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Subway overhead!

A new LRT station underpins an existing subway line **P. 12**

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ON THE COVER LEA Group provided engineering services for three large underground stations of the massive Eglinton Crosstown light-rail transit (LRT) line project. The greatest challenges were at the Eglinton Interchange station, ensuring existing service could continue while constructing the Crosstown beneath the subway. See story on p. 12.
PHOTO COURTESY OF LEA GROUP.

Comment

by Peter Saunders

New generations of consulting engineers

Every consulting engineer in Canada has their own individual story of what drew them to the industry, what they have learned over the years, which projects they have worked on and where they expect to be heading next. And in our next issue (the July/August 2022 edition), we will be sharing a selection of these stories with you.

By way of explanation, that is the edition in which we will be showcasing all of the winners of our inaugural Top 10 Under 40 Awards Program. When we launched this young professionals (YP) initiative earlier this year, I have to admit, we were not sure what level and type of response we would see from Canada's consulting engineering community.

"We received a plethora of thoughtful nominations for highly worthy candidates."

Thankfully, we were pleasantly surprised by the feedback, as we received a plethora of nominations with warm, thoughtful, detailed descriptions of highly worthy candidates.

It was also a pleasure, albeit certainly a more difficult one, to review all of these nominations and then choose the top contenders from among them. In general, I would say, the more information we received from the mentors, colleagues, clients and relatives who were nominating them, the stronger the case became for those particular nominees to be honoured.

As for those who unfortunately did not make the cut this year, we are heartened to share that many of them are still young enough that they will certainly have another opportunity next year. And with that in mind, if you did not get around to nominating anyone in time for our inaugural program deadline, please start thinking now about who you personally feel should be in the running in 2023 and how you can help them get there. Your support for them will be key!

At press time, as I finish writing this editorial, I am in the midst of interviewing the first roster of winners for the July/August feature. They are a diverse bunch, from all across the country, currently at a variety of stages in their promising careers and representing a couple of generations of leaders in their fields.

Some of them have risen through the ranks of well-known Canadian consulting engineering firms and are now shifting into management roles. Others have gone out on their own as entrepreneurs and launched successful businesses that are experiencing rapid and inspiring growth.

And speaking of promising, here's another pleasant surprise I can share with you now: in an industry that has long struggled to achieve anything close to gender equity, half of this year's winners are women.

Now, depending on when you happen to receive this issue (in print or digital format) and read these words, you may already know all of the winners' names from our online news coverage about them … but it will be from our next issue that you will know their stories, which we are excited to share with you.

Stay tuned, let us know what you think and, as always, feel free to suggest other new initiatives for the future. What content would you like to see in these pages? We are open to your ideas. **CCE**

Peter Saunders • psaunders@ccemag.com

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CIMA+ appoints new president and CEO

By unanimous consent of its board of directors, Montreal-headquartered CIMA+ has named Denis Thivierge president and CEO. Effective Aug. 1, he will succeed François Plourde, who is set to retire at the end of the year.

Thivierge has more than 25 years of experience in consulting engineering. He joined CIMA+ in 2007 as vice-president for the buildings sector in the metropolitan Montreal region. He became a partner in 2008, director of the Montreal office and member of the executive committee in 2016 and chief operating officer (COO) and interim chief financial officer (CFO) in 2019.

Plourde has been with the firm for 33 years and led it for the past eight. He will remain in place this year to help ensure a smooth executive transition while continuing to manage the firm in its normal course of business.

PHOTO: COURTESY OF CIMA+

Denis Thivierge
CIMA+ president and CEO

Aecon JV wins contract to renew Buffalo Pound Water Treatment Plant

The Buffalo Pound Water Treatment Corporation (BPWTC) has awarded a $273-million design-build contract for its plant renewal project near Moose Jaw, Sask., to a 50/50 consortium between Aecon Group and Graham Construction.

The scope of work includes demolition, earthworks, structural fabrication, electrical and instrumentation work and the construction of concrete foundations and commercial buildings, yielding both new and retrofitted infrastructure. The plant supplies water to more than 260,000 people in Regina, Moose Jaw and other communities in the region. Construction is expected to begin in the second quarter of 2022 and completion is anticipated in Q2 of 2025.

PHOTO: COURTESY OF BPWTC.

The Buffalo Pound Water Treatment Corporation

PHOTO: COURTESY OF GOVERNMENT OF B.C.

B.C. promises $2.4 billion in Metro Vancouver transit improvements

British Columbia's provincial government says it will contribute more than $2.4 billion to TransLink for priority projects, including the Surrey Langley SkyTrain and electrification of its bus fleet.

The announcement is part of the province's ongoing commitment to fund 40 per cent of the Mayors' Council 10-Year Vision.

"We're making investments to support a better future for people throughout Metro Vancouver with more affordable and convenient travel options and less pollution," says George Heyman, provincial minister of environment and climate change strategy (and minister responsible for TransLink). "We're building more vibrant communities with easier access to jobs, housing, recreation and services."

TransLink's plan includes actions to maintain and expand transit service, support faster, more reliable service through bus-priority infrastructure, transition bus fleets from diesel to zero-emission vehicles (using a mix of electric batteries and renewable natural gas) and increase active transportation. The new provincial commitment builds on previous funding for increased bus, HandyDART and SkyTrain services and construction of the Broadway subway line.

"The 2022 investment plan will stabilize transit funding for the region," says Jonathan Coté, mayor of New Westminster and chair of the Mayors' Council on Regional Transportation. "We are grateful for the province's continued support across Metro Vancouver."

David Murray, P.Eng., is Chair of the Board of Directors for the Association of Consulting Engineering Companies – Canada (ACEC-Canada).

