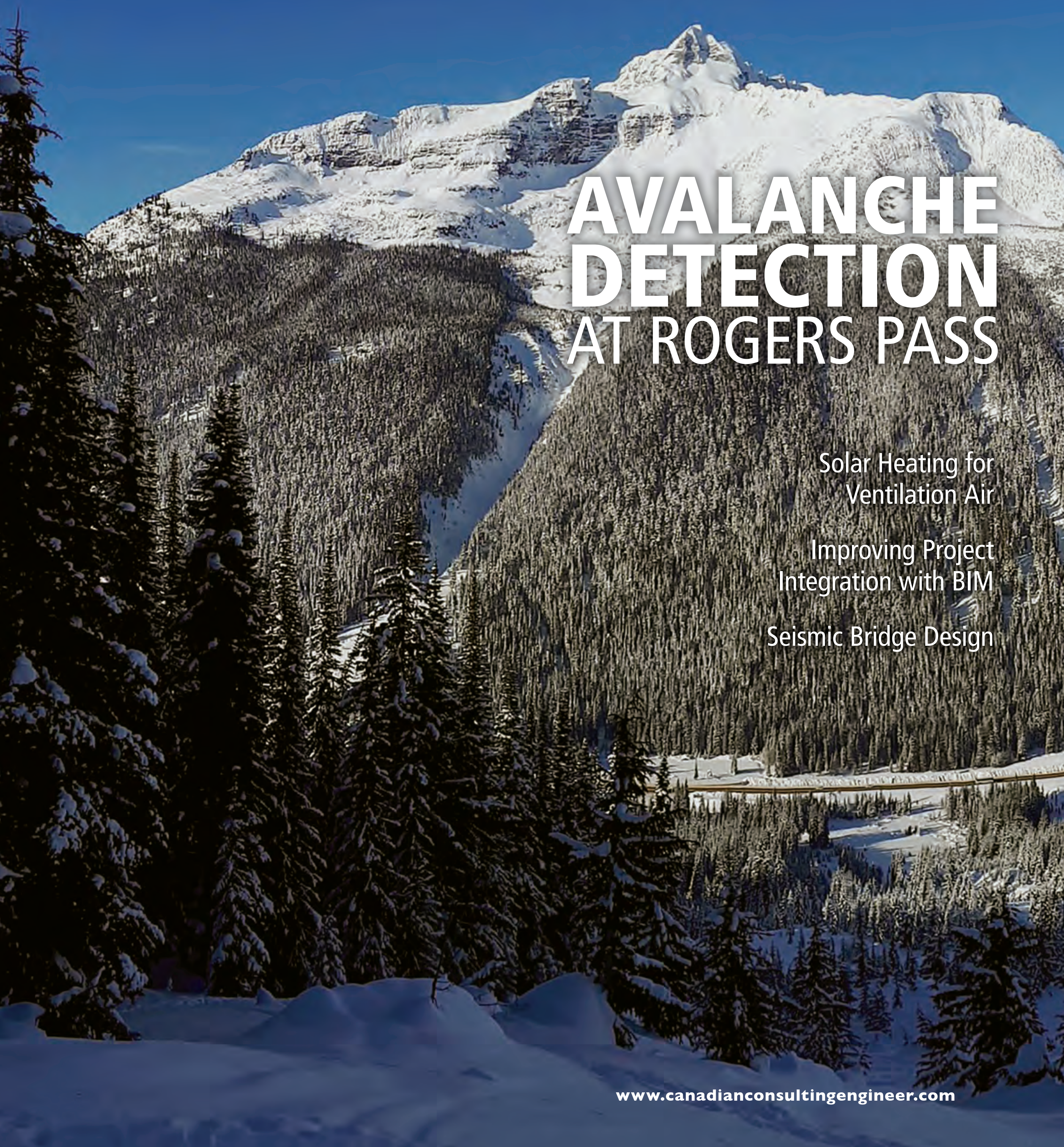
For professional engineers in private practice

DECEMBER 2020

# CANADIAN CONSULTING engineer



## AVALANCHE DETECTION AT ROGERS PASS

Solar Heating for Ventilation Air

Improving Project Integration with BIM

Seismic Bridge Design

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December 2020
Volume 61, No. 7

Photo courtesy Parks Canada
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**Next issue:**
Screening wastewater for the novel coronavirus.

# on topic

# We asked, you answered!

In between determining the winners of the 2020 Canadian Consulting Engineering Awards and sending them their plaques and announcing the results to the broader community, we recently interacted with you in a different way: a readership survey, our first in years.

It was a great chance to check in with you during the global COVID-19 pandemic, as we have not been able to run into each other at conferences, trade shows and other in-person industry events.

We were impressed and grateful to see nearly 300 of you—representing consulting engineering firms that tackle a relatively even mix of work across the commercial, industrial, institutional, transportation, residential and public sectors—respond to this short survey. You provided feedback on what you'd like to see from us in the future; not only within this printed magazine, but also in a variety of electronic and online formats. The undertaking yielded a number of insights.

First, you're more interested in news, case studies and research than in how-to articles or white papers. In the world of social media, you strongly favour LinkedIn over Twitter and Facebook.

In term of specific topics, you expressed more interest in feature articles on training and skills development (incidentally, check out the timely one on page 22 of this issue) than in such day-to-day business matters as management and insurance.

This is all helpful for us to learn as we plan our content for 2021 and how best to deliver it to you. Thanks to all who took part. And remember, I'm also always open to hearing from you directly with your thoughts on the magazine. My email address is below.

