodology and observations. There is also a discussion on why the failure occurred and what could have been done to prevent it.

Photo 1: Water dripping from behind the siding.

Methodology

This investigation began after the homeowner observed water dripping from behind the vinyl siding on the north and south sides of their residence for several years (Photo 1). This only occurred when the exterior temperature increased following a period of below-freezing temperatures. There were also prominent waves in the siding in these locations.

The scope of the investigation included:

- interviewing the owners;
- reviewing the drawings for the

Photo 2: Wet and frozen insulation and OSB sheathing.

Photo 3: Bowing in the OSB sheathing.

residence;

- reviewing the building in the affected areas during winter;
- recording the ambient temperature and humidity conditions;
- making and repairing interior and exterior exploratory openings in the affected areas;
- recording the moisture content of framing and sheathing at exploratory openings;
- reviewing the building enclosure with a thermal imaging camera under positive and negative pressurization, and;
- completing smoke pen testing and recording pressure differences with a digital manometer in localized areas.

Following the investigation, remedial work was completed. The demolition phase of construction afforded an opportunity to further investigate the failure. The exterior walls were reviewed following removal of the siding, OSB sheathing, and insulation. Additional thermographic imaging with positive pressurization was completed at that time.

Observations:

The exterior walls in the affected areas were constructed as follows (from exterior-to-interior):

- vinyl siding
- asphalt saturated kraft building paper
- OSB sheathing
- 2x6 wood studs with fibreglass infill batt insulation
- polyethylene air/vapour barrier
- interior painted drywall

An insulated rim joist product consisting of a closed-cell polyurethane foam core and two-by-two wood framing sandwiched between two layers of OSB sheathing was installed at the second-floor perimeters. No additional insulation or membrane was installed in the rim joists. Refer to Figure 1 for an illustration of the rim joist assembly.

When the investigation was completed, the interior temperature and relative humidity were 21°C and 32 per cent respectively. The exterior temperature was 0°C. These are normal and acceptable interior temperature and humidity conditions for this exterior temperature and generally result in a low risk of condensation in the building enclosure. The owners confirmed they regularly monitor the temperature and humidity levels, and that these were typical conditions through the winter.

At the exploratory openings in the affected areas, the OSB sheathing had elevated moisture content. Due to the high moisture content, there was swelling and bowing in the OSB sheathing, and suspected mould growth in several locations (Photos 2 and 3). The waviness in the vinyl

Photo 4: Unsealed cable penetrations through the polyethylene sheet.

Photo 5: Typical unsealed plumbing and electrical penetrations extending through the second-floor sill plate.

siding was caused by the bowing in the OSB sheathing.

The elevated moisture content and associated effects were observed primarily around discontinuities in the interior polyethylene sheet, and unsealed plumbing and electrical penetrations that extended between the second-floor cavity and exterior walls (Photos 4 and 5). There was also apparent air leakage at these locations visible with the thermal imaging camera under positive pressurization (Photo 6).

Due to the configuration of the insulated rim joist assembly, the unsealed penetrations through the wall sill/top plates represented discontinuities in the air and vapour barrier (Figure 1).

The home had a forced-air HVAC system with a natural-gas-fired furnace. Heated air was delivered directly to the rooms via metal ducts. However, the second-floor joist cavities were utilized as a return air plenum to deliver return air from each room back to the furnace.

When the furnace blower was operating, the second-floor cavity and interconnected spaces (including the exterior walls above and below the floor cavity) were depressurized (Photo 7). Consequently, when the furnace blower was operating, air was being drawn from the interior space to the second-floor cavity through the exterior walls (Figure 1).

Discussion

Based on the available information, it was concluded that the most likely cause of the failure was condensation within the exterior walls.

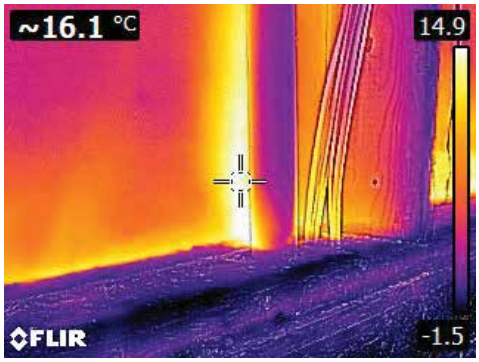
The unsealed penetrations in the exterior walls resulted in airflow pathways between the interior, exterior walls, and second-floor cavity. Pressure differences induced by the HVAC system drove air from the interior to the second-floor cavity through the exterior walls.

When interior air reaches colder surfaces in the exterior walls that are below the dewpoint temperature of the air, condensation occurs, resulting in wetting and the other effects discussed. During below-freezing weather, the condensate freezes and accumulates. At this residence, it accumulated within the wall cavity and directly behind the siding. When the weather warms, it melts, resulting in the dripping.

While the discontinuities in the air/vapour barrier can alone result in condensation within the exterior walls, the coupling between the furnace blower and the building enclosure resulted in substantially increased moisture deposition, and explains the severity of the condensation despite the acceptable indoor temperature and humidity conditions.

Prevention

For air leakage to occur through a material or assembly, there must be an opening and a pressure difference to move the air. In theory, removing either prevents air leakage.



From left to right: Photo 6: Air leakage at the penetration shown in Photo 5.

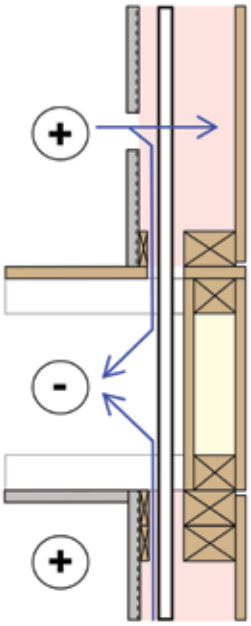


Figure 1: Second-floor rim joist configuration with positive/negative pressures and airflow pathways (blue lines) indicated.

Photo 7: Crude but effective visual of depressurization of the exterior wall below the second-floor cavity.

Of course, it's not practical to seal a building enclosure so it is 100 per cent airtight. Still, significantly reducing the openings by sealing the large penetrations may have prevented the failure, and would have at least reduced the impact.

A forced air HVAC system should be designed so it doesn't impart a pressure difference that drives air through the building enclosure. One option would be to install well-sealed sheet metal ducts for return air instead of utilizing the floor cavity as a return air plenum. At a minimum, the floor joist cavities acting as the return air plenum should be well sealed.

Building enclosure assemblies with exterior insulation also reduce the risk of interstitial condensation by increasing the temperature of the stud cavity during cold weather.

In our case, resolution of the problem included a combination of sealing penetrations through the air/vapour barrier from the exterior, and providing alternate return airflow pathways through the residence via transfer grilles to reduce the pressure difference across the second-floor cavity. ■

THE REVAY CORNER:
Is your schedule telling you the truth?

By Suzanne Checkryn, P.Eng., PMP, MBA –
Director, Prairies at Revay and Associates Limited

Suzanne Checkryn is a professional engineer with more than 25 years of experience working in engineering, construction and consulting. Throughout her career, Checkryn has worked with major firms to complete projects on schedule and to overcome significant engineering and construction challenges. She has been involved in a variety of projects, including multibillion-dollar projects with complex engineering, supply chain, construction, project controls, risk management and change management requirements. Checkryn has extensive field experience working with owners, engineers, consultants, general contractors, subcontractors and suppliers.

