

Complex infrastructure needs require new



The need for infrastructure renewal has long been known and potential solutions that seek to do more with fewer resources, while accounting for severe weather events over the long term, are debated daily in the public policy realm. How is engineering practice adapting to this new imperative?

engineering approaches

By Michael Mastromatteo



Don't look now, but the crumbling state of Ontario's aging and overstretched infrastructure, combined with taxpayers' calls for greater value for public money spent, are requiring engineers and others involved in making infrastructure decisions to devise more effective, efficient and sustainable ways of fixing the province's roads, bridges, structures, transit systems and water treatment facilities.

Adding to the complexity of finding appropriate solutions are concerns about extreme weather incidents and climate change, which, as Engineers Canada's Public Infrastructure Engineering Vulnerability Committee has noted, are nullifying much of the existing data on nature's impact on built infrastructure.

In 2012, four organizations, including the Canadian Society for Civil Engineering (CSCE), released the first-ever Canadian Infrastructure Report Card. It reported that while not all the infrastructure news is dire, there are some daunting challenges ahead for decision makers and those supporting them.

The initial infrastructure report card confined itself to municipal drinking water, wastewater, storm water and road systems. It found that nearly 10 per cent of these systems are in poor or very poor condition, while another 23 per cent are in only fair condition. The report card pegged the overall value of Canada's municipal infrastructure at approximately \$538 billion.

One of the key recommendations of the report card's authors is that cities across Canada must adopt new and innovative ways to assess, manage and build municipal infrastructure.

The civil engineering society strongly recommends developing new systems and techniques to promote better decision making related to the planning, design, construction, operation and funding of municipal infrastructure across the country.

For Ghani Razaqpur, PhD, P.Eng., professor of civil engineering at McMaster University and head of its infrastructure research group, the decision making around infrastructure investment cries out for greater engineering involvement.

"We need participation from the broad engineering community," Razaqpur told *Engineering Dimensions* in an interview. "We need designers, researchers, construction and materials experts, and we need engineers who work at the cutting edge of infrastructure research and development to be part of the problem-solving team."

He says other professional disciplines and forms of expertise will always be a part of infrastructure rehabilitation solutions, but that their input will remain secondary to the technical and scientific contributions of engineers.

PURVIEW OF ENGINEERING

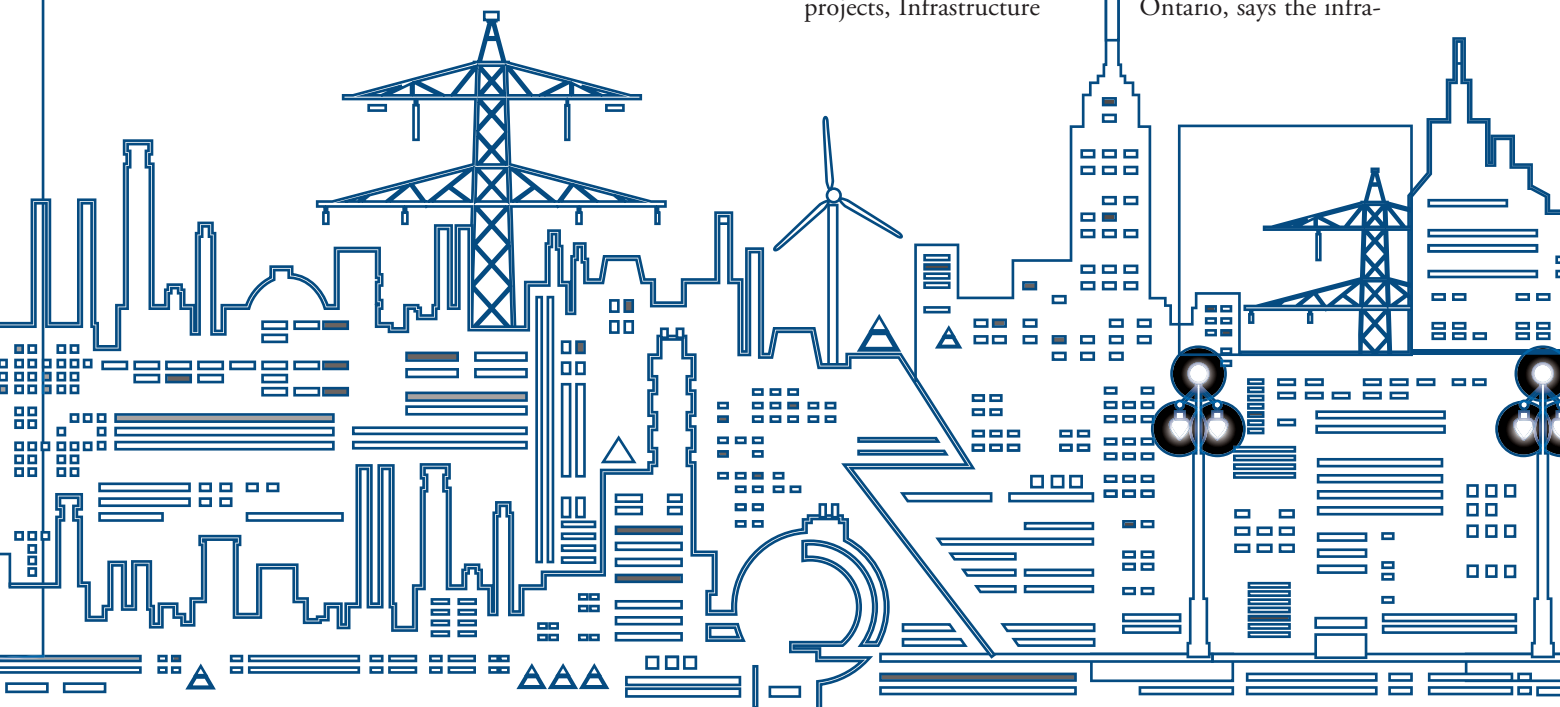
"The actual design and implementation to make [public infrastructure] durable and sustainable falls squarely within the purview of engineering," Razaqpur adds. "Regrettably, today the debate is led by non-engineers, and the engineer often plays a secondary role with regard to planning and decision making."