And don't worry, we didn't forget about the prize draw we promised! Everyone who took the survey and provided their email address was eligible, but in the end, only one participant could win the $100 Best Buy gift card: Bryn Harris of Alexandria, Ont.

**Peter Saunders**
**psaunders@ccemag.com**

CORRECTION
In our special October/November Awards Issue, we tried something new this year by adding a map of all the winning projects' sites across Canada, on page 13. Unfortunately, we made an error on this map, switching the positions of the Engineering a Better Canada Award winning Arviligruaq Ilinniarvik School and the Award of Excellence winning Mould Bay Causeway Reconstruction. We fixed the mistake in the digital edition (DE), but were not in time to amend it in print. We apologize for the error.

FOR PROFESSIONAL ENGINEERS IN PRIVATE PRACTICE
CANADIAN CONSULTING engineer

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PEOPLE

### Morrison Hershfield

Catherine Karakatsanis

Catherine Karakatsanis, chief operating officer (COO) of Morrison Hershfield, headquartered in Markham, Ont., has been elected to a four-year term with the board of the Fédération Internationale Des Ingénieurs-Conseils (FIDIC), a global standards organization for the consulting engineering profession. Also, her firm has promoted Todd Baker, based in Burnaby, B.C., to global waste practice lead.

### WalterFedy

The board of directors for WalterFedy, headquartered in Kitchener, Ont., named Garth Cressman, P.Eng., CEO of the engineering and architecture firm and its sister company, AEC Developments. He succeeds Paul Reitzel, who is now chief financial officer (CFO). Also, three of WaterFedy's shareholders—Patrick Darby, P.Eng., Matt Ninomiya, P.Eng., and Russ Parnell, P.Eng.—have joined its ownership team.

### The Hidi Group

Ahmad Shaki, principal with the Hidi Group, is manager of the firm's newest office in Ottawa. Headquartered in Toronto, the firm also has offices in Calgary and Dubai, U.A.E.

Rendering courtesy Diamond Schmitt Architects

## Exp, Crossey and Diamond Schmitt to develop Fredericton's new performing arts centre

Fredericton's municipal government has selected Diamond Schmitt Architects and Exp Engineering to design its new performing arts centre, with Crossey providing mechanical and electrical engineering.

Diamond Schmitt will develop a detailed design to assist with discussions with other levels of government for project funding. Exp will serve as associate architect and provide structural and civil engineering, accessibility measures, commissioning and support for Crossey's mechanical and electrical systems.

The facility will be constructed on the site of the current Fredericton Playhouse, which was built in 1964, to provide a larger, modern building that can host more visitors for year-round events. It will also connect to the adjacent Fredericton Convention Centre.

## NRCan selects BBA to enhance cybersecurity for energy infrastructure

Natural Resources Canada (NRCan) has awarded a mandate under its Cyber Security and Critical Energy Infrastructure Program (CCEIP) to Montreal-based BBA to assess risks for industrial control systems (ICSs) connected to energy infrastructure.

With $160,000 in federal government funding, BBA's ICS cybersecurity risk methodology project will develop a model to help organizations in the energy sector identify, assess and manage cyber risks associated with their operational equipment, so they can improve their resilience to attacks and become better-prepared to respond to incidents. The federal government is concerned such attacks pose risks to national security and the economy.

## Vancouver's Wavefront Centre earns Canada's highest accessibility rating

Photo courtesy Wavefront Centre

The Wavefront Centre for Communication Accessibility's new building in Vancouver has achieved the highest national accessibility rating to date under the Rick Hansen Foundation Accessibility Certification (RHFAC) program.

With a score of 96 out of a possible 100 points, the building has earned gold-level RHFAC. The program rates "meaningful access" based on the user experience for people with disabilities affecting mobility, vision and hearing.

The Wavefront Centre provides services to help break down communication barriers for people who are deaf, deafblind or hard of hearing. Its new head office is intended to showcase universal design.

Local firms that were involved in the project include Aqua-Coast Consulting Engineers (building envelope), Opal Engineering (electrical), Fluid Mechanical Engineering (mechanical), Wicke Herfst Maver (structural), Protection Engineering (code consulting), DENV Engineers (sprinklers) and Bunt & Associates (transportation engineering).

### Metrolinx awards new contracts to Wood

Ontario public transportation agency Metrolinx awarded several new infrastructure contracts to engineering firm Wood to expand and upgrade its transit network.

The work includes leading design for two bridge projects: the structural rehabilitation of the approximately 120-year-old Rouge River railway bridge (pictured) to extend its service life and improve its resilience; and the replacement of the Birchmount bridge to expand its track capacity and prepare it for future GO Train system electrification.

Metrolinx has also awarded contracts to Wood for the Barrie railway corridor and further expansion of Toronto's subway system, all part of an overall effort to double the use of transit across the Greater Toronto and Hamilton Area (GTHA).

Rendering courtesy Stantec and Exp

### Stantec and Exp to design Île-d'Orléans cable-stayed bridge

Quebec's ministry of transportation has selected the Groupement Origine Orléans joint venture (JV), including consulting engineering firms Stantec and Exp, to produce the preliminary design for a new cable-stayed bridge connecting Île d'Orléans and the north shore of the St. Lawrence River, near Quebec City.

The 2.1-km bridge is to be built west of an existing bridge that dates back to 1935. The replacement will feature two wider lanes of traffic, shoulders and a multi-use pedestrian and cyclist lane on both sides, along with nighttime illumination. Preliminary works are slated for 2022 and commissioning for 2027.

