BUILDING SCIENCE perspective

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INAUGURAL ISSUE

MACKIMMIE COMPLEX REDEVELOPMENT PROJECT: Double-skin façade, LEED platinum sets it apart

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Study and socialize at the Singhmar Centre for Learning

Performance Pandemonium: Designing and modifying the ETFE Skylight System for the Calgary Zoo's Panda Passage Exhibit

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Amir Hassan
President, ABEC (North)

Message from the ABEC North President

In 1984, a group of building envelope trailblazers incorporated the Alberta Building Envelope Council (ABEC) as a non-profit organization in Edmonton, Alberta. There was a need for an organization to muster the limited knowledge of a growing field. Although ABEC faded, Alberta Building Envelope Council South (ABECS) survived and thrived. The need has increased since as technologically advanced building envelope systems have been introduced accompanied by a higher demand for better performing buildings under stricter energy codes. Therefore, Alberta Building Envelope Council North (ABECN) was incorporated in 2018 in the same city to carry the torch. Collaborating with our neighbour to the south, ABECS in Calgary, was seamless since we share the same passion and are looking ahead for the same targets: efficient, durable, and better performing buildings.

ABECN is a non-profit society dedicated to encouraging the pursuit of excellence in the design, construction, and performance of building enclosures and to advancing educational and technical standards within the building envelope industry. This council is open to anyone who's interested in this evolving field. We need to hear from all professionals: Architects, engineers, façade consultants, system manufacturers, building managers, contractors, insurers and even lawyers. We can all learn from each other.

We are always trying to educate the construction community and public in general about the importance of building science by offering monthly technical presentations. Another way to share the wealth of knowledge and experience is through your new magazine *Building Science Perspective*. An amazing team of dedicated building scientists used their time and passion to produce a rich medium filled with technical articles in a continuing publication. You can find our members on our website for any questions or comments at www.ABECNorth.org, and follow us on ABECN LinkedIn page. Happy reading!

Amir Hassan, M.Sc., P.E., P.Eng.
President, Alberta Building Envelope Council (North)

Fred Edwards
President, ABEC (South)

Message from the ABEC South President

It is my distinct pleasure to welcome our readers in this inaugural issue of the *Building Science Perspective* magazine, a joint publication between ABEC North and South. Established in 1982 and incorporated as a volunteer-based not-for-profit organization in 1989, ABEC South has produced a variety of technical literature pertaining to building envelope construction in Alberta over the years. Published technical literature from ABEC South has been on somewhat of a hiatus while we focused on regular, in-person monthly technical sessions and annual courses. Those sessions will continue (when allowed under provincial health restrictions), and this publication is intended to enhance the educational opportunities we offer to our members and the general public.

While ABEC South operates predominantly in southern Alberta, it is important that this magazine is not focused on one market. We have embarked on this journey in partnership with ABEC North and hope to include content from across Western Canada as this magazine evolves. Revenue generated through advertising in this magazine will be used to cover costs, and any profit generated will be distributed evenly between ABEC South and North to assist with delivering educational resources to our members and the industry as a whole.

ABEC was established with one stated goal that has remained consistent through the years: to promote the education of building science and enhance the industry's understanding as to the function of the building envelope. We hope that this publication serves that goal. Thanks for reading and we welcome your comments.

Fred Edwards, P. Eng.
President, Alberta Building Envelope Council (South)

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North Board of Directors

ABEC North Event Calendar

May 19 – **Topic to be announced**.

ABEC North live event
Every third Wednesday of each month – https://www.abecnorth.org/

Do you have a story for

BUILDING SCIENCE **perspective**?

Please send your ideas to info@abecnorth.org or registrations@abecsouth.org

South Board of Directors

ABEC South Event Calendar

Luncheons and Golf

Lunch meetings will resume in September. We will update members regarding the June golf tournament in May.

Other education and events

The following events are posted for our members' interest:

Ontario Building Envelope Council – https://www.obec.on.ca/events/upcoming-events

IIBEC (Canadian Prairies Chapter) – https://canadianprairies.iibec.org/events/warm-vs-cold-parapets/

Calgary Construction Association – https://cgyca.com/events/upcoming-events/

CSC Conference, Saskatoon, May 26th – https://csc-dcc.ca/Conferences/schedule

Manufacturers – lots of online learning opportunities on most of the manufacturers' websites

Seminar Planning

The education committee is planning for an autumn day-long seminar. We ask our members for their input on topics of interest. Please email registrations@abecsouth.org with the subject line "Seminar".

THE CALM BEFORE THE STORM

By Brian Shedden, BSS®, Principal, Entuitive

I must admit that there was a time when I thought that "global warming" sounded like a pretty good thing. After all, this is Canada. As I sit in Edmonton today to write this article, with a windchill of -25° Celcius, I think that most folks could empathize with a desire for a little more warmth.

Alas, about 15 years ago, we began to morph from global warming to the more accurate definition of "climate change", and then everything changed. The effects of the warming of the planet began to manifest itself in rising sea levels, disappearing sea ice, more severe storms, increased flooding, wildfires and general mayhem, all of which threatened the built environment which humans have continued to build from time immemorial.

As you are reading the inaugural issue of ABEC's new magazine, let's turn our attention to what brings us together: the building envelope.

As we have seen in Alberta over the past few years, tremendous hail storms and wildfires have had the biggest impact on our buildings and their envelopes. We have seen entire communities in Northeast Calgary have their vinyl siding shredded in violent hail storms and in Fort McMurray, the wildfires swept through entire neighbourhoods in 2017 and the rebuilding is still not complete. In both of these cases, I would argue that the lack of robust building envelope assemblies is in part responsible for the extent of the damages.

The protection that a 24-inch deep soffit used to provide to our walls is gone in favour of a "sleeker" look. Vinyl siding, the use of which has really hit what I would term "peak vinyl", has provided our walls with protection against rain, but not high winds or hail. The use of materials which provide no protection against fire have proliferated to the point where frankly, the first two of the Three Little Pigs had structures that were as robust as we construct now.

It's April in Alberta. It's the calm before the storm period. Over the next two to three months, our structures will be subjected to ever increasingly intense storms and what are we, as building science practitioners, going to do about it?

I have a few ideas:

1. Friends should not let friends clad their structures with vinyl siding. When light reflected from an adjacent window can melt it, don't use it.
2. Soffits not only provide protection to walls, but they are also great for venting the attic spaces. Where is the soffit in your design?
3. Engage your clients in undertaking preventative roof maintenance and check their roofs twice per year and let's challenge the roofing manufacturers to provide options that are more robust than single ply membranes.
4. Think about fire. How combustible is the material you are designing with?
5. Think about impact. This could be from things as simple as landscaping maintenance or flying debris. Check out Dade County's requirements for impact damage if you want to get ahead of the curve here. They know

As you are reading the inaugural issue of ABEC's new magazine, let's turn our attention to what brings us together: the building envelope.

a thing or two about hurricanes and high winds.

6. Think about embodied carbon. After all, that is one of the reasons we have the mess we are now facing. Which materials will lessen the impact on the environment?
7. Think about glass. If the outer lite of the glazing you are designing is not tempered or laminated, ask yourself why?

I know, the age old saying that "we don't have the budget" is usually the reason we end up with structures that do not perform well. So, start looking at the life-cycle costs, look at the carbon costs, look at the maintenance costs and be ready to discuss all of this with your clients. After all, our role in this industry is to move it forward, employing science in service of our goals.

Use this period of time before the next big storm hits to really consider what you as a designer can do to mitigate its effects. It's a challenge that I know we are up for and I look forward to seeing what we can collectively achieve here in Alberta.

Brian Shedden, BSS®
Principal, Entuitive


MACKIMMIE COMPLEX REDEVELOPMENT PROJECT: Double-skin façade, LEED Platinum sets it apart

By Cindy Chan

The MacKimmie Complex and Professional Faculties Building Redevelopment Project straddles the line between new construction and renovation, which involves the redevelopment of the MacKimmie Library consisting of two building components, a tower and an attached block building.

According to John Souleles, partner at Dialog and project architect, the project is an adaptive reuse and new academic building in the heart of the University of Calgary campus. The existing library tower, built in 1968, has been repurposed into a new office tower, and the new block and link, a four-storey low-lying building, will house classrooms and student services. The Hunter Hub for Entrepreneurial Thinking, an interdisciplinary nucleus for activities that will support entrepreneurial student experiences, is located on the fourth floor of the block and link building. Souleles says the tower was initially 13 storeys but was extended to 15 storeys.

"We removed the existing precast concrete façade, interiors services, bringing it to a bare structure," Beau

Brown, senior project manager for Stuart Olson Construction, says. "We then installed a double-skin glazed façade, all mechanical and electrical services and interior finishes."

"Enveloping the tower in a double-skin system makes it one of the most energy efficient-buildings in Canada," Boris Dragicevic, associate vice-president of facilities development for the University of Calgary, says.

"This redevelopment involves a deep retrofit to the tower; retaining the structure dramatically reduced the amount of demolition waste and decreased the embodied carbon for the project," Adam Stoker, sustainability consultant for University of Calgary, says. "The block and link portion is undergoing a larger change; the old building was demolished and a new building designed to accommodate the new function is being constructed in its place."

Construction on the 35,800-square-metre project began in 2018, slated to be complete by 2022. The tower is now complete, and the block and link are currently under construction, says Souleles. A facility assessment report was done that year to assess the feasibility of using the maximum amount of existing structure and materials possible. While they weren't able to salvage the block and link, they were able to salvage the majority of the tower.

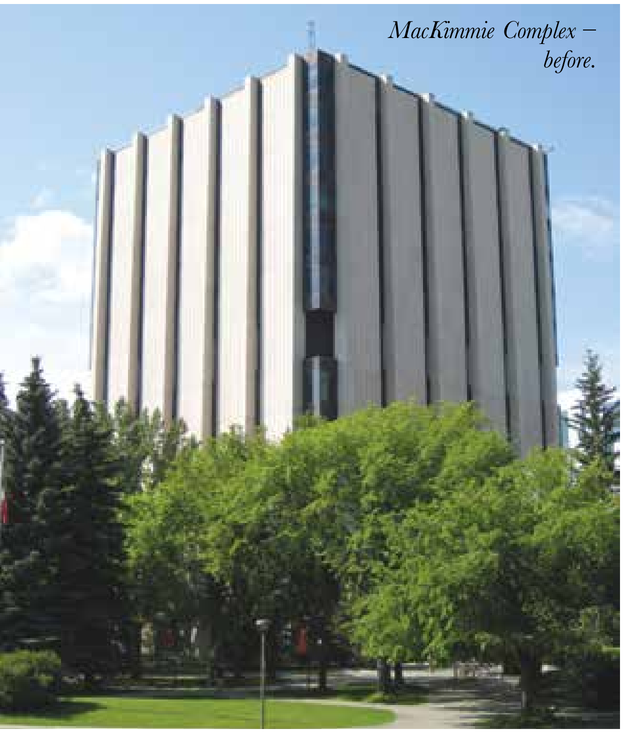
"It used to be the University Library. They vacated the library from that tower, leaving it mostly empty," Souleles explains. "We added the low-lying academic building to have a larger classroom space and to house the registrar, which is currently sitting in a temporary location. Once we finish the block and link, they'll move there."

This is not a typical construction project for the University of Calgary. In the midst of the construction, they are also striving for a highly aggressive green building strategy for the campus. The project is currently tracking LEED Platinum for Building Design and Construction and is a net-zero carbon building. Early in the project, MacKimmie participated in the Canada Green Building Council's Zero Carbon Building Pilot Program, achieving design certification as a net-zero project. Souleles says they are currently working through the completion of the project to receive final certification.

Stoker says the University of Calgary issued its initial climate action plan in 2010, which was renewed in 2019. When the Canadian Green Building Council put a call out for projects to pilot the zero-carbon building standard, Stoker says it aligned with their goals.

"Each building constructed today needs to be built with the future in mind and this includes minimizing greenhouse gas emissions," he says.

The double-skin façade on both the tower and block building will continuously respond to weather changes daily, and will adapt through each season, requiring less energy to keep building occupants comfortable.



MacKimmie Complex – before.

According to the University of Calgary website (ucalgary.ca), through a "combination of automated windows and blinds, the skin of the building will facilitate natural ventilation and passive heating and cooling." Its outer façade will work in concert with the mechanical system to decrease energy consumption and improve the indoor environment in terms of thermal comfort, day lighting and air quality.

