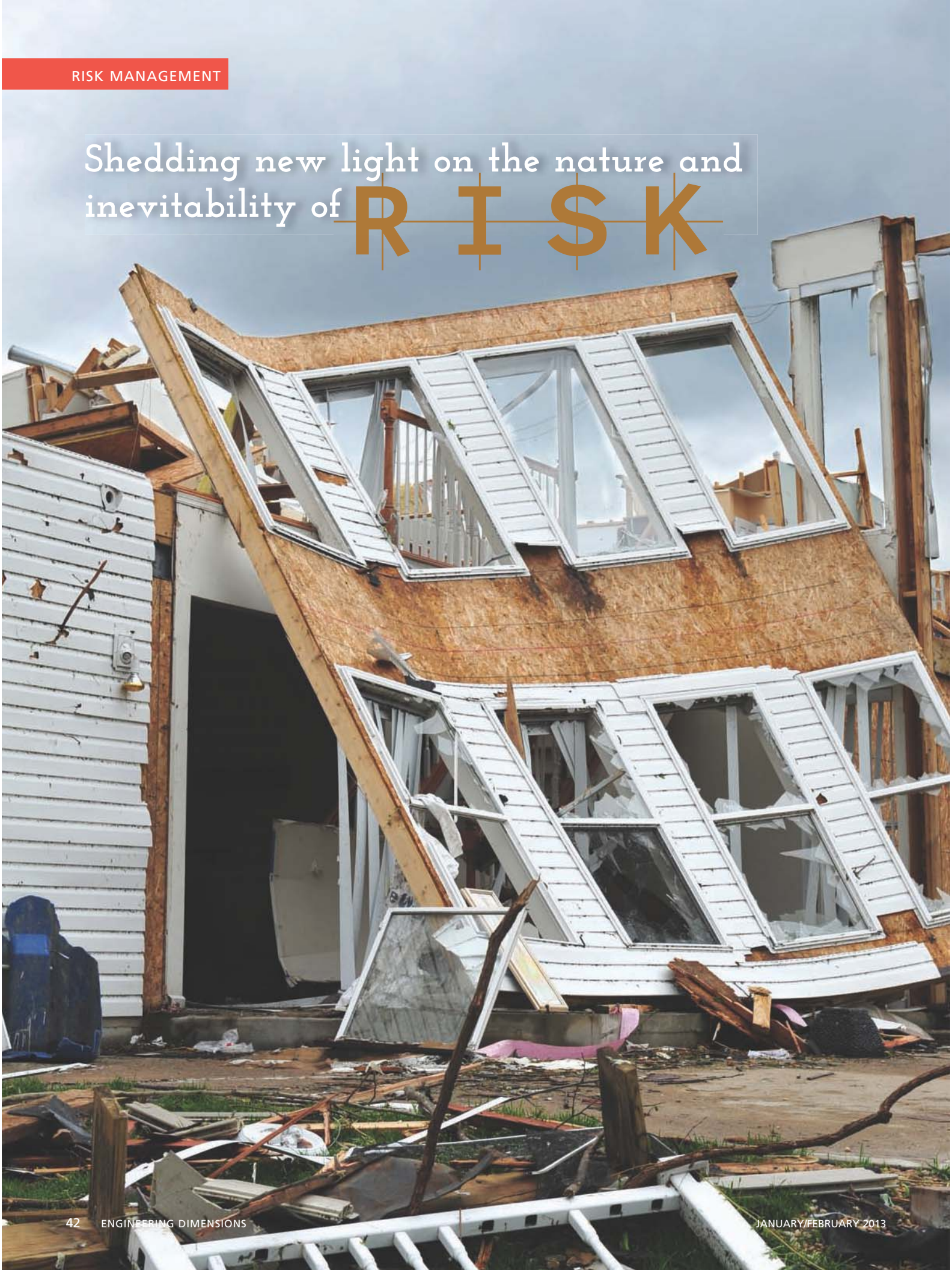
Shedding new light on the nature and inevitability of RISK



BY MICHAEL MASTROMATTEO

Severe weather is but one of the issues driving the engineering profession to step up its emphasis on identifying hazards and managing risk. Engineers are also being called on to determine the safety and durability of aging infrastructure.

