Simple Steps Towards Building Resilience

By Jean-François Côté, PhD

Figure 1 – Aerial image taken on May 4, 2019, showing floods in Sainte-Marthe-sur-le-Lac, Québec, across the Saint Lawrence River from the western tip of the Island of Montréal. Photo courtesy of National Aerial Surveillance Program (Canada), under the Creative Commons 4.0 License.

In recent years, Canadians have experienced increased frequency and severity of weather events. The Fort McMurray wildfire in 2016 was the largest natural disaster in Canada's history. According to the Insurance Bureau of Canada,[1] this event alone triggered over 60,000 insurance claims and generated over $3.6 billion (CAD) in damages. Wildfires are again threatening western Canada in 2019 as communities around Slave Lake—only 250 km (155 miles) north of Alberta's capital, Edmonton—have been under mandatory evacuation orders as of this writing. Springtime floods were also more frequent and severe, often hitting national news. Since 2008, New Brunswick's Saint John River has flooded the surroundings of Fredericton and Saint John every year but two.[2] This past spring, eastern Ontario and southern Québec were exposed to record floods (see *Figure 1*) that triggered governments to review urban planning rules in flood-prone areas.

It is one thing to plan how we build our communities in order to reduce the exposure to natural disasters, but not much can be done when fire blazes through an entire neighborhood or water rises by 8 meters (26 feet) close to downtown. Under such circumstances, buildings located near the devastated areas should remain safe and operational despite temporary interruption of utilities (power, water, gas, etc.) and should be easily repaired if slightly damaged. The same can be said of buildings suffering damage after exposure to an extreme wind event or an incident caused by human activity (accidental or intentional).

When a building is temporarily out of power and/or its primary heating source, HVAC systems will no longer function. Whether it is a hot summer day or a cold winter night, the performance of the building enclosure will dictate how long the occupants will be able to safely stay in the building. Airtightness of the enclosure and thermal efficiency will be key factors. Time required to bring the building back to normal operation will also play a fundamental role.

INFLUENCE OF AIRTIGHTNESS

A properly designed and installed air barrier system will reduce thermal gain or loss due to uncontrolled air leakage through the building enclosure. Continuity at junctions between adjacent air barrier assemblies has historically been identified as challenging. For example, failure of the connection between the wall air barrier and the roof air barrier is an element brought up in many investigation reports (see *Figure 2*). Simple strategies can be implemented at the design stage to ensure that this transition is made correctly.

The use of a deck-level, self-adhered roof air barrier sheet membrane installed before parapets or flashings are constructed on the building perimeter (see *Figure 3*) is a good example.[3] Upon its installation on the whole surface of the roof deck, the self-adhered sheet membrane can be extended down the face of the wall (keeping the release film on) until the wall air barrier assembly is installed. The self-adhered sheet membrane can then be tied to the wall air barrier assembly after removing the release film. Additional sealing materials may be required to complete the junction on uneven surfaces and ensure a fully continuous transition. The use of this deck-level self-adhered air barrier has also been demonstrated to reduce the potential for moisture condensation in the insulation layer and on the bottom surface of the roof membrane in cool climates,[4] as well as to increase wind uplift resistance of mechanically attached roofing assemblies.[5]

As the building will be more airtight, strategies should be implemented to ensure adequate indoor air quality following failure of the HVAC system. Reduced glazing area on sun-exposed orientations, operable windows, and adaptative shading might be beneficial to limit solar heat gain. Natural ventilation strategies will most likely be required in both heating and cooling scenarios.

Figure 2 – Premature deterioration caused by defective connection between roof air barrier and wall air barrier. Photo courtesy of Soprema.

INFLUENCE OF THERMAL INSULATION

The potential for occupants to remain in a building will also be linked to the overall thermal efficiency of the building enclosure. A building designed and constructed today with the intent to just meet the current code requirements for energy efficiency may not be operational for more than a couple of days during a power outage in the middle of a Canadian winter, especially if no emergency heating system is present. One can only imagine the level of thermal performance of all existing buildings, presumably offering even lower thermal performance than what current codes require.