New Evidence Strengthens Case for QBS

This year has seen the release of three separate but important studies on procurement, each further demonstrating that more upfront investment in engineering results in better project outcomes. The University of Alberta released a long-awaited study in late 2021 that evaluated and confirmed the benefits of Qualifications Based Selection (QBS). Then, in 2022, two other important studies were also released. One by the Construction and Design Alliance of Ontario that demonstrates the benefits of more investment in project planning and design in engineering. The other is an update of a landmark study on QBS commissioned by ACEC-US and the American Public Works Association. You will find a summary of the findings from these important studies in the pages that follow and the results in their entirety at www.Yes2QBS.com.

All three studies demonstrate that upfront procurement decisions have a significant impact on not only the cost and quality of the design and construction phases of a project, but on operations and maintenance of infrastructure assets. These studies add to an existing body of knowledge that continue to show that engineering and other professional services typically account for only 6% to 18% of capital costs of infrastructure projects and 1% to 2% of total costs over the asset's life cycle. Yet these services dramatically impact all aspects of the financial and operational success of infrastructure for decades. It's one of the reasons ACEC-Canada advocates for the use of Qualifications Based Selection (QBS) for the procurement of professional engineering services.

An internationally recognized procurement best practice, QBS is a systematic and transparent process for selecting the most appropriate engineering firm for any project.

Recent studies are an opportunity for our industry to educate stakeholders and reform procurement.

Since QBS focuses on the qualifications of the project team and their understanding of the project objectives, the project scope, schedule and budget are realistic and commercially fair and responsible. This results in cost savings to the client and the taxpayer by ensuring high quality projects with increased service life and significant life-cycle savings over the project's entire design life. Using QBS also protects the public interest through the design, construction, operations, maintenance and eventual upgrading or de-commissioning of the project; because consulting engineering firms directly impact the health and safety of our communities, procuring their services based on qualification versus lowest price ensures public welfare. La SBC offre aux petites entreprises l'occasion de mettre en valeur l'expertise unique qu'elles pourraient apporter à un projet. Enfin, elle favorise l'innovation technique en permettant au client de développer la portée du projet pendant le processus de sélection. QBS provides smaller firms the opportunity to showcase the unique expertise they could bring to a project. And finally, it fosters technical innovation by allowing the client to develop the project scope during the selection process.

While some jurisdictions use QBS as their procurement model – it is mandated by law in the United States since the 1970s and more recently been used by the City of Calgary and the Province of Quebec – many clients are unaware of this practice or its value in maximizing sustainability, innovation, and life-cycle savings. For years, ACEC-Canada and the provincial and territorial associations have advocated to public sector clients the impact of this best practice on maximizing outcomes for taxpayers. However, it has been a challenge to effectively advocate for procurement reform and the adoption of QBS in Canada for several reasons. Increasingly, procurement is being managed by people with little knowledge of engineering and no stake in the long-term success of the project. The optics, perceptions, and implications of not selecting the lowest priced submission is also a major stumbling block for many public servants and elected officials.

The release of these studies represents an exciting time for our industry. It's an opportunity to refresh and reinvigorate the education of stakeholders that influence procurement with current data, and in particular Canadian data to augment the body of knowledge available from the United States. ACEC-Canada and the provincial and territorial associations can now more effectively advocate for procurement reform and the adoption of QBS with procurement professionals, senior public servants, elected officials, and management consultants that are advising clients. When I step down as Chair of the ACEC-Canada Board of Directors this fall, I will do so knowing that as an industry, we are positioned to make important inroads in promoting QBS and showcasing the positive impacts – financial, environmental, and social – of procuring professional services based on qualifications versus lowest price.

You get what you plan for: QBS is the best approach against the worst project outcome

Owners want projects to be delivered on time and on budget. And they want their assets to do what they were designed to do. Whether a business is constructing a new manufacturing facility, a province is expanding public transit, or a city is developing a new commercial district, consulting engineering firms play a critical role in ensuring the rapid and cost-effective delivery of infrastructure. The barriers that stand in the way are often out of the firm's control, but important measures can be taken from the outset of a project to reduce construction delays and cost overruns. In fact, these same measures can also result in better outcomes that address owners' financial, social, and environmental goals. Project success starts with procurement, which is where Qualifications-Based Selection, or QBS, comes in.

Issues at the procurement stage tend to compound over the life of the project. If not addressed during procurement, they can add delays and create problems during the design phase, and those issues regularly bleed into the construction phase and can even have operational and maintenance implications for decades. Now, three recent and thorough studies have provided evidence that confirm that owners are experiencing these procurement-based issues and also show that there are better and more effective ways to procure project planning and design services.

These studies continue to confirm that the recognized best practice of QBS offers reliable improvement of design documents, which benefits not only the clients but the entire project delivery team, including consulting engineers, architects, general contractors, and subcontractors, throughout the project life-cycle. QBS procurement focusses on identifying the best available team, based on experience and qualifications, with the best proposal and project fit, to deliver the project. An NSERC-funded study from the University of Alberta found that the average design cost index of non-QBS projects was 27.2% higher than QBS projects.[1] QBS is the best approach to protect project owners against the worst project outcomes.

Recent studies provide evidence that there are better and more effective ways to procure project planning and design services.

In Canada, the main barriers to QBS implementation are a lack of understanding of qualifications and criteria to be considered during procurement, difficulty in quantifying the impact of A/E qualifications on project performance outcomes, and lack of an automated and objective decision support

1. AbouRizk, S et al. Detailed Reports, Impact of Qualification-Based Selection of Engineering Services on Project Outcomes. University of Alberta. Edmonton. 2021.
2. AbouRizk, S. et al. Executive Summary Reports, Impact of Qualifications-Based Selection of Engineering Services on Project Outcomes. University of Alberta. Edmonton. 2021.

system for evaluating A/E services.[2] However, these studies also provide an opportunity for ACEC-Canada to further promote the benefits of QBS with federal, provincial, and municipal governments that would benefit from more cost-effective and timely delivery of infrastructure projects. Along with our provincial and territorial associations, we will continue to make project owners aware that investing more at the right time, early in the project pays long-term dividends.