At Revay, Checkryn is responsible for the firm's Calgary office which services Alberta, Saskatchewan and Manitoba. She has been retained as expert for referee, mediation, arbitration and litigation. Checkryn also delivers training focused on claims avoidance and claims management to clients and industry associations across Canada and at the University of Calgary.

The last Revay Corner discussed whether projects should consider producing detailed specifications for temporary works, along with the potential benefits to owners and contractors of having detailed specifications for these scopes. When it comes to project schedules, in Revay's experience, it is important that all scopes – including the temporary works – be included in schedules. This column provides practical considerations for developing and maintaining project schedules to help ensure that your schedule is telling you (and the other stakeholders on your project) the truth.

Revay has been involved in the development and analysis of countless schedules, which we view as vital project documents. Having a reliable schedule that is maintained throughout the project lifecycle is important for many reasons, including:

- It is essential for proper project planning.
- It is an integral communication tool for all project stakeholders.
- It is used to identify, quantify, and mitigate delays and disruptions early.
- It creates the as-built record of the project.
- It is used in delay analysis if/when delays occur. It may be even more important if disputes arise.

This is not an exhaustive list.

In Revay's experience, it is typical that the project schedule is developed and maintained by the construction contractor. Depending on the project's contracting model, this could be the general contractor or the construction manager. In the case of design-build and construction management projects, the schedule will be developed before design is complete. In the case of design-bid-build projects, consultants will typically be involved in the development of schedules prior to the tendering of construction.

In order for a schedule to be reliable, it must be built on a solid foundation. This "foundation" is the complete project scope (i.e., all activities applicable to the project and not only the construction activities). Among the myriad of challenges Revay has seen with respect to project schedules, Revay has often found that schedules omit, or include inadequate time for, key activities. Examples of activities commonly omitted/understated in schedules are:

- Design activities, including sufficient review time and time for iterations.

In order for a schedule to be reliable, it must be built on a solid foundation. This "foundation" is the complete project scope (i.e., all activities applicable to the project and not only the construction activities).

- Other submittals by the contractor, such as shop drawings, including sufficient review time and time for iterations.
- Permitting and other pre-requisites to starting construction work.
- Activities related to temporary works.
- Owner activities.
- Commissioning activities.
- Subcontractor activities.

For projects with a significant amount of subcontracted work, as is common with commercial, institutional, and residential building projects, the subcontractors represent an important stakeholder group. The schedules for such projects can only be reliable with (continuous) input from the subcontractors. Further, in Revay's experience, the subcontracted work can only be effectively planned and managed if subcontractors have access to, and provide input into, the overall project schedule.

Once a solid "foundation" is established, there are numerous other requirements for schedules to be reliable. From a technical perspective, this includes, among other things, logic links for all activities, proper dates and calendars, reasonably short durations, adequate float, and the minimal use of constraints.[1] Omitting, or understating, activities and technical schedule components results in an incomplete schedule. With this, the schedule may (knowingly or unknowingly) be unachievable, meaning the desired project completion date is potentially at risk from the outset.

In the end, a schedule can only be effectively developed with inputs from all project stakeholders. And, only a complete schedule, from both scope and technical perspectives, can properly communicate impacts so that mitigation measures can be implemented. These may seem like simple rules to follow; however, in practice, we all too often come across incomplete or inadequate schedules on projects. Having a complete and technically sound schedule is the only way your schedule will tell you the truth.

[1] This column is not intended to discuss all technical aspects of scheduling. A common reference for developing schedules and assessing the technical quality of schedules is the Defense Contract Management Agency ("DCMA") 14-Point Assessment. ■

CAUSE FOR CONCERN? ADOPTION OF THE UNVENTED WOOD ROOF IN ALBERTA

By Fred Edwards, B.Sc., P. Eng. LEED AP

Fred Edwards is a professional engineer who has practiced building science for RJC Engineers in Calgary since his graduation from the University of Calgary in 2006. Edwards is a lifelong Calgarian and is formally trained in thermal and hygrothermal simulation of building enclosures.

Unvented wood-framed roofing is gaining momentum in Canada. It is a substantial shift in the residential construction landscape in this country; nearly all wood-framed single-family homes have historically been constructed with a vented roof – that cold (or hot) attic space above your upstairs bedroom.

Alberta is leading the charge. Our provincial government has taken the significant step in permitting an alternate solution to vented roofing provincewide. While other jurisdictions in Canada (like B.C.) have allowed such variances on a case-by-case basis, Alberta seems to be the first to approve a blanket variance based on a report not linked to a specific property. The days of the vented roof as the only prescriptive solution (i.e. not requiring professional involvement) in wood homes appear to be behind us. I am referring to the Alberta Government's 2022 STANDATA variance number 19-BCV-22, which establishes unvented roofing as a province-wide acceptable alternate solution to the requirements of the National Building Code – 2019 Alberta Edition.

Notably, the National Research Council, who ultimately are responsible for updating Canada's National Building Code, did not take the lead on the matter. The latest edition of the National Building Code, NBC 2020 – now in force in Alberta – reads much like the previous versions of the code when you get to the part about roof ventilation, article 9.19.1.1. Roofing used in NBC 2020 Part 9 compliant buildings should be constructed as vented assemblies with prescribed areas for intake and exhaust vents. The NBC, however, provides an out. Venting of roof assemblies is only necessary unless it can be shown to be unnecessary. Enterprising spray foam manufacturers and distributors take note, the door is open. It has been for years, only now the Alberta Government has taken the next step via the STANDATA referenced above.

Unvented wood roofs are almost exclusively constructed using spray foam as the air and thermal barriers. They are quite common. Balconies over occupied living space were, up to now, the most prevalent occurrences of unvented roofing. Flat roofs like this are notoriously difficult to vent effectively. Although flat roofing is addressed in Part 9, its venting requirements were not conceived with flat wood-framed roofing in mind. Clause 9.19.1.1, which has been included in the NBC in some form since 1960, was conceived to accommodate vented attic spaces immediately below steep slope roofing. In the traditional residential home, convection within the attic space drives the ventilation with little need for mechanical intervention. Flat roofing is different. There is less of a temperature gradient between the intake and exhaust, and the buoyancy of heated air has little or no slope to follow to the exhaust vent. This leads to stratification and stagnant air flow in the vented cavity.

That is a big problem with vented flat roofing, which Part 9 has never taken steps to address. In many cases, the alternate solution has been to abandon the concept of ventilation in favour of increasing air-tightness and lowering vapour permeability (unvented solution). It is a wholly different strategy. Rather than accommodate some air leaks and moisture originating from inside the building via venting, it stops the source of moisture into the roof and therefore eliminates the need to

accommodate.

The problem is, and has always been, that achieving perfection in an air barrier is difficult at best. Spray foam application has come a long way in the last 20 years and it has never been more possible to achieve a near-perfect air barrier than it is now, but perfection is a unicorn. We want to believe that perfection is possible but cold, hard reality tends to get in the way. One fundamental reality is that all roofs leak, eventually.

Once you establish, however, that a perfect air barrier is possible and assume as much in your calculation of moisture movement through roofing, the pieces of the unvented puzzle begin to fit together.

