PRACTICE ADVISORY

ELECTRICAL ENGINEERING CONSIDERATIONS IN FLOOD-RESILIENT DESIGN OF BUILDINGS

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This practice advisory has been issued to inform Engineers and Geoscientists BC registrants (engineering professionals) of their responsibilities when preparing engineering designs for electrical systems in building projects located in areas that may be subject to flooding over the design life of the building, and in particular their responsibility to give due consideration to relevant life-safety issues.

This practice advisory was developed in response to a Canadian Standards Association (CSA) report published in March 2019 titled "Development of Climate Change Adaptation Solutions Within the Framework of the CSA Group Canadian Electrical Code Parts I, II and III" (CSA 2019). This practice advisory is intended to act as interim guidance for engineering professionals on related practice issues, while the CSA committee responsible for developing the *Canadian Electrical Code* (*CE Code*) actively considers revisions to section 6 of the *CE Code* expected to become effective in 2021.

Engineering professionals have a professional responsibility to uphold the principles of the Engineers and Geoscientists BC Code of Ethics, including to hold paramount the safety, health, and welfare of the public and the protection of the environment. As such, in the absence of legislated or prescribed codes or standards in a specific area of practice, or where such codes or standards may be inadequate to protect public safety in the circumstances of a project, an engineering professional should use a risk-based approach[1] to decision making when providing professional services, and one of the risk factors that should be considered is climate change.

In circumstances where climate change poses risks to the design or future building safety and function, an engineering professional has a responsibility to notify the client of those risks, propose reasonable design or adaptative measures to manage the risks, and expressly communicate the potential impacts should the client refuse to implement the recommended measures. The engineering professional also has a responsibility to be aware of and meet the intent of any climate change requirements imposed by the client or the Authority Having Jurisdiction (AHJ).

[1] A risk-based approach systematically quantifies consequences, which are used with hazard scenarios to estimate risk. Human safety and economic and environmental losses are typically the most important consequence categories. The resulting risk estimates are then evaluated by comparing them with existing local or provincial risk tolerance criteria or, in the absence of those criteria, with applicable international criteria.

BACKGROUND

There are regulatory requirements related to designing buildings when they are located in a floodplain and other areas (such as alluvial fans) that are potentially exposed to riverine and coastal flood hazards, or to pluvial flooding events at sites with unfavourable topography. For example, in response to the *Flood Hazard Area Land Use Management Guidelines* published by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (Province of BC 2018), AHJs may have adopted a range of floodproofing measures in municipal bylaws and policies. This typically includes specification of a flood construction level (FCL), and special restrictions for any proposed building use below the FCL.

Some AHJs have also established minimum building elevations (MBE), where what is described as “normal” flood conditions do not exist. MBE have been established in locations where the municipal infrastructure is anticipated to become flooded by a major storm event, and several of the measures mentioned in this practice advisory could be considered as approaches to be used as part of the electrical design for buildings subject to MBE.

This practice advisory has been prepared as a reference for projects subject to an FCL (enforcement of which rests with the AHJ), or at sites where improved resiliency to flooding is desired.

For further information on FCLs and related considerations, refer to the *Flood Hazard Area Land Use Management Guidelines*, as well as:

- local AHJ bylaws and policies;
- the *Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC* (Engineers and Geoscientists BC 2018); and
- the *Professional Practice Guidelines – Geotechnical Engineering Services for Building Projects* (Engineers and Geoscientists BC 2020).

The *Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC* provide a mechanism for a qualified professional—as defined in those guidelines—to determine whether it is appropriate to build in an area that is potentially subject to flooding, and to specify pertinent floodproofing measures (including provisions pertaining to electrical equipment, if applicable).

The FCL generally establishes the minimum elevation of the underside of a floor system or the top of a concrete floor slab of a building used for habitation, business, or the storage of goods that could be damaged by flood water. It also establishes the minimum elevation for the installation of fixed equipment susceptible to damage by flood water. In general, building areas below the FCL are not intended for such building use; however, vehicular parking below the FCL is generally allowed. Where a building is protected by a standard dike, local bylaws and policies may provide a reduced FCL, or may allow for building use below the FCL (recognizing that the building could be flooded in a dike-breach scenario).