QUALIFICATIONS BASED SELECTION

Low-bid procurement are disincentives to collaborative, innovative and investment in the design stage. The studies show that problems stemming from that process have grown steadily worse over the past decade, as 95% of general contractors (GCs) say they have not received a complete set of design documents in the projects they've worked on. Completeness is an issue, but consistency is another challenge. Nearly 40% of subcontractors think that the quality of documents is poorer than on typical projects in the past.[3] Over 50% of GCs indicated that the level of document consistency was poorer now than on similar projects in the past. All participants, including project owners, architects, and designers were asked about the quality of design documents (QoD) and 60% answered that they have gotten worse over the past decade.

QBS addresses a major flaw in the low-bid procurement model. It creates greater collaboration, trust, and compensation in the design phase that benefits all parties. When surveyed, over one quarter (27%) of A/E respondents indicated that contractual design time frames were insufficient. The most significant factors contributing to insufficient design time were scope or requirement changes by the client or authorities having jurisdiction, rework caused by unclear client requirements, and rework or interruptions caused by coordination issues between designers. Further, 52% said that the design fees were less than reasonable.[4]

In Ontario, 43% of projects suffered bid cancellation or extension, which adds major front-end costs for project owners. It was found that 59% to 72% of projects suffered some degree of construction schedule delay– averaging 36% of planned project duration (5.43 months). The vast majority of projects (79% to 92%) suffered cost overruns, averaging 22% of the contract value.[5] We simply cannot afford low-bid procurement.

Importantly, in the United States, project success has been a key metric for evaluating the benefits of QBS. Among project owners, 89% reported high or very high satisfaction with projects that used the QBS model, compared to 75% for non-QBS projects.[6] Designers also gave QBS high marks, with 88% of QBS projects receiving a rating of high or very high.[7] That same study found that QBS projects saw a 50% reduction in project cost growth, and a 30% reduction in project schedule growth compared to non-QBS projects.

QBS clearly provides substantial advantages for all parties on a construction project – most importantly the client and owners. Demonstrating the strength of QBS to policymakers will continue to be an important pillar of ACEC-Canada's advocacy; these studies will ensure ACEC-Canada's team has the data to better advocate for the use of this recognized procurement practice.

PHOTO: ISTOCK

3. Construction & Design Alliance of Ontario (CDAO). Impacts of Pre-Project Investment & Quality of Documents on Project Delivery Efficiencies. Toronto. 2021.
4. Ibid.
5. Ibid.
6. ACEC Research Institute. Savings, Innovation & Efficiency: An Analysis of QBS in the Procurement of Engineering Services.
7. Ibid.

Subway overhead!

A new LRT station underpins an existing subway line.

By Peter C. Ojala, P.Eng.

The greatest challenge at this station was ensuring service could continue while constructing the Crosstown beneath the subway.

PHOTO: LEA GROUP.

Over the last decade, Ontario transit agency Metrolinx and the Toronto Transit Commission (TTC) have undertaken the planning, design, and construction of the Eglinton Crosstown light-rail transit (LRT) line, which is slated for completion this year.

Uniquely integrated into the city's existing TTC subway system, the 19-km long line is the largest transit expansion project in the city's history. It will allow riders to travel east and west through 25 stations and stops along Eglinton Avenue, up to 60-per-cent faster than the existing bus service.

Opening later this year as Line 5, the Crosstown is owned by provincial transit agency Metrolinx and will be operated by the TTC. Among the stops are 15 underground stations with connections to the TTC's Line 1 (at Eglinton and Cedarvale Stations), Line 2 (at Kennedy Station) and Line 3 (Scarborough), three GO Transit rail lines and more than 50 links to bus routes.

Design, construction and maintenance have been the responsibility of Crosslinx Transit Solutions, a consortium of ACS-Dragados Canada, Aecon Group, EllisDon and SNC-Lavalin. The design joint venture (JV) has been led by SNC-Lavalin and IBI Group, working with more than 30 architectural and engineering firms. LEA Group, for example, has provided engineering services for three large underground stations, including the most complex: the Eglinton Interchange station, connecting TTC Line 1 and the Crosstown.

The greatest challenge at this station was ensuring existing service could continue while constructing the Crosstown beneath the subway.

Located below the very active intersection of Eglinton and Yonge Street (and approximately 13.5 m below the existing Yonge-University subway line), the station provides access between Lines 1 and 5, with a bus terminal and to all four corners of the intersection.

Simply constructing beneath the existing subway wasn't the only challenge. In addition to three secondary below-grade entrances, the design had to consider at-grade facilities, including a glazed main entrance at the intersection's southwest corner, an emergency exit building integrated with tunnel ventilation shafts (TVSs), the Toronto Salvation Army's new headquarters (HQ) east of Yonge and further new TTC subway TVS buildings north and south of Eglinton.

270

The cut-and-cover excavation was 270 metres wide and, on average, 23.5 metres deep. With an average external width of 17 metres, the station accommodates a 95-metre-long passenger platform.

The main LRT station structure box consists of two- and three-level reinforced concrete units. It transitions at its east and west ends, with reinforced concrete tunnels and a crossover specialty track structure to connect to twin-bored tunnels previously procured and constructed under a prior contract. Below a temporary traffic deck installed along the station area at Eglinton is a deep shored excavation, where the station was constructed using the "cut-and-cover/bottom-up" technique.The cut-and-cover excavation was 270 metres wide and, on average, 23.5 metres deep. With an average external width of 17 metres, the station accommodates a 95-metre-long passenger platform.

Structural engineering requirements

As part of the Crosslinx team, LEA provided structural and utilities design services and construction assistance for three of the Crosstown stations.