Increasing thermal performance of the whole enclosure above code level takes into account potential increase in future climatic loads that will affect the building. Furthermore, reaching passive house or net-zero levels will extend the time during

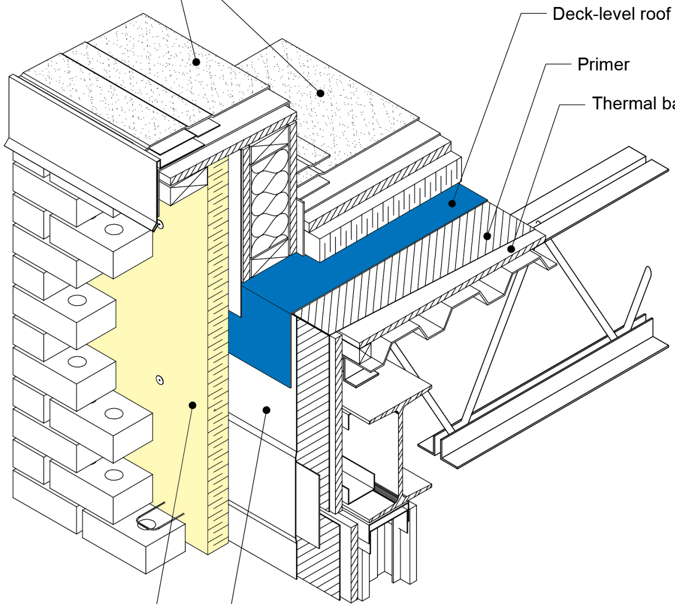

Figure 3 – Detail showing deck-level roof air barrier (blue) installed before construction of the parapet and connected to wall air barrier. Also shown is the continuous insulation board (yellow) used on the exterior wall. Graphic courtesy of Soprema.

which the building can safely operate while not being properly serviced. However, such levels of thermal performance cannot be met by simply widening the walls and filling these cavities with more insulation. Thermal bridges must be reduced significantly through the use of continuous insulation, most of the time located on the exterior of the wall structure (see *Figure 3*). For both new and existing buildings, care must be taken to ensure that the enclosure is able to effectively manage moisture through the various seasons in order to prevent condensation and mold growth within the enclosure.

Figure 4 – Use of pre-assembled panels combining roof membrane, cover board, and insulation can accelerate and simplify installation, which can be an advantage when contractor crews are stretched thin. Photo courtesy of Soprema.

CAPACITY TO RECOVER QUICKLY

When a disturbance (natural or human related) occurs on a building and affects one of the control layers (water, fire, air, thermal, moisture), the potential to repair damages in a timely manner will enhance the building's resiliency. Designers should give preference to materials known to allow for simple repair procedures. Following a wind event, professional contractor crews will be stretched thin and may opt to proceed with numerous emergency repairs on multiple roofs, rather than replacing entire roof assemblies on a smaller number of buildings. The ability of a roof to be brought back to function (watertightness) is therefore a key element to consider.

Fast and easy repair procedures can be implemented if the roof membrane in place is thermofusible, regardless of weather and temperature conditions. Small-scale repairs, such as open seams, can usually be dealt with by simply heat-welding adjacent sheets back together, regardless of the age of the roof. For more extensive flaws, such as tears in the membrane, a piece of new membrane may simply be heat-welded over the affected area. When a larger roof section requires intervention, pre-assembled panels combining roof membrane, cover board, and insulation (see *Figure 4*) can be selected to reduce the amount of labor required to fix the problem and rapidly move to the next building.

When attempting to meet Passive House and net-zero performance levels, building owners often want to couple an efficient enclosure with local power generation. Power generation devices such as photovoltaic (PV) arrays are often located on the rooftop (see *Figure 5*). This may enhance the resiliency of the building but can actually reduce that

Figure 5 – Photovoltaic arrays are often located on rooftops. Photo courtesy of Soprema.

of the roof. Designers must consider that rooftop PV arrays may increase stress on the roof system and reduce the building's ability to resist loads. But more importantly, after a disturbance, their presence will complicate the repair procedures. For safety concerns, PV devices must be disconnected and potentially removed from the roof before contractors can access the affected areas. This additional delay could increase the cost of repairs, as larger areas of moisture-sensitive building materials (fiberboard, perlite, wood deck, etc.) and interior building components might be affected.

The means to improve the resilience of buildings are at our disposal, and many of them have minimal impact on construction cost. Codes and regulations might evolve and require enhanced resilience practices for new construction, and even some retrofits. Building owners purchase insurance to protect themselves financially should their buildings experience certain disasters. They could also consider small investments in more resilient buildings so that if a disturbance occured, their buildings could remain operational for a longer time and be brought back to function quicker and at a lower cost.

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Jean-François Côté

Jean-François Côté is the Director of Standards and Scientific Affairs at Soprema. He holds a PhD in materials science from INRS-Université du Québec. In his current role, he represents Soprema on technical committees of industry associations (ARMA, CIMAC, and PIMA) and is actively engaged in various North American standards development organizations. He is chair of the CSA A123 technical committee on Bituminous Roofing Materials, and is co-chair of the ASTM D08.04 Subcommittee on Felts, Fabrics and Bituminous Sheet Materials.