

Infrastructure Climate Risk Assessment Backgrounder

February 2013

Introduction

It is fundamentally clear that climate change represents a profound risk to the safety of engineered systems and to public safety in Canada and around the world. As such, professional engineers must address climate change adaptation as part of our primary mandate – protection of the public interest, which includes life, health, property, economic interest and the environment. Climate change results in significant changes in statistical weather patterns resulting in a shifting foundation of fundamental design data. Physical infrastructure systems designed using this inadequate data are vulnerable to failure, compromising public safety.

Engineering vulnerability/risk assessment forms the bridge to ensure climate change is considered in engineering design, operations and maintenance of civil infrastructure. Identifying the highly vulnerable components of the infrastructure to climate change impacts enables cost-effective engineering/operations solutions to be developed.

It is a structured, formalized and documented process for engineers, planners and decision-makers to recommend measures to address the vulnerabilities and risks to changes in particular climate design parameters and other environmental factors from extreme climatic events. The assessments help justify design, operations and maintenance recommendations and provide documented results that fulfill due diligence requirements for insurance and liability purposes.

Currently, climate change models do not provide the granularity required for the site-specific scales used in engineering design of individual infrastructures. Engineering vulnerability/risk assessment provides a recognized methodology that handles the uncertainties that are inherent in climate change projections. It enables the identification of key vulnerabilities and risks in a form that enables engineers to exercise their professional judgment for infrastructure design, operations and maintenance recommendations.

PIEVC Engineering Protocol

Since 2005, Engineers Canada has been leading a project in Canada in partnership with Natural Resources Canada to complete a national engineering vulnerability assessment of existing and planned public infrastructure to the impacts of climate change. The project has received three rounds of funding contribution from the Canadian government and the latest round (referred to as Phase III) continued to March 2012.

One of the key outcomes from Phase II, completed in April 2008, was a formalized risk assessment procedure or tool, known as the PIEVC Engineering Protocol (“the Protocol”). Since its development and refinement it has been successfully applied in 24

case studies of infrastructures located across Canada (that were completed in September 2012). This tool is available for use at no financial charge through a license agreement with Engineers Canada.

The Protocol systematically reviews historical climate information and projects the nature, severity and probability of future climate changes and events with the adaptive capacity of an individual infrastructure as determined by its design, operation and maintenance. It includes an estimate of the severity of climate impacts on the components of the infrastructure (i.e. deterioration, damage or destruction) to enable the identification of higher risk components and the nature of the threat from the climate change impact. This information can be used to make informed engineering judgments on what components require adaptation as well as how to adapt them e.g. design adjustments, changes to operational or maintenance procedures.

It has been applied to case studies of individual infrastructures in Canada within four infrastructure categories that include buildings, storm water/wastewater systems, roads and associated structures (e.g. bridges and culverts) and water supply and management systems. It can be applied to any type of civil infrastructure and Engineers Canada is seeking studies for other types of infrastructure going forward.

The first national engineering vulnerability assessment report from Engineers Canada was issued in April 2008 at the end of Phase II. It includes appendices with the individual case study reports and an initial assessment of the collective results from the first seven case studies. The report is available at the website www.engineerscanada.ca/pievcd/documents.ca.

Since publication of this report, the Protocol and the results of the case studies both collectively and individually have been presented at numerous technical conferences and professional society meetings on infrastructure, climate change and asset management in Canada and the United States.

Internationally It has been presented in side events organized by the World Federation of Engineering Organizations at the United Nations Framework Convention on Climate Change meetings in Bonn, Germany in June 2008, 2009, 2010, 2011 and 2012, to the World Bank in May 2009, and at the World Engineering Convention in Brasilia, Brazil in December 2008 and at the UPADI (a North, Central and South American regional engineering body) meeting in September 2009.

It has been presented at conferences of the Canadian Water Resources Association, Canadian Dam Association, Federation of Canadian Municipalities and Transportation Association of Canada Annual Conferences, Canadian Public Works Association, AMERICANA and INFRA conferences and the American Water and Wastewater Association to name some examples.