"The decision to get a double-skin façade was made early in the project through an analysis with our climate engineers, Transsolar, out of Germany," Souleles says, adding that double-skin façade was important to the university because access to ventilation and natural lighting was basically unheard of in towers. "We're heating up the building when we want, and flushing the building through natural ventilation when we want to give the building a head-start in terms of heating and cooling for the following conditions and day."

Christian Oberdorf, project manager and engineer at Transsolar, knows that the weather in Calgary can get extremely cold in the winter but is also often sunny at the same time. "We make use of the abundance of sun in the winter," he says. "You can use the sun to passively heat the space."

"The double-skin façade ultimately acts as a blanket around the building," Brown says. "We have a fully automated and dynamic vent system through both the interior and exterior façade that is assessing all of the climate conditions relevant to its operation."

The system monitors sun position, temperature, wind, rain and other elements, modulating those vents to maintain a comfortable and desired temperature in that space, which also reduces demand on its mechanical and electrical systems for operation on the building.

"Rather than relying solely on those conventional means, the university will instead benefit from the passive capabilities and energy contributions of the building itself," Brown says.

The building management system (BMS) controls the double-skin façade, allowing them to take a building that had an energy use intensity (EUI) of 500 kWh/(m² yr) to almost an eighth of that. This, plus the connection to the university's district energy system, allowed the tower to reach a target of 65 to 70 kWh/(m² yr) EUI.

"The vent windows are integrated with the BMS system to assist with heating and cooling of the building," Anton Vlooswyk, principal at Building Envelope Engineering Inc., says, adding air and water tightness of the vent windows is critical to the system performance, so the vent design was tested at a research lab prior to assembly for the project. This was particularly challenging for the back sloping vents.

Vlooswyk adds the exterior curtain wall provides the primary air tightness, water tightness, and thermal resistance for the assembly in this design. High-performance triple-glazed insulating glass units were used to provide enhanced thermal resistance. A complex sample of the curtain wall construction was tested at a U.S. lab to confirm performance and allow for "fine-tuning" of the design prior to fabrication for the project. The performance mock-up tests included stringent requirements for air tightness, water tightness, structural wind loads, movement between floors and thermal performance, which are all critical for Calgary's harsh environmental conditions. The interior wall was constructed using a unitized window wall system, which also incorporates a number of operable vent windows. A walkway is provided between the interior and exterior glazing systems to allow for glass cleaning and maintenance. The glazing design for the block and link also incorporates a double-skin façade; however, the functions of the inner and exterior façades are reversed from the tower.

Since the project has achieved zero-carbon status based on its design, the next milestone is the operation. Once construction is complete, the university would like to prove the theory that comes with the model and demonstrate that they can walk the walk.

"We are looking forward to showcasing what is possible," Stoker says. ■

PERFORMANCE PANDEMONIUM:

Designing and modifying the ETFE skylight system for the Calgary Zoo's Panda Passage Exhibit

By Jelena Bojanic, BSc, P. Eng, Project Engineer, Read Jones Christoffersen Ltd.

The panda exhibit ETFE skylight at the Calgary Zoo.

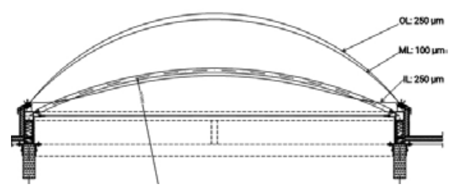


Figure 1: Section through ETFE skylight showing thickness of individual layers. (Image imported from ETFE manufacturer's shop drawings[1].)

The former Eurasian Gateway & Elephant Crossing at the Calgary Zoo has been re-used and re-adapted multiple times since 1963 to house animals including elephants, giraffes and the more recent rhinos and komodo dragons. In 2015, the Calgary Zoo announced that the giant pandas are being transferred from Toronto in 2018 to be housed in the former Eurasian Gateway building at the Calgary Zoo. The well-being of the pandas was predicated on creating a habitat in which the animals would thrive. The Calgary Zoo, along with the support of the project design team, decided to install two new ethylene tetrafluoroethylene (ETFE) skylights above the panda exhibit. ETFE is a highly transparent material over a wide spectrum of natural light providing better conditions for the pandas.

Read Jones Christoffersen (RJC) provided technical support for design considerations including snow and wind design loads, hail impact, temperature fluctuations and recommendations to address inherent air barrier deficiencies and thermal bridging. Support was also provided during the installation to ensure the intended design parameters were achieved and that performance aligned with current industry standards. The ETFE skylights were designed and manufactured in Germany and installed by a local contractor. These are some of the first ETFE installations in Western Canada.

Background

ETFE was proposed for this project because the material is one of the few tensile fabrics used for roofs that allow UV light to pass through and complies with the living building challenge "Red List" material restrictions. Other important considerations for choosing this product included cost, future recyclability, embodied energy, durability, chemical resistance, etc. RJC's Calgary office, along with a few other offices (Edmonton, Toronto, and Vancouver), worked together to research a product that incorporated key design objectives and that was within the client's budget.

Originally invented for the aeronautics industry, ETFE was introduced to the construction industry in 1980s and has since been utilized on projects around the world. It is a lightweight material, weighs approximately one per cent of glass and allows up to 95 per cent of light transmission. The latter can be adjusted by varying the number of cushions and applying films. Thermal performance is higher in a three-layer ETFE system versus a single-layer system. To incorporate the new dome-shaped ETFE skylights above the panda exhibit, the existing glulam beam supported metal roof deck underwent structural and building envelope modifications.

Design considerations

There were several design considerations the team had to take into account while working on this project, from cushion design and the supporting structure to the air barrier and drainage, and to thermal performance.

Cushion design and supporting structure

For the ETFE skylight to resist specified snow and wind loads, and hail impact, design was focused on the individual foil thickness, number of layers and internal cushion pressure. The cushions are inflated with a built-in blower/compressor that maintains air between the individual layers and pre-stresses each layer resulting in a dome shaped skylight that is stable against wind and snow loads1. The skylight manufacturer used RJC's recommendations for snow and wind loads, and Calgary's temperature fluctuations to ensure conformity with the local standards. RJC posed the question regarding hail impact damage testing for the ETFE. The manufacturer provided a paper with test results from experiments conducted in Zurich, Switzerland. It also highlighted case studies with hail damage. The results showed that the ETFE can, indeed, be damaged by hail, dependent on the size of individual hail pieces and temperature of the film itself[2]. The extent of damage varies from dimpling of the surface to full puncture[2]. Given that Calgary experiences severe hail storms during spring and summer months, with hail pieces 25 millimetres to 50 millimetres in size, this was an imperative design load to consider. The solution was incorporating a three-layer system with a slightly under-inflated outer cushion. The inner and outer layers (IL, OL) are each 250µm thick, while the middle layer (ML) is 100µm thick, as shown in Figure 1.

The two cushions are inflated to different internal pressures, with the inner cushion at 300Pa, and the outer at 250Pa[1]. The translucency of the ETFE foil was reduced slightly, with a three layered system; however, the resultant light transmittance was approximately 76 per cent[3], which was within acceptable range for the panda exhibit. The inner ETFE layer is supported by steel pipe arches that are fastened to steel perimeter beams made of square tube sections. The beams are further supported by steel columns also made of square sections. Tension rods are incorporated throughout the frames to mitigate deflection of the structure.

Air barrier and drainage

The air barrier plane for the ETFE system relies on multiple components, including the ETFE foil, the ethylene propylene diene monomer (EPDM) edge gasket, the EPDM cover gasket and the air barrier membrane tied from the aluminum profile to the existing roof deck. The manufacturer's shop drawings had inherent air barrier and drainage flaws. The design showed a condensation gutter that drained externally through the air barrier membrane (Figure 2, part 23) via four drain pipes, two on each of the east and west elevations, and none on the south and north elevations. The drain pipes were positioned at quarter points with a large spacing. A metal sheet section was shown to extend from the underside of the aluminum profile to the exterior sill (Figure 2, part 41) creating thermal bridging within the assembly.

Calgary experiences significant temperature fluctuations and extreme cold weather conditions with a winter design temperature of -32° Celcius[4]. Openings to the exterior would introduce cold air into the system, resulting in higher levels of condensation and freezing of any moisture in the system. Ice build-up inside the system could block the intended drainage path and damage connections along the gutter. Typical metal skylights glazed with sealed units

Table 1: Parts reference for Figures 2 and 3.

PART NO.	PART NAME
1	Aluminum cover profile
2	EPDM edge gasket
4	Aluminum frame profile
5	Condensation gutter
7	EPDM cover gasket
9, 10, 11, 12	Stainless steel hex head bolt, washer, nut
22	Metal sill flashing
23	Condensation drain pipe
24, 25, 26	Outer, middle and inner layer of ETFE foil
29	Air barrier
41	Metal sheet

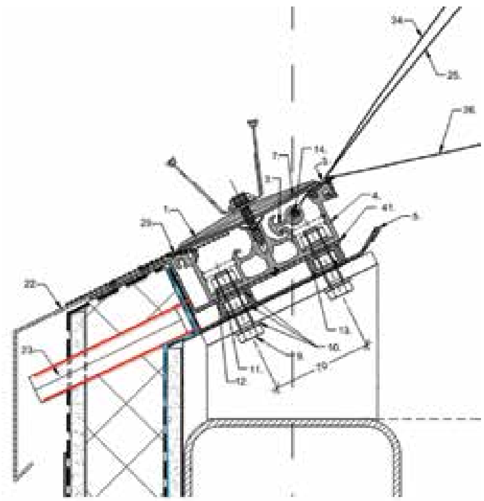


Figure 2: Section through the ETFE system with external drainage (red line) through air barrier (blue line). (Image imported from ETFE manufacturer's shop drawings[1].)

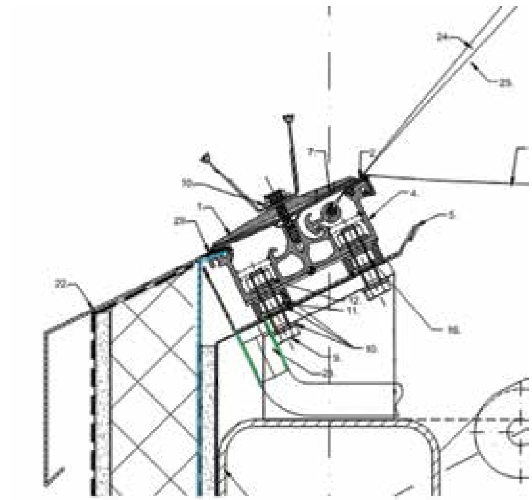


Figure 3: Revised ETFE system with internal drainage (green line) and air barrier detail (blue line). (Imported from ETFE manufacturer's shop drawings[1].)

incorporate pressure equalization and internal drainage without impacting the air barrier or resulting in thermal bridging. RJC suggested that the above items be revised as they were not acceptable per industry standards. The proposed spacing between drain pipes was likely inadequate for water to access and expel out of the system and should be revised. The sill should be water and air-tight, with no unsealed openings through the air barrier. We suggested providing internal drainage if draining to the exterior was not a possibility without affecting the air barrier. The metal sheet (Figure 2, part 41) was to be modified to eliminate the thermal bridge through the skylight sill.

The manufacturer revised their design following most of RJC's recommendations. Internal drainage was provided through the condensation gutter and directed to the interior panda space. The layout of the drain pipes was not changed during design revisions. Thermal bridging was mitigated by removing the metal sheet section intended to provide support for the roof membrane tie-in. The final design included tying the air barrier into the aluminum profile, creating a continuous air barrier plane. Figure 3 shows the revised section of the system.

Thermal performance

The thermal transmittance (U-Value) for the ETFE aluminum profile was calculated to be 5.90 W/m2K, 1.9 W/m2K for the three-layered ETFE cushion, and 2.1 W/m2K for the combined system3. These values were calculated by the manufacturer using set temperature parameters of 20˚C for interior and -10˚C for exterior3. Condensation is expected along the EPDM edge gasket and along the aluminum base. Realistically we expect a higher volume of condensation as Calgary temperatures can reach -32˚C4 during winter. This moisture is intended to drain via condensation gutter underneath the aluminum profile and expel from the system via drain pipes.

