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WEB EXCLUSIVE: Potential Impact of Climate Change on the Building Envelope

There are signs that we be may begin to see the early signs of what is now commonly referred to as the effect of climate change on new and existing buildings, and most engineers agree that any significant change in weather patterns will almost certainly require a modification to the manner in which we design, construct, manage and maintain buildings.

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Many scientists believe that what appears to be a gradual warming of the earth's surface and atmosphere may be the result of human activity and increasing urbanization around the globe. Many also believe this warming trend has the potential to destabilize weather patterns and increase the frequency and intensity of severe weather related events. For example 2005 was the warmest year on record and coincided with the most active hurricane season since record keeping began. In July of 2009, Hamilton, Ont. got 109 mm of rain in two hours, one of the biggest bursts of rain on record in Canada. Insurance losses were between $200 and $300 million. Following unprecedented rainfall in Peterborough, Ont. in 2004, floods swept through the downtown, causing more than $112 million in damage.

Whatever the reasons may be for changing climate conditions, according to research undertaken by Engineers Canada this phenomenon appears to be having an impact on Canada's building stock and building occupants.

To meet the climate change challenge, Engineers Canada has established four expert working groups under the auspice of the Engineering Vulnerability Committee (PIEVC), an initiative which involves all three levels of government together with private organizations to systematically examine the vulnerability of buildings and infrastructure to climate change.

The PIEVC defines climate change as: *Any systematic change in the long-term statistics of climate elements sustained over several decades or longer. Climate change may be due to natural external forcings, such as changes in solar emission or slow changes in the earth's orbital elements; natural internal processes of the climate system; or anthropogenic forcing.*

Impact on Enclosure Systems

The building envelope is particularly vulnerable to changes in climactic conditions. These systems have become thinner and lighter with the evolving construction technology and materials and enclosure systems are especially susceptible to even minor changes in weather patterns as a result. For example, a 25 per cent increase in peak wind gusts could lead to a significant increase in damage caused by wind borne debris and wind loading in excess of the design loads.

As one would expect, cities with their high density of property, people, and services make urban areas particularly vulnerable when extreme weather or natural disasters strike or when weather patterns are altered.

Premature weathering and/or deterioration of building enclosure systems because of the stress on the building envelope caused by changes in the weather patterns is a serious concern and this phenomenon is, with good reason, quickly becoming the focus of a great deal of attention in many regions of Canada.

For buildings, the foremost concern involves the health, safety and well-being of the occupants and it is difficult to adequately judge the potential impact at this stage. We do know that Canadians spend approximately the 90 per cent of their time indoors. As one might expect, in addition to temperature extremes, occupants can be adversely affected by changes in humidity levels and other factors such as air quality and by the presence of chemicals, pollutants and/or mould.

The outside of the building enclosure system is also in direct contact with the elements. As such the envelope serves an important function as an environmental separator between the outside elements and interior conditions.

Impact of Climate Change on Building Performance

When it comes to existing buildings, the age and condition of the structure, the materials used in its construction and the type of building envelope system can influence the structures ability to resist the forces of climate change.

For example a 50-year-old masonry building constructed using a "face sealed" cladding system will, in most cases, have very little capacity to resist the impact of climate change because the "shell" of the building is directly exposed to the ever-changing and more hostile exterior environmental conditions. (For buildings which incorporate pressure equalized rainscreen walls, the primary environmental separators -- i.e., seals, insulation, etc. -- are concealed and are not generally exposed to the elements.)

The climate change factors that may have a direct impact on the building envelope include:

- A higher solar intensity resulting in higher exterior and interstitial surface temperatures and for the exposed components, higher levels of UV and resultant damage;
- A shift in the type, form, pattern, and intensity of precipitation, including an increase in the frequency of instances of freeze - thaw cycling, melting permafrost, freezing rain and rain on snow;
- Shifts in precipitation patterns can also increase the number of times components may experience wetting and drying and increase frost penetration;
- Shifts in the peaks and frequency of high humidity levels;
- Changes in seasonal range of temperatures combined with increased frequency and longevity of heat waves or cold snaps;
- Increased frequency and intensity of wind and flooding events.

These changes in temperature, moisture levels and the forms of precipitation acting on the enclosure systems can lead to dimensional changes of materials which in turn can lead to cracking and fissuring in polymer-based materials such as vinyl cladding, window frames, sealants and gaskets. Similarly, thermal stress in the form of freeze-thaw cycles can lead to premature aging of porous materials such as stone, masonry and mortar.

Other environmental factors including any increase in dust, particulate matter, smoke and acid rain can also have significant implications for building envelopes. In addition to the effects of UV radiation, mechanical agents such as wind-driven dust or rain or rain loads themselves may act as structural loads and can contribute to premature or accelerated deterioration

Biological agents carried by the atmosphere can deposit fungi or moulds on surfaces while chemical agents transported by atmospheric moisture (e.g. rain or water vapour) or by direct deposition can lead to corrosion in metals or deterioration in concrete, stone, fenestration components, as well as roofing and cladding materials.

Another impact is related to the uncertainty caused by changing climactic conditions that may undermine the meteorological data we use to design our buildings and infrastructure.

Climate Change Testing and Computer Simulations

It is a relatively straight-forward building science exercise to simulate at least some of the impacts of various climate change scenarios on full-scale mock-ups of building envelope assemblies in laboratory settings. Computer simulation might also prove useful. Both of these strategies might assist in determining what changes in design, building codes and building practice may assist in mitigating the potential impact for new and existing buildings.

Some strategies are already being formulated that may enable structures to resist the effects of climate change. Engineers are also taking a similar approach with regard to infrastructure components such as roads, bridges, electrical distribution systems and our water distribution/marine infrastructure.

Given the size and importance of our building stock and infrastructure it's important that we continue to monitor the issue of climate change and continue to support the efforts Engineers Canada and their Public Infrastructure Engineering Vulnerability Committees. It is also apparent that we also need to substantially increase the funding, research and general attention given to the topic as it is becoming increasingly obvious that the “political will’ to take any proactive measures is diminishing.

While the risks appear to be increasing, the potential impact has moved beyond what was once considered an environmental concern to include long-term political and financial issues that will eventually impact energy production, agriculture, industry and transportation.

On a somewhat smaller scale in the building sector, some professionals are suggesting these apparent changes will represent a huge long-term challenge for the people who deal with these components of modern buildings -- architects, engineers, technologists and building scientists. In many ways adopting a proactive approach to the potential impact of climate change is also an opportunity for building professionals to take a leadership role.

Summary of Potential Impact and Risks

- Increasing health and safety risks for occupants caused by a reduction in the quality of the indoor environment;
- Premature or accelerated deterioration;
- Reduction of design safety margins;
- Reduced service life and functionality of components and systems;
- Increased risk for catastrophic failure;
- Increased repair, maintenance, reserve fund contingencies and energy costs;
- Increases in service disruptions and emergencies;
- Increased liability as a result of premature aging or deterioration.

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Caption: Climate change can result in a shift in type, form, pat...

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