Under such assumptions, it is possible to achieve the desired result through computer modeling of complex physical phenomenon. Unvented roofing can achieve acceptable performance commensurate with that of vented roofing, particularly in that it will resist the tendency to accumulate moisture over time. So, when you set up a computer program with assumptions that ignore some fundamental realities of construction, like failure of a roof membrane and wetting of a wood roof deck is inevitable, you can arrive at just about whatever result you desire. In most of Canada, trained then licensed and regulated professionals are required to make the call as to whether the assumptions are valid.

Thus, qualified professionals can justify the use of an unvented roof assembly in a wood-framed building, thereby utilizing the out clause in Part 9. Up until 2022 this was the process in Alberta and it still is throughout most of Canada if you wanted to use an unvented roof in a wood home. Professionals performed calculations specific to your building, using the environmental conditions of the area, and made certain assumptions regarding the quality of the construction. They stated those assumptions and designed accordingly. Unvented roofing therefore was always an exception to the rule, to be specified after careful consideration by professionals with appropriate knowledge, and installed by builders with appropriate qualifications.

The unvented roof is now one of two acceptable solutions under Part 9 which are deemed by the province to be equivalent and used at the discretion of the builder without professional involvement.

Equality, at least for the moment, remains elusive and it is having consequences for at least one homeowner already.

Unvented conversion causes damage to two-year-old shingle roof

This summer I was engaged to review a curious issue on a wood-framed steep-slope roof in a single-family residence. The homeowner reported and provided images of buckling two-year-old shingles which had shown up for the first time this summer during the hottest part of July. I was surprised to uncover the cause of the issue was the conversion from a vented roof to an unvented one. I should take a moment to note that the homeowner has agreed for the details in this article to be published, without specifics as to the home or owner.

Re-roofing occurred in 2022 when the home still incorporated a vented roof. At the time, the homeowner paid a premium to install a continuous

Photo 1 - Steep slope roof, ridging clearly visible in shingles following the rafters.

self-adhering underlay below the shingles. The underlay, similar to the Ice and Water Shield product by IKO Industries, is common in wood-framed roofing but is usually limited to the bottom three feet of a steep-slope shingle roof.

In this case, the homeowner installed the membrane over the entirety of the roof below the shingles. Given the vented construction when the roof went on, this vapour barrier was not expected to have adverse effects as drying could occur to the attic and through the numerous roof vents which were present.

Two years later, the homeowner decided to undertake a far more substantial interior renovation. The entire house was vacated and exterior walls/ceilings stripped down to the studs from the inside. The roof sheathing, two-year-old shingles, and underlay remained. In developing the design for the renovation, the homeowner established the goal of substantial energy improvements and consulted a qualified energy advisor

Photo 2 - Attic spray foam conversion.

on the best approach. The advisor was not, however, a licensed professional as defined by the Building Code. The advisor recommended converting the home's air and vapour barrier system from drywall and sheet polyethylene to a medium-density polyurethane spray foam. Even the attic could be converted to interior usable space by applying the foam to the underside of the roof (Photo 2) and providing high-efficiency HVAC above the ceiling. Substantial improvements in air-tightness were the goal of that recommendation.

In forming their recommendation regarding the roof, the advisor specifically referenced Alberta's new variance to the NBC-2019AE permitting unvented roofing. Further analysis by a professional was not mandatory; the advisor had the generic engineering report[1] and a statement of equivalency from the province. The spray-foam installation conformed with the stringent requirements of the report, and this was documented by the builder.

Roughly four months after conversion, in the first summer post renovation, problems with the shingles began to appear. The shingles were buckling and to a degree that the ridges were clearly visible from ground (Photo 1). After a brief and relatively simple investigation, it was determined that the shingle failure was the result of wrinkles forming in the self-adhered membrane (Photo 3).

Summer heating of the dark-coloured roof increased temperatures on the roof and the spray-foam insulation locked moisture and heat in the outer layers of the roof. Even small increases in roof temperature can have a substantial impact on vapour pressures. It is clear that vapour pressure spikes below the adhered underlay caused the blistering and visible ridges. The ridges subsided with colder weather, but will be back next summer. The long-term effect of this natural seesaw brought on by unvented roofing is difficult to predict.

Worse than the shingle buckling, the conversion also seems to have voided the roof warranty early in the life of the assembly. In preparing for this article, I spoke with one major shingle manufacturer who sells in the Alberta market. Unvented shingle roofs are not yet warrantable by this manufacturer. The long-term effects resulting from the substantial increase in solar gain on these roofs is not well established, and manufacturers understandably shy away from long-term commitments in that sort of situation. Until more data is available, and this homeowners' specific experience isn't pointing to an outcome favourable to the public looking for roof warranties, shingle roofing with long-term manufacturer backing will be limited to the old tried-and-true vented roof systems of the NBC.

Aggressive lobbying clearly a thing in the Alberta construction industry

I do not object to large manufacturers creating innovative and novel products. Under the right circumstances, I am personally happy to assist with testing products and sometimes recommending them to my clients. I have recommended unvented roofing on a few occasions over the years. The innovation that large product manufacturers bring to our industry is a primary means of achieving forward progress.

This change to Part 9 of the Alberta Building Code seems to be different than manufacturers bringing a new technique/product to market. The report on which the decision to provincially accept unvented roofs relied was commissioned by the American Chemistry Council (ACC). Google them. The ACC appears to be a consortium of manufacturers of chemical products, including, notably, the large America-based spray-foam manufacturers. It seems the ACC commissioned a report with

Even small increases in roof temperature can have a substantial impact on vapour pressures. It is clear that vapour pressure spikes below the adhered underlay caused the blistering and visible ridges.

Photo 3 - Roof investigation at one of the shingle ridging locations. Sheathing removed to expose spray foam.

the specific purpose of lobbying the government to change the rules in their favour. More concerning is that the committees appointed by our local elected officials appear to have adopted the change recommended by the ACC with little or no visible objectivity or sober second thought. The ACC report is heavy on the merits of unvented roofing, but low on the risks. Shingle buckling and roof warranties being voided are not in there. Perhaps a report outlining the risks and summarizing the shingle manufacturer's position should be posted along with the document commissioned by the ACC.

During this American election season, I am accustomed to hearing about the system of lobbying south of the border. It is a way of life down there and their political system incorporates the checks necessary to vet opinions put forth by lobbyists. The present situation makes me leery that existing rules within our political system are either not being followed or are insufficient to deal with the coordinated and sophisticated American system of lobbying clearly at play here.

Final thoughts

Even though the homeowner suffered a roofing failure and is now staring down the barrel of replacing a two-year-old roof, their home is indeed far more energy-efficient and air-tight than the original structure was. Perhaps this is a fair trade in the long run. My primary concern lies not with the forward progress that a move to more air-tight construction brings, but the unsuspecting casualties along the way. The average homeowner has no idea what clause 9.19.1.1 or STANDATA are, and the public are relying on balanced and objective analysis of new solutions to protect their interests. I think many Alberta residents will pay a similar price to my client in the years to come, and that is a shame because it is completely unnecessary.

The vented roof is one of the most under-appreciated assemblies referenced in our building code. As Dr. Joe Lstiburek notes in BSI-141: Shakespeare Does Roofs, vented roofs successfully and economically address issues common to cold climates, like ice damming. Did things really need to change in this market? One of the options to resolve the unvented roof failure in this article, and the most robust one in my opinion, is to construct a hybrid vented roof on top of the now substantially air-tight and insulated structure. If the homeowner elects to do this, they will have one of the best wood roofs I have ever seen and, coincidentally, the roof recommended by Dr. Lstiburek in BSI-141.