To address air and water tightness concerns ahead of time, RJC asked for a small corner sample of the aluminum profile that would show the corner joinery and frame sealing. Unfortunately, the corner sample was not provided, rather a small typical section of the frame arrived that did not show either items. RJC was told that the EPDM cover gasket would be glued at the corners with an EPDM adhesive, and the aluminum frame would not be sealed at the corners. Water that gets through the frame would be captured within the condensation gutter and drained to the interior.

Construction

In the construction industry, it is often expected that as-built details won't always align with the initial design. This is tolerated to a degree, because one cannot predict the exact site conditions during construction. Identifying and correcting these deficiencies during early construction stages is crucial for a project to be on schedule and to avoid additional costs. During installation deficiencies with the skylight frame and ETFE

Far right: ETFE skylight above panda exhibit being inflated with a blower.

Right: Steel frame structure for ETFE skylight with steel arches, beams, columns and tensioning rods.

cushions were noted. One of the first obvious issues was the inadequate gap at the mitered corners. The aluminum profiles were misaligned such that the coupling surfaces at the corners were offset from one another. The misalignment was partially due to the aluminum profile not being set true and level. The structural steel below the aluminum profile was not perfectly level, and the aluminum profile did not incorporate adjustability (i.e. levelling nuts or incremental shims). The suggested improvement was for the contractor to adjust the positioning of the aluminum frame by using adjustable levelling bolts/nuts, see parts 9, 10 and 12 in Figures 2 and 3.

During a subsequent review, standing water was visible in the skylight gutter after a rainfall. This was prior to the ETFE foil being installed. As suspected, water was not draining properly; the system did not incorporate a transitional slope from the north and south elevations (without drain openings), nor to the east and west elevations (with drain openings). The drain layout was not practical for the perimeter of the skylights. Water was actively dripping through the condensation gutter corners and at the bolted connections, indicating that the membrane liner was not continuously sealed in these

Most of the flaws identified during the initial design and construction were corrected during each phase by being proactive with our input and discussions with the manufacturer and contractor.

locations. The repair strategy included installing additional drain openings on the north and south elevations and additional sealing of the corners and at the bolted connections.

Once the ETFE cushions were attached to the aluminum profile they were inflated with the blower. Each skylight was inflated in approximately one hour, with minor adjustments required for the EPDM edge gaskets, which were displaced during ETFE install.

The contractor used ETFE tape as additional reinforcing at the corners. The air barrier membrane was tied in from the roof deck, onto the new built-up curb, and tied into the aluminum profile. In addition to the air barrier membrane, the contractor tied the thermoplastic polyolefin (TPO) single ply roofing membrane into to the aluminum profile, increasing the overall material thickness. This created problems for installing the EPDM cover gasket and cover plate. The solution was to terminate the TPO membrane at the top of the curb, instead of extending it onto the aluminum profile to allow for sufficient and continuous pressure between the gasket and the air barrier.

The metal sill flashing was installed without a slope, resulting in standing water along the sill and EPDM gasket. The flashing was modified to ensure it slopes away from the cushions and the main gasket. The EPDM cover gasket was glued at the corners and reinforced with an additional EPDM strip using an EPDM adhesive to reduce the risk of moisture ingress.

Field diagnostic testing such as air leakage characterization and water penetration resistance could not be completed because of the project schedule restraints that impeded safe access for testing. RJC recommended thermographic scanning from the exterior once the building was commissioned to normal interior operating parameters.

Closure

Most of the flaws identified during the initial design and construction were corrected during each phase by being proactive with our input and discussions with the manufacturer and contractor. As the building envelope consultants, the goal was to ensure the design and installation of the ETFE skylights conformed to industry standards, with the aim of improving the long-term durability of the ETFE skylights and its supporting structure, and eliminate air/moisture barrier deficiencies. By providing recommendations for design loads, air barrier and drainage components and consistent input during construction this goal was achieved. The key benefit of the building envelope consulting services provided by RJC was the team's local knowledge of practical issues that affect building envelopes in Calgary and the ability to bring these to the forefront, assisting the sophisticated ETFE manufacturer from Germany.

Considering that this is not a typical product installed by the construction industry in western Canada, several issues were anticipated during design and construction. As this system installation becomes more mainstream in the future these issues will likely diminish as designers and installers become more familiar with the product.

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About

Jelena Bojanic, BSc, P. Eng., is a building envelope and restoration project engineer at Read Jones Christoffersen. She graduated from University of Calgary as a civil engineer. Since joining Read Jones Christoffersen in 2014, Jelena gained a wide variety of project experience in the assessment and restoration of structures and building envelopes. Her range of services include assessment and rehabilitation of structural elements, building envelopes including roofs, fall protection and heritage buildings. ■


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APRIL SHOWERS BRING MAY (AND SPRING) BUILDING LEAKS

Springtime brings with it many idyllic visuals – buds on trees, flowers blooming, and staining at balcony corners. Wait… what?!

By Heather Elliot, P.Eng., LEED® Green Associate, Associate, Entuitive

Yes, stains are a treasure map when it comes to building inspection, leading us to potential sources of moisture management and drainage issues! One of the best times of year to perform a visual inspection of the exterior systems at condominium properties is when the spring rains begin. This is time to check for signs of potential weak points in the building envelope and assess overall moisture management.

This article will share the causes of leaks, the effects of leaks and what you can do about them.

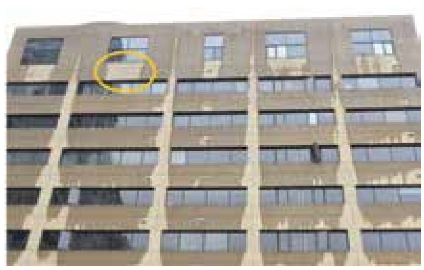
Causes of leaks

Leaks are most often caused by:

- roofing, cladding, and sealant failures;
- voids in water resistive barriers, damp-proofing, and waterproofing;
- defective flashings and drainage methods.

The first two items may relate to aging of assemblies, but can also become a factor if poor quality materials or detailing were used in the original construction. The third item is something that can often become apparent immediately following a large rain.

A review of your building exterior can showcase staining and areas of repeated wetting, especially if done at this time of year. The effects can often be obvious. Take the image below – can you tell which band of windows has flashing at the base? Flashing is generally prefinished metal extended beyond the face of cladding and bent out with a drip edge to help force water to drip off before wetting cladding below.



In this case, one row of windows at the top floor has sill flashing with a drip edge (one typical window highlighted), and you can see how it is more effectively directing water away from the wall compared to lower level windows where cladding is wet below.

Other areas that exist on a variety of condominium buildings and where staining is often first noticed include:

- balcony and window corners, where water can be directed against the adjacent wall instead of out and over the leading edge of the balcony or windowsill;
- areas where roof gables intersect with other assemblies such as chimneys and walls, but no flashing is provided to direct water away; and
- below ends of eavestroughs where they are installed tight against adjacent walls or where the gutter repeatedly overflows.

Effects of leaks

Repeated wetting that does not get the chance to dry out between rains can cause accelerated deterioration of finishes and eventually, damages to underlying elements. The effects of poor moisture management may extend all the way through the building. Although elements closest to the exterior are likely to be the most affected, water also tends to follow the pathways open to it, sometimes finding its way deep into the structure. A question to ask if significant signs of moisture staining are noted is "are the interior materials resilient enough to withstand intruding moisture, or will they be damaged?"

Moisture-related damage can be minimized if the more obvious signs are addressed proactively. By focusing on potential weak points and addressing aging systems through repairs and replacements, it is likely that the interior elements will never be exposed to water.

In wood frame construction, if temperatures are right, deterioration can begin as soon as materials become wetted. The longer water ingress goes unaddressed, the larger the overall cost and disruption will become when repairs are completed.

Intruding moisture can also create problems with indoor air quality. Moisture can combine with organic material in wood and facers used in building products, such as framing and drywall, to create a breeding ground for rot and mould.

What you can do about them

Moisture-related damage can be minimized if the more obvious signs are addressed proactively. By focusing on potential weak points and addressing aging systems through repairs and replacements, it is likely that the interior elements will never be exposed to water.

Following a large rainfall or other precipitation event, it might also be useful to check:

- eavestroughs for adequate slope and ability to drain. If eavestroughs are undersized, walls below may be wetted due to overflow;
- downspouts to ensure water is directed away from building foundations and does not pool. Use splashpads and downspout leader extensions to control the flow; and
- plaza areas, decks, and balconies for ponding water. Generally, water should be able to drain freely to internal drains or from the leading edge, with no standing water after a 24-hour period.

And when things have dried up from that rainfall, check alignment of landscaping sprinklers to ensure they are not repeatedly wetting the base of a wall.

Spring is in the air, the birds are singing and we should all be out enjoying the green grass, as well as the finer views this season brings. If those views are marred by things like staining, it is time to take a second look! ■

BUILDING ENVELOPE COMMISSIONING: GET READY FOR THE STORM

By Niall McCarra, Bsc., CET, LEED AP BD+C

Imagine you are part of a project team that finishes a project and, shortly after completion, you get a call back because of water leakage issues during a storm. Not something anyone wants to see or have to deal with shortly after the completion of a new building.

Building Envelope Commissioning (BECx) is a great way to test the performance level of a building envelope and verify that the envelope was constructed in general conformance to the project documents, and will perform to a level that will meet the demands of weather conditions the envelope will be exposed to. BECx can involve testing the building as a whole (whole building air leakage testing, thermography) or a specific component or assembly such as a window (water penetration/air leakage testing) or wall.

Currently the Government of Alberta requires all new construction and major renovation projects to meet a minimum of Silver certification under LEED V4, the U.S. Green Building Council's Leadership in Energy and Environmental Design green building rating system. "The enhanced commissioning credits are mandatory, with additional options for Enhanced and monitoring-based commissioning, and Envelope commissioning1 . LEED requires that the commissioning process (CxP) for the building's envelope is completed in accordance with ASHRAE Guideline 0–2005 and the National Institute of Building Sciences (NIBS) Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process, as they relate to energy, water, indoor environmental quality and durability.

Even for projects that are not seeking LEED certification, BECx can be a requirement set out by the design authority or owner, to verify whether the performance of the final product complies with the design requirements of the project. Too often it seems, products installed on site do not meet the requirements of the project specifications and contracts agreed between owner and contractor. BECx can be beneficial from the viewpoint that testing will identify deficiencies that may exist with a product (such as a window that does not meet the design criteria when installed) during construction stage, providing the owner and contractor with the opportunity to have deficiencies repaired before the end of the project or before product and workmanship warranty periods end. This could save the owner and contractor money in the short term by reducing the number of callbacks and even in the long term by increasing the chances of avoiding expensive lawsuits because of failures that stem from deficiencies during construction, deficiencies that could have been avoided if BECx was part of the project quality control procedures.

A Building Envelope Commissioning Agent (BECxA) will perform the commissioning of the building envelope. "The BECxA is a specialist in designing, testing, and building of specific building envelope assemblies under the expected conditions (both interior and exterior) on the type of building that is being considered"1.

A BECxA will act as an independent reviewer and can perform many duties including but not limited to the following:

- Attend design charrettes and aid in the schematic design and design development stages of a project.
- Review and comment on the architectural drawings and specifications at various stages of development.
- Periodic review of work in progress.
- Carry out performance testing on exterior cladding assemblies such as windows, curtain wall, etc.
- Thermography of the whole building to assess continuity of insulation and air barriers.
- Warranty reviews before warranty periods end.

Field testing during the construction phase

Although there are many components to BECx, air and water penetration field testing of assemblies is one way to determine that the building envelope assemblies are storm ready and give the Owner reassurance that the risk of water leakage is reduced.

Project specifications will set out the field-testing requirements for assemblies to be tested on site based on the Owner's Project Requirements (OPR) and the Basis of Design (BOD) (Figure 1).

ASTM E1105-15: Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors and Curtain Walls is used during field water penetration testing procedures. This is a qualitative test to determine if water leakage is evident through the assemblies tested. Water leakage rates typically are not quantified as part of this testing.

When testing to ASTM E1105, an airtight chamber is required to be constructed on the interior side of a test specimen (e.g. window or portion of curtain wall, etc.) and that chamber is held at specific static pressures during the course of the test (Photo 1). The test can be performed by using one of two approved testing procedures:

- Procedure A is based on a 15-minute cycle where the interior chamber pressure is held at a constant static pressure for the duration of the test.
- Procedure B tests the assemblies under is a cyclic static air pressure difference in four six-minute cycles where the air chamber was pressurized for five minutes, followed by one minute without pressure.

