FACILITIES BUILDING ENVELOPE STANDARD – ENCLOSED PEDESTRIAN BRIDGES

MX-FAE-STD-C010

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METROLINX

Facilities Building Envelope Standard – Enclosed Pedestrian Bridges

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Preface

This is the first edition of the Facilities Building Envelope Standard—Enclosed Pedestrian Bridges (MX-FAE-STD-C010). The purpose of this standard is to provide minimum civil engineering requirements and design guidance to designers for Metrolinx-owned assets.

This standard is to be followed by Engineering and Design Consultants working on Metrolinx projects and internal Metrolinx staff.

The technical content within the Facilities Building Envelope Standard—Enclosed Pedestrian Bridges (MX-FAE-STD-C010) was developed by the Metrolinx Facilities, Architecture, and Engineering's Civil Engineering Team within the Asset Management and Maintenance Division, which includes specialized subject matter experts.

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Suggestions for revision or improvements can be sent to Metrolinx Facilities, Architecture, and Engineering (FAE) Civil Engineering Team, Attention: Senior Manager, FAE Civil Engineering, who will introduce the proposed changes to Metrolinx FAE Civil Engineering. The Senior Manager, FAE Civil Engineering, ultimately authorizes the changes. A description of the proposed change shall be included along with information on the background of the application and any other useful rationale or justification. Proposals for revisions or improvements shall include your name, company affiliation (if applicable), email address, and phone number.

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1. General

1.1 Purpose

1.1.1 This standard outlines the requirements for enclosed pedestrian bridges within the Metrolinx stations network and properties, ensuring their safety, functionality, and durability.

1.2 Scope

1.2.1 An enclosed pedestrian bridge is designed to facilitate the movement of pedestrians over features such as roads, railways, bodies of water, or natural environments.

1.2.2 An enclosed pedestrian bridge has a complete envelope that fully separates the interior space from the external environment. Depending on specific usage, thermal comfort, and environmental conditions, the bridge may be:

a) Conditioned: temperature-controlled, relying on HVAC or other means to maintain interior comfort levels; or

b) Unconditioned: not temperature-controlled, relying on either passive or mechanical ventilation to manage airflow and maintain interior temperatures.

1.2.3 The scope of this standard includes specific design requirements for structural integrity, bridge envelope, ventilation, thermal comfort, and corrosion mitigation, ensuring that these bridges meet the necessary performance criteria and maintain long-term reliability in compliance with relevant codes and guidelines.

1.2.4 This includes adherence to the Waterproofing (MX-FAE-STD-C009) and Low-Slope Roofing (MX-FAE-STD-C011) Standards and other relevant documents, which are integral to the design and quality assurance process.

1.2.5 This document shall be read in conjunction with the Metrolinx Facilities Civil Engineering and Building Envelope Standard – General (MX-FAE-STD-C001).

1.3 Limitations

1.3.1 This section specifies the limitations and scope exclusions of this standard.

1.3.2 Regulatory Compliance

a) This standard is supplementary and does not replace any regulatory requirements, such as CAN/CSA S6 Canadian Highway Bridge Design Code, CAN/CSA S7 Pedestrian, Cycling, and Multiuse Bridge Design Guideline, and the Ontario Building Code (OBC).

1.3.3 Applicability

a) This standard does not apply to semi-enclosed pedestrian bridges (e.g., roof but no vertical envelope) or exposed pedestrian bridges (e.g., fully exposed deck).

b) This standard does not apply to multi-use bridges shared by pedestrians, motorized and non-motorized modes of travel.

c) This standard does not apply to railway supporting bridges. Bridges supporting rail elements shall comply with Metrolinx General Requirements for Design of Railway Bridges and Structures (RC-0506-04STR).

1.3.4 Design Requirements Not Addressed

a) Lighting requirements are not included and shall comply with applicable codes and standards, such as OBC, GO Design Requirements Manual (DRM), and applicable Metrolinx Facilities Architecture Design Standards.

b) Crime prevention requirements are not included. Refer to Metrolinx Crime Prevention through Environmental Design (CPTED) principles.

c) Crash/protection wall design requirements are not included. Refer to Metrolinx General Guidelines for Design of Railway Bridges and Structures, American Railway Engineering and Maintenance-of-Way Association (AREMA) Chapter 8, concrete structures and foundations, and CAN/CSA S6.

1.3.5 Clearance Requirements Not Addressed

a) Minimum vertical and horizontal clearances over railways shall comply with Metrolinx General Guidelines for Design of Railway Bridges and Structures.

b) Minimum vertical clearances over roadways shall comply with TAC Geometric Design Guidelines for Canadian Roads in conjunction with the Ministry of Transportation of Ontario (MTO) guidelines.

1.3.6 Ventilation Requirements

a) The passive and mechanical ventilation requirements in this standard are supplementary and do not replace any mechanical or electrical requirements outlined in the DRM.

1.3.7 Electrification and Electrification Protection Barriers

a) Electrification and Electrification Protection Barrier requirements, such as grounding, bonding and clearances, etc., are not included and shall comply with Metrolinx Performance Specification for Structures Passing Over Electrified Corridors and Metrolinx Performance Specification for Electric Traction Enabling Works.