Homeowners who are adversely impacted by this change to the building code should submit a complaint to the Safety Codes Council at www.safetycodes.ab.ca/permits-inspections/complaints.

[1] RDH Building Science Laboratories M-25608.000 ACC – Alberta Unvented Roofs Evaluation Report. March 4, 2022. ■

AIR BARRIER SYSTEMS: HOLISTIC DESIGN WITH SPRAY FOAM

By Mickel Maalouf

Mickel Maalouf is a LEED green associate and sustainable building science manager with Huntsman Building Solutions (HBS).

Photo courtesy The Stack

The use of spray polyurethane foam (SPF) insulation as the air barrier system is a critical aspect of modern architectural and engineering practices to enhance building energy efficiency and durability. Using SPF as a comprehensive air barrier system in new constructions and selective retrofits (subject to review by the building envelope consultant) requires careful consideration of essential design aspects. Keeping that in mind, the focus should be on mitigating air leakage and enhancing air-tightness, refining application techniques, and ensuring compliance with prevailing building codes and standards.

In Canada, building codes and regulations are evolving to emphasize the importance of air barrier systems in improving energy efficiency and building performance. Key developments include increasingly stringent air- tightness requirements which push for more advanced air barrier solutions. Additionally, government programs and incentives are promoting the adoption of energy-efficient building practices, including the use of effective air barrier systems. Further, the shift towards performance-based codes, which focus on the overall energy performance of buildings rather than prescriptive measures, is encouraging innovation in air barrier technology.

To illustrate, the National Energy Code for Buildings (NECB) mandates building assemblies be tested as "air barrier systems" to control air leakage and ensure resistance to high wind pressures. These products provide robust solutions for achieving the required air-tightness levels, contributing significantly to improved energy- efficiency and building durability, enhancing long-term resiliency.

The development and adoption of technologies are significantly transforming the air barrier systems industry. For example, spray foam, which combines insulation and air barrier functions, has been tested and approved in several assemblies for decades as an air barrier system. It has been frequently used in large buildings due to its excellent air sealing properties and thermal performance and is now being used in buildings that need to meet the

Contractor spraying a polyurethane spray foam insulation product. Photo courtesy Huntsman Building Solutions (HBS).

new stringent NECB requirements. Understanding the properties of spray foam insulation, including its thermal resistance and the distinctions between open-cell and closed-cell foams, is crucial.

Understanding spray foam insulation properties

Spray foam insulation is renowned for its high thermal resistance and air-sealing capabilities, which contribute to enhanced energy efficiency and indoor comfort. SPF is available in two primary types: open-cell and closed-cell foam.

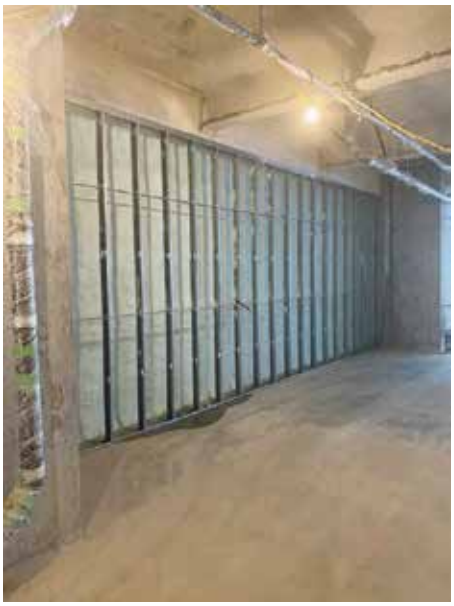
Open-cell spray foam insulation provides a superior air barrier compared to traditional insulation in various applications such as walls, floors, and attics. Recognized as a versatile option for home insulation, it expands upon application to fill gaps and cracks, thereby forming an effective air barrier. By adhering to most construction surfaces and creating a tight-seal, open-cell SPF enhances a building envelope's air-tightness while acting as an effective sound barrier.

Closed-cell foam, on the other hand, is denser and offers a higher RSI-value per inch, providing excellent thermal insulation. Its impermeability to water vapour makes it ideal for use in exterior applications and areas prone to moisture exposure. Closed-cell foam also adds structural strength to the building envelope due to its rigidity and adhesive properties.

Understanding the differences between these foam types is crucial for selecting the appropriate SPF for specific applications and ensuring optimal performance as an air barrier system.

There are many new types of spray foams on the market today to choose from. Some enhanced versions of closed-cell spray foam, manufactured in Canada, feature specific Environmental Product Declaration (EPD) and have been tested as air barrier systems in accordance with CAN/ULC S742, Standard for Air Barrier Assemblies, as well as for radon resistance. The hydrofluoroolefin (HFO) blowing agent used in them is the most environmentally conscious to date, with zero ozone depletion potential (ODP) and a global warming potential (GWP) of one. They are compatible with most building products and can be used in various applications, including unique wall assembly systems that allow for the installation of insulation from the interior while managing the thermal bridging of the studs and structure. These are considered "all-in-one" spray foam products as they are air barrier, vapour barrier for interior,

Spray polyurethane foam (SPF) plays a significant role in mitigating common air leakage paths, such as joints, seams, and penetrations, thereby enhancing the airtightness of buildings.



Far left: Application of hydrofluoroolefin (HFO) to achieve high RSI-values.

Spray polyurethane foam (SPF) can be applied using various methods, including spray guns and portable units. The choice of application method depends on the project size, complexity, and specific requirements.

exterior applications above- and below-grade, and rain screen.

Mitigating air leakage and enhancing air-tightness in buildings

SPF plays a significant role in mitigating common air leakage paths, such as joints, seams, and penetrations, thereby enhancing the overall air-tightness of buildings. Effective air sealing reduces energy loss, improves indoor air quality (IAQ), and enhances occupant comfort.

Sealing around penetrations, such as pipes, ducts, and electrical conduits, is crucial to prevent air leakage. SPF can be used to seal these areas effectively, providing a continuous air barrier.

Thermal bridging occurs when conductive materials, such as metal studs or concrete, create a path for heat flow, bypassing the insulation. SPF can be applied over these thermal bridges to reduce heat loss and improve the overall thermal performance of the building envelope.

SPF application as a continuous insulation must cover the entire building envelope without gaps or interruptions. This ensures a consistent thermal barrier and minimizes the risk of thermal bridging and air leakage.

To meet NECB requirements, there are high-performance spray foam products in the market that are effectively tested as air barrier systems in accordance with CAN/ULC S742.

Application techniques for optimal air barrier performance

Application techniques for SPF are crucial in ensuring the optimal performance of air barriers. Achieving uniform thickness and density in SPF application is crucial for maintaining continuous insulation and air sealing, especially over complex geometries and thermal bridging areas.

Additionally, in Canada, where spray foam application standards are embedded into code, compliance means spray foam must be applied in accordance with the CAN/ULC S705.2 standard of application. This ensures only trained and licensed contractors can install the product.