While the conservative approach to flood risk management in high hazard areas (e.g., exposed to high-velocity flows or waves) is avoidance, the design of structures below the FCL may be considered. One approach is to design any systems that could be damaged by flood water, including by elevated groundwater, so they are enclosed—or “tanked”—below the FCL.

FCLs in coastal areas are determined based on a designated event with a specific annual exceedance probability. FCLs take into account factors such as tides, allowances for projected relative sea-level rise, estimated storm surge and wave effects associated with the designated storm event, and freeboard. Thus, the FCL is not necessarily the only maximum flood level that could occur, as the FCL determined for a site could change over time as a result of climate change, or as new projections emerge for climate-change effects on flood hazards. The extent of the identified floodplain may also change due to climate change and improved analysis. Additionally, as noted above, for some areas protected by a standard dike, a reduced FCL is specified that is less than the flood level resulting from a dike breach. This may have implications for the safety and functionality of a building over its design life and must be considered with respect to potential life-safety considerations. Thus, flood hazards that correspond to more extreme events than the designated storm, or those that incorporate more pessimistic allowances for climate change effects, could be considered for design, depending on the potential consequences (e.g., life safety, or cascading effects) and client requirements related to resiliency.

Special consideration needs to be given to the potential for flooding of any building area below the FCL, especially where a reduced FCL is provided in an area protected by a standard dike. Additionally, although a property may not be physically within a flood hazard area, it may be adjacent to a flood hazard area, and still require some floodproofing considerations (particularly below grade portions of the property). Identification of this condition should be considered by engineering professionals with the appropriate experience and expertise.

Current regulatory measures do not address pluvial flooding as rigorously as riverine flooding (and are generally silent on groundwater flooding), and FCLs are typically only defined for designated floodplains. However, in some locales, pluvial flooding can be a significant risk, as drainage infrastructure is generally designed to a lower level of service (typically a 10-year return period), and existing drainage plans and mapping may not properly identify overland flow paths or low areas with inadequate outlet capacity through a piped drainage system. Climate change-driven increases in extreme rainfall will significantly increase runoff volumes and flow rates. Engineering professionals should be aware that upgrades to existing off-site drainage system capacity (e.g., municipal drainage infrastructure) may not keep pace with the impacts of increased rainfall or may not occur for a significant portion of the design life of the facility, resulting in a period with heightened pluvial flood risk exposure. Rainfall events resulting in overland flow could introduce significant volumes of water to underground structures, including basements, parkades, and machinery or electrical service rooms.

The potential for cascading hazards and risks (e.g., flood due to fire, fire due to flood) should also be identified by the design team professionals and communicated to the client and/or the coordinating registered professional.

While considerations relating to the architectural, structural, building enclosure, mechanical, geotechnical, and electrical design features of a building help contribute to its overall flood resilience, this practice advisory is focused on the following few key electrical engineering matters that design teams should consider in the development of a building design.

PRACTICE NOTES

Flood-resilient design of electrical systems should apply in the following situations, where:

- the building use is proposed below an established FCL;
- a reduced FCL is provided in an area protected by a standard dike;
- electrical facilities are located on the property outside the building (i.e., below the FCL);
- a building located adjacent to a flood hazard area is proposed to include space below ground;
- there are hydraulic connections (piped or preferential groundwater flow paths) between an electrical system and an area prone to flooding; and/or
- an alternate scenario has been identified where there is the potential for flooding, resulting in an unacceptable risk to life safety related to the building electrical system.

In general, electrical service equipment that must be accessible for disconnection under flood conditions should be located above the area potentially subject to flooding, in order to prevent a shock hazard to the persons operating the means of service disconnection. All electrical distribution and utilization equipment located below the FCL, including electrically connected life-safety systems, and all wiring used for connection of this equipment, must be protected against flood water.