The JV, chosen from among three bidders that submitted conceptual designs, also includes Lavigne & Chéron Architectes, Michel Virlogeux Consultant, Ramboll and Ombrages/Éclairage Public.

Photo courtesy Wood

COMPANIES

### Jensen Hughes acquires CFT

International security and safety consulting engineering firm Jensen Hughes has acquired fire protection engineering and building code consulting firm CFT Engineering in Burnaby, B.C. The acquisition strengthens a regional foothold for Jensen Hughes, which already has an office in Vancouver. CFT's principals will remain with the business.

### Hatch integrates with LTK, RobertsDay, X-Terra

Hatch has integrated with LTK Engineering Services, an international firm focused on passenger rail systems; taken over RobertsDay, an Australian urban design firm; and signed a memorandum of understanding (MoU) with X-Terra Environmental Services to join forces in serving clients in Saskatchewan.

### Haag expands into Canada

Haag Global, a 96-year-old forensic engineering and consulting company based in the U.S., began its international expansion with the launch of Haag Canada. CEO Chris Giffin, P.Eng., is heading development of a team of multidisciplinary professionals and their new headquarters (HQ) in downtown Toronto. Services include loss remediation and mitigation, among others.

# AVALANCHE DETECTION AT ROGERS PASS

Photos courtesy Parks Canada

By Heather Kent

With 134 avalanche paths endangering a section of the Trans-Canada Highway through Rogers Pass in British Columbia's Glacier National Park, effective detection measures are crucial. With that in mind, the federal government's Avalanche Detection Network (ADN) aims to improve local forecasting. Once completed, it will be the world's largest project of its kind, according to Lisa Dreier, project manager for the Canadian division of Swiss-based Wyssen Avalanche Control (WAC).

Consulting engineering firm McElhanney has worked with Parks Canada on ADN, which uses WAC's Infrasound Detection of Avalanches (IDA), Long Range Avalanche Radar (LARA) and 'WAC.3' integrated web-based alert platform, which processes and displays large amounts of data on a readily accessible map.

"It detects avalanches in all conditions—in the middle of a storm, at night, when visibility is reduced to nothing," explains Alan Jones, P.Eng., principal with Dynamic Avalanche Consultants, based in Revelstoke, B.C. "Forecasters have a limited ability to know when to close the highway. The goal is to increase their confidence and improve the efficiency of closures."

IDA was tested at Rogers Pass over the 2016/2017 winter. Jones says the results showed potential for reliable detection of avalanches up to 3 km away. As a result, four units were installed in the winter of 2018/2019 and a further nine were added the following fall.

The goal is to cover approximately 75% of the highway through Rogers Pass. Overlapping array sensors installed on the valley bottom continuously 'listen' for avalanche activity on all of the surrounding slopes. Software can then determine the direction of the beginning and end of an avalanche, as well as its duration. WAC.3 highlights paths on a map where an avalanche is most likely to be released. As Jones explains, the technology will be re-evaluated and the software algorithm refined, as an ongoing process.

Meanwhile, LARA monitors predefined areas, selected by forecasters. High-resolution cameras installed on counter slopes, with direct sightlines to the avalanche paths, are triggered as soon as an avalanche is detected. They can measure an avalanche's specific direction and velocity. One was installed in the winter of 2018/2019 and three more were added the following fall.

Further, whenever avalanche activity is detected, WAC.3 sends automatic email and text messages to the forecasters. The platform is accessible from any web-enabled device.

"Forecasters love it," says WAC's Dreier. "It's very intuitive to use." **CCE**

*Heather Kent is a freelance writer based in the Vancouver area.*

The Infrasound Detection of Avalanches (IDA) technology uses overlapping array sensors installed along the valley.

# Balancing IAQ and Energy Efficiency Via SOLAR HEATING

With the COVID-19 pandemic, the paradigm is shifting for ventilation air.

By John Hollick, P.Eng.

Given its attention in mainstream media, political rhetoric, industry guidance and changing regulations, the focus on ventilation air has never been more prominent than it is now. For years, buildings have reduced their fresh air intake to help minimize energy consumption (and corresponding carbon emissions) and achieve better performance standards. This strategy, however, is now being challenged by the need to dramatically increase fresh air intake to improve indoor air quality (IAQ) and minimize the risk of indoor airborne transmission of the novel coronavirus.

This is an important discussion for consulting engineers and building designers to contemplate now—and there are ways to increase ventilation air intake without incurring a corresponding increase in energy costs and carbon emissions. Among such options is the use of solar air heating.

## No need for a trade-off

One example of this technology is the use of a perforated metal collector system to preheat ventilation air before it enters the fresh air side of a building's HVAC unit. These systems can be mounted on a building's wall or roof, sized to accommodate anywhere from 1 to 10 cfm of ventilation air per sf.

Photo courtesy Conserval Engineering

Halifax's Dalhousie University uses solar air heating on the Mona Campbell Building to warm daytime ventilation when it is occupied.

The Toronto Transit Commission's (TTC's) McNicoll bus garage features 24,000 sf of solar air heating systems along its south and west elevations.

Photo courtesy Strasman Architects

The technology has already been used extensively over the past 30 years across North America for many types of buildings, including schools, universities and colleges, and has allowed them to meet or exceed their required ventilation intake without increasing energy costs. Thus, there is no need for an energy efficiency trade-off when tacking the problem of COVID-19.

## ASHRAE recommendations

One of the prominent industry advocates in the media has been William P. Bahnfleth, professor of architectural engineering at Penn State University and chair of ASHRAE's Epidemic Task Force.