Best practices for SPF application include:

- **Surface preparation:** Proper surface preparation is vital for adhesion and performance. This includes cleaning the substrate to remove dust, debris, and contaminants, as well as ensuring the surface is dry and free of moisture.
- **Application methods:** SPF can be applied using various methods, including spray guns and portable units.
  The choice of application method primarily depends on the project size, complexity, and specific requirements. Regardless of the method, a consistent application technique is critical to avoid gaps, voids, and uneven thickness.
- **Layering and curing:** Applying SPF in multiple layers can help achieve the desired thickness and density. Each layer must be allowed to cure properly before applying the next to prevent issues such as shrinkage and poor adhesion. Monitoring the curing process and environmental conditions, including temperature and humidity, is essential for optimal air barrier results.

While application technique is important, so is the equipment. It must be capable of delivering a precise 1:1 volume ration of polymeric isocyanate (PMDI) and polyol blend at appropriate temperatures and

The Stack, a modern office building in Vancouver, B.C., is an example of using spray polyurethane foam (SPF) insulation as the air barrier system to enhance energy efficiency and durability. Photo courtesy of The Stack.

spray pressures. It is crucial to use trained and certified applicators to ensure these parameters are met and proper installation is achieved. Ensure the substrate temperature is at least five degrees above the dew point, with optimal processing results achieved when ambient humidity is below 80 per cent. The substrate must be free from moisture (dew or frost), grease, oil, solvents, and any other contaminants that could negatively impact the adhesion of the polyurethane foam. This product is not suitable for covering flexible ductwork. Additionally, it must not be used when the continuous service temperature of the substrate or foam falls outside the range of -60 to 80 C (-76 to 180 F).

It is also required this product be separated from the building's interior by an approved thermal barrier or a finish material equivalent to a thermal barrier, as per applicable codes. The most common thermal barrier is a regular 12.7-mm (0.5-inch) interior gypsum board commonly used as finishing material.

Compliance with building codes and standards

Understanding compliance associated with integrating SPF into air barrier systems, including adherence to the latest building codes and standards is critical. This includes navigating the requirements of energy codes, fire safety standards, and environmental regulations. Having SPF also contributes to achieving certifications under various green building frameworks, such as LEED.

Energy codes

In Canada, the energy efficiency of buildings, including the use of air barrier systems made of spray foam insulation, is governed by several codes and standards:

- NECB
- Thermal performance: Spray foam insulation must meet effective thermal resistance (RSI-value) requirements to cut thermal bridging and enhance the energy efficiency of building envelopes overall.
- Air leakage control: The NECB mandates stringent air leakage control and high wind pressure resistance measures, requiring assemblies be tested as air barrier systems. As such, several assemblies insulated with spray foam are tested as air barrier systems in according with CAN/ULC S742 to meet those requirements.
- National Building Code of Canada (NBC)
- Section 9.25—Heat Transfer, Air Leakage, and Condensation Control: This section details the requirements to control heat transfer, air leakage, and condensation within building envelopes. Spray foam insulation used as an air barrier must comply with these specifications to ensure energy efficiency.
- Provincial and territorial codes
- Various provinces and territories may have their own energy efficiency requirements, often based on or more stringent than the NECB. Builders must comply with local regulations regarding the use of spray foam as an air barrier.

Fire codes

Fire safety regulations for spray foam insulation used in air barrier systems are governed by the NBC and specific ULC standards:

- NBC
- Section 3.1.5—Noncombustible Construction: This section includes requirements for combustible materials used in noncombustible buildings. Spray foam can be used in noncombustible buildings given it meets certain standards, such as flame spread rating, and that it is separated from adjacent spaces by a thermal barrier.
- Section 9.10.17—Flame Spread Limits and Section 9.25.2—Thermal Insulation. These sections provide guidelines for the installation of foamed plastics in housing and small buildings, notably regarding their flame spread index and their protection by a thermal barrier.
- CAN/ULC-S101, Standard Methods of Fire Endurance Tests of Building Construction and Materials
- Fire Endurance Testing: Some high-rise building assemblies using combustible insulation may need to undergo fire endurance testing to ensure they can withstand fire exposure and maintain structural integrity. There exist several assemblies with spray foam insulation

that have been tested to meet CAN/ULC S101 standards to comply with code requirements in such instances.

- CAN/ULC-S102, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies
- Flame Spread and Smoke Developed Index: Spray foam must be tested for its surface burning characteristics, including flame spread and smoke development ratings.
- CAN/ULC-S124, Standard Method of Test for the Evaluation of Protective Coverings for Foamed Plastic
- Protective Coverings: Spray foam must be covered with approved protective materials to separate it from adjacent living spaces.

Environmental regulations

Environmental regulations for spray foam insulation focus on its impact on the environment, particularly regarding the use of blowing agents and the material's lifecycle impact:

Canadian Environmental Protection Act (CEPA)

Blowing agents: The use of hydrofluoroolefin (HFO) blowing agents with low GWP and zero ozone depletion potential (ODP) is mandatory to minimize environmental impact.

Chemical safety: Compliance with regulations on the use and disposal of chemicals used in spray foam production and application.

EPDs

Transparency and sustainability: EPDs provide detailed information on the environmental impact of spray foam products throughout their lifecycle, from raw material extraction to disposal.

Green Building certifications

LEED: Spray foam insulation can contribute to LEED certification points by improving energy efficiency, reducing air leakage, and using environmentally friendly materials. Some of the best products on the market are made of recycled plastic materials, rapidly renewable soy oils, and fourth-generation blowing agents with zero ODP and less than one GWP. This type of spray foam product meets all the requirements of the Paris, Kyoto, and Montreal protocols.

Indoor environmental quality: SPF helps maintain indoor air quality and comfort by reducing air leakage and controlling moisture. Some SPF products are UL GREENGUARD GOLD-certified for IAQ, meeting volatile organic compounds (VOC) emission standards such as those other building materials to ensure safety and healthy indoor environments. This certification aligns with the LEED Indoor Environmental Quality category, emphasizing the importance of creating healthy indoor spaces.

Case study: The Stack

To illustrate the effective integration of SPF with air barrier systems in modern building designs, consider The Stack in British Columbia. Situated in the vibrant heart of Vancouver, The Stack stands as a testament to modern architecture and innovative design. This project has transformed the city's skyline, heralding a new era of state- of-the-art office spaces.

With its ascending and intricate twists, the building transcends conventional standards of architecture. It also emphasizes a deep commitment to sustainability. Notably, The Stack is Canada's first commercial high-rise office tower to achieve the prestigious Canada Green Building Council's (CAGBC) Zero Carbon Building— Design Standard certification. Its pursuit of LEED v4 Core & Shell Platinum certification further underscores its dedication to environmental responsibility.

Architects and engineers faced the challenge of creating intricate and visually appealing structures for the building without being constrained by building envelope restrictions. Given the specific insulation performance criteria set for this project, they chose an innovative spray foam solution that acts as an effective air and vapour barrier, seamlessly integrating with diverse architectural elements, and sealing all joints and material junctions to create a perfectly sealed, more energy-efficient building. Meanwhile, to reach the LEED and Zero Carbon Building objectives, architects chose spray foam insulation for its low-embodied carbon and the high energy efficiency it provides.

Conclusion

Integrating spray foam insulation with air barrier systems is a strategic approach to enhancing building performance, sustainability, and occupant comfort. By comprehending the properties of SPF, ensuring material compatibility, refining application techniques, and adhering to building codes and standards, architects and engineers can achieve optimal results. The benefits of SPF, including superior thermal resistance, air sealing capabilities, and contributions to green building certifications, make it a valuable component in modern construction practices.