On the exterior of the test specimen water is sprayed with a calibrated water spraying apparatus (spray rack) to provide a uniform water spray at a pressure consistent with the requirements of the standard (Photo 2). To meet the standard, water must be sprayed at a consistent water pressure of 12 psi (flow rate of five gallons/square feet).

It is also common to use non-toxic smoke to determine locations of air leakage through the specimen in

Figure 1: Example of testing requirements set out in a project specification.

1.6.5.1 Water Penetration: Field testing in accordance with ASTM E1186 Standard Practices for Air Leakage Site Detection in Building Enclosures and Air Barrier Systems and ASTM E1105-15 Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors and Curtain Walls, by cyclic static air pressure difference, using AAMA 502-12 Test Method B and calibrated nozzle per AAMA 501.2. The water test pressure shall be two-thirds of the maximum positive design pressure.

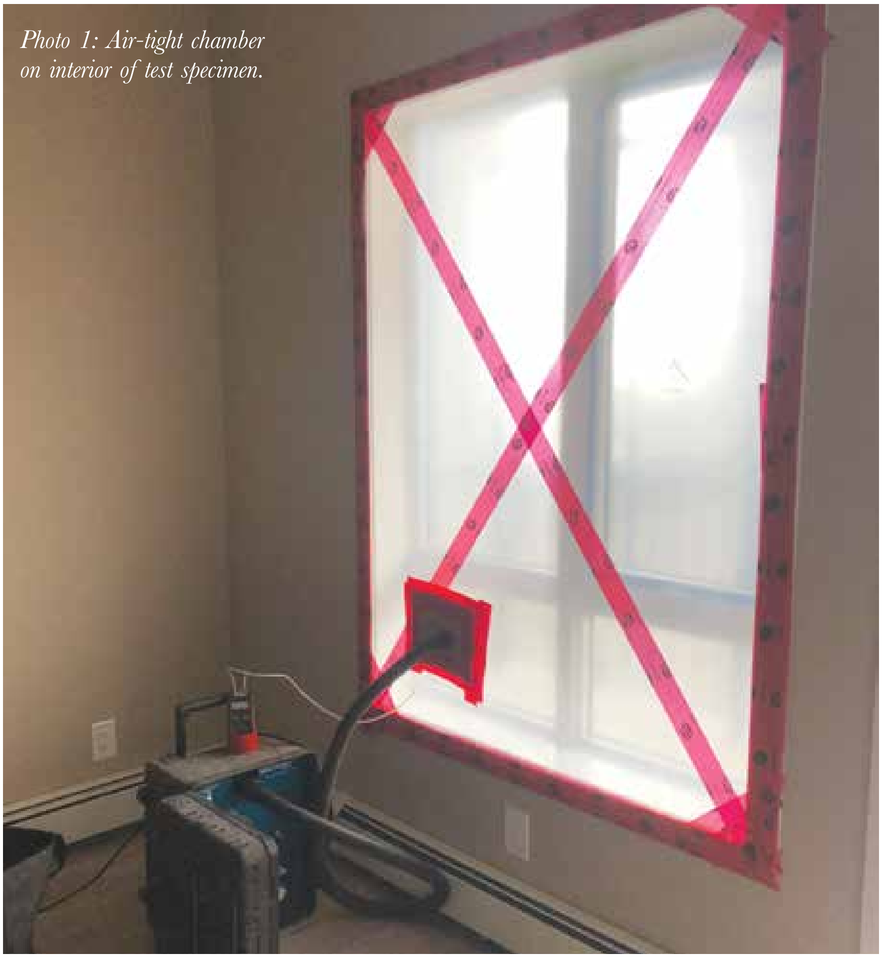


Photo 1: Air-tight chamber on interior of test specimen.

Photo 2: Spray rack on exterior of test specimen.

Photo 3: Water penetration failure.

accordance with ASTM E1186 Air Leakage Site Detection in Building Envelopes and Air Barrier Systems with the same test specimen as the water test.

What classifies a 'fail' or a 'pass' when testing to ASTM E1105?

A 'pass' is considered to be when no water penetration is noted through the assemblies that extend beyond the inner most surfaces of the specimen being tested.

A 'fail' is considered to be when water penetration extends past the inner most surface of the specimen being tested (Photo 3).

What pressure should the interior test chamber be pressurized to?

The interior test chamber pressure is measured by using a device such as a manometer. The interior test chamber pressure can be based on a variety of different requirements. Typically, field test pressures are specified in the project specifications as noted in Figure 1. If the project specifications do not specify a test pressure for the water penetration testing, the field test pressure must be decided by the design authority before testing begins. The AAMA 502, Voluntary Specification for Field Testing of Newly Installed Fenestration Products does not require test specimens to be field tested to the same pressures as laboratory tests. AAMA 502 restricts the field test pressures to two-thirds of the laboratory test pressures. For example, if a window with a laboratory water penetration test pressure of 720 Pa (maximum allowable test pressure for Canadian fenestration products), the field test pressure would be 475 Pa; however, an owner or designer can still specify higher pressures as a requirement of the contract.

What happens if the test specimen fails early during the test process?

We have seen test specimens fail early in the testing. Yes, it is a poor-performing specimen but what if there are other points of failure in the specimen? We want to know the whole story of the specimen's performance level. An example of this would be when testing a ganged mullion window (two separate windows joined together to make one larger window). At the beginning of the test, the window could fail through a deficient glazing seal. However, the ganged mullion, considered one of the weakest points in this type of window assembly, might also be a failure point and we want to know how it performs over the course of a full test or to the point of failure. Past experience suggests that it is worthwhile, if conditions permit, to continue testing until more failure points are identified or the test has completed it's full course. Many test specimens have failed near the end of the test, so tests should complete full cycles when possible.

Conclusion

BECx may be a requirement for your project if the project is pursuing LEED certification; however, BECx should not be limited to LEED projects. There are benefits to having any type of building envelope commissioned to provide the owner, contractor and design team reassurance that the building envelope will perform as intended and is durable enough to stand the test of any storm that comes its way. So get storm-ready and have your building envelope commissioned by a qualified BECxA.

1 Guideline for Building Envelope Commissioning: New Buildings – Alberta Infrastructure & Technical Design Requirements for Alberta Infrastructure Facilities Version 6 – Alberta Infrastructure.

*Latest version of LEED in Canada is LEED v4.

About

Niall is a building envelope specialist in the Edmonton office of RJC Engineers. He works on both new and existing buildings and has a good understanding of how buildings perform. He can be reached at nmccarra@rjc.ca. ■

GOVERNMENT OF ALBERTA, LEED AND BUILDING ENVELOPE COMMISSIONING

Supplied by Government of Alberta &
Technical Design Requirements for Alberta Infrastructure Facilities Version 6 – Alberta Infrastructure

As mentioned in the preceding article, the Government of Alberta requires a minimum LEED Silver certification for major new construction and renovation projects as the sustainability measurement tool, an accountable and credible means for measuring its green building goals, including building energy goals.

Most relevant to this building envelope publication is the specific approach of making energy efficiency and commissioning credits mandatory, where some other credits are pursued as they fit specific project needs. The certification process that includes building envelope commissioning provides verification and accountability, reducing the risks of lower quality facilities and higher operational costs.

- The Government of Alberta adopted the LEED system in 2006.
- Since 2009, standards require that new building designs cost at least 23 per cent less in energy bills, and include meters that will help track progress during operations.
- The Government of Alberta has demonstrated environmental leadership in this area, awarded the 2013 Canada Green Building Council's Government Leadership Award.
- As of February 2020, the Government of Alberta has achieved 211 LEED certifications, and has 100 buildings currently undergoing the LEED review process.
- Of the Government of Alberta certified buildings:
  – 12 are certified;
  – 125 are Silver certified;
  – 71 are Gold certified; and
  – 3 are Platinum certified.
- Most recently, the Government of Alberta is engaging third-party review to measure the results of the commitment to LEED, to measure if buildings use less energy and water and reduce impact on the environment. ■

THE EVOLUTION OF BUILDING SCIENCE AT SAIT

By Blair Marsden, Academic Chair, Architectural Technologies & Civil Engineering Technology, School of Construction

For the public at large, Building Science rarely comes to mind when we are in the built environment. Indeed, many of the metrics of a successful building suggest that people should not notice good building science at all.

Here at SAIT, we have put efforts into the Architectural Technologies program to integrate building science into all aspects of the curriculum. The aim in general is to facilitate a curriculum that is a more applied, holistic project-based approach that closely mimics how buildings come together and how the various disciplines and process are realized from start to finish. To that end, every core subject, their respective educational outcomes and their learning objectives touch the project directly and by extension touch every other course. We aim to break down the silos of teaching independent courses and focus instead on a fully integrated and meaningful collaborative approach. All courses serve the semester project at hand and all courses overlap and inform each other.

In years past, building science-specific courses were part of the curriculum. All the basic concepts of building science were taught in those courses via conventional teaching methods, but what was lacking was real application of these concepts to building projects. A more explicit project-based approach allows for these learned concepts to be actualized, challenged, critiqued and revised as the project evolves. In short, the consequences of building science are more visible.

All this to help students understand that the myriad quantity and variety of components, materials, assemblies, products and services actually mean something; that there are systems nested inside of other systems that make for a meaningful interconnected whole that directly affect the well being of the user. They learn that the interaction of the building with the outside environment as well as the interaction of the building with itself requires a variety of means to analyze and measure the building performance. They better understand the various forces and phenomenon at play in and around a building. Last, they come to appreciate that sound building science enable the optimization of both cost and performance.

We strive to work with students so that they are better equipped to identify and evaluate building systems, how they relate and where to apply them. In practicing how to co-ordinate and implement this type of approach our belief is that student better understand how their actions affect owners, contractors and eventual end users.

Broadly on a semester-by-semester project basis, the projects increase in scale and complexity. As materials and systems are introduced to the student projects, the material and systems purpose and performance is explored, discussed and applied. In Semester 01, students learn the basic concepts of water control, air control, vapour control and thermal control. Students then apply these concepts to a conventionally designed cavity insulated single-family home project. In Semester 02 students build on earlier concepts further by exploring and applying commonly applied products and systems found in a split insulated low-density multi-family project. This may involve the integration of a few commercial products or systems. Additionally, it may also involve a deeper dive into energy performance of the project. Semester 03 is where students are introduced to the principles to date and how they relate to more commercial applications. This is a critical semester in so far as helping students understand that a lot of the principles learned prior can be applied into a commercial instance; a specific challenge comes up when students first try to create an envelope strategy for fully external insulation solutions. In Semester 04, the program's Capstone semester, students are in the driver's seat where they establish the parameters, materials, systems and strategies that best suit their selected the Capstone. At this point in time we start to see the students exhibiting a much deeper understanding that building code, pertinent bylaws, product specifications and programming constraints all inform each other and all point toward an optimal solution.

Last, harnessing Revit and the developments in VDC are critical with our efforts in manipulating the parameters of wall assemblies, schedules, costs and so on. A deeper dive into the capabilities of Revit, for example, enable students to not only set a system in place but also how to test it, and where necessary, make changes based on the feedback. For example, a student's work might lead them to fully explore blind side waterproofing which may lead to the eventual choice of a particular acoustic control measure. The core task of designing adequate control mechanisms can be applied, and eventually demonstrated through the technical detailing.

In summary, using an intense project-based approach a lot of the former difficulties students had putting it all together is in front of them every day in every class. The lines between so-called courses is blurred and the dependencies of all decisions become more evident. ■

BUILDING SCIENCE PROGRAMS ACROSS CANADA

University of Toronto

The Building Science program at the University of Toronto has a long, distinguished history and has trained many of the industry's current leaders. The Building Science group offers both undergraduate courses and graduate courses through the MEng, MASc and PhD programs. Fundamental courses include building science theory, HVAC fundamentals and sustainable buildings and applied courses include indoor air quality, design of building enclosures, case studies in building science and building performance assessment. Research areas include indoor air quality, indoor environmental quality, building energy performance, and occupant comfort and behaviour. Many graduates go on to positions in leading building science firms across the country or further graduate studies in building science.