"The U.S. Centers for Disease Control and Prevention (CDC) have stated airborne transmission of SARS CoV-2 can occur when there is inadequate ventilation indoors," he says. "This is also corroborated by evidence from superspreader events. Multiple analyses of infection risk have concluded the combined effect of ventilation, filtration and air cleaners should be equivalent to four to six air changes per hour of outdoor air, although there is considerable uncertainty associated with these estimates. HVAC systems should be inspected to confirm they are bringing in at least the outdoor air supply required by a minimum design standard, such as ASHRAE 62.1."

ASHRAE also released a position document on infectious aerosols, including the following recommendations:

- Disable demand-controlled ventilation and open outdoor air dampers up to 100%, as conditions permit, to eliminate recirculation.
- Keep HVAC systems running longer hours—if possible, 24-7.
- Bypass energy recovery ventilation systems that could leak potentially contaminated exhaust air into the outdoor air supply.

Solar air heating systems are ideally suited to help meet all of these recommendations, as there are numerous ways to incorporate them into buildings' mechanical ventilation systems.

"We have successfully incorporated solar air heating for schools, including both new construction and upgrades," says Robert Cenedese, principal at

**"Since the arrival of COVID-19, our ventilation loads have increased."**

*Nathan Gerber, Fanshawe College*

Fanshawe College in London, Ont., has integrated solar air heating systems alongside other metal wall cladding systems for its main common building, in an effort to keep the exterior design visually pleasing.

Rocky Point Engineering in Langley, B.C. "The original design intent of preheating demand-controlled ventilation air has proven to work effectively. Interestingly, an additional feature has been implemented through direct digital control (DDC) programming. When conditions permit, preheated solar air is used as first-stage heating for the spaces served, regardless of the carbon dioxide ($CO_2$) demand. Thereby, in addition to heating the spaces using free solar energy, the ventilation airflow rate increased, resulting in improved IAQ without increased energy consumption or carbon emissions. A true win-win!"

## Case in point

Fanshawe College in London, Ont., is an example of a large campus that has implemented a greenhouse gas (GHG) reduction road map and action plan to ensure low-carbon buildings.

The process included an ASHRAE Level 1 energy audit, with the goal of reducing GHG emissions by 30% between 2013 and 2030—and 50% by 2050.

The college found ventilation air heating was a significant contributor to its GHG emissions, due to the consumption of natural gas as a source of heat energy.

"The college was looking to reduce GHG emissions and saw energy harvesting through the use of solar air heating as an innovative yet natural technology that addressed this need," says Nathan Gerber, Fanshawe's energy co-ordinator. "This, along with the fact the technology could be used on an existing wall area, in an esthetically balanced if not pleasing way, provided a good opportunity for further investigation."

Fanshawe went on to specify solar air heating for five of its buildings, with 11,000 sf of the systems applied to two residences and another 21,000 sf for three other buildings. The systems were integrated into multiple walls for these applications, supplying several rooftop air handling units.

Today, in total, they condition 115,000 cfm of ventilation air while avoiding the consumption of 152,000 $m^3$ of natural gas per year, emissions of 286 t of $CO_2$ per year—5.3% of the college's total emissions—and the use of 1,530 MWh of energy per year.

"The goals of the initiative were to reduce GHG emissions, provide learning and research opportunities for staff and students and address deferred maintenance needs in some of our older buildings," says Gerber. "Now, since the arrival of COVID-19 and its actual and potential implications on IAQ, ventilation loads have increased, resulting in an even greater impact on GHG emission production and subsequent potential avoidance through solar radiation harvesting."

## Transforming thinking

Similar to how the Leadership in Energy and Environmental Design (LEED) rating system transformed the industry's thinking on energy performance for buildings, so now will COVID-19 transform thinking on the 'health' of buildings.

That is to say, it will reinforce the need to design and operate buildings that not only meet energy standards, but also meet health standards for an indoor environment with plenty of ventilation air.

Different technologies will play a role in helping to achieve both goals, including solar air heating systems, for institutional, commercial, industrial and multi-tenant residential buildings. CCE

**"Analyses of infection risk have concluded the combined effect of ventilation, filtration and air cleaners should be equivalent to four to six air changes per hour of outdoor air."**
*William P. Bahnfleth, ASHRAE Epidemic Task Force*

*John Hollick, P.Eng., is president of Conserval Engineering and inventor of the company's SolarWall unglazed transpired collector technology for solar air heating.*


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# Successful Strategies for SEISMIC BRIDGE DESIGN

Photos courtesy Pedelta

By Juan A. Sobrino, P.Eng.

Designing buildings and infrastructure to withstand major earthquakes is challenging and has a significant cost, but can be justified as a preventative measure when, by way of example, the Insurance Bureau of Canada (IBC) estimates the cost of a magnitude-9 earthquake in British Columbia would be almost $75 billion.

Universities across Canada have conducted research on earthquake engineering for those provinces with higher seismic risk, including British Columbia, Ontario and Quebec. Professional and technical associations have also developed seismic design guidelines.

As a result of these efforts, seismic design has evolved significantly in the past decade, as reflected in the latest revisions of most structural design codes. Provisions of the Canadian Highway Bridge Design Code (CAN/CSA-S6-14) and National Building Code (NBC-2015) have been revised substantially to incorporate advances in seismic design and newly available earthquake data.

**Performance and probability**

The revised codes incorporate new seismicity maps and design provisions. CAN/CSA-S6-14 adopted a performance-based design (PBD) approach, with criteria for meeting specific requirements for different bridge categories, based on their importance and given a specified seismic hazard. Unlike traditional force-based design (FBD), which uses minimum earthquake force to ensure no collapse, the PBD approach sets out structural, functional and service performance criteria to limit damage and ensure serviceability and emergency response.