A recent spate of structural and infrastructure failure and extensive damage from natural disasters, ranging from building collapses to Hurricane Sandy, present some troubling questions for professional engineers.

Beginning with reports of falling window glass from high-rise condominium towers in Toronto, and including such high-profile fatal accidents as the partial collapse of the Algo Centre Mall in Elliot Lake, and the stage tower collapse at an outdoor music concert at Downsview Park in Toronto this past summer, the public is starting to wonder just how safe and well maintained some of Ontario's infrastructure is.

Hurricane Katrina in August 2005 and other severe weather events closer to home also challenge engineers. In the Hurricane Katrina example, US engineers later determined that much of the death and destruction could have been prevented by design improvements and regular maintenance of levees and floodwalls in the New Orleans area.

In response to the recent Ontario structural collapses, PEO President Denis Dixon, P.Eng., FEC, has called for the creation of an Ontario provincial engineer with authority for the overall health of Ontario's engineered works, much like the provincial chief medical officer of health looks systemically at the health of Ontario's people. As Dixon points out in his proposal, responsibility for the safety of major engineering projects passes from engineer to owner once the projects are completed. The ongoing assessments of safety, reliability and remedial maintenance are left to each owner's discretion. Discussion of the concept with the Ontario government has been ongoing since the summer.

Meanwhile, Engineers Canada, the federation of Canada's provincial and territorial regulators, has for several years promoted an engineer's duty to accommodate climate change into infrastructure design. Its Public Infrastructure Engineering Vulnerability Commit-

tee (PIEVC) notes that engineers have a responsibility to prevent or minimize weather-related disruptions and reduce risks by designing, building and maintaining resilient infrastructure that can adapt to the impacts of a changing climate.

The PIEVC highlights the risk-management imperative by calling on the engineering profession to develop new design and operational practices to withstand changing climate conditions. A key element here is for engineers to augment historical data and consider updates to design, operation and maintenance codes, standards and practices when it comes to infrastructure durability.

BETTER ASSESSMENT TOOLS

Robert Tremblay, director of research for the Insurance Bureau of Canada, told *Engineering Dimensions* December 3 that professional engineers have been key contributors to the development of the bureau's municipal risk assessment tool that will help municipalities identify infrastructure vulnerabilities and better allocate improvement funds.

Tremblay also says Engineers Canada's PIEVC work was "the inspiration" for the development of new and updated risk-assessment tools, which over the last two decades have been embraced by municipalities and insurance industry officials to better protect communities from severe weather incidents.

"Climate is no longer stable and it creates a problem" Tremblay says. "Infrastructure is under-designed for new climatic realities and so the question is, Where are we heading? What should engineers plan for? Rain intensity, for one, has changed and we have to adjust our designs to increase the resiliency of communities."

Tremblay adds that engineers remain key players in the risk-management area because they are the designers and sometimes the operators of much of the key infrastructure. In addition, engineers develop models based on the best available data. "Without access to good data, it's difficult to develop a good risk-assessment tool," Tremblay says.

Lawyers have also begun to weigh in on the engineering profession's potential liability vis-à-vis severe weather. In an August 2012 presentation to engineering societies, Toronto-based attorney Patricia Koval, LLP, emphasized that "… if infrastructure is not adapted to these changes and events, property damage and/or personal injury is almost certain to occur. This has potentially serious ramifications for design professionals, including engineers…The issue of potential legal liability for failing to adapt infrastructure to climate change-related risk has become a key issue over the past year. Laws, building codes and standards are beginning to be amended to take into account the potential impact of climate change on infrastructure assets, but significant changes are still some time away" (see "Climate change risk: Is liability lurking for professional engineers?," p. 27).