One response to engineering/infrastructure challenges is seen at the University of Toronto, which recently instituted a master's program in cities engineering and management in its faculty of applied science and engineering. Initiated in 2013, the program looks to turn out engineering graduates with a deeper understanding of the complex, cross-disciplinary issues facing cities throughout the world.

"Engineers have long been concerned with designing and managing components of cities, but now, enabled by information technology, we are able to look at cities in a more integrated fashion," says Chris Kennedy, PhD, P.Eng., former director of the program. "There's also an emergence of analytical technique and models that begin to transcend the grey space between engineering and urban planning."

Other professional engineers heavily involved in infrastructure agree that new thinking and approaches are clearly in order.

Derrick Toigo, P.Eng., senior vice president, major projects, Infrastructure Ontario, says the infra-



structure deficit has forced government decision makers and engineers to be alert to different approaches to the funding, delivery and maintenance of new projects.

Infrastructure Ontario is a provincial government body created in 2005 to stimulate infrastructure construction projects, primarily by looking for new procurement and funding models. It teams up with public sector agencies, municipalities and other organizations to procure and deliver large-scale infrastructure projects. The agency is an early exemplar of the public-private partnership (P3) system that many hold out as a logical combination of resources to confront and overcome the infrastructure deficit in Ontario.

Infrastructure Ontario relies heavily on engineering input because of the requirement for significant due diligence and risk analysis before any project gets underway.

Engineering due diligence is done mainly in such areas as geotechnical, hydrogeological and hazardous materials testing. These are areas of risk, Toigo says, that must be addressed prior to issuing a request for proposal.

“We also assess, through written reports and visual inspections, the structures affected by our projects. Our project teams have many individuals who are professional engineers, but we work with the broader engineering community that has expertise in these fields to assist us in the due diligence.”

Toigo was one of half a dozen engineers presenting at the September 16 to 17 Future of Canada’s Infrastructure Summit in Toronto (see p. 21). He says engineers are key in the design of infrastructure, but also need to be familiar with all-encompassing approaches to the planning, development, operation and maintenance of infrastructure assets.

“Infrastructure Ontario has many diverse team members, but I would say the cornerstone to many of our teams are the engineers who work with us,” Toigo says. “The engineers working at Infrastructure Ontario have a mindset for following processes, but also for creative problem solving. The ability to recognize risk and determine the probability and impact of the risk occurring is important to identifying where there may be potential pressures on project budgets and schedules.”

BETTER DECISION MAKING

Arnold Yuan, PhD, P.Eng., director of Ryerson University’s Institute for Infrastructure Innovation, says engineering can also contribute to the development of better decision-making tools for the entire infrastructure industry.

Yuan is part of a research cluster promoting a risk-informed, life cycle-based dimension to infrastructure planning and decision making. He calls it a systems approach to infrastructure development, aimed at improving the information available to engineers and decision makers. “It’s a key way of bringing all the factors and constraints together and avoiding the ‘silo’ approach to decision making that occurred in the past,” Yuan says.

Indeed, speakers at the Future of Canada’s Infrastructure Summit identified this silo approach of separate departments and agencies within municipal government all struggling with different aspects of infrastructure renewal as a major obstacle to making progress.