Seismic forces are random and complex to assess. For this reason, structural design codes incorporate a probabilistic approach. Critical parameters, such as earthquake magnitude and seismic activity for specific return periods, location and geological and site soil conditions, define the maximum earthquake ground acceleration, which in turn informs the design spectrum. The seismic force on a particular bridge is defined by its mass, structural system, dimensions and materials.

**Revised codes incorporate new seismicity maps and design provisions.**

There are multiple ways to design a safe bridge under seismic actions, but it is not economical to attempt to avoid all damage from a strong earthquake. The PBD approach allows for some damage while ensuring no collapse for a moderate to strong seismic event with low probability and preventing brittle failures. Seismic design principles incorporate ductility, energy dissipation and capacity concepts to achieve fusion-like action or damping, accepting reparable damages in specific parts of the structure or large displacements during an earthquake.

### Technological tools

Two of the most effective tools for protecting bridges from earthquake damage by reducing seismic forces are (a) base isolation and (b) energy dissipation devices. Both of these technologies are suitable for either new construction or retrofits.

#### *Base isolation*

The concept of base isolation is to introduce specially designed, flexible bearings that accommodate large seismic displacements and decouple the structure from ground motions, shifting the vibration periods of the structure to reduce the earthquake's acceleration—keeping in mind the bridge will experience larger displacements that, in some situations, are difficult to accommodate.

In typical circumstances, base isolation is achieved by installing the bearings for horizontal target flexibility, while adding energy dissipation devices to control the displacements. The use of base isolators is a cost-effective approach for small- and medium-span bridges in high seismic regions.

#### *Energy dissipation*

The energy dissipation concept introduces additional damping in the structural system, typically by installing

Figure 1: Base isolators for bridge over 44th Street in Cali, Colombia.

shock absorbers that allow slow movements in service conditions, but provide displacement control, dissipate energy and transmit forces under sudden movements, such as earthquake motions.

As mentioned above, shock absorbers are often combined with seismic isolators to both reduce seismic forces and control displacements.

**It is not economical to attempt to avoid all damage under a strong earthquake.**

## Lessons learned in Latin America

Colombia is one of the seismic-prone countries with the highest earthquake hazards, with maximum peak ground accelerations comparable to the most dangerous locations in British Columbia and Quebec. For this reason, seismic isolation is frequently used for the country's short- and medium-span bridges. The two following examples illustrate the effective use of base isolation and shock absorbers.

First, in the city of Cali, a new south expressway spans 44th Street with a 120-m long, 12.4-m wide bridge, monolithically connected to a 130-m long, 7-m wide ramp structure (see larger photo on page 12). The superstructure is a post-tensioned concrete slab.

Both technical and esthetic considerations drove the design of this urban bridge. The project included high-damping rubber bearings (base isolators) in all piers and abutments (see Figure 1, above). With this approach, the vibration period increased from 0.33 to 1.90 seconds. By shifting this fundamental period, seismic demand was reduced by 65% in the longitudinal direction and 57% in the transversal direction, leading to significant cost savings in the foundations and substructure.

Secondly, in the town of Honda, the Magdalena River is crossed by a new 407-m long, 16.3-m wide cable-stayed bridge with two traffic lanes, a main span of 247 m and two back spans of 80 m each (see smaller photo on page 12). The stays are anchored in H-shaped towers, 60 m high above the deck level. The towers are founded on 12.2-m diameter concrete caissons, up to 38 m deep.

The abutments are massive counterweights to which six stays are anchored. Through free pot confined elastomeric bearings, they take the uplift force from the backstays.

Due to the high seismicity and poor soil conditions of the location, the project team decided to use high-damping rubber bearings over the piers to increase shock absorption in both directions, accepting minor repairs in case of earthquake. With this strategy, the fundamental vibration periods were increased to 5.5 seconds in the longitudinal direction and 3.1 seconds in the transversal direction, achieving a 40% reduction of seismic forces.

To limit the longitudinal direction's displacements, the design incorporated four hydraulic dampers with a load capacity of 750 kN each and a 300-mm stroke capacity. The combination of shock absorbers and base isolation (see Figure 2, below) resulted in a considerable reduction of the foundations and, thus, considerable cost savings. **CCE**

*Juan A. Sobrino, P.Eng., is CEO of Pedelta, an international bridge and structural engineering consulting firm headquartered in Toronto.*

Figure 2: Shock absorbers for bridge over Magdalena River in Honda, Colombia.


# ALUMINUM'S ADVANTAGES for Bridges

A higher initial cost can yield savings in maintenance and repairs.

By Alex de la Chevrotiere, P. Eng., and Martin Hartlieb

Photos courtesy MAADI Group and Viami International

Aluminum became a common construction material choice relatively recently. Today, it is successfully used for many applications. Its low weight is an advantage for cars and planes, for example, to improve their fuel efficiency. It is the most easily and frequently recycled material and offers the highest scrap value. And it is a durable option for buildings and structures.

Steel and concrete were dominant materials for pedestrian and vehicular bridges for decades, while aluminum was given little consideration. Today's architects, however, recognize the advantages of aluminum with regard to total cost of ownership (TCO); while the initial costs of construction and installation are higher, the ongoing costs of repairs and maintenance are lower.

That said, early attempts to use aluminum in bridges were not always successful, as engineers did not yet fully understand the material and how to work with it. Only now is that changing.

## Attractive characteristics

Aluminum has many characteristics that make it attractive for a variety of applications, including pedestrian and vehicular bridges.