Given the increased public scrutiny attached to failures, collapses and natural disasters, engineers are being called on more than ever to bring their problem-solving, analytical mindset to the study of risk management, prevention and hazard identification.

But risk management for engineers isn't a new topic, nor has its significance been lost on the wider profession.

When *Engineering Dimensions* last handled this topic (see "Relief, mitigation, prevention: P.Engs and public safety," May/June 2006, p. 60), the messages were that individual engineers have a responsibility for worker and public safety, and that the profession is steadily advancing its knowledge and tools for measuring risk, which resources should be made available not only to current practitioners, but also to students about to enter the profession.

The same year, the Association of Professional Engineers and Geoscientists of Alberta published the *Guideline for Management of Risk in Professional Practice*. Meanwhile in a document by the Association of Professional Engineers and Geoscientists of British Columbia, it states: "It is not the professional engineer's responsibility to determine what is an acceptable level of risk…such determinations need to be established by government after considering a range of societal values."

As a regulator, PEO doesn't proactively identify risk and determine whether new standards are needed to deal with it. Instead, PEO's Professional Standards Committee looks at issues as they arise, decides whether a practice standard or guideline is needed and, if needed, strikes a subcommittee of appropriate practitioners to draft a standard or guideline, which is circulated for comment before being finalized.

At the national level, Engineers Canada recently distributed a "model guide" for risk management for professional engineers. Completed in August 2012, the model guide was written by the Practice Commit-

tee of the Canadian Engineering Qualifications Board (CEQB). The lead author was Malcolm Symonds, P.Eng., FEC, vice chair of the CEQB and a licensed engineer in Manitoba.

The model guide was circulated among constituent member associations of Engineers Canada and received generally positive feedback. It will be up to each individual association to decide how or whether to use it to guide its licence holders.

The model guide posits risk management as an area of knowledge with which all engineers should be familiar. "The degree of familiarity, or depth of knowledge, will depend on the specific engineering discipline and the nature of the field of practice," the 2012 guide states. "Nevertheless, a constant awareness of the risk management process, and some degree of competence in its application, are essential for all engineers."

INHERENT LEVEL OF RISK

The guide goes on to suggest that engineering work requires assessing and managing risk, identifying hazards, and analyzing consequences and probabilities: "Simply put, the practice of engineering carries with it an inherent level of risk that engineers must seek to understand and manage."

The Engineers Canada model guide also says that in addition to determining the extent of risk in a given situation or project, engineers must strive to manage it. "This is arguably the most important step in the process as responsibility has now been taken for assuming the risk and preventing any undesirable incident from occurring. A key engineering tool employed in this stage is a management system appropriate for the risks being managed. Once a risk is accepted, it does not go away; it is there waiting for an opportunity to happen unless the management system is actively monitoring engineering and company operations for concerns and taking proactive actions to correct or mitigate potential problems."

In a November interview, Symonds said risk is especially relevant to engineers because of its integral association with the design process. Symonds also favours an expansion of risk management-type programs and courses for undergraduate engineering students. "I am interested in risk because it is integral to the design process," Symonds says. "Every decision that is made has to be weighed against the probability of success for the design and its influence on the performance, reliability, economics and, finally, safety of the product or process. In this way, the company and ultimately the public, society and the environment are protected."

Symonds adds, however, that engineers tend to have a more nuanced understanding of hazard and risk than the general public. "Engineers have a different view because they have a better understanding of the technical issues surrounding an issue and the influence that material, operation, aging and factors of safety have on the ultimate viability of a product or process," he says. "They also do not have the same emotional issues that result from fear or ignorance. Having said that, engineers should also try to understand the public issues and endeavour to include the reaction into the design."

The Engineers Canada model guide is indebted to a 2006 paper, *Risk Management: An Area of Knowledge for all Engineers*, co-authored by Paul Amyotte, PhD, P.Eng., FEC, of Dalhousie University, and Doug McCutcheon, PhD, P.Eng., of the University of Alberta.

