UNFCCC – Nairobi Work Program **September 24, 2009**

Report on WFEO Action Pledge - "Adaptation of Sustainable Civil Infrastructure to Climate Change Impacts"

The World Federation of Engineering Organizations (WFEO) is an international body that is comprised of national engineering organizations, international organizations and individuals from over 90 countries representing more than 15 million engineers. Engineers Canada is a member of the WFEO, representing the Canadian engineering profession. Engineers Canada currently chairs the WFEO Standing Committee on Engineering and the Environment (WFEO-CEE).

In March 2009, the WFEO adopted an action pledge related to the adaptation of infrastructure to the impacts of climate change that was subsequently communicated to the UNFCCC Nairobi Work Program. The pledge is structured as a specific engineering project with two purposes:

- To develop and implement engineering tools, policies and practices for risk assessment and adaptation of existing and new civil infrastructure to climate change.
- To build knowledge, experience and appropriate techniques to enhance the technical capacity of engineers to adapt civil infrastructure to climate change, particularly within developing and least developed countries.

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.

PIEVC Engineering Protocol

Since 2005, Engineers Canada has been leading a project in Canada to complete a national engineering vulnerability assessment of existing and planned public infrastructure to the impacts of climate change. A formalized risk assessment procedure or tool, known as the PIEVC Engineering Protocol ("the Protocol"), was developed and successfully tested in seven case studies. This tool is available for use 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.

The protocol was applied to case studies of individual infrastructures in Canada within four infrastructure categories that included buildings, storm water/wastewater systems, roads and associated structures (e.g. bridges and culverts) and water supply and management systems. The first national engineering vulnerability assessment report from Engineers Canada was issued in April 2008 and includes appendices with the individual case study reports and an initial assessment of the collective results. The report is available at the website www.pievc.ca.

Since publication of this report, the Protocol and the results of the case studies have been presented at numerous climate change and infrastructure asset management conferences and meetings in Canada and the United States. It was presented internationally in side events organized by WFEO at the UNFCCC meetings in Bonn, Germany in June 2008, and June 2009, 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.

Canadian Case Study Results and Application of Findings

The seven case studies of infrastructure engineering vulnerability assessment completed as of April 2008 include:

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 include:

- 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. sever 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.

Emerging Good Practices and Lessons Learned

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.

The following are recommended good engineering practices that have so far emerged from this work as well as lessons learned for future engineering vulnerability assessments:

- To precisely define the engineering vulnerabilities of a particular infrastructure, it is necessary to define the individual components of the infrastructure "system".

- The performance response of infrastructure components that require estimation of climate change impacts include structural integrity, serviceability, functionality, operations and maintenance, emergency response risk, insurance considerations, policies and procedures, economics, public health and safety and environmental effects.

- It is most important to calibrate vulnerability/risk assessments of existing infrastructures with the on-site managers, operators and maintainers. These people serve as the reality check for assumed impacts and consequences of future climate changes and events. We found this input is best achieved through a workshop to develop consensus on the risks and impacts/consequences. This also achieves "buy-in" by these people who will be involved in implementing adaptive solutions to address the vulnerabilities and risks.

- Qualitative vulnerability/risk assessment based primarily on professional judgment from a multi-disciplinary team of engineers, identifies those components that are not at risk as well as those that are clearly at risk. Quantitative risk assessment is often required to resolve the level of, and nature of the engineering vulnerability for those components that cannot be estimated by qualitative assessment. These analyses will also help determine the most appropriate engineering or operations solutions

- Two levels of infrastructure vulnerability based on professional judgment (engineering and operational) have been identified. High vulnerability means a high risk of reduced or limited performance and perhaps even failure of the component due to the indicated climatic factor. These require remedial action in the short to medium term. Medium vulnerability means there is a moderate risk of significant impact or failure of the component and remedial action is required in the medium to longer term

- Engineers need to work with municipal planners and infrastructure asset managers to determine appropriate levels of services that anticipate climate change impacts

Emerging Opportunities and Challenges

The Protocol has been successfully applied in Canada and the work continues to complete additional case studies to build a knowledge base in each of the four infrastructure areas. One new case study has been completed in July 2009 for another section of the Metro Vancouver sewerage collection and treatment system which will be placed on the website in the fall of 2009. Several other case studies are underway and still others in negotiation. The next round of case studies will be competed and published on the website at various times up to March 2011.

The knowledge base resulting from these case studies will be assessed by Canadian engineers and scientific experts to develop recommendations for adjustments to infrastructure design and operation/maintenance codes, standards and engineering practices to account for climate change impacts. These recommendations will be completed by the fall of 2011.

The Protocol is the intellectual property of Engineers Canada. By virtue of its membership in WFEO, there is an opportunity to apply the same methodology to individual infrastructures by conducting case studies in newly developed and developing countries. In these countries, the capacity to perform these assessments and to take remedial action does not generally exist.

The long-term goal is to successfully transfer the application of the protocol to newly-developed and developing countries to provide a relatively low cost assessment tool to plan cost-effective adaptation of existing and planned infrastructure to the impacts of future climate change. Adaptation is most effective when it is implemented locally in response to local needs and capabilities. For newly developed and developing countries there must also be a capacity at the country level given the scarcity of human and financial resources.

There is an opportunity to develop this capacity and to identify and address infrastructure vulnerabilities through a case study approach that matches Canadian engineers with infrastructure engineers, planners and decision-makers in these countries. The challenge is to identify and secure funding for these projects.

Engineers Canada, through the WFEO-CEE has developed two concept proposals to conduct a knowledge development and capacity building projects in newly developed countries.

- **Knowledge Development and Capacity Building Project: Engineering Vulnerability Assessment of Infrastructure to Climate Change in Eastern Caribbean Countries (in development) with World Bank)**

The overall goal of this project is to build the capacity for engineers in the four East Caribbean countries to lead engineering vulnerability assessments of their civil infrastructure to the impacts of future climate change. Each of the four countries will have completed a vulnerability assessment for one of their key infrastructures that can be used as an example for follow-on assessments.

Risk assessment of civil infrastructure to climate change requires a multi-disciplinary approach. Thus another important objective is to build capacity in other supporting disciplines and stakeholders including meteorologists, climate change scientists, engineering and technology professionals as well as management, operations and maintenance personnel administering and operating the infrastructure.

- **Knowledge Development and Capacity Building Project: Engineering Vulnerability Assessment of Infrastructure to Climate Change - Costa Rica (in development) with World Bank and other International Financial Institutions)**

Costa Rica is a member of the WFEO and the WFEO-CEE. The Colegio also chairs and maintains a leadership role in Unión Panamericana de Asociaciones de Ingeniería (UPADI), a Pan-American multi-lateral organization of national engineering organizations within the Caribbean, Latin America and South American regions. Success in Costa Rica will translate into access to developing countries and, by working in close partnership with the Colegio, we should improve the chances for successful capacity building in other developing Pan American developing countries.

These two projects would be followed by similar projects in other developing countries with the long-term goal to standardize the Protocol as an accepted engineering and planning practice for infrastructure climate change vulnerability assessment worldwide. There are tremendous opportunities for international, regional and local cooperation to build local awareness and expertise to adapt infrastructure to climate change impacts in a cost-effective manner that best addresses the engineering vulnerabilities and risks.