For the interchange station, considering the location's existing geotechnical conditions and proximity to adjacent high-rise buildings, including a 65-storey condo development at the intersection's northeast corner, structural engineering required a rigid re-

inforced concrete box, as buildings impose higher surcharge loads on both the permanent LRT structure and temporary shoring systems. For the main entrance, a below-grade reinforced concrete structure will interface with the TTC subway concourse and the Crosstown upper concourse levels, while an above-grade frame includes a steel structure at the building faces and roof, consistent with system-wide detailing.

In terms of esthetics, the main entrance integrates a full-height glazed, exposed structure and entrance façades with art and precast panelling. The structure frame also includes eight large steel columns, engineered to carry loads for future Build Toronto high-rise developments planned for the area.

Among the challenges for engineering and constructing the Eglinton Interchange station was the underpinning of the existing TTC subway. The excavation extended approximately 13.5 metres below this line, which remained fully operational throughout all stages of construction.

The construction process included erecting and jacking structural steel for underpinning beams and columns below and next to the subway line, followed by tied-back shoring and excavation to the base of the interchange station, as well as bottom-up construction of the permanent reinforced concrete station structure, providing support to the subway. Engineering design and approvals for the underpinning took place between 2015 and 2018. Construction took place between 2018 and 2021.

Challenges

Among the challenges for engineering and constructing the Eglinton Interchange station was the underpinning of the existing TTC subway.

An underpinning "needle beam" grid was installed below the TTC subway base, along with support girders and columns at each side. The construction created a structural steel "cradle," which carried the TTC subway load to deep foundation units that had been pre-installed prior to excavation.

Throughout construction, movement control at the subway ensured a 2-mm differential deflection limit at existing structure joints. Computerized jacking control was implemented during the installation of the needle beams under the subway, sequentially balancing and transferring the subway load to these supports.

Large-scale jacking capability was also provided at each underpinning support column for necessary adjustments of the overall subway structure during subsequent excavation and construction.

The structural components of the interchange station were complex, substantial and critical. They were completed through thorough modelling, analysis and engineering design, extensive geotechnical investigations, carefully sequenced underpinning construction, shoring and permanent work stages, and continuous monitoring of existing TTC and support-of-excavation structures during the process.

For permanent construction, the needle beams below the subway were encased in a 1.5-metre-thick reinforced grillage slab, while additional columns were installed below this grillage. An important consideration was the removal of all earth fill and limits on activity on the subway roof until the completion of the permanent unit below.

In addition, several new vertical circulation elements have been constructed to connect the subway and LRT lines, including a new staircase through the invert slab of the subway, a dual escalator set connecting to the south side of the LRT station and a new dual escalator and elevator at the existing Line 1 Eglinton station.

A new 55-metre-long TTC TVS fan plant building is being constructed under Yonge and north of Eglinton, while a separate TVS fan plant building has already been constructed south of the subway's Berwick Portal, over an open track-bed portion. This is a two-level reinforced and precast concrete structure, spanning over the subway tracks.

Developing a solution to support TTC's existing Line 1 Subway and maintain service while constructing the Crosstown LRT beneath it required extensive planning, coordination, and the area's preeminent design and construction capabilities. LEA's structural engineering team provided the technical expertise to overcome the challenges and accomplish this feat of extreme engineering. CCE

Engineering for GW&CC

Some hydrotechnical aspects of global warming and climate change

By Stan Ridley, BSc(Hon)Eng, MSc(Eng), DIC, C.Eng., MICE

Globally, our climate is changing rapidly as a result of the global warming and climate change (GW&CC) crisis and these changes are profoundly affecting the meteorology, precipitation and hydrology in many parts of the planet.

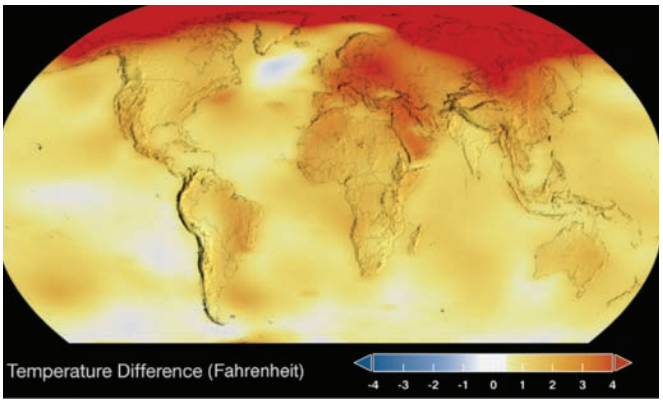
In British Columbia (B.C.), hydrotechnical and engineering aspects and issues, mainly related to our rapidly changing climate, have been very evident over the last few years and particularly in 2021.

Possibly because of the high temperature increases and resulting rapid melting of the Arctic, we in Canada seem to be experiencing a sobering preview of extreme climate changes that will surely "touch" most parts of the planet. The NASA figure below needs no explanation and the U.K. and Europe also look awfully warm when compared to the 1884 global ambient temperature base.

In B.C. our weather has been changing relatively fast and in 2021 we experienced an extreme heatwave (e.g., 49.6 Deg.C i.e., 121 Deg.F.in Lytton) and massive flooding in November of 2021.

As a result of the changing climate and particularly precipitation in B.C., the weather patterns are changing rapidly, probably "for the wetter" in the autumn and winter and "for the dryer" in the summer. As a result, it will be necessary to reassess our hydrotechnical design basis standards for both major existing infrastructure and for proposed facilities.

Of course, GW&CC are not the only phenomena affecting our climate, meteorology and hydrology. In B.C., the logging of significant areas of our massive forests and industrial, commercial and residential developments, have, over many decades, incrementally contributed to the rate and magnitude of runoff and changes in topographic drainage profiles. However, recent flooding and other climate changes have not been "incremental" but extreme, as noted above.