As demonstrated by The Stack, the effective integration of SPF with air barrier systems results in improved energy efficiency, reduced environmental impact, and enhanced building durability. This promotes wider adoption within the construction industry, ensuring buildings perform at their best, supporting sustainability goals, and providing comfortable, efficient environments for occupants.

Endnotes:

1. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/TheStack_EXT_PodiumMelville_04@2x-Enhanced-SR.jpg
2. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/B.4.jpg
3. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/B.5.jpg
4. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/B.6.jpg
5. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/B.8.jpg
6. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/B.9.jpg
7. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/The-Stack-Spray-Application- of-Heatlok-Soya-HFO-spray-foam-to-achieve-high-R-values-_hbs-Enhanced-SR.jpg
8. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/The-Stack-Spray-Foam- Application_hbs3-Enhanced-SR.jpg
9. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/thestack-hero.jpg
10. [Image]: https://www.constructioncanada.net/wp-content/uploads/2024/09/Mickel-Maalouf.jpg

Source URL: https://www.constructioncanada.net/air-barrier-systems-holistic-design-with-spray-foam/ Copyright ©2024 Construction Canada unless otherwise noted. ■

RISKY BUSINESS

Improving our understanding of wind loads on roofs and building exteriors

By Brian Breukelman, M.ESc.,P.Eng., and Marty Deemter, P.Eng., CPHD

Wind is a powerful force of nature and when it's not correctly accounted for, it can lead to structural or enclosure failures that can cause damage and jeopardize the safety of a building's occupants. This article by Brian Breukelman, M.ESc.,P.Eng., founding principal of Motus Consult Ltd., and Marty Deemter, P.Eng., CPHD, founding principal, Motus Consult Ltd., will discuss the effect of wind loads on roofs and building exteriors, the considerations that need to be factored into a building's design (codes and standards, site-specific issues, material choices, etc.), and the measures that need to be taken to ensure structural and enclosure integrity.

Some recent experiences at Motus led us to believe that a review of how wind loads are determined for roofs and walls is timely. The code figures we use for developing the wind loads on a building are the result of many wind tunnel tests and the code writers had to summarize enormous amounts of data. Key aspects of wind loading such as spatial and time correlation (variation of the loads along a distance and over time) cannot be readily communicated and thus we do lose information in the data reduction. Use of some of the online tools that have been developed can also lead to incorrect or inappropriate conclusions.

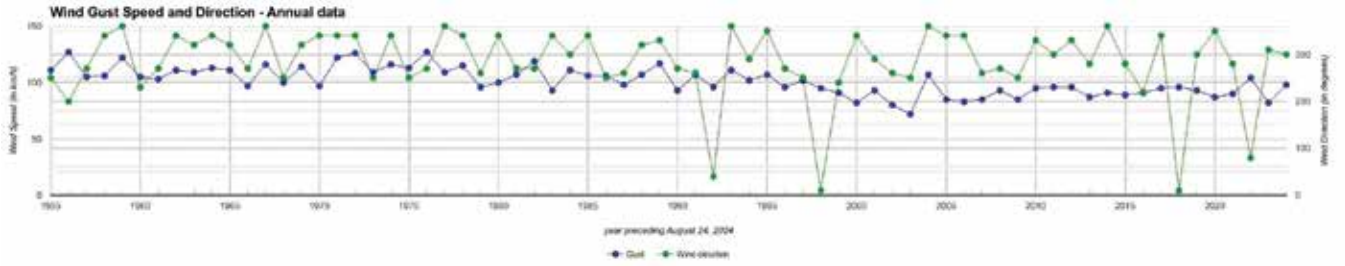
It may be helpful to review the Wind Loading Chain as first proposed by Alan Davenport, founder of the Boundary Layer Wind Tunnel Laboratory (BLWTL) in London, Ont. The links of the chain can be broadly described as climatic effects, exposure, shape, and gust factor(s).

The first component in understanding the wind is the climate of our building location – in most cases we are given the reference 10- and 50-year wind pressures for the location of our building, but there are scenarios which will require us to do some interpolation and even possibly determine the design wind pressure using recorded data from nearby anemometer locations. The directions that strong winds come from is an aspect that is not treated in detail in the Canadian code, however, many locations have very strong directional winds. In contrast to Canada, the U.S. codes have adopted 'Special Wind' regions which require practitioners to dig a little deeper into the wind behaviour in these locations.

Some jurisdictions have developed more granular wind pressures than those provided by the National Building Code of Canada (NBCC) – perhaps one day we may be able to get localized design wind pressures like we are now able to for seismic code data. Global weather simulations utilizing mesoscale modeling can be a tool in predicting wind speeds at remote locations. For simple buildings this is not economic, but for larger building or complex structures, these tools can provide valuable input in determining the climatic effects.

The next important aspect is to understand the impact of exposure on the wind loads. Simplifying the exposures to either open or rough as one might do with the online calculators removes the need for further interpretation. Designating all roofs with 'open' exposures due to a lack of understanding the impact that exposure has on the wind loads means that many roofs and buildings will be conservatively overdesigned and constructed, resulting in unnecessarily higher construction costs for owners. Effects

Figure 1: Annual Extreme Wind Speeds & Direction for Calgary



of topography and shielding also need to be considered as part of the exposure aspect of the wind loading chain. Buildings planned for locations with complex terrain may benefit from further investigation of the impact of the terrain on the directionality of the wind.

Figure 1 is a graph showing the recorded annual maximum wind speed and direction for Calgary, Alta. The green line indicates wind direction and the typical directions for strong winds in Calgary come from the west to north as the mechanism for these winds tends to be chinooks or otherwise known as down-slope winds. An extreme value statistical model can be readily developed to predict the combined probabilities of wind speed and direction. For some projects, utilizing this detailed information for the exposure can provide more accurate wind loading information.