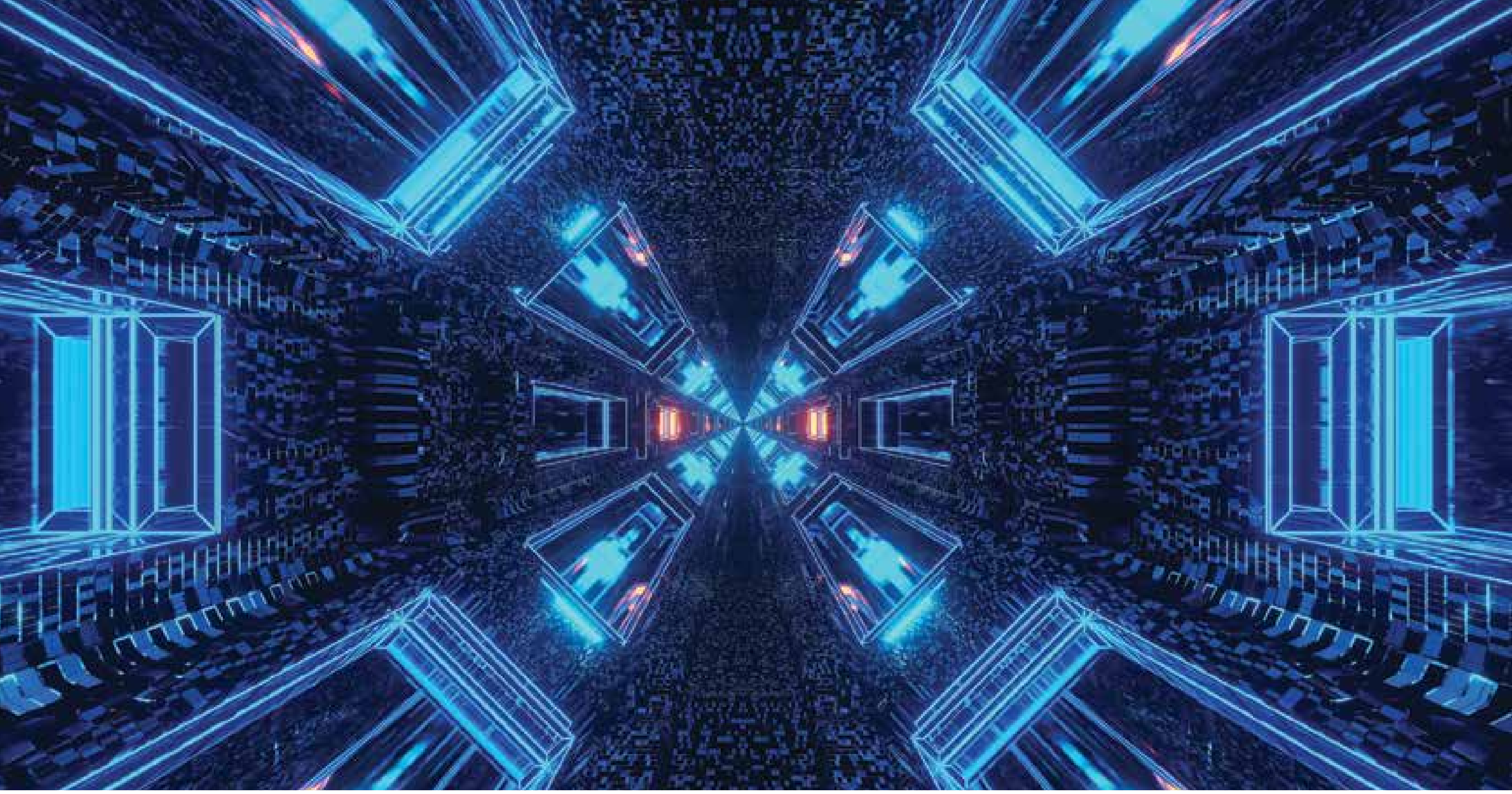
Ryerson University

Ryerson's Graduate Program in Building Science is an engineering-based graduate program offering degrees at the Ph.D., M.A.Sc. and M.B.Sc. levels. The program is unique in Canada, offering a graduate-level building science education to prepare students for careers in the building science industry and academia. As part of the Department of Architectural Science, the program is influenced by its roots in architecture with a culminating graduate building science studio course and other collaborative design opportunities offered throughout each year. Our diverse students come from various backgrounds, including engineering, architecture, planning, and others. Students receive a building science education rooted in theory with a high level of practical application. Core courses focus on building science theory, building envelope systems, sustainable design, ecological design, energy efficient HVAC systems with elective courses focusing on a variety of complimentary applied topics, including building performance simulation, restoration, building performance assessment, life cycle assessment and renewable energy systems, just to name a few. In addition to courses, students have the opportunity to engage in a variety of building science research activities in the department. Graduates gain employment across the spectrum of our industry, including working for consulting engineering firms, large and small construction firms, developers, government, NGOs. For more information, visit our website at https://www.ryerson.ca/architectural-science/building-science/home or contact us directly at bldgsci@ryerson.ca.

Northern Alberta Institute of Technology (NAIT)

The Northern Alberta Institute of Technology's (NAIT) Architectural Technology program consists of learning free-hand sketching techniques and computer-aided drawing skills to develop graphic images and technical drawings. A program advisory committee of industry representatives ensures that the courses are current and relevant to the skills required in the workplace. The program offers two levels with two terms per level. In Level 1, students can take Introduction to Construction Documents and Detailing, Design Studio I: Fundamentals of Design, Building Technologies I: Structures and Building Systems, Introduction to Revit and more. In Level 2, students can take Architectural Construction Documents II - BIM Application, Building Technologies II: Building Envelope Construction and more. In the first semester students are learning basic residential construction, whereas in the second semester they are learning about the rainscreen principle in the building envelope course. In addition to the fundamentals, the program has also adapted to include up-and-coming topics, and we want students to know the trends in the industry.

Aside from architectural technologists, students have graduated from the program to become draftspeople in architects' offices, salespeople for building materials and product manufacturers. Graduates have also done inspection, estimation and contract administration. Students interested in problem-solving and doing and learning something new every day are encouraged to apply. Find more information at nait.ca/programs/architectural-technology?term=2021-fall.



Western University

The wind-engineering group at Western University has a long tradition of excellence in building aerodynamics. It is the only university in Canada that provides courses in wind effect studies at undergraduate level and has unique MESc, MEng, and PhD programs in wind engineering. The wind engineering group at Western offers courses in Building Information Modelling, Building Sustainability, Wind Energy and Sustainability, Wind Engineering, Computational Wind Engineering, Bluff Body Aerodynamics, Wind effects on Building Components and Claddings, Wind-Excited and Aeroelastic Response of Structures and Boundary layer meteorology. The wind engineering group has executed more than 2,000 wind studies on tall buildings, large span roofs and other wind-sensitive structures located on different parts of the world. The wind engineering group is active in building sustainability and climate-resiliency research. The wind group assists the building industry in wind tunnel-based wind load evaluations and building energy and thermal performance, wind-driven-rain/snow, natural ventilation, and air quality modeling and simulation. The group is home to the historical Boundary Layer Wind Tunnel Laboratory and the unique three-dimensional wind tunnel, WindEEE Dome, capable of generating tornadic, downburst, hurricane flows to study extreme wind impacts on buildings. For more information, you can contact us at windeee@uwo.ca or info@blwtl.uwo.ca.

British Columbia Institute of Technology

The Building Science Graduate Program was launched in 2011 in a response to industry demand for qualified practitioners in building science. The program has a unique, interdisciplinary curriculum that provides students with an integrated science-based body of knowledge and skills necessary to meet the challenge of delivering durable, healthy, energy-efficient and sustainable buildings. The curriculum focuses on advancing the state of practice and responding to future trends in building materials and building envelope designs, mechanical systems, indoor air quality, thermal comfort, and acoustics, with due consideration given to practical applications..

The program offers two master's degrees: A Master of Engineering (M. Eng.) in Building Science, a course based degree; and a Master of Applied Science (M. A.Sc.) in Building Engineering/Building Science, a research-intensive degree. Both programs can be taken on a part-time basis. Graduates from a four-year bachelor's degree in an engineering field or architecture or a four-year bachelor's degree in a related science field with a GPA of 2.8 out of 4.0 (70 per cent) and the required mathematics courses are encouraged to apply. Now, applications are being accepted for September 2021 intake. The full program entry requirements can be found at bcit.ca/programs/building-science.

Concordia University

The Building Engineering program at Concordia is the first and the only one offering an accredited undergraduate program and a full range of graduate programs in Canada. With funding support from the federal and provincial government, Concordia established the Center for Building Studies in 1976 and launched Building Engineering programs at the Master's, PhD and Bachelor levels.

The Building Engineering program at Concordia provides students with an integrated body of knowledge for a holistic understanding of building as a system through its life cycle. It emphasizes the fundamentals and consolidates theory with practical applications in the areas of building science, building materials, indoor environment, building envelope, structures, building services and construction management. The program aims to educate well-rounded building engineers and equip graduates with the knowledge and skills required for creative solutions in the design, construction, operation and maintenance, and disposal of buildings to achieve energy efficiency, help combat global warming, decarbonize economy and improve quality of life.

Concordia has established unique world-class research facilities and has excellent researchers in the areas of solar energy utilization in buildings, building envelope and materials, building automation systems and energy efficiency, wind effects on buildings, indoor air quality and building ventilation, building automation and HVAC controls, building structures, computational and modeling techniques at building and city levels, and construction engineering and management. The Building Engineering program at Concordia is well-equipped with state-of-the-art labs and research facilities to support undergraduate teaching and graduate research to train the next generation of building engineers to tackle the current and future global challenges. For more information, please visit https://www.concordia.ca/ginacody/building-civil-environmental-eng/about.html.

University of Waterloo

There is little doubt to members of building enclosure councils as well as architecture, and building science engineering offices that the building industry is large, exciting and faced with a host of new challenges: energy efficiency, climate resilience, and changing urbanism among them. There is a need for engineers technically skilled in the whole scope of building design, construction, assessment, repair, and refurbishment who understand all of the technical systems in modern buildings and respect the non-technical drivers of building design and construction. An exciting new Architectural Engineering co-op engineering program, focused entirely on buildings, is being delivered by UW's Civil & Environmental Engineering Department in collaboration with the Waterloo School of Architecture to deliver just such graduates.

The Architectural Engineering program has "Design from Day One" as its mantra. A common Architectural Engineering class held in a studio setting is the core of each term and knits together issues such as design, technology, aesthetics, environment, and professionalism in the context of engineered buildings. A studio teaching experience, common in design-centric programs such as Architecture and Industrial Design, allows for enhanced peer-learning, better collaborative work, inspiration from surroundings, rapid modelling and prototyping, and hands-on investigations and exploration. Another of the distinctive features of the program that it entire third takes place at the University of Waterloo Cambridge campus, immersed in the School of Architecture, working alongside architecture students. Check out the website (uwaterloo.ca/architectural-engineering) for more information. ■

THE DAWN OF THE ENERGY CODE

By David Leonard, P.L.Eng., Eng.L., Associate, Entuitive

The updating and implementation of Building Codes is not a new concept to the construction industry as various provincial and federal codes have been developed, updated and implemented over the years. As we have now seen the development and later implementation of the National Energy Code of Canada for Buildings (NECB), there has been a fundamental shift in how a new project, addition project or various renovation projects have had to be designed. Previous to October 1, 2016, there were no code minimum requirements for overall building energy requirements within Alberta. We designed buildings following good current practice and improved on methods from previous years and decades incrementally. The NECB was published for the first time in 2011, then 2015 and 2017; it is an objective-based National Model Code that can be adopted by provincial and territorial governments. The principle to develop objective-based codes arose out of the strategic plan adopted by the Canadian Commission on Building and Fire Codes (CCBFC) in 1995.

The NECB does not list acceptable proprietary building products. It establishes the criteria that building materials, products and assemblies must meet. Some criteria are explicitly stated in the NECB while others are incorporated by reference to material or product standards published by standards development organizations. Only those portions of the standards related to the objective of this Code are mandatory parts of the NECB.

Following October 1, 2016, implementation of an energy use minimum standard with NECB 2011 was set using prescriptive envelope requirements which could then be adjusted by making adjustments from the inefficient prescriptive mechanical requirements. It was a simple solution, to use better/more efficient mechanical systems and keep doing what we were doing on the building envelope (IE lower thermal performance targets than what was listed as the prescriptive requirement in NECB). We saw a small improvement with building envelope assemblies to minimize the use of more expensive but extremely efficient mechanical systems.