Global Warming Temperature Changes to end of 2020 Changes since 1884: Data source: NASA/GISS.

Revelstoke Dam spillway near the city of Revelstoke in British Columbia.

PHOTO: NASA'S SCIENTIFIC VISUALIZATION STUDIO

As an example of infrastructure of major importance are our hydroelectric facilities with their > 60 dams, > 30 hydroelectric facilities and associated reservoirs, spillways, power plants (about 16,000 MW, 55,000 GWh/Yr.) and reservoir landslide areas (https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-british-columbia.html).

The major B.C. electric utility, B.C. Hydro, that owns and operates most of the major hydroelectric facilities in B.C., operates a substantial dam safety program that reassesses, on an ongoing basis, the hydrological and seismological safety and stability of their major structures and systems, including the spillways and major landslide structures above the large reservoirs (e.g. https://docplayer.net/120262234-Landslide-risk-management-at-bc-hydro-experience-with-landslide-monitoring-and-drainage.html).

For high-risk dams, the meteorological and hydrotechnical analyses and assessments require the estimation of the probable maximum precipitation (PMP) and the probable maximum flood (PMF) inflows for each major reservoir.

PHOTO: © BY JKGABBERT / ADOBE STOCK

The PMF is the flood that can be expected from the most severe combination of critical meteorological and hydrological conditions that are reasonably possible over and in the drainage basin under study. This PMF is the estimated upper limit for determining the inflow design flood (IDF) that includes inflows from the PMP.

For less critical structures, most of Canada's hydrotechnical design standards were developed on a probabilistic basis of up to about 1:1,000 annual probability, based on historical records of typically less than 100 years. However, with the rapidly changing climate, these historical records may not be relevant going forward.

However, for major high-risk structures, like the spillways of major reservoirs and dams, deterministic/maximization models are typically used to calculate the PMF design inflows. These analytical models attempt to maximize weather/storm systems over the subject catchment basin and the antecedent snow pack and soil moisture content, the latter to minimize the runoff concentration time for each drop of rain (and/or melting ice and snow) to flow into the river/reservoir.

"Back calculating" the PMFs so obtained, using probabilistic analyses and based on the extrapolation of relatively short historical records of river flows, can result in very long estimated return periods like 1:10,000 to 1:100,000 annual probabilities with quite a lot of sensitivity "scatter" within the jaws of analytic uncertainty.

However, today, with rapidly progressing GW&CC, our historical records may not be relevant and reassessments, relying on past meteorological and hydrological records, seem less than relevant.

The photo above shows a test of the Revelstoke spillway passing a small % of the PMF, i.e., the two gates only slightly opened. Passing the full design PMF down that spillway would be quite a spectacular event.

Of course, the point is that so much of our major infrastructure, both existing and future, depends on reliable climatological and hydrotechnical data and analyses. Many of these facilities will need to be checked and possibly reconfigured to accommodate our changing climate and resulting meteorological and hydrological conditions, but using what input data?

The recent major November 2021 floods in B.C. caused extraordinary damage to our infrastructure, particularly our highways, that cut-off and restricted access for goods and services across B.C. for many weeks.

The meteorological and hydrotechnical specialists surely have their "work cut-out," re the recalculation of realistic major floods with up to 1:1,000 annual probabilities and also the much larger deterministic PMFs for high-risk structures.

Meteorological and hydrotechnical aspects of our changing climate are not the only GW&CC adaptation challenges. With a tornado/waterspout forming off of Vancouver's International Airport on Nov. 6, 2021, there are other design standards that we will need to reassess.

In Canada, both federally and provincially, we have strong protocols in place to regularly reassess our engineering standards. The call to action suggested by this brief article is to try to come to grips with the reality that we seem to be facing major changes in our climate systems. While we need to take action now to reassess the relevant design standards, the big question is on what basis? **CCE**

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Legal

By Alison Espetveidt & Rahul Ranade


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New Alberta law will require prompt payment in construction

In recent years, several Canadian jurisdictions have enacted prompt payment laws creating mechanisms for construction contractors and subcontractors to obtain timely payments on construction projects. These include amendments to the Construction Act in Ontario that came into effect in October 2019 and the enactment of the Federal Prompt Payment for Construction Work Act in July 2019 at the federal level (yet to come into force).

Alberta is set to join the list of prompt payment jurisdictions on August 29, 2022, when amendments to the Builders' Lien Act enacted through Bill 37 come into force. Besides adding new prompt payment provisions that are discussed below, Bill 37 changes the name of the Builders' Lien Act to the Prompt Payment and Construction Lien Act (the "Prompt Payment Act" or "Act").

The Province recently issued a new regulation - Prompt Payment and Adjudication Regulation ("PPA Regulation") – and amendments to the existing Builders' Lien Forms Amendment Regulation ("Forms Regulation"), both of which come into force at the same time as the Act.

Prompt payment provisions

The most significant aspect of the Prompt Payment Act is that it provides specific payment deadlines on construction projects. An owner must pay the contractor within 28 days of receiving a "proper invoice" while the contractor must pay their subcontractors (whose work is included in the invoice) within seven days of receiving payment. The subcontractor, in turn, must pay their own subcontractors within seven days of receiving payment.

Simplistically, the Act can be seen as providing a cascading scheme that works on a '28-7-7' basis, with a 28-day payment limit at the head contract level, and seven-day limits at the levels below the head contract.

Importantly, payors (owners, contractors, and subcontractors) are not subject to their respective payment deadlines if they provide to their payees a notice of dispute within the time period set out in the Act. The form of such notices must be as provided in the Forms Regulation.

A "proper invoice" is defined in the Act as an invoice that contains several pieces of information listed in section 32.1(1) of the Act. In addition to the listed requirements, the invoice must meet other requirements specified in the contract between the parties. If invoices are not paid within the statutory deadlines, the unpaid balances will be subject to interest at the rates prescribed in the PPA Regulation.