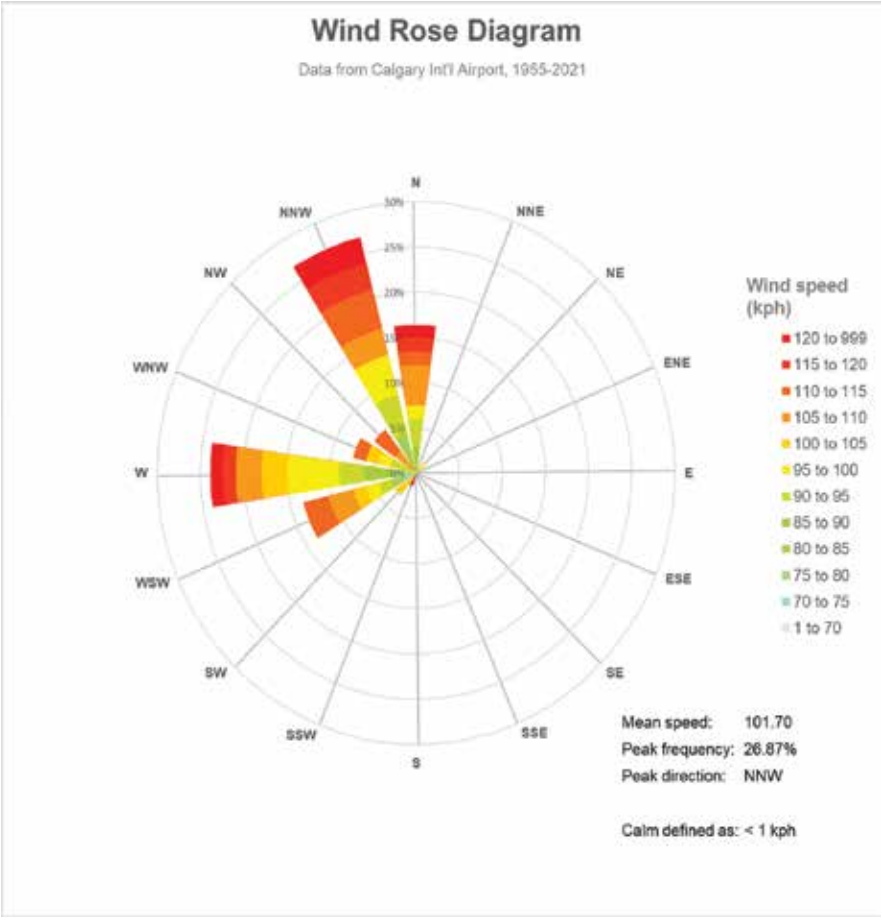


Figure 2: Wind Rose diagram for Calgary Airport (1955-2021).

The impact of the building shape (pressure coefficients) and gust factors on the wind loads are the next two components. The Canadian code presents these as a combined value (CpCg) but the pressure coefficient can be found by dividing the combined value by the appropriate gust factor. For most low buildings, we do not need to consider dynamic factors, and thus the gust factor (the effect of the peak wind loads) is normally 2.5 for components and cladding (which also applies to roofs) and 2.0 for overall structural loads.

For the design of all low-rise structures less than 20 metres in height, a single figure is given with tabulated coefficients for changes in roof slope and wind direction. Seven additional figures are presented for designing the secondary components (joists, girts, etc.) and cladding (roofing, siding, etc.). When we review the geometries of our buildings, they are far more varied than the code figure and thus it quickly becomes apparent that the basic code can be clumsy. For this reason, for more significant projects, wind tunnel testing of the building can be a powerful tool in getting improved wind loading information.

The impact of internal pressures

Photo 1 - Test setup at contractor's yard.

on the overall wind loading is often poorly understood. For instance, the online National Research Council (NRC) calculator requires an internal pressure in its analysis, but if the roof structure cannot transfer the pressure to the roofing membranes, it should be removed from roof wind load calculations. Another common issue is the belief that the peak pressures shown in the relevant zones are all simultaneously reached. The code provides an approach to deal with the lack of correlation of the wind loads over larger areas by the graphing CpCg versus the area under consideration.

Many practitioners also take the position that the code-derived wind loads represent 'truth' and using the code literally 'eliminates' the risk for failures due to action of the wind. This is an incorrect understanding and unless one has taken the most conservative approaches, there could still be risk that the real conditions that a building or roof may experience could be worse than predicted by code.

John Holmes, a globally respected wind engineer from Australia published some papers in 2008 and 2009, where the external wind pressure coefficients for a simple geometry building predicted by a range of global building codes were compared. The values predicted by the Canadian code are highlighted in yellow in Table 1. The coefficient of variation of the predicted wind loads ranges from 20 per cent to 30 per cent and some codes even show values in a different direction of design wind load.

Our codes provide a mechanism for coming up with wind loads that are different from the acceptable solutions outlined in the code. This approach is called an Alternate Solution. A series of functional statements and objectives related to various aspects of building safety and performance are provided. It is possible to work through those relevant to wind loading and demonstrate using physics, statistics, and good engineering judgement that the risks for selecting non-code compliant wind loads may be acceptable.

An example of using alternate solutions would be the use of wind tunnel test data for a building with a similar geometry to the one being designed. If the exposure impacts are properly accounted for, one can demonstrate that different peak pressure coefficients are appropriate

Photo 2 - Roof blown off at northwest corner of building.

Photo 3 - Underside of roof assembly showing parapet components which had been nailed to the CMU parapet.

even though they are different from the Acceptable Solutions as defined by the NBCC. These alternate solutions must be reviewed and approved by the relevant Authority Having Jurisdiction (AHJ).

Case studies

Commercial Building, Calgary

This commercial building located in Calgary was the subject of a commercial disagreement related to the anticipated performance of a new roofing installation. The concern was that the various layers of insulation and roofing were not properly bonded and subsequent ASTM E907 testing showed some variability in the bonding. Motus was retained to provide additional guidance to the owner to help resolve the issues.

A statistical investigation of strong winds (see wind speed and direction in Figure 1) was completed and demonstrated that only one corner of the building was at a small risk of roof failure. A wind rose of this investigation is shown in Figure 2. The building was generally oriented north to south and Motus recommended that a simple solution of adding ballast pavers in the northwest corner of the building would reduce the risk for the owner.

Roofing adhesion testing

In a similar vein, Motus was asked to review a proposed re-roof design using low-rise expansion foam adhesive to adhere Type II EPS insulation to a vapour barrier layer of 'flam-sand' SBS roofing. As this was not an approved manufacturer's 'system', and therefore not in compliance with the project specifications, the contractor was asked to prove NBCC compliance by the prime consultant. To assist with demonstrating that the roof would perform acceptably, Motus developed a test setup to test the installed conditions against those in the specification (Photo 1). If the wind uplift resistance of the as-built assembly could be proven to perform with a large margin of safety, the debate about the performance of the roof under the design wind load of 1.5kPa could be settled.

A load cell was employed to measure the uplift force for both test cases. The test force was converted to a pressure to compare with the design wind load. The as-built assembly and the control (roof constructed per the engineer's design and specification) both resisted pressures in excess of 4.5kPa. The test for the as-built assembly was continued to failure and the test structure of laminated plywood failed at almost 18kPa – the bonds between the various layers of the assembly successfully resisted these loads.

The roofing engineer subsequently accepted the as-built scenario upon witnessing the testing and reviewing the Motus test report.

Failure Case Study, Calgary, Alta.

We were asked to investigate a roof failure in southwest Calgary after a significant wind event. The winds were generally from the northwest and were noted to be approximately 60 to 90 kph. The roof peeled off the building as shown in Photos 2 and 3. The roof was described as a 'mop and flop' where layers are adhered using

hot asphalt. In this case, multiple factors contributed to the wind uplift of the roof, as follows:

- The parapet flashings were inadequately nailed down into the CMU parapet wall.
- The roof assembly was poorly adhered with asphalt.

The combination of conditions led to catastrophic failure and required the roof to be replaced fully to meet the requirements of the building insurer and property manager. In this situation, if the aforementioned weaknesses could have been identified ahead of a roof failure, the parapets could have been re-secured and the corners could have been ballasted with concrete pavers.

Parapets are often overlooked in their contribution to allowing air into the system, reducing any safety factors in a properly designed roof. Good design is no substitute for proper quality control during roof installation.

Conclusions

Too often, engineers rely too heavily on building code requirements and not on sound engineering principles. Most roof failures stem from poor detailing at the roof (parapet) edge, where wind is allowed to get under roof components, and forcing individual components apart rather than roofs being pulled apart by upward suction pressures. Taking care to adequately detail and review edge of roof components will have a much greater positive impact than simply specifying higher uplift pressures.