On December 1, 2019, the NECB 2017 came into effect. This was another baby step in the movement towards more energy-efficient buildings. In the long term, net zero, net positive, minimum carbon emissions, no carbon emissions and retrofit code requirements are anticipated to become part of the language of the Codes, setting even more stringent requirements for how a building is to be designed, constructed and operated. NECB 2015 was skipped in Alberta but is in use in other provinces such as Ontario.

When you're considering adding to an existing building, the addition will be considered independent of the existing building. It is mandatory that any additions greater than 10 square metres of conditioned floor space must meet the requirements of the NECB. This is a unique definition to the NECB. However, at the discretion of the design team, there may be situations where there are benefits to upgrading elements of the existing building to achieve a more efficient overall building design. If a building was required to meet the NECB at the time of its construction, future renovations must demonstrate that they do not reduce the level of compliance previously achieved. If the building was not required to meet the NECB compliance levels at the time of construction, then the renovations are not required to meet NECB standards.

Generally speaking, if your building falls into occupancy classifications A, B or F1 or it exceeds 600 square metres in a building area or three storeys in height, it is within the scope of the NECB. Additionally, at the applicant's discretion, any project within the scope of Alberta Building Code 9.36 may choose to use the NECB technical requirements in lieu of ABC 9.36.

Several types of spaces can be unconditioned and thus need to be treated differently, e.g., mechanical rooms, crawl spaces, garages, loading docks. There is also a need to consider components that separate spaces that are conditioned to substantially different temperatures (e.g., swimming pools, skating rinks). With NECB 2017, we have to mostly consider the Overall Thermal Transmittance (U-value). The overall thermal transmittance, U-value in W/(m2•K), is the inverse of the effective RSI in m2•K/W.

We have three paths to demonstrate compliance with NECB 2017 including the Prescriptive Path, the Trade-off Path and the Performance Path. The first compliance option is to apply the prescriptive requirements of the Code, which generally dictate minimum thermal characteristics for envelope elements and energy efficiency measures that can be stated as specific instructions. The second option affords some degree of flexibility in the application of the prescriptive requirements. For example, the trade-off paths for Part 3 allow Code users to vary the thermal characteristics of one or more components of the building envelope and/or vary the fenestration and door area from that permitted in Section 3.2., provided it can be demonstrated that the resultant building envelope will not transfer more energy than it would if all its components complied with that Section. The trade-off options present an easy way to make small adjustments to the characteristics of the building without having to follow the whole-building performance route. The third option is a performance path, if some aspects of the prescriptive and trade-off routes are considered too limiting, the building could, for example, be designed with any thermal characteristics desired (subject to certain limitations), provided that it would not have a calculated energy consumption under standardized conditions that is greater than it would have been had the building been designed in strict conformity with the prescriptive requirements, all other aspects of the building (those that are not the object of a requirement in this Code) remaining the same in both cases. The proof of compliance when using the performance path option is achieved through two energy analyses: one on the building as if it met the prescriptive requirements, which gives the "target" performance of the reference building, and the other on the actual design of the building.

Nearly every project we've worked on since NECB came into effect starts with a chicken-before-the-egg conversation. The architect and/or energy modeller would ask what R-values we need to use on the project. My response was almost always, "you tell me." We can design any thermal performing assembly we want, that is where the innovation comes in. But really, we need the energy modeller to tell us what inputs they used in their model and whether or not those inputs told us the building would be compliant or not. We would typically make recommendations on what the assemblies could be as a starting point but the reality is that no matter what we come up with we are in a realm where there are too many variables to create a rigid performance requirement for the building envelope. This is where parametric energy modelling can play an efficient role in determining where the greatest energy consuming components in the building are so we can maximize efficiency in those areas and save on other areas which have a minimal impact on the overall building's energy use.

When practised, the changes to the calculations of Overall Thermal Transmittance may be the most significant changes in the code. The NECB 2017 calculation method considers a host of elements that weren't previously considered in the analysis when demonstrating compliance with the Code. These elements, when considered into an effective thermal transmittance, have the potential to reduce the demonstrated effective performance by HALF.

There is published data to suggest the derated values for the overall building envelope can range from 30 per cent to 500 per cent, depending on all the variables that can go into the performance of the building from orientation of the building, to WWR, to building geometry, to connections of systems and quantities of those connections.

We note that mechanical penetrations, fasteners and enclosed unconditioned spaces are still not a requirement in our analysis when determining compliance of the proposed building with the reference/prescriptive building.

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Analysis for 2011 was actually fairly simple. We didn't have to "show our work"; generally, as long as the thermal performance values were presented on the architectural assembly page and were described as effective R-values as opposed to nominal R-values, the AHJ was satisfied and we got our building permit. It was unlikely that you were getting held up at BP provided a few of the necessary bits of information were being provided.

as effective R-values as opposed to nominal R-values, the AHJ was satisfied and we got our building permit. It was unlikely that you were getting held up at BP provided a few of the necessary bits of information were being provided.

We need to consider linear interface details; these details are generally expressed in our plan and section details in the architectural drawings. These details can have the biggest impact on the overall thermal transmittance of the building. We then also have the point interface details, minimizing these conditions such as structural penetrations for a canopy or sunshades will help to reduce the overall thermal transmittance of the building envelope.

Under NECB 2017, we must provide a thermal analysis package with every BP submission. It is common that the package is provided by the building envelope consultant, energy modeller or architect. While it wouldn't be a requirement to provide the thermal calculations to the construction team, there would be benefit to the project so the contractor and their trades and their suppliers can understand the buildings performance requirements.

Incorporating earlier discussions on projects around energy performance and how we are going to meet those targets will establish constructible and more cost effective assemblies as we consider budget and energy use in tandem. Considering a performance-driven design will ultimately result in reduced construction and design costs to meet the energy requirements. Delay of these discussions likely results in potential cost increases.

We have seen cost savings on projects by relying on the accuracy of the model and the recommendations the consultants provide, and then exploring savings that can be found in reduced construction and/or operational costs. Further, looking at more efficient methods of insulating and sealing a building ultimately provides more value both during construction and operation of the building.

Canada has a target of being net zero ready by 2030, and this document outlines the plans for how we're supposed to get there. We need to consider that 2030 isn't going to be a monumental year like the fall of 2016 wasn't by any means a date that will live in infamy. 2030 will come and go like any year and, looking beyond that, we need to consider where the industry will be going, driven by Codes which set the minimum standards, by building owners who want a better buildings to market to their tenants/residents or have reduced operational or maintenance requirements, by designers who take consideration to how their building will perform as much as how it will look, by consultants who can inform the designers and owners on where they can leverage and maximize their designs, and by contractors who can understand the designs and the importance of the materials they're procuring and installing.

We should consider the next steps, which could involve carbon emissions targets, net positive targets, retrofit requirements. We want to plug in and use more energy than ever, having a building that could not only operate itself but output power to all the electric cars we are going to own in the future.

We also need to be cognizant of the fact that as buildings become more efficient, the risks of creating new problems may exist. We look at all these old masonry buildings that have been around for 100 years as compared to that condo that went up in 2008 that is falling apart. While the newer buildings can use less energy to heat and cool them, the importance of the systems that directly relate to reducing that energy demand become even more critical. ■

THE EVOLUTION OF BUILDING SCIENCE AT NAIT

By Mehdi Zahed, Architect AAA, Ph.D. c., MRAIC

Overall building performance in Canada and cold-climate buildings, as well as special considerations of the economic, social and environmental sustainability landscape in Alberta, makes the topic of Building Science an unconditionally important subject. A brief definition for Building Science provided by WBDG is: “Building science is a field of knowledge that draws upon physics, chemistry, engineering, architecture, and the life sciences”.

Back in 2011 when I joined the Northern Alberta Institute of Technology (NAIT), I was assigned to teach the building science and building envelope courses in the Construction Engineering Technology program. The focus of CET is construction management and project control, incorporating the practical, local construction with the theoretical framework of Building Science. The course covers the fundamental theories of Building Science and incorporates hands-on experience with an expected outcome of being able to assess and adequately diagnose building envelope problems and propose constructible remedial solutions.

Later on, I had the opportunity to also help with the Architectural Technology program. Many courses have a close relationship with the fundamentals of Building Science, with objectives including: building material and methods, building systems, working drawings, plan and section generation and computer applications, including Building Information Modelling (BIM). Without any hesitation, I can say that the courses’ syllabi and content integration at NAIT, as well as the internal cohesiveness among the topics, theoretical bases and design projects, all revolve around the key concepts of building science fundamentals.

The Architectural Technology program at NAIT not only has the fundamentals of architectural design built into the courses, but also has a strong mandate to educate and graduate qualified technologists who properly incorporate design excellence and industry standards to produce effective drawing sets for building construction. The program sequentially divides the courses based on the type of structural system employed, starting in the first year with wood frame construction, then concrete and masonry buildings. In the second year of school, steel structures are introduced in the program outcomes. These courses deliver substantial technical knowledge about materials, methods, systems, drafting technologies, industry standards and software applications.

As a tangible example of the process of envelope and façade design, our students learn technical terminology and the practical meaning of key concepts such as airtightness, envelope leakage, moisture barrier, water management system, thermal insulation and thermal bridging in order to be able to practically utilize them in drawings and specifications. In this important and contemporary area of sustainability, our courses not only address the social and economic aspects of the topic, but also deeply explore concepts like energy efficiency, renewable energy use, natural lighting, thermal comfort and durability, all in the context of local construction, tied with architectural design.

Another interesting fact about NAIT is that all programs have an advisory committee that includes seasoned industry experts with experience and a sharp vision about the market and labour needs of the field. Programs collect the latest needs of the industry yearly and re-design courses based on those current market needs. This is an example of an objective-based outcome system used in polytechnic education in Alberta. I would encourage all industry experts, including the Building Science Specialists of Alberta, to reach out to the program chairs and the Associate Dean of Industry-Engagement in the School of Applied Science and Technology (SAST) at NAIT to advocate for their field and have a voice in polytechnic education in the growing Alberta economy. ■

STUDY AND SOCIALIZE AT THE SINGHMAR CENTRE FOR LEARNING

By Cindy Chan

In addition to education, the Singhmar Centre for Learning prioritizes sustainability and comfort for the students and staff of NorQuest College.

Located in Edmonton, NorQuest College's Singhmar Centre for Learning is a four-storey, 22,500-square-metre facility that ties into the college. The new building boasts a large, bright atrium; classrooms that can seat 40, 50 and 100 students; a spiral staircase; and a unique double façade on a portion of the west elevation. According to Kevin Burghardt, senior project manager at PCL Construction, the building was an expansion to primarily increase the college's teaching capacity, as well as to centralize their various campuses around Edmonton to one downtown location. Niall McCarra, project technologist for RJC Engineers who provided building envelope commissioning services, says the building envelope posed challenges tying the old to the new while maintaining a high performance building envelope assembly.

"NorQuest College has a diverse population, so one of the goals is to make the centre vibrant and inviting where everyone can learn," Diana Smith, mechanical engineer and associate with DIALOG, says.

Construction on the centre began in June 2015 and completed in September 2017 just in time for the start of the new school year. According to Jason Schuller, manager with facilities operations and maintenance, and Matthew Orlando, manager of planning and projects for NorQuest College, the centre mostly consists of classrooms, labs and amenities such as a library, daycare and student union space.

"The main floor atrium and staircase is a major feature of the building, which is also used for events and student activities," Orlando says. "In conjunction with clerestory glazing (the windows at the very top of the atrium), a large V-shaped light deflector was constructed to deflect natural light into the atrium and throughout the facility. The benefits of natural daylighting include providing building occupants

with a connection between the indoor space and the outdoors, increasing occupant comfort and productivity and reducing lighting energy use."

The spiral staircase promotes physical activity within the building rather than relying on elevators and escalators. On the main floor, an Indigenous Student Centre is located on the east side of the building, which is used for gatherings and culture ceremonies. The second floor of the centre features movable walls between classrooms so that they may open up to become a larger space.

Another unique feature is a child-care facility so that students are able to bring their children to school with them.

Smith says the evening sun can generate a large amount of heat gain in west-facing classrooms. However, what is interesting about that side of the building is the dynamic buffer zone (double façade) on the second floor, which acts as a barrier that captures heat within. There are fans located inside, which exhausts hot air outside and pulls fresh air in, thus preventing the heat from getting into the space. Operable blinds also help to prevent heat and glare.