A "proper invoice" is defined in the Act as an invoice that contains several pieces of information listed in section 32.1(1) of the Act.

It should be noted that the Prompt Payment Act will only apply to any contract entered into on or after August 29, 2022

Dispute adjudication

The Act provides for a dispute adjudication mechanism under which an owner, contractor or subcontractor may refer a dispute arising out of prompt payment or builders' lien provisions for adjudication. Interestingly, the scope of such adjudication is broader than only prompt payment and builders' lien, as parties may also refer disputes related to change orders for adjudication.

The requirements for qualification and nomination of adjudicators are provided in the PPA Regulation. This regulation also addresses procedural requirements

IMAGE ©MAKSYM YEMELYANOV / ADOBE STOCK.

including what notices are owed by the parties, the adjudication process, and termination of adjudication.

Holdback provisions

The core provisions of the existing Builders' Lien Act regarding holdback remain largely unchanged. Owners are still obligated to retain 10 per cent of payments as holdback, which act as a limitation of the owner's liability. Unpaid parties will continue to have the right to file liens, and owners may have such liens discharged under certain conditions. The Prompt Payment Act clarifies the scope of the existing lien/holdback framework by expressly providing that the furnishing of concrete as a material or work is covered by holdback provisions.

Relevance for consulting engineers

It is important for consulting engineers to understand legislated prompt payment requirements. Consulting engineers are likely to be involved on both sides of a construction project – paying and receiving payments. Consulting engineers often act for project owners as contract administrators or payment certifiers and, in such roles, would be responsible for understanding and implementing owners' payment obligations. On the other hand, consulting engineers are also called upon to prepare invoices, either acting for contractors or working as subcontractors themselves (for example, on design-build projects).

In situations where consulting engineers are acting on behalf of payors and are responsible for approving invoices, they should note two important deadlines under the Act – those for filing notices of disputes and those for making payment. Failing to meet either deadline could result in commercial or legal risk for the payors. Further, engineers should note that the form of the notices must follow that set out in the Forms Regulation.

On the other hand, when acting for payees and preparing invoices, consulting engineers should know the requirements for "proper invoices." A defective invoice will prevent the engineer or their clients from getting the benefits of prompt payment.

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An owner must pay the contractor within 28 days of receiving a "proper invoice" while the contractor must pay their subcontractors (whose work is included in the invoice) within seven days of receiving payment.

Conclusion

While the recent wave of legislative reforms related to prompt payment in Canada does not directly pertain to the consulting profession, consulting engineers will often find themselves operating right where the statutory rubber hits the road, when they prepare and review construction invoices on behalf of their clients and when they themselves act as subcontractors on construction projects.

Failure to meet these legislative requirements could result in a commercial disadvantage for clients or the engineers themselves. While the Act does not come into force until later this summer, preliminary copies of the Prompt Payment Act, the PPA Regulation, and the Forms Regulation are all available for review. It would be prudent for consulting engineers with any involvement with construction in Alberta to familiarize themselves with these provisions before they come into force. **CCE**

Data centre design

Tips for designing HVAC systems for data centres and pitfalls to avoid.

By Andrew Snook

There is a push toward sustainable data centres. *Photo: JCI.*

For companies that want to maintain complete control of their infrastructure, data centres are often a key component. That said, they are also energy intensive and can be costly to maintain, so designing an efficient HVAC system for them is extremely important. There are several key factors to consider when designing an HVAC system for data centres.

"We see environmental impact, initial capital cost, and capital cost being primary considerations when deciding on cooling methodologies," says Dave Ritter, product manager for Johnson Controls. "Finding the right balance to meet space constraints, PUE (power usage effectiveness), and WUE (water usage effectiveness), while remaining scalable and cost effective has become more challenging in recent times."

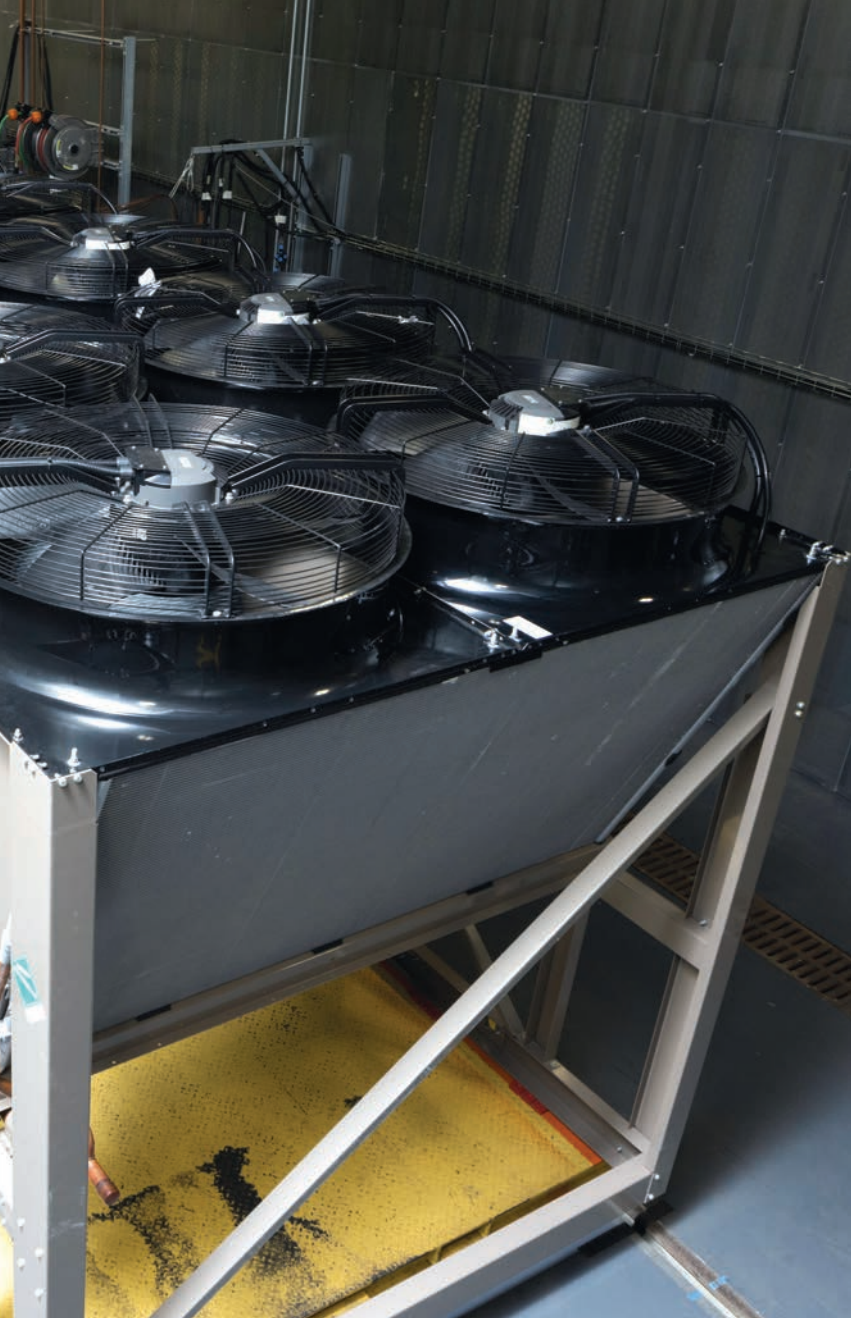
Michael Strouboulis, director of business development for data centres at Danfoss, says the most important items to consider are rack density, the surrounding environment, uptime requirements and the targets for PUE.