In addition to recommending that the engineering profession embrace risk management as a more cogent area of study, the Amyotte-McCutcheon paper concluded that there is a strong legal mandate for good risk-management practices in engineering activities in Canada.

"The regulatory regime in Canada is changing to some degree and is different from the United States and Europe," the authors write. "This latter point is especially important for those engineering firms that practice globally. The bottom line concerning Canada's risk management practices is that these will definitely not be viewed as 'voluntary' by the courts should a loss producing event occur. Due diligence will be expected by the courts, and this means engaging in best-practice, state-of-the-art risk management activities as the only accepted way to do business. Such activities would include basic concepts with which engineers are quite familiar–codes, standards, and management systems."

As a professor of chemical engineering, Amyotte has long focused his research on providing engineering methodologies for advancing

industrial safety. He is heartened by the fact that risk management appears to be pervading the engineering consciousness.

"I think that the 'high-hazard industries' have always been aware of the hazards and risks they face. But recent events with infrastructure issues have increased awareness of the need for effective risk management in other engineering sectors," he told *Engineering Dimensions*.

MOVE IN THE RIGHT DIRECTION

This new awareness is also translating into greater emphasis on safety and risk study at the undergraduate level. The engineering faculty at the University of Alberta, for example, is one of the few places in Canada offering a safety and risk program component. Since 1988, it has offered its unique engineering safety and risk management program (ESRM), which focuses on applying industrial safety and loss/risk-management strategies to continuously reduce risk exposure for people, the environment, facilities/assets and production. It is also considered a pioneering effort to introduce industrial safety and risk management as a core competency for senior engineering students.

John Cocchio, P.Eng. (Alberta and Ontario), is an industrial professor in the ESRM program. Along with program chair Gordon Winkel, P.Eng. (Alberta), he believes it's key to develop a risk-management ethos early in an engineer's formation.

"Engineering professionals should have risk management engrained in what they do, and thus risk management will be reflected in all their undertakings, rather than a continual or periodic reminder that 'you need to consider giving some priority to safety and risk management in your project,'" Cocchio says. "We believe there is a need for professional development in risk management. Our first opportunity is to reach all engineering students prior to graduation, and our second opportunity is to develop and offer a graduate engineering program that meets the needs identified by industry and by engineering professionals themselves."

Amyotte also believes the move to emphasize risk studies in engineering undergraduate education bodes well for the future. "The recent move by the Canadian Engineering Accreditation Board to emphasize graduate attributes relating to safety and risk management is a positive move in the right direction," he says. "My own students at Dalhousie who have been on co-op work terms in industry absolutely get it. They have seen the practice of process safety and risk management in industry and they understand the importance of teaching these subjects at the undergraduate level."

Another organization keen to promote health and safety education is Minerva Canada Safety Management Education Inc. A not-for-profit corporation comprising volunteers, engineers and safety professionals, Minerva has developed over 20 engineering modules to assist professors in teaching best practices in health, safety and risk management, which have been endorsed by the national deans of engineering and applied science (see "Educating future engineers about health and safety," p. 48).

Veteran engineers, however, also appear to be focusing on risk management as a way to assure the public that the engineering profession stands ready to safeguard crucial infrastructure. Gerry Mulhern, P.Eng., executive director, Ontario Concrete Pipe Association (OCPA), is committed to the profession's due diligence mandate. As a representative of the concrete pipe industry, Mulhern is leading a campaign to persuade Ontario's transportation ministry to complete a more thorough inventory of the health and safety of the province's bridges, culverts and other buried infrastructure.

He is especially concerned about reports of sinkholes and culvert-related road and bridge failures in Ontario. In 2006, an 18-year-old Sudbury-area woman was killed after driving her car into a sinkhole. Although the incident generated some brief debate on the safety of Ontario roadways, it quickly disappeared from the public consciousness.