Where electrical equipment is located below the FCL and may be subject to flooding, a remote shut-off should be installed above the FCL to allow for safe disconnection. Water leak detection sensors connected to an early warning system, which in addition to an audible alarm at the building, will provide a signal to a remote 24-hour monitoring station, should be installed in service rooms located below the FCL. This design approach will facilitate effective shut-off of equipment prior to damage and/or shock hazards manifesting.

Where it is deemed appropriate to locate electrical equipment in an area that is susceptible to flooding, some strategies for flood-resilient electrical design and installation could include:

- locating service entrance equipment, unit substations, transformers, control panels, generator rooms, and communication rooms above the FCL;
- installing elements such as automatic sensors, early warning systems, and means to turn off power to certain areas at the onset of flooding of the building;
- locating penetrations through the building envelope for electrical and communications utilities above the FCL;
- designing egress features (including signage), emergency lighting, and fire alarm systems so they will be operational before, during, and after a flood; and
- floodproofing secondary component switches, convenience outlets, light fixtures, junction boxes, and interconnecting wiring so they are suitable for submerged installation, if and where required.

Where an elevator is in a building that could be subject to flooding, the following flood-resilient design measures should be considered and, if adopted, coordinated with the consultant providing elevator design services:

- Emergency communication from within an elevator should include a manual back-up or alarm that is available during failure scenarios, allowing required emergency communication to be maintained for four hours from the time of a power outage.

- Elevator equipment must be designed for wet locations and include environmental product declarations (e.g., from NEMA [National Electrical Manufacturers Association]).
- Elevators must be designed to allow for safe operation and egress above the FCL.
- Elevators should be designed to remain operational for evacuation purposes and include:
  - connection to the early warning system or a pit flood sensor;
  - water sensors that prevent the elevator equipment from travelling below the FCL;
  - indicators in the car and hall, to show that the sensors are active; and
  - systems that shut down the elevators above the FCL, where the elevator is not designed for evacuation purposes.
- The designated level should be above the FCL. If the designated level is at or below the FCL, the alternate level should be above the FCL.
- Mechanical equipment such as hydraulic cylinders, motors, machines, and pumps are not recommended to be installed within the elevator pit.
- The potential for the elevator pit floor drain to act as a source of flood water should be considered and designed against.
- Elevator machine rooms must be located above the FCL.

Flood-resilient design features that conflict with building code provisions (e.g., of the *BC Building Code*) must be brought to the attention of the coordinating registered professional. For utility and telecommunication connections, coordination with the service provider is required to determine the floodproofing measures that need to be accommodated. Determination of flood-resilient design features could also require communication with other stakeholders, including but not limited to purchasers, end-users, and insurers. Flood-resilient design features implemented may be identified through a design philosophy statement and must be recorded for posterity using legal instruments such as covenants on title.

REFERENCES AND RELATED DOCUMENTS

Canadian Standards Association (CSA). 2019. Development of Climate Change Adaptation Solutions Within the Framework of the CSA Group Canadian Electrical Code Parts I, II and III. Final Report. Toronto, ON: CSA. [accessed: 2020 Nov 16] https://www.csagroup.org/wp-content/uploads/CSA-RR_CEC-ClimateChange.pdf.

Engineers and Geoscientists BC. 2020. Professional Practice Guidelines – Geotechnical Engineering Services for Building Projects. Version 2.0. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2020 Nov 16]. https://www.egbc.ca/Practice-Resources/Individual-Practice/Guidelines-Advisories

Engineers and Geoscientists BC. 2019. Climate Change Information Portal. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2020 Nov 16]. https://www.egbc.ca/climateportal.

Engineers and Geoscientists BC. 2018. Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC. Version 2.1. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2020 Nov 16]. https://www.egbc.ca/Practice-Resources/Individual-Practice/Guidelines-Advisories.

Province of BC. 2018. Flood Hazard Area Land Use Management Guidelines. [Amended January 1, 2018]. Victoria, BC: Ministry of Forests, Lands, Natural Resource Operations and Rural Development. [accessed: 2020 Nov 16]. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/flood_hazard_area_land_use_guidelines_2017.pdf.

VERSION HISTORY

VERSION NUMBER	PUBLISHED DATE	DESCRIPTION OF CHANGES
1.0	December 18, 2020	Initial version.

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