One of the most basic of solutions, as presented to the summit by Darla Campbell, P.Eng., chief executive, Ontario Coalition for Sustainable Infrastructure, is for all stakeholders to share information readily and strive for consistent approaches to common problems.

Another approach to infrastructure renewal and investment that’s gaining prominence is the concept of asset management. The CSCE’s infrastructure report card empha-



sizes the need for municipalities to have an asset-management system in place to increase the longevity of its assets by optimizing investments in maintenance and rehabilitation.

A mature, infrastructure asset-management system should provide repeatable and “auditable” evaluation of infrastructure condition and investment needs. CSCE says this would enable infrastructure owners to establish asset-management plans that consider rates of deterioration and community-service levels.

The Canadian Network of Asset Managers (CNAM) is an organization promoting asset management programs as a key ingredient in municipal infrastructure investment and rehabilitation. An association of municipal employees, consulting engineering firms and other stakeholders, CNAM provides a forum for city governments to exchange information related to municipal infrastructure asset management from both operational and strategic perspectives.

Alain Gonthier, P.Eng., Ottawa’s manager, asset management, business and technical service, is the past chair of CNAM. “Asset management is the coordinated activities of an organization to maximize the usage and value of its physical assets,” he says, adding that service and users, rather than the physical assets themselves, are the key focus for infrastructure asset managers. “Infrastructure assets only exist to support the delivery of services to the community. If there were not a service to be provided, there would not be a need for the asset,” Gonthier says.

“It’s no longer a question of how to design bridges, structures, roads and different pieces of infrastructure,” he adds, “it’s understanding how these assets will be managed over their service life. Many of these assets have very long, in some cases, decades-long lifespans. Understanding the true cost over the asset life goes well beyond the initial construction cost.”

Gonthier notes that an asset-management system helps establish priorities when it comes to the allocation of funding and resources.

“If we had unlimited dollars, we could look at [assets] in isolation, but because we don’t have unlimited dollars, we have a lot of funding challenges,” he says. “There are a lot of needs and expectations, and linking these back to service levels challenges us in terms of what are the best decisions to help support the services we are delivering.”

Gonthier says engineers involved in infrastructure asset management will have to learn to engage more directly with other disciplines in developing an innovative approach to managing infrastructure assets.

“Historically, we didn’t talk much about asset management,” he says. “If you go back 15 years, you would probably be hard pressed to find any references to infrastructure asset management. That term has really evolved over the last decade because of the realization that it’s not just about building new infrastructure. Now, not only is there pressure to build new infrastructure, but there is also a need to invest in infrastructure that already exists.”

ENGINEERING INFLUENCING ORGANIZATIONAL DECISIONS

Gonthier notes that engineers involved in infrastructure asset management are “taking engineering from a pure applied science and expanding that to influence decisions made at the organizational level—one where we are setting out plans and directions for strategic investments.”

Indeed, the debate about infrastructure investment and renewal involves complex decision making against a dizzying array of new constraints—increasing urbanization, limited financial resources, and severe weather patterns being chief among them. It is not only about what, when and how to build, but also sometimes about when to knock down and start over.

In addition, engineers involved with infrastructure must be constantly focused on the future. Says Razaqpur: “What is needed foremost is to have a rigorous and detailed plan, at least for the next 25 years, to have an inventory of what we have, what we need to build, how much we need to maintain the existing facilities and what it will cost to build and maintain new facilities. We also have to ask who will pay for all this, and what technical and engineering know-how we need to ensure we get the best return on our investment.”

“To me, it’s about rediscovering our cities,” says Kennedy. “Look at the construction in downtown Toronto, or downtown Kitchener, for that matter. Infrastructure is being recognized as a key ingredient for making them healthier and more vibrant. It’s a different type of infrastructure, though, from the last century, with more emphasis on ‘quality of place.’”

CSCE and its partner organizations are scheduled to release the second Canadian Infrastructure Report Card in September 2015. The report card will give an update on the state of the selected infrastructure, which may indicate how well engineering is adapting to the complex decision making needed for infrastructure that builds better communities. Σ

Guidelines for infrastructure engineering

To assist professional engineers involved in the design and management of public infrastructure, PEO publishes the following professional practice guidelines:

- Acting Under the *Drainage Act*
- Engineering Evaluation Reports for Drinking Water Systems
- Engineering Services to Municipalities
- Land Development/Redevelopment Engineering Services
- Roads, Bridges and Associated Facilities
- Solid Waste Management
- Transportation and Traffic Engineering

The guidelines are available from PEO’s website at:
www.peo.on.ca/index.php?ci_id=4377&la_id=1