"Rack density and outside temperatures will determine whether an air or liquid cooling system should be used. To meet uptime requirements, it is essential that the sub-components within the cooling equipment are of high quality, high reliability, highly engineered and tested components – such as compressors, heat exchangers, motors, fans, flow and automatic controls. Technologies such as oil-free compressors can eliminate known cooling system failure modes, such as failures due to loss of lubrication of oiled compressors," he says.

Increasingly, consulting engineers are expected to design for improved data centre operational efficiency and reduced power consumption and to employ equipment that decreases the carbon emissions of the data halls

Since data centres are high energy users, and we live in an era where businesses are expected (and sometimes legally obligated) to reduce carbon emissions and lower their energy costs by improving efficiency, there is a push toward sustainable data centres, Strouboulis says.

"Increasingly, consulting engineers are expected to design for improved data centre operational efficiency and reduced power consumption and to employ equipment that decreases the carbon emissions of the data halls," he says, adding that PUE, WUE, and energy reuse effectiveness (ERE) all should be considered in the design process. "There is an opportunity to improve ERE by capturing and reusing the heat generated by the data centre using energy transfer stations and district energy loops for commercial, residential and industrial heat consumers nearby."



Common mistakes

One of the more common mistakes sometimes made when designing a data centre is not taking into consideration the entire system as a whole.

"The components in a data centre HVAC system must work together; therefore, the entire system must be considered in the design process," Strouboulis says. "For example, specifying a balanced chilled water hydronic loop in the data centre is just as important as the chiller or cooling tower or variable speed pump specifications. Pressure independent control valves and smart actuator specifications help eliminate hot-spots, a very common issue, by delivering chilled water where it is needed most, in the racks with the highest loads, and help reduce commissioning time significantly. And if they are equipped with sensors that collect data about the hydronic loop, they can dynamically optimize its operation in real-time."

Another pitfall is going with a design that does not permit flexibility in allowable rack density.

Common mistake

One of the more common mistakes sometimes made when designing a data centre is not taking into consideration the entire system as a whole.

"As IT equipment is replaced and upgraded over time, rack density will change. Data centre operators will be at a major disadvantage if the racks are not re-configurable for different rack density, potentially resulting in inadequate cooling," Strouboulis says. "A future-proof design will use components that can automatically adjust operational characteristics based on the local rack needs. And pay attention to cable management. An incorrect configuration could cause unintended blockage of air flow in the rooms."

Ritter adds that some components in HVAC systems have a 15- to 30-year life, which far exceeds the useful life of the IT equipment in the data hall, so it's important to ensure HVAC investments are futureproofed.

"For example, as thermal guidelines and rack density continues to expand, consider if designs are adaptable to take advantage of a changing landscape," he says.

Another common mistake is when companies take any unoccupied room in their office (mailrooms, empty office, janitorial closets) and convert it into a data closet, and rely on the existing HVAC infrastructure for climate control.

"This approach may be the right choice in terms of square footage needed, but when it comes to proper climate conditions for sensitive IT equipment, it could not be more wrong. At best, these spaces are cooled using only the building's AC system. At worst? An open window," says Herb Villa, senior applications engineer at Rittal Corporation. "A building's existing air conditioning system - or combined heat and air conditioning system - is designed to create comfortable environments for employees – the reason they are sometimes referred to as 'comfort systems.' When IT racks need to be placed somewhere on site, it's thought that 'any old room' will do because AC ductwork usually terminates in these spaces. However, the reality is that even if you were to add ducts to supplement the building's AC, relying on a system designed for humans is not a good solution for IT equipment."

Villa says there are five enclosure climate control challenges to consider that create hidden risks when relying on a building's HVAC system:

- ***Contaminants:*** *A repurposed space can be exposed to airborne dust, gasses and moisture that seep into the room and compromise the quality of the air and the performance of the equipment; these may not be adequately removed from the room using only the existing AC.*
- ***Reliability/redundancy:*** *Even a short interruption in power supply to computer equipment can lead to loss of data, and the same is true for interruptions in cooling. Most buildings do not have redundant*

Since data centres need to operate 24 hours a day, seven days a week, 365 days a year, they are extremely energy intensive. *Photos: Danfoss.*

cooling in place and often an AC system breakdown can last hours – a costly risk for IT equipment.