The centre achieved LEED Gold certification as sustainability is a huge driving factor for the school. The project diverted 85 per cent of construction waste from the landfill. The school also has a rainwater collection system; the cistern in the parkade collects rainwater from the roof, which is then used for irrigation watering. Roofs above overhanging features of the building exterior contribute to rainwater collection. A raised floor system throughout most of the building ties into the displacement ventilation, where air pushes through from the floor instead of coming down from overhead ducts.

"The certification was achieved by multiple aspects," Smith says. They received points from being in a dense,

downtown area with plenty of public transportation options and bike storage. They also received points for the low-emitting materials used for the project, including the paints and flooring systems.

The high-performing building envelope uses triple-pane, low-e-coated, argon-filled insulated glazing units. It is a mixture of precast concrete panels, curtain wall, aluminum composite, zinc composite and wood veneer panels, according to Burghardt. He adds those are standard building envelope materials for the Alberta climate.

"The building envelope is very robust and consists of exterior insulated walls incorporating rain-screen principles throughout," McCarra says. "There is a continuous air barrier/vapour retarder and insulation layer on the exterior of the walls. A combination of horizontal and vertical sub-girt cladding attachment system is installed to reduce thermal bridging through the zinc, aluminum and wood panel cladding assemblies. The precast concrete panels are attached to the structural backup walls with point connections, reducing the extent of thermal bridging through the assemblies. Insulation in the exterior wall assemblies consists of closed cell polyisocyanurate insulation, typically installed in two layers to achieve an average nominal R-value of approximately R30. The windows are all comprised of curtain wall frames with triple-glazed, insulated glass units with low-e coatings. The roof is single-ply thermoplastic polyolefin (TPO) with an R-value of R40." The hard work and diligent effort that was put in to achieve a high-performing building envelope has contributed to 44 per cent energy cost reduction over the ASHRAE 90.1-2007 Baseline Building.

For more information, visit norquest.ca/about-us/campuses-maps/edmonton-campus/singhmar-centre-for-learning.aspx. ■

HIGH-PERFORMANCE FIBERGLASS WINDOWS AND DOORS

Driving the benchmark "lower"... in U-values!

By Aynsley Dueck, Operations Manager at DUXTON Windows & Doors

University of Alberta, Lister Hall, Mackenzie Tower. GEC Architecture; RJC Engineers; Precision Contracting.

J22 Building, Edmonton, AB. Dialog Architecture; All-West Glass.

For those of us who are living and breathing U-values* day-to-day (and that number is small but growing), the concept of a "lower" benchmark will resonate. As the climate crisis continues to bear a larger impact on building design, the typically weakest link – windows and doors – need to meet the demand.

Frame Considerations

Although commercial projects tend to favour metallic frames for their durability and aesthetics, they are becoming a less logical solution. Metallic frames transfers hot/cold easily, regardless of the thermal break, which makes for a less-than-ideal thermal insulator. This is where fiberglass and vinyl have some inherent benefits, and wood, to some degree.

Fiberglass continues to offer further benefits in durability than some hybrid products. Where vinyl may meet structural requirements on some low- to medium-rise buildings, the material characteristics can require substantial steel inserts, that are often not properly identified in U-value reports. NFRC (National Fenestration Rating Council) requires performance on an "individual box" basis, as opposed to full assemblies where reinforcing is often required. The beauty of a fiberglass system is that it achieves both the U-value and the strength in the same breath.

Canada's national energy code is headed towards a more and more aggressive approach for fenestration, and most systems will need to continue to improve to meet the long-term needs

Wapanohk School with Steel Security Screen. Stantec; NDC Construction.

of the building industry. The long-term U-value target is being influenced by Passive House, and certainly British Columbia's step code. Fiberglass frames and triple pane with two Low-E coatings are well positioned to meet the upcoming demands.

Now, trying to slot in non-combustible systems into the picture, becomes the next major challenge. Currently, aluminum products fulfil the code, but with recent successful industry testing of fiberglass and vinyl systems, the building code is undergoing a change to accept these other products. As various provinces ultimately adopt the new code, this will be a new norm, but in the interim, it requires a specific approval dependent on the particular project.

Preventing Glass Breakage

A huge topic in specifying windows and doors revolves around preventing glass breakage. This may be to prevent a break-and-enter, to reduce vandalism, to reduce the cost of maintenance and/or to avoid having plywood in the windows for an extended period of time, to name a few. Specifications for schools and sometimes multi-family housing, often include six-millimetre triple pane configurations or more.

You may combine the above solutions in situations with a higher risk of vandalism, or more remote locations. For example, we often see a Steel Security Screen in combination with six-millimetre tempered, or a 10-millimetre Lexan Sull Sash with 10-millimetre Tempered Glass.

Some products may have limitations, however; the glazing pocket needs to be large enough to fit a six-millimetre triple, for example. To have reasonable airspaces and a low U-value, you need a minimum 1.5-inch unit thickness, and in some cases, even a two-inch thickness. Trying to fit these thicker glazing configurations into a standard dual pocket of 7/8 inch will often not be achievable, or the configuration needs to change to thinner glass, and/or narrower airspaces.

Structural Ratings

From a structural/wind loading point of view, three primary

COMPARISON OF SOLUTIONS TO AVOID GLASS BREAKAGE

	Ability to Prevent Glass Breakage	Visibility	Cleanability	Accessibility	Relative Cost
Expanded Metal Mesh	Excellent	Poor *Does not look as inviting*	Difficult	Average *Substantial weight challenges*	High
Steel Security Screen	Excellent	Very Good *Much improved over Expanded Mesh*	Average	Good	Very High
Lexan Sull Sash	Very Good *Can be scratched or burned*	Good	Average	Very Good	Medium-High
6 mm Tempered (exterior lite)	Good	Excellent	Excellent	Very Good	Medium
8 mm Tempered (exterior lite)	Very good	Excellent	Excellent	Good	High
10 mm Tempered (exterior lite)	Very good	Excellent	Excellent	Difficult *Less availability*	Very High

Pump House with FiberWall Series 458. Alston Properties; 5468796 architecture; Holz Constructors.

factors will typically influence a window specification: the climate data for the location, the building's number of storeys and size of the opening, among other considerations. The number of storeys can have a significant bearing on the product series, type, and glass thickness. One owner of many residential high-rise buildings commented, "We used to use vinyl but we could hear it creaking and it just wasn't tough enough. We switched to fiberglass to avoid the maintenance and have the longer-term durability."

Regarding the size of the opening, we are finding that openings are generally getting larger. Designers are trying to bring in more natural light, whether it's for a more pleasant school atmosphere, or more natural light through a home, with bigger views. These large openings often need a deeper frame system to be able to meet the structural integrity required. While many systems in the market are designed at a 3¼-inch frame depth (added jamb extensions do not add to the strength), they are often not suited to this type of application, and a deeper system at 4.5 or 6.5 inches should be specified. A commercial fiberglass product such as FiberWall™ is an example of a more robust series, that aesthetically matches the lighter duty systems, but allows for the larger applications such as an eight-by-eight-foot opening or a long nine-foot strip of windows running the length of the building.

Balcony Door Solutions

In multi-family applications on medium- to high-rise buildings, finding the appropriate balcony doors can be challenging. In replacement projects, we are often removing aluminum systems that are VERY drafty, but also generally feel cold. The trick is finding a warm, low U-value solution that meets the water and wind-loading criteria, and also provides for ease-of-use to the tenants. Once again, fiberglass offers a positive solution, from a swinging or sliding door perspective.

In a sliding door, it is important to find a system with a true 1 3/8-inch or larger pocket to hold triple pane glass. Furthermore, you need heavy-duty wheels to hold the weight, and allow tenants to easily move the sash. The ability to assemble doors on-site (KD or knock-down kits) may also be critical due to limited elevator space. To execute site-assembly or site-glazing properly, is CRUCIAL to work with an experienced installer with a long history in similar projects.

In a swinging door, features such as continuous weatherstripping and heavy duty multi-point locks can stand up to challenging air and water specifications. More European mushroom-style multi-points not only latch in multiple locations, but they progressively pull in the door upon lifting the handle; latch in more locations, catching the corners more effectively; and allow for better adjustability.

For more information, visit www.duxtonwindows.com. ■

BUILDING ENVELOPE ISSUES – EXPECT THE UNEXPECTED (PART 1)

By Sathya Ramachandran Architect, AAA, B.Arch., M.A.Sc., and Greg Hildebrand C.E.T., M.Sc. (Eng.), EXP Services Inc.

Alberta has been blessed with visionaries that have earned a reputation for defining the skylines of our urban landscapes through iconic built forms, such as the Calgary Tower and Edmonton CN Tower of the '60s, Saddle Dome and Edmonton Convention Centre of the '80s, the Bow Building, Roger's Arena, Stantec Tower, National Music Center, Central Library, Brookfield Tower and Telus Tower of the past decade. Or, consider some of the projects currently underway, such as the Calgary Cancer Centre, Calgary Event Centre, Red Deer's Justice Centre and Edmonton's growing ICE District. Whether it's future-fit city-building initiatives with destination-class placemaking, or simple buildings intended to put a roof over citizens' heads, the project goals for stakeholders remain the same – long service life (durability) with resiliency, optimal energy conservation and efficiency, balanced indoor air quality, occupant comfort, ease of maintenance and enhanced user experience. Building envelope plays a significant role in achieving these goals.

The primary functions of a building envelope are to control heat, air and moisture to provide environmental separation for the intended interior conditions. Simple as it may sound, practitioners have learned time and again that building envelope issues are often more than the failures in achieving the intended functions and are compounded by unforeseen secondary problems. Building envelope design is often simplified for the day-to-day practice, i.e. the use of critical barriers, rules of thumb, good industry practices, codes and standards and lessons learned. Nevertheless, knowledge and consideration of the principles of building physics, climatology, geometry, building materials and constructability can prevent unforeseen issues through the lifecycle of a building. The varying environmental conditions contained by the building envelope with changing planes, opaque and glazed, with

Anonymous valuable lesson: *A world-class building was constructed in the last decade to expand an existing heritage building in a major 'cold climate' metro. Designed with exemplary articulation by an internationally renowned architect, it required careful consideration of the building science principles to ensure performance of the building envelope. Two teams of contractors consisting of building science specialists were contracted to design the system and conduct detailing, resulting in an outcome of two different design options – one 'performance-driven' option considering the rainscreen principles closely matching the architect's design intent and the other mainly 'cost-driven'. Unfortunately, the 'cost-driven' design was chosen over the 'performance-driven' design by the cost-conscious project team. Water leakage and icicle formation issues in the first few years of operation required mould remediation and cordoning-off the adjacent public spaces. The building required major renovations within 10 years of service life, costing millions, as well as causing inconvenience to the occupants and receiving public backlash.*

penetrations, transitions and terminations, interfaced with the exterior to different levels of exposure and varying climatic conditions, pose a myriad of challenges to the design. Thus, the building envelope design must consider use, occupancy and interior conditions; exposure to micro and macro climatic conditions; and shape, massing, orientation and articulation of the intended design. One poor detail at multiple locations, or multiple deficiencies at different locations, can cause a systemic premature failure to render an otherwise stellar project unsuccessful. It is important to scale up and down the design to review and recognize challenges and potential issues that may blind-side the design and construction teams. To put it simply, expect the unexpected.

The building science community has encountered several unprecedented issues and plenty of lessons learned, particularly in the recent past, due to the continually evolving building envelope practice attributed by the increasing ability to implement eccentric visualizations, advanced technology to simulate the environment, advent of new building materials and innovative construction technologies, more importantly driven by the need to counter climate change. Following is a tip of the iceberg discussing the primary issues, with the remainder to follow in subsequent editions of the *Building Science Perspective* magazine.

Water entry: Regardless of the amount of precipitation experienced in a particular region, a building envelope that doesn't manage liquid water can leak with dire consequences resulting in significant damages, occupant discomfort and user inconvenience. For instance, despite the moderate precipitation and longer drying periods experienced in Alberta, forensic investigations and the restoration of projects experiencing water ingress issues are routine among local building envelope specialists. It is vital to demarcate the water shedding and waterproofing surfaces of the building envelope; detail to contain and channel to adequately deflect the runoff water; select and apply appropriate continuous waterproofing and water resistive barriers; and use 'rainscreen principles' for the water shedding surfaces, using two lines of defense, ventilation and compartmentalization.