More recent results were presented in a special session on climate change as part of the World Engineering Convention in Geneva in September 2011.

Canadian Case Studies

The seven case studies of infrastructure engineering vulnerability assessment completed in Phase II (April 2008) included:

1. City of Portage la Prairie – water supply and treatment infrastructure
2. Town of Placentia, Newfoundland, coastal water control infrastructure
3. Metro Vancouver – Vancouver sewerage area collection and treatment infrastructure vulnerability
4. City of Greater Sudbury – city-wide roads and associated structure (bridges and culverts) infrastructure
5. City of Edmonton – Quesnell bridge and roadway infrastructure
6. Government of Northwest Territories – building foundation infrastructure using thermosyphons in warm permafrost
7. Government of Canada office/laboratory building campus, Tunney's Pasture Ottawa, building infrastructure vulnerability

Examples of key vulnerabilities and recommended remedial actions from these assessments included:

- In the Metro Vancouver sewerage area, the sewer trunks, interceptors and sanitary mains are vulnerable to increased frequency and magnitude of intense rain events. These results have led to more intensive engineering investigations by the city.
- In Placentia Newfoundland, the coastal structures are vulnerable to the combination of increased storm surge combined with high tides and intense rain events.
- Storm water and wastewater as well as water treatment systems are vulnerable to interruptions in power supply resulting from climate change impacts e.g. severe weather events that may be local or located some distance away. Ensuring access to appropriate standby power is the recommended remedial action.
- Roads and bridges in Sudbury and the Quesnell Bridge are highly vulnerable to increased ice accretion and freeze-thaw cycles that will accelerate wear and tear. Heavier snows in Sudbury will require adjustments to snow removal procedures.
- The external cladding on Ottawa Tunney's Pasture buildings have high vulnerability to changes in the intensity and frequency of snow and wind events.
- Virtually all the infrastructure components that are highly vulnerable are due to increased frequency and severity of severe weather events. Better methods to track, predict and broadcast such events at local scales are needed.

Phase III Case Studies - April 2009 to Present

A focus of Phase III was to complete more case studies across the country in the four categories of infrastructure in small and medium sized municipalities as well as larger cities, and to reflect all climatic zones in Canada. These studies contribute to a knowledge repository that is under development at Engineers Canada.

The 24 case studies were collectively assessed to determine the need and basis for review of codes, standards and engineering practices for those components that are at higher risk from the changing climate. These reports are available on this website.

Table 1, which can be downloaded as a separate file, provides a list of the case studies completed and underway as of February 2013. Since February 2011, Engineers Canada has expanded the types of infrastructure to include airports and electrical supply

systems. Further information on case studies can be obtained on request from Engineers Canada at the contact/address at the end of this document. The geographic distribution of the case studies by infrastructure category is displayed on the map of Canada.

Case Studies Completed and in Progress



Training and Capacity Building in Canada

Engineers Canada, in partnership with its constituent associations, delivered 20, one-day training workshops in the 10 provinces and two territories to nearly 750 engineers and other professionals from November 2009 to present. These workshops start with a presentation on the local (provincial/territorial) climate, both present and future projections, as well as the principles of risk assessment that are the scientific basis for the Protocol. Following an introduction to the protocol steps, participants engage in small group exercises to work with the protocol on a case study of an infrastructure. In addition, presentations on completed case studies by guest speakers complete the very full day workshop.

Engineers Canada offers the workshop on a cost-recovery basis to infrastructure professionals, managers and operators within local municipalities as well as to other levels of government.

Recently an initial training workshop was delivered in partnership with the Greater Toronto Airport Authority as a first step in the execution of a case study of the Pearson Airport infrastructure. In February 2012, Engineers Canada partnered with the

Federation of Canadian Municipalities to deliver a training workshop prior to their 2012 Sustainable Communities Conference and Trade Show in Ottawa. The success of this workshop has led to the planning of additional joint workshops at several locations across the country.