It has resurfaced, however, with the September 2012 road collapse on Highway 174 near Ottawa, in which a motorist's vehicle completely disappeared below the road surface. The apparent cause of the sinkhole was corrosion of a three-metre steel pipe under the roadway, which led to erosion of the nearby subsoil and the eventual cave-in. Luckily, the motorist survived the ordeal.

Mulhern says the Ottawa sinkhole should serve as a wakeup call for municipalities across the province, especially in view of news that the damaged steel pipe had been inspected in 2011, and was identified as in need of renewal.

Mulhern and other officials with the OCPA have twice met with Ontario Transportation and Infrastructure Minister Bob Chiarelli, to discuss the ministry's new culvert inventory system. The ministry is now collecting data that will be used to monitor pipe performance and other features. The results obtained will assist in refining culvert practices and standards in design, construction and maintenance.

According to a 2009 Ontario Auditor General report on bridge inspection and maintenance, there is a lack of legislation requiring municipalities to comply with the bridge inspection regime demanded of bridges under provincial

authority. As each municipality is responsible for bridges in its own jurisdiction, there is no provincial body with authority over municipal compliance with bridge safety. As well, there is no central database on the number of municipal bridges and their overall condition.

"My position on risk is that a professional engineer can do four things with risk," Mulhern says. "They can avoid it, they can transfer it, they can mitigate it, or they can accept it. I don't think enough engineers spend enough time thinking about it and, too often, they are accepting it because they are working for a municipality or a consultant who is actually calling the shots."

Mulhern says the sinkhole incidents raise the issue of risk management being subordinated to budgetary considerations in some municipalities.

DELAYING DECISIONS FOR BUDGET REASONS?

"The key point has to be that public safety is paramount and that an engineer's bridge inspection report, including remedial actions and timing of remedial actions, should not be influenced by the availability or non-availability of funds," he said.

Mulhern recommends a detailed program to reduce risk and ensure the safety of Ontario's buried infrastructure. The plan includes asset management, dedicated funding toward infrastructure renewal, creation of a provincial database for bridges and culverts (including a history of specific bridge inspections) and improvements to public transportation and highway legislation. Such legislative amendments would give the province authority to enforce bridge inspection requirements at the municipal level.

Lastly, Mulhern believes safety would be enhanced by encouraging the independence of engineers and bridge inspectors. "Bridge engineers and bridge inspectors should be allowed to work independently and objectively," Mulhern says. "The recommendations should not be primarily based on financial considerations. Public safety should be paramount."

AWARENESS SPREADING

Despite Mulhern's concerns about budgetary considerations possibly trumping safety issues, it appears that, in general, risk-management concepts and the extension of safety parameters are spreading, and that individual provincial regulators are taking note.

"I am obviously biased, but to me, risk management is at the very core of engineering," says Amyotte. "Engineers Nova Scotia has launched an excellent series of continuing professional development events aimed at increasing awareness of various aspects of safety in engineering practice."

Cocchio has suggested that engineers continue to play a key role in developing and enhancing safety-related regulations, including the updating of codes. "Professional engineers should be and need to be contributing stakeholders in the development of new codes and standards; however, it should go beyond that," he says. "It is our professional ethics that should drive us to identify the risks, and to develop the appropriate risk-management strategies to manage the residual risk. It is part of this process that may include influencing the development of government regulations as needed."

In addition, climate change and severe weather incidents seem to be accelerating the process, bringing some impetus to harmonizing standards for safety across jurisdictions and elevating the priority of risk management in public spending allocations.

"While it is generally accepted that there is climate change, the nature and severity of this issue is less clear," says Symonds. "In some ways we are reacting to events as they happen. Hurricane Sandy will have a huge impact on the definition of infrastructure design and renewal. The issue of piecemeal safety/building standards across various jurisdictions will always exist due to parochial reactions to political and fiscal issues." Σ