The first, as mentioned earlier, is its high strength-to-weight ratio, which improves efficiency for its transportation, assembly and installation. Further, by reducing the dead load of a bridge deck, the live load can be increased.

Aluminum is highly resilient. It can flex under loads and spring back from the shock of an impact. It is also great for cold weather. Unlike most other materials, it does not lose its ductility when the temperature drops. Instead, aluminum actually becomes stronger at lower temperatures.

For outdoor structures, durability is its most crucial advantage. Aluminum generates an invisible protective oxide coating, providing high resistance to atmospheric corrosion.

Thanks to its high malleability, alu-

Built 18 years ago, the Verdun marina bridge, made with mill-finish aluminum, has never required maintenance or repairs.

minum can be transformed for many applications. It offers high rigidity and energy absorption. Through extrusion, aluminum profiles can assume complex shapes, maximizing geometric properties or incorporating grooves, hollow areas or other linear features for a specific purpose.

Aluminum can be easily assembled with other materials and today's engineers can avoid common problems, like galvanic corrosion, seen in the past.

Unlike steel, aluminum does not require paint or any other protective finishing, except to enhance its appearance. Indeed, aluminum structures do not need to be painted for their entire lifetime, up to 100 years. Also unlike steel, they can be sanded or pressure-washed to remove graffiti without damaging their finish.

As mentioned, aluminum can be easily recycled. Claims that steel has a smaller carbon footprint are true only in comparison to primary aluminum, which is produced from raw bauxite/alumina, but most aluminum used in North America, including extrusions for bridges, contains recycled aluminum, representing a much smaller carbon footprint than steel. Aluminum has a much lower melting point and basically does not lose any of its inherent properties or quality during recycling.

Additionally, the cost of recycled aluminum is lower than that of primary aluminum.

**Early attempts to use aluminum in bridges were not always successful.**

## Improved alloys

The first aluminum bridge structures built from the 1930s and '60s were made of Al-Cu alloys, which were strong but difficult to extrude into complex shapes. They were also subject to significant corrosion problems, leading to early failures.

The introduction of Al-Si-Mg alloys, which depend on $Mg_2Si$ precipitation hardening, facilitated the extrusion of beams with complex hollow cross-sections that were more resistant to corrosion. Newer bridges around the world have been made with these alloys—and, in most cases, with a high amount of recycled content or certified sustainable low-carbon primary aluminum.

Design choices are often limited by stiffness and fatigue. Most bridges today use standard Al-Si-Mg alloys with T6 temper because they offer the same modulus of elasticity and fatigue strength as special high-strength versions.

In one commercially available bridge design, weld-free aluminum decking enables a maximum allowed vehicle weight of 15 tons for pedestrian, movable, temporary and military bridges, maritime structures and construction platforms.

## Real-world performance

To illustrate the differences between steel and aluminum, consider two pedestrian bridges along the St. Lawrence River. The first, located in Verdun on the island of Montreal, is an aluminum bridge built 18 years ago. The second is a steel and concrete bridge installed in 1988 in Longueuil, on the south shore. A few kilometres apart, they face the same climate and were designed for the same live load.

### *Verdun marina mill-finish aluminum bridge*

The Verdun marina bridge is a 25-m long and 3-m wide arched pony truss bridge constructed in 2002 with Cumaru wood decking by Technomarine in accordance with CAN/CSA-S6-00, the Canadian Highway Bridge Design Code. It was designed for a live load of 4.8 kPa.

Only the vertical pickets have a powdercoated finish. The rest is natural mill finish aluminum.

According to the Borough of Verdun, the bridge has never required any repairs or maintenance in its 18 years. Indeed, it should not require any maintenance or major repairs over the next few decades.

### *Marigot hot-dip galvanized steel footbridge*

The Marigot pedestrian bridge on Marie-Victorin Boulevard in Longueuil is a galvanized steel structure with a reinforced concrete deck, 127 m long and 3.86 m wide, featuring several simple spans with steel pony trusses. It was built in 1988.

Reinforced concrete slabs comprise the deck, which rests on steel girders arranged in three simple spans. It is longer than the aluminum bridge, but similar in width, design, use and live load.

**The material becomes stronger at lower temperatures.**

The Marigot bridge has required repairs and regular preventive maintenance. In 2014, for example, the cost of preparing and metal spraying the steel surfaces and taking environmental protection measures was $302,000. Similar maintenance was needed again in 2019, by which point it cost more than $322,000—and that same year, the bearings, deck support and guardrails were replaced at a cost of $190,000.

So, the bridge needed $814,000 in repairs and maintenance over a five-year period. Additionally, several hundred thousand dollars were incurred for organization, administration and traffic management on the site.

### Comparing TCO

Comparative analysis of maintenance costs confirms the TCO of hot-dip galvanized steel in an urban setting exceeds that of aluminum after 33 years. And as mentioned, a well-designed and constructed aluminum bridge has a lifespan of 100 years. The lowest initial cost, therefore, is not necessarily the best option. CCE

*Alex de la Chevrotiere, P. Eng., is president of MAADI Group, based in Boucherville, Que. Martin Hartlieb is president of Viami International, based in Beaconsfield, Que. For more information, please visit www.maadigroup.com and www.viami.ca.*

Longueuil's Marigot steel footbridge has needed repairs and regular maintenance.

# Leveraging BIM to Improve PROJECT INTEGRATION

There is no one-size-fits all solution.