A longer, more in-depth course focused on particular categories of infrastructure is under development. A “train-the-trainer” course is also under consideration. But the best way is to “learn by doing” by engaging in an assessment of an existing or planned infrastructure using the protocol.

International Training and Capacity Building

Engineers Canada is a member of the World Federation of Engineering Organizations, an international non-government organization with headquarters in Paris that has membership from over 90 countries and represents more than 15 million engineers worldwide. Since November 2007, Engineers Canada hosts and chairs the World Federation of Engineering Organizations Committee on Engineering and the Environment. This committee is engaged in a multi-year strategic plan that includes a strong focus on climate change adaptation of infrastructure which is led by Engineers Canada.

Our leadership on this element of the strategic plan has enabled the delivery of training workshops on the principles of climate risk assessment and the introduction of the Protocol. These workshops are similar in format and delivery as the workshops in Canada. Engineers Canada is pleased to offer such workshops on a cost-recovery basis to any country or organization that is interested.

So far workshops ranging between a half day and two days have been delivered by a Canadian training team in Costa Rica, Honduras, Guatemala and Panama. The objective of these introductory workshops was to develop an initial awareness of the need and tools for infrastructure climate risk assessment. Follow-on workshops and case studies will follow, subject to funding support, to develop the capacity for in-country professionals to undertake their own independent assessments using the Protocol.

International Application of the Protocol

In March 2011, Engineers Canada, through the Committee on Engineering and the Environment of the World Federation of Engineering Organizations, completed a knowledge development and capacity building project using the Protocol for an infrastructure climate risk assessment in Costa Rica in close partnership with the Costa Rica Colegio of Engineers and Architects.

Known as the Limon Project, the Colegio worked with the country’s water supply authority (AyA) and its meteorological service (IMN) as the Costa Rica Team to complete an assessment of a sewage treatment collection and treatment system in the City of Limon, Costa Rica. Through a series of on-site training workshops, technical advice, coaching and mentoring by Canadian trainers of the Protocol, the Costa Rica team was able to successfully use the Protocol, to identify the highest risks to their system and propose adaptation actions to improve its reliability and capability in view of current climate and the future changing climate. These three organizations had never

worked together before but by the end of the project they jointly presented final results to many senior government officials as well as the senior management of the plant itself.

The project was so successful that Engineers Canada and the Colegio signed a three year licensing agreement that permits the Colegio to offer the protocol for infrastructure vulnerability assessment in Costa Rica.

In January 2012, Engineers Canada, through the sponsorship of Environment Canada International Affairs Branch commenced a project with the Republic of Honduras and the Colegio of Civil of Engineers Honduras to assess the engineering vulnerability of four highway bridges to climate change. The project includes a review and recommendations of bridge construction and procurement policies and standards to ensure they are modified to include appropriate references to and consideration of, climate risks. This project continues to March 2013.

Additional efforts are underway to raise awareness of the Protocol, in Central and South America through introductory workshops and presentations.

Further Development of the Protocol

Engineers Canada has completed the initial development and testing of a Triple Bottom Line Decision Support Module. This tool evaluates adaptation recommendations from the Protocol using a multi-factor analysis that includes social, environment and economic factors. Engineers Canada is offering this additional tool as a compliment to the Protocol. Further applications are being investigated.

Next Steps

The Protocol has been successfully applied in Canada the Costa Rica and Honduras (by April 2013). For Canada, efforts continue to undertake additional case studies to build the knowledge base in each of the four infrastructure areas. The knowledge base resulting from these case studies will be assessed by Canadian engineers and scientific experts to further develop and refine recommendations for reviews of infrastructure design and operation/maintenance codes, standards and engineering practices to account for climate change impacts.

The Protocol is now available for assessments of all types of infrastructure through a license agreement with Engineers Canada at no financial charge.

Internationally, Engineers Canada, through the World Federation of Engineering Organizations, continues to pursue new opportunities for the delivery of training workshops and international case studies with countries to develop their own capacity by learning and applying the Protocol as a tool for their own infrastructure climate risk assessment for adaptation decision-making.

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