- ***Comfort systems cycle on and off:*** *The temperature in the closet will decrease when the cooling system is on and increase when it is off, resulting in temperature swings throughout the day that can stress the equipment more than a consistent higher temperature. Moreover, the issue is not only related to daily temperature swings, but more sustained periods that put the equipment outside the zone. Comfort cooling systems are often programmed for higher temperature set points on weeknights and weekends to conserve energy. The average temperature within a server closet will generally increase by the amount the temperature set point is increased.*
- ***Combined heating and cooling HVAC systems deliver heat in winter:*** *The same ductwork that supplies cool air to the IT closet in warmer months will deliver heated air in colder months. This almost guarantees overheating of the equipment and increases the risk of equipment failure.*
- ***Inability to scale:*** *Every kilowatt of power used by the IT equipment creates a kilowatt of heat that must be removed. If you were to add an additional rack and more equipment, the existing HVAC system would be even less capable of maintaining the ideal temperature.*

Design tips

Strouboulis offers the following recommendations for designing the system to be as energy efficient as possible:

- Keep current and future energy density in mind. This will aid in selecting the right equipment initially and help avoid unnecessary and often -sub-optimized expansion later;
- Consider free cooling in order to benefit from higher operating temperatures allowed by IT equipment manufacturers;
- Centralize the cooling instead of using multiple modular units to increase overall energy efficiency. However, this must be analyzed against the need for varying cooling needs over different racks; and
- Use adiabatic cooling to provide cooling without compression. This needs to be done with due consideration of water usage (for example, using oil-free high-pressure pumps with very-fine-misting nozzles instead of water spray grids).

Sustainable solutions

Since data centres need to operate 24 hours a day, seven days a week, 365 days a year, they are extremely energy intensive. Strouboulis says to create more sustainable data centres, engineers must consider PUE, WUE and carbon usage effectiveness (CUE). "With the trend toward low-GWP and low-density refrigerants, Danfoss and other manufacturers have developed compatible compressors, heat exchangers, sensors and flow controls," he says. "Regions with favourable climate conditions are ideal for the adoption of free cooling techniques. Danfoss and others have gasketed plate heat exchangers for liquid-to-liquid free cooling as well as components for evaporative and adiabatic coolers for data centres, using specially designed oil-free high pressure pumps and nozzles for very fine water misting that saves water."

Recovering heat from data centres and providing this heat for industrial or district energy needs is an important step in sustainability, Strouboulis adds. "Avenues for simple heat recovery with liquid-to-liquid heat exchangers or heat pumps that provide useful heat to district heating or water heating applications are worth considering when designing data centres."at. **CCE**

Literature review

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Professional directory

Educating tomorrow's building scientists

Cynthia Cruickshank, P.Eng., is the director of Carleton University's newly built Centre for Advanced Building Envelope Research (CABER) in Ottawa. As a professor in the school's Department of Mechanical and Aerospace Engineering, she has focused on the optimization of energy systems for buildings, from super-thin insulation to solar-assisted heat pumps. The CABER is a $5.1-million, 6,000-sq.-ft. lab that will facilitate large-scale testing of products and methods for improving energy efficiency and resilience for new and existing buildings—but its main goal, in partnership with Natural Resources Canada (NRCan), is to develop the next generation of building scientists.

"We knew there was a gap to fill in training students as building scientists."

How did the focus of your research expand from mechanical systems to the building envelope?

In 2013, in partnership with Algonquin College and Queen's University, I was one of the lead faculty advisors for Team Ontario in the Solar Decathlon, which challenges students to design and build net-zero energy homes. Although my main focus was developing an integrated mechanical system, this project also introduced me to the design and testing of the building envelope, a key factor in reducing energy consumption. Team Ontario won first place in the engineering contest because of both our mechanical system design and our energy-efficient building envelope.

How did that experience lead to developing the CABER?

Afterwards, I reached out to NRCan—which had supported our Solar Decathlon team—to explore possible research opportunities with its buildings and renewables group. We knew from a needs assessment of the construction industry that there was a gap to fill in training students as building scientists.

There was also a need to test materials that were new to the building industry, such as vacuum-insulated panels that had previously only been used in freezers. In collaboration with NRCan, I set up a guarded hot box in my lab—i.e. a cube with an internal chamber wired with sensors that provide data to help calculate a wall's ability to resist the transfer of heat.

Two years later, we recognized the need for larger-scale equipment. I applied for and received funding from NRCAN's Office of Energy Research and Development (OERD) and the provincial government through the Ontario Research Fund (ORF) for new equipment and training for students.

What can the new facility do?

The CABER features a two-storey hot box and a pressurized spray rack to assess the air and water tightness of wall samples. There are six openings along the circumference of the facility where smaller samples can be placed for testing—even for up to two to three years.

Construction of the CABER is now complete and commissioning has started. After it opens, we will test systems for single-family homes, multi-unit residential buildings (MURBs) and commercial and institutional projects. We have a 16-tonne crane and can test up to 600-mm wide envelopes, so we can handle large-scale applications. We also have a climate chamber that can simulate temperatures from -35 to 50 C.

In the meantime, we are starting our grad-level building engineering program this fall.

Cynthia Cruickshank

-35 TO 50 C

We also have a climate chamber that can simulate temperatures from -35 to 50 C.

The CABER will facilitate large-scale testing of products and methods for improving energy efficiency and resilience for new and existing buildings.

Are you partnering with industry, too?

Yes. We are in the process of developing an industry advisory committee to ensure what we are working on has the most impact. Consulting engineering firms are welcome to reach out and join us! **CCE**

PHOTO: COURTESY OF CYNTHIA CRUICKSHANK.

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