Images courtesy Victaulic

By Ralph Schoch

A recent survey of the construction industry by the Building Innovation Research Centre (BIRC), an organization within the University of Toronto's (U of T's) civil and mineral engineering department, found most respondents believed building information modelling (BIM)—*i.e.* digitally representing a built environment's physical and functional characteristics—will continue to become more prominent across various sectors. Indeed, some 75% of respondents agreed governments, owners and clients will either insist on BIM adoption or simply go ahead and implement it themselves.

Yet, while it appears the industry is actively working to implement BIM methodologies, many respondents also reported they have not established a process to create teams to evaluate and assess the viability of new approaches. The sheer volume of available software can be daunting to such teams when determining if BIM can live up to the hype of sales pitches and actually drive efficiency after it is integrated into their workflows.

As the Canadian construction industry continues to move forward with BIM, it is important to recognize it is not a one-size-fits-all solution for engineers. Rather, it is a process, a method for implementing best practices, that can achieve strong results when tailored to a specific business.

## Capitalizing on integrated technology

When the construction industry discusses BIM, it tends to focus on streamlining processes to take a project toward successful completion, but the technology has the potential to deliver much more, if all the pieces that make up the program work together seamlessly. So, it is important to consider software integration and compatibility.

A report from JBKnowledge noted 80% of companies use up to five different software platforms, most of which do not integrate with one another. Project managers need co-ordinated tools from conception through installation to improve their workflows.

"Software integrations eliminate redundancies and improve efficiencies for companies across projects, offices and divisions," wrote JBKnowledge's analysts.

Typically, such gains in efficiency are only achieved when various programs both function well and communicate with each other.

### Preconstruction

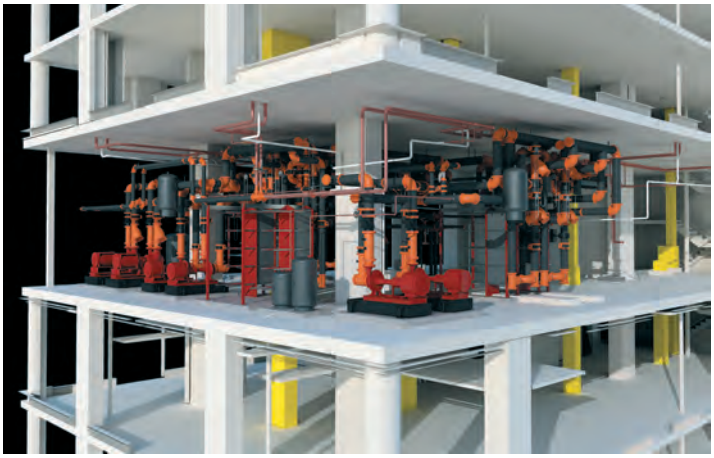
The successful implementation of BIM tools begins at the earliest preconstruction stages of a project.

In recent years, the first choice for BIM software has shifted from Autodesk's AutoCAD Verticals to Revit. One key reason is Revit's ability to connect and work with other software packages and add-ons, building upon initial software investments. This interoperability is best showcased through the addition of three-dimensional (3-D) point scanners, virtual reality (VR), augmented reality (AR) and mechanical, electrical and plumbing (MEP) modelling collaboration programs.

During preconstruction, 3-D scans of a job site can be imported into a series of compatible programs, allowing final images to be viewed in both AR and VR platforms. This allows companies to visualize designs of MEP systems not only as 3-D models unto themselves, but also within the spaces where they will eventually be installed. This can help identify issues that traditionally would only have been revealed on-site, once installation was already taking place.

Software interoperability can also enhance collaboration between teams and eliminate bottlenecks during modelling and co-ordination processes. Prior to using BIM, when a company modified a computer-aided design (CAD) model, the changes had to be emailed to the end user, triggering a project review. This time-consuming process would involve at least several back-and-forth emails, until the change was eventually approved. Today, software can allow team members to exchange comments in real time, streamlining the process.

Seamless integration helps project managers move through the modelling process quickly, the trades co-ordinate their efforts more easily and crews to start work on the job site earlier.



The right software mix is key to integrated project delivery (IPD).

### Fabrication

With a BIM workflow, the streamlining of co-ordination can be applied at every stage of a project, including fabrication.

Fabrication spools can be created and published in Revit. Then, using other programs like GTP's Stratus, each spool's status can be updated both in the fabrication shop and within the Revit model.

This integration provides a higher level of control for project managers over the co-ordination process, and real-time updates on the status of each spool piece within the shop. Data is integrated into the Revit model for viewing by multiple stakeholders. And as a spool moves through the shop, its status code can be updated in both Stratus and Revit without the need for republishing.

**The sheer volume of available software can be daunting.**

Prefabrication in Revit is simplified because team members can visualize the project site, identify any clashes before they occur and then co-ordinate their efforts to find solutions. Designers can create virtual mockups with specific components, enabling more precise estimating, as well as the ability to verify all aspects of a project are compliant with relevant codes.

Thus, through greater awareness, adoption and integration of BIM tools, the construction industry can continue to improve efficiency and deliver greater value than was possible through traditional approaches.

### Laying a foundation for success

Recent data suggests 40% of the construction sector's current workforce will retire within five years. The industry cannot afford to lose this knowledge. To make up the difference, companies will have to trade in the traditional spreadsheet for an advanced alternative, sooner rather than later. Being able to 'do more with less' will continue to be a reality for many firms.