Air intrusion and leakage: Air movement into (intrusion) and through (leakage) the building envelope acts as a medium for transfer of heat and moisture. This may lead to heat loss, interstitial and surface condensation, water leaks, icicle formation and cold drafts resulting in moisture damage including mould growth, increased energy consumption and occupant discomfort. It is critical to achieve a robust air barrier system ensuring continuity throughout the building envelope. Recognizing the challenges with the design and construction, the standards quantitatively allow for a certain tolerance to air tightness in the assemblies and building. This can be construed as an excuse to intentionally not achieve complete air tightness that could otherwise be easily achieved. A classic example is when a window manufacturer refuses, or charges extra, to seal the entire perimeter between the frame and IGU, quoting that the window can adequately perform per the requirements in the standards without the continuous seal, but overlooking its impact causing cold drafts and potential condensation, or even icicle formation. As practitioners, when we do not enhance our specification beyond the minimum requirements and do not catch it during shop drawing reviews, not only are we throwing the heat out the window by not achieving air barrier continuity, but also our reputation out the window

Anonymous valuable lesson: *The exterior wall assembly of the first ever LEED certified mixed-use building, with residential and commercial occupancy, in one of Alberta's major metro areas, from about 15 years ago, had to be fully remediated. The 'split insulated' exterior wall assembly was installed with a layer of continuous extruded polystyrene rigid insulation over a layer of building paper, over OSB sheathing, over wood framed stud wall, over a layer of poly vapour retarder and drywall. Significant moisture damage to the structural components was experienced due to the entrapment of incidental water between the rigid insulation and building paper. While the designers must have analyzed the thermal and vapour gradient and the resulting condensation potential from vapour diffusion in deciding the thickness of the extruded polystyrene insulation, consideration to water management, drying potential and use of durable building materials to handle liquid water and bulk vapor movement from air leakage were missed. Combination of water that entered due to poor flashing details, moisture that accumulated and entrapped as it was unable to drain and dry and less durable building components that deteriorated due to continued water run off and moisture entrapment, lead to the damage. The cladding system mechanically attached with wood blocking through the insulation worsened the condition by limiting the drainage path of liquid water. The adjacent sister building with the same design by the same architect and developer, but constructed with better water management detailing with the use of proper flashing and joint sealants, and use of two layers of building papers, had limited damage underlining the prognosis. Regrettably, this type of assembly is continuing to feature in several of the wood framed multi-family residential buildings as a reaction to improve energy performance to meet the energy code.*

for producing uncomfortable conditions within the building. This is exacerbated when the perimeter heating systems are eliminated as a cost avoidance measure, which seems to get increasingly popular. Tracing the lines of air barrier systems, as trivial as it may seem, is becoming increasingly important, particularly with the increasing requirements for quantitative air leakage to meet the demands set by regulatory bodies to address climate change.

Vapour diffusion and movement and drying potential: Since the days of the energy embargo and the unsuccessful attempt to conserve energy by adding insulation without an appropriate vapour retarder, the industry has gained an understanding of vapour diffusion through the assembly and its potential for interstitial condensation contributing to systemic failures. Nevertheless, issues with condensation, icicle formations and moisture damage, where movement of vapour (whether through diffusion or air circulation) into spaces that are isolated from heating sources, and sometimes separated with acoustic insulation, are continuing to recur in our buildings. Yet another interesting issue is moisture entrapment and reduced drying potential leading to building envelope failures. The recent focus on energy conservation has increased the popularity of continuous insulation and split insulation wall assemblies. It is important for practitioners to not lose sight of the more important durability goal when trying to achieve energy performance goals.

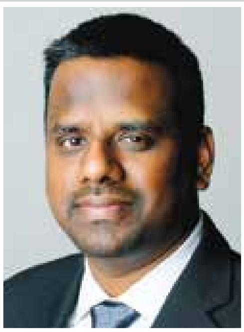
Construction moisture: In general, our region has a short construction season that is interrupted with periods of rain. Entrapment of construction moisture can cause damages (such as corrosion and rot) to susceptible building envelope and structural components. Effective construction management through proper handling and protection of building materials, monitoring of weather, timing of the installation of sensitive materials and temporary protection may alleviate some of the potential issues. However, our past mistakes have taught us to consider the use of non-susceptible materials for components that may be exposed to moisture during construction, and requirements for drying and verification of the moisture condition prior to wrapping with non-breathable layers. With the increasing popularity of mass timber and cross-laminated timber constructions, it is imperative that the design and construction teams be cognizant of potential construction moisture issues. One another classic issue from the recent past, particularly in hotel construction, is the entrapment of moisture and mould in the drywall between poly vapour retarder and wallpaper, installed prior to the drying of moisture from drywall mud.

The architect plays a significant role striving to establish a vision for the buildings and their influence on the skyline of cities. It is the job of the specialists to ensure the architect's vision comes to functional life, with due consideration to the targets set by the current trends, whether it is the climate conscious energy efficiency design, increased focus on the

Anonymous valuable lesson: *A landmark project built not too long ago with a construction period stretching across multiple seasons (due to the large scale of the project) in a rainy climate was in trouble. As early as midway through the construction, it was experiencing mould issues in the roof assembly on structural wood elements and paper faced insulation components. The selected assembly was unconventional to the contemporary practice, wherein the installation of an air barrier/vapour retarder over the sheathing in a 'sandwich' roof assembly was eliminated through a value engineering process. Despite the initial reaction to claim the cause was the eliminated vapour retarder in the roof assembly, the peer reviews and indulgence of multiple parties revealed that the practitioners had ensured the building envelope assembly was designed adequately for the required performance during its operation, with consideration to the climate and use of space below. The issue was the construction moisture that was not considered during design leading to the experienced mould issues. Regardless of the measures tried during construction including heaters to dry the plywood substrate the issue persisted. High moisture content readings were measured at areas that appeared to be dry.*

comfort and wellness of occupants, need to create an enhanced user experience, or the growing demand to meet the envisioned ‘eccentric’ articulation with amassing accessories, all while without compromising the durability and resiliency and keeping it within the project budget. Challenging mission it may seem, but with proper collaboration with the designers starting at the early stages, even better in an integrated approach, is a possible road to success. It is essential to consistently accumulate knowledge and be up to date with the lessons learned, and more importantly, involved in the research, development, testing and standardization to ‘expect the unexpected’.

‘Building Envelope Issues’ is intended to be a permanent feature of the *Building Science Perspective* magazine with several other lessons learned to be shared in the future issues. Subsequent parts of this article will feature thermal bridging; overheating issues; spatial separations; fenestration issues in controlling heat, air and moisture; energy, heat, acoustics and light performance issues of insulating glass units (IGU); premature systemic IGU failures; glass breakage; glazing distortion; snow drift and accumulation issues; icicle formation; issues with penetrations including lighting, LED and other accessories; façade staining; hail damage; wind uplift resistance of roofs; fire resistance of roofs; below grade waterproofing issues; expansion joint leaks; material incompatibilities; differential movement and tolerance issues; accessibility issues for maintenance; radon mitigation etc. Stay tuned! ■



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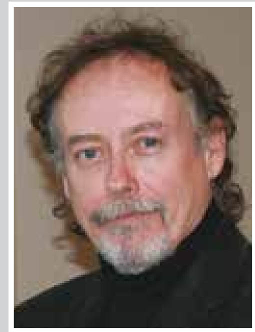


LESSONS LEARNED: BEFORE YOU PAINT THAT STUCCO...

An older walk-up apartment in southern Alberta with batt-filled stucco-clad walls – there are thousands just like it across the province. The stucco was looking shabby, so maintenance had it painted using a recommended "permeable" acrylic paint. Just a few years later, it started to look bad again, with little rusty streaks this time.

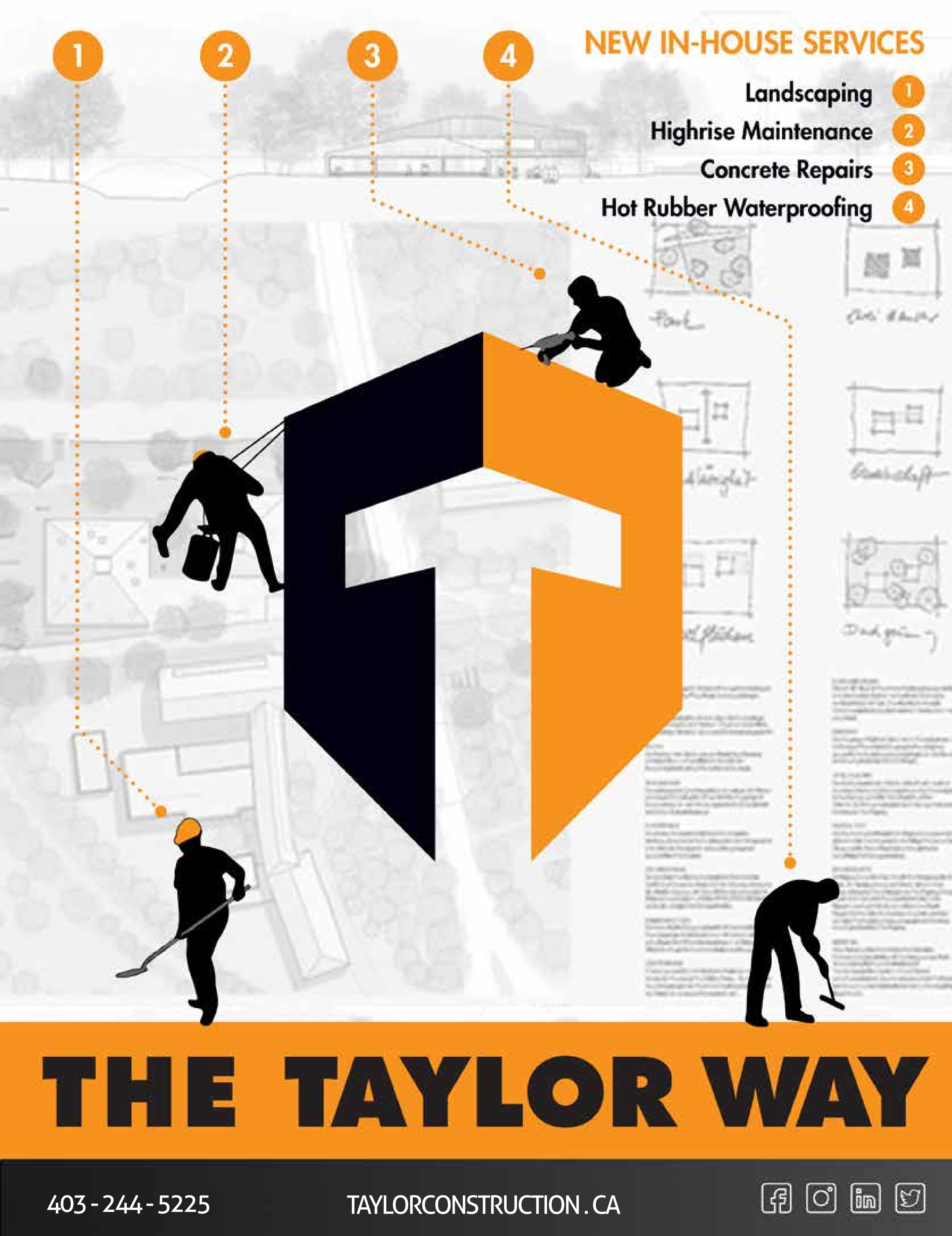
Turns out those typical stucco walls work because they allow moisture to dry to the exterior, and even permeable paint reduces a stucco wall's ability to dry. It is also true that:

- windows leak a little rain water and a little condensation into the wall framing;
- polyethylene film is a great vapour barrier but not a good barrier to moist interior air;
- flashings are never perfect;
- building paper is a 'paper' with impregnated asphalt that can wash off, so do not expect miracles; and
- even galvanized steel will rust.

Luckily, only a little stud framing needed replacement and there was hardly any mould on the interior gypsum. Everything else came off from the outside including the insulation; expensive but it looks way better now with the new cladding.

So before you paint that stucco, maybe consult someone from ABEC North or South? ■

Do you have a "Lessons Learned" horror story you'd like to share? Send us your pitch and pictures to info@abecnorth.org and registrations@abecsouth.org.



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