Risk due to wind loads can be mitigated by digging deeper into the code and developing a better understanding of the various parameters in the code. Taking the most conservative view of every parameter will reduce the risk of failure but can add significant costs. The goal should be to have an acceptable level of risk and thus the most cost-effective solution. Risk can also be reduced by physical testing, such as wind tunnel testing or material performance – when practical these can add significant information and answer underlying questions.

Brian Breukelman, M.ESc.,P.Eng. is a founding principal at Motus Consult with a focus on wind and vibration effects on structures. His career has led him around the globe dealing with vibration of some of the world's tallest buildings, evaluating heavy structures including headframes and underground structures, and designing many conventional buildings as well. As a principal at Motus he relishes on a technical challenge and is responsible for developing a team of highly engaged engineers and technologists. His portfolio spans a range of industry sectors, including transportation, commercial, residential, sports and recreation, industrial, and mining.

With over 30 years of industry experience, Breukelman is known for his client-centric focus, collaboration skills, and strong technical experience he brings to each project. He repeatedly demonstrates exemplary technical leadership which also allows him to bring innovative approaches to projects.

Marty Deemter, P.Eng., CPHD is a founding principal at Motus Consult with a focus on building envelope rehabilitation and structural restoration consulting projects. He started his professional career as a journeyman carpenter and small-business contracting company owner, working on residential and commercial construction projects in both new construction and restoration projects. After a decade in construction he completed his civil engineering degree. Now, Deemter combines his construction experience with engineering knowledge to provide evaluation, restoration, design development, and construction administration/field services for roofing, building envelope, and secondary structural elements of new and existing buildings.

Deemter is most passionate about buildings and people. He strives to help owners get the best out of their buildings, whether they are historic, brand new, or anywhere in between, while also taking great care to grow great relationships that underpin long-term successful business growth and long-term client satisfaction. He has successfully delivered hundreds of building envelope rehabilitation and structural restoration consulting projects of all sizes and uses, from early concept and design phases through to delivery. ■

PROLONGING THE LIFE OF YOUR ROOFING SYSTEM

By Stephen Epp

Stephen Epp is a project engineer with the RJC Engineers Building Science and Restoration Group. He has been with RJC for 11 years and enjoys the variety of challenges in this industry. Epp has a beautiful wife, two daughters, and a dog that delightfully fill up all his free time outside the office.

Imagine your roofing system as a multi-layered cake can be a helpful way to understand its components.

With proper installation and regular maintenance, flat commercial roofs tend to have a typical life expectancy of approximately 20 to 25 years in the Canadian climate.

Roofing systems make up the top covering of a building, providing shelter and protection against rain, snow, sunlight, fluctuating temperatures, and other adverse conditions. In other words, the roof is an integral part of the building envelope and shouldn't be neglected.

Given that most roofs aren't built to endure decades upon decades of exposure to the elements, there comes a time in every building's lifespan when the roof—or components of the roof—need to be replaced. As I tell my clients, imagining your roofing system as a multi-layered cake can be a helpful way to understand its components.

Cake is a universally understood dessert that can have just as many different options as a conventionally insulated commercial roof system, and the layers correlate nicely. Think of the icing on top of the cake as the waterproofing membrane, and the top crust of the baked cake as the overlay sheathing to support that membrane layer. On the inside, the moist layers of cake are your insulation layers.

Continuing further down, I like to compare the bottom crust of the cake to the air vapour barrier and the plate the cake sits on to the structural deck. Not only does it create a nice, relatable image of an otherwise complicated system, seeing the roof like a multi-layered cake also helps illustrate the point that building owners don't always need to replace the entire system when undergoing a replacement project.

With the right conditions, it is possible to replace just the icing and leave the rest of the delicious cake all the way down to the plate. This prolongs the life of the components that are still functioning optimally, potentially saving your team considerable time and money.

Skinning vs. full replacement

With proper installation and regular maintenance, flat commercial roofs

tend to have a typical life expectancy of approximately 20 to 25 years in the Canadian climate. When the time comes for a life-cycle replacement project, I advise proactive building owners to consider whether the roof has been performing as it should.

If the roof is generally aging, but still functioning as intended with no major leak events or concerns, your team could consider an approach referred to as skinning. This approach includes removing and replacing just the waterproofing component of the roof, leaving the insulation layers and the air vapour barrier intact. So, when using our layers of cake analogy, skinning would replace just the icing and the top crust, leaving the bulk of the delicious cake as it was.

Skinning can save substantially on demolition costs, labour costs, and on new material costs for replacing the entire assembly. While each skinning project is unique, owners could anticipate up to 20 to 25 years of additional performance from their existing roofs depending on the circumstances. That said, skinning should only be considered if the underlying layers of the cake are in good condition and fully adhered to the existing structure, which also must be in good condition. When eating cake, you normally consider the type of plate holding it. If a heavy cheesecake is placed on a flimsy paper plate, you could have issues. If an ice cream cake sits on a paper plate too long, the plate can get mushy. The structural deck must be able to support both wind uplift loads, the weight of the roof itself, and loading from rain or snow. There is also the opportunity to add insulation for increased thermal performance, or a tapered insulation package to improve drainage. Insulation may even be added on top of the existing system, then a new waterproofing membrane installed.

The key is to ensure the existing roof is in good condition, not saturated, and fully adhered to a solid structural deck below. The air vapour barrier and insulation will remain in place, and it may act as the substrate for your new roof system.

Testing your roof's condition

To determine a roof's condition and adhesion, a series of exploratory openings and wind uplift tests may be conducted. If there are isolated areas of saturated materials, these can be replaced on a case-by-case basis.

If the roof is not fully adhered to the deck below, owners may consider applying mechanical fasteners through the existing system before the new roof system is installed. One of the biggest indicators that a roof may not reach its intended service life is drainage. An insufficient number of drains forces water to travel a long distance before it reaches a drain, increasing the chances of ponding water. Meanwhile, a lack of slope at the membrane level can also lead to water ponding on the membrane. Membranes are not typically intended to remain submerged for extended periods of time and seams in the membrane can prematurely fail through exposure to repeated freeze-thaw cycles of the water ponding on top of it.

In any roof replacement project, owners should review the number of drains, how far the water needs to travel, the slope of the deck, and if there are any major obstructions in the flow path.

The number of mechanical units and roof-mounted equipment is also a good predictor of service life. Roofs with a lot of equipment typically equates to many visits by maintenance workers.

Of course, traffic on the roof increases the risk of material being dragged across the roof, or sharp tools being dropped, or even workers inadvertently dragging their feet across the roof leading to punctures, scrapes, gouges, or granule loss. While roof membranes are designed to accommodate this type of activity, small incidents can become big problems over time. Owners may want to consider increasing the membrane thickness or adding sacrificial walkways around units where the highest traffic is expected.

There are many nuances when it comes to roof maintenance and replacement. As building operators know, each property is unique and comes with its own set of challenges. Having a third-party perspective from a roof consultant is always recommended before entering into a costly project. For more information on preserving the life of your commercial roof or for cake recommendations, visit RJC.ca or contact myself at sepp@rjc.ca. ■

INDEX TO ADVERTISERS

How's your relationship with your contractor?

We're one you can trust.

EPIC
ROOFING & EXTERIORS
COMMERCIAL

Flat Roofing | Building Envelope Restoration | Metals | Service