In this context, the value and benefits will become all the clearer for investing in integrated software platforms that provide a foundation for streamlined processes, seamless communications, real-time collaboration and decision-making and greater productivity. CCE

*Ralph Schoch is software, technology and internal support manager for the virtual design and construction (VDC) department at Victaulic, which manufactures mechanical pipe-joining and fire protection systems. He primarily focuses on 3-D piping system layout, design and fabrication.*

# TRANSFORMING SEWAGE TREATMENT

## A pilot program is engineering wetlands in Chestermere, Alta.

By Peter Saunders

Photos courtesy Magna Engineering

Left: Untreated wastewater sample from septic tank. Right: Sample after treatment by wetlands.

Magna Engineering Services, a consulting firm based in Chestermere, Alta., recently partnered with the local government and Calgary-based Eco-Growth Environmental on a sewage treatment pilot program that aims to use engineered wetlands and dehydration to turn raw sewage into biofuel, fertilizer and water.

The program takes inspiration from green infrastructure practices that have benefited small European communities for nearly 100 years, but have rarely been imitated anywhere in North America.

"Nature knows best," says Magna CEO and owner Jennifer Massig, P.Eng., formerly a city councillor and senior engineering consultant for Chestermere. "I started this company to do sustainable, long-term projects for municipalities. In this case, I talked to regulators about what Europe does in terms of using wetlands for wastewater treatment. Chestermere wants to be at the forefront of innovation and my main job in this respect is advocacy."

Drawing wastewater from a local septic tank, the project is using a Magna Omni-Processor (MOP) for naturalized wastewater treatment and an Eco-Growth system within a public works yard, combining micro-screening (to separate liquids from solids), small-scale engineered subsurface wetlands and a solids handling dehydrator and boiler, so as to transform liquid waste into high-quality water and solid waste into energy and ash for fertilizer or road materials.

"This particular technology is only from the last three years," Massig explains.

In the past, Chestermere's sewage has been transported elsewhere for treatment. One goal of the project is to instead provide complete autonomy over its water resources.

The project is also supported by Alberta Innovates, the National Research Council of Canada (NRC) and the Canadian Environmental Technology Advancement Corporation - West (CETAC-WEST). The system began full operations on Sept. 10 and ran until Nov. 20, at which point full results could be reviewed and, for that matter, the project could avoid the need for full winterization.

"From day one, we had some epic fails," Massig laughs. "We were using agricultural chemical totes to hold sand, gravel and organics, for example, but they didn't work well and they developed hairline cracks. We also sourced mulch from the landscaping industry that turned the water a terrible red colour. At the same time, though, we also hit our targets with Environment Canada from day one, with really positive results. We thought we would have to recycle the water for a while to let the vegetation 'take,' but no, the system worked from the day we turned it on."

Next, Magna will scale the technology up for a larger coastal project in Prince Rupert, B.C., which is expected to be up and running in June 2021. CCE

# Specifier's Literature Review

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## professional directory

# The Next Generation of Business Leaders

## Today's firms will rely on tomorrow's managers.

*Andrew Steeves, P.Eng., a member of this magazine's editorial advisory board (EAB) and past-chair of ACEC-Canada, has seen a growing need for the industry's young professionals (YPs) to expand upon their engineering skills with business management acumen, so they can take on leading roles for both new and old firms–and as engineer-in-residence at the University of New Brunswick (UNB), he is particularly well-aware of opportunities to build upon a post-secondary education.*

***What opportunities do you see for YPs to thrive in today's industry?***

I worked for more than 30 years at an employee-owned firm, ADI, and we shared numbers that showed how we made or lost money. You need to know your break-even point.

A relatively small firm, with 15 or so people, can do very well in this industry—better than a 50- to 100-person firm with higher overhead costs. And there are many niches, like corrosion or loss prevention, where a specialized firm can work with the big guys.

***What are your thoughts on ho mergers and acquisitions (M&A) have reduced the number of consulting engineering firms across Canada?***

The trend is driven by small firms that were run well in the past, but now their owner is looking to sell—and since the employees are not aware of or privy to the firm's business performance, they are not willing to invest in it. A larger firm, on the other hand, may have access to the numbers and the expertise to assess the opportunity.

**There's a lot of interest in adding non-technical social and business skills.**

A lot of today's firms date back to shortly after the Second World War, when engineers returning to Canada could start and run a business based mainly on their own confidence—but now there is increased responsibility to conduct assessments and complete reports. As engineers have become more specialized in their technical expertise, they have not necessarily built up their entrepreneurial expertise, as they have wanted to design, rather than manage design.

There's a lot of interest in adding those non-technical social and business skills, such as communication, teamwork, career planning, project management, working with clients, managing contracts, mentoring staff and, in the overall sense, running a profitable business.

***How are you developing and providing such education?***

I'm one of the founding partners in Design Firm Seminars (DFS), along with John Boyd and Ben Novak. We have planned, created and delivered programs to improve the business skills of consulting engineers, from in-house seminars to annual group teaching programs.

Collaborating with ACEC-Canada, we have most recently developed the ACEC Certificate in Management Essentials. Launching in January 2021, it involves a series of four two-hour virtual learning sessions, which participants can access live or recorded.

After these sessions, they will be challenged to demonstrate their understanding of business management concepts by working online with fellow participants to answer a specially formulated case study. Then they will have the opportunity to present their conclusions to a panel of ACEC board directors and past chairs.

For successful completion of the group case study, ACEC will issue a certification of completion. The program will assist in professional development unit (PDU) accreditations.

In the meantime, we also need more research into professional engineering firms and how they can best operate, especially the employee-owned ones, which seem more willing and able to try new things. **CCE**

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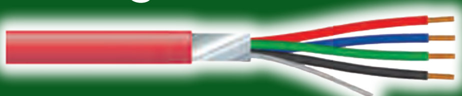

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