2. Definitions & Abbreviations

2.1 Definitions

2.1.1 The capitalized terms used in this standard shall have the meaning prescribed in Table 1.

Table 1: List of Definitions

Term	Definition
Bird-Friendly Glazing	Glass treated with patterns (such as frit dots) to reduce bird collisions, as per CAN/CSA A460 standard.
Conditioned Space	An enclosed space where temperature is actively controlled to maintain thermal comfort.
Corrosion Mitigation	Design strategies to prevent material deterioration due to environmental exposure, including coatings and material selection.
Crime Prevention Through Environmental Design (CPTED)	A design approach that enhances security by incorporating visibility, access control, and territorial reinforcement.
Dry Bulb Temperature (DBT)	The temperature of the air as read by a standard thermometer. Does not include the effect of heating from the sun or any influence of humidity.
Egress Capacity	The ability of a pedestrian bridge to allow safe and efficient movement of people, particularly in emergencies.
Enclosed Pedestrian Bridge	A pedestrian bridge with a complete envelope that separates the interior space from the external environment.
Expansion Joint	A joint that allows for expansion and contraction of the structure caused by temperature changes or structural loads without distress.
Fall Arrest Roof Anchors	Safety anchors installed on the roof for workers to secure using fall protection/arrest systems.
Glazing	The use of glass or transparent panels in the bridge envelope, which may include laminated or tempered glass for safety.
HVAC	Heating, Ventilation and Air Conditioning.

Term	Definition
Louvres	Slatted openings designed to allow airflow while preventing rain, snow, or vandalism.
Mechanical Ventilation	A system relying on fans and other means (not HVAC) to maintain airflow and air quality in an enclosed space.
Passive Ventilation	A natural airflow system relying on openings, louvres, wind scoops, or other means to regulate temperature and airflow without mechanical systems.
Pendulum Test Value (PTV)	A measurement of surface friction used to evaluate slip resistance, requiring a minimum value of 36, tested as per ASTM E303.
RSI Value (R-Value)	A measure of conductive heat flow resistance through a material or assembly; higher values indicate better insulation. RSI is in metric units, and R-Value is in imperial units.
Slip Resistance	The ability of a surface to provide adequate traction in wet and dry conditions.
Thermal Bridging	The transfer of heat through materials with higher thermal conductivity (e.g., metals) leads to energy loss.
Thermal Comfort	Thermal comfort refers to the condition in which occupants express satisfaction with the thermal environment, as defined by ASHRAE Standard 55.
Unconditioned Space	An enclosed space without active temperature control, relying on either passive or mechanical means of ventilation.
Wet Bulb Globe Temperature (WBGT)	A common metric used for measuring heat stress. Accounts for air temperature, solar radiation, wind, and humidity. Shall be measured with specialized equipment.

2.2 Abbreviations

2.2.1 The abbreviations used in this standard shall have the meaning prescribed in Table 2.

Table 2: List of Abbreviations

Abbreviation	Definition
AMCA	Air Movement and Control Association International Inc.
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AODA	Accessibility for Ontarians with Disabilities Act
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASTM	American Society for Testing and Materials
BTU	British Thermal Unit
CIAR	Construction Impact Assessment Report
CPTED	Crime Prevention Through Environmental Design
CSA	Canadian Standards Association
DRM	Design Requirements Manual (Metrolinx)
DS	Design Standard (Metrolinx)
FRP	Fibreglass Reinforced Plastic (related to envelope)/ Fibre Reinforced Polymer (related to structure)
GIMP	Geotechnical Instrumentation and Monitoring Plan
IGMAC	Insulating Glass Manufacturers Alliance of Canada
LOS	Level of Service
MTO	Ministry of Transportation of Ontario
OBC	Ontario Building Code
OHSA	Occupational Health and Safety Act
QA/QC	Quality Assurance / Quality Control
RSI	RSI-Value System International (Thermal Resistance)
TAC	Transportation Association of Canada
TTC	Toronto Transit Commission

3. Design Requirements

3.1 General Design Requirements

3.1.1 Design Responsibility

3.1.1.1 The design of enclosed pedestrian bridges shall be undertaken and sealed by a Professional Engineer licensed to practise in the Province of Ontario.

3.1.2 Structural Requirements

3.1.2.1 All structural design requirements, such as loading combinations, foundation design, seismic design, safety considerations, thermal expansion and contraction, pedestrian and wind-induced dynamic forces and sway vibration caused by pedestrian live loading, among others, shall comply with the requirements outlined in CAN/CSA S6, CAN/CSA S7 and the OBC.

3.1.2.2 Sections of an enclosed pedestrian bridge that span over the rail corridor shall be single-span structures with supports beyond the operating right-of-way. Supports/piers within 7620 mm (25 ft) from the centre line of adjacent tracks shall be protected by crash protection walls. Intermediate supports within the rail corridor shall not be permitted. If single-span structures are not feasible due to project constraints, a technical justification including a comprehensive cost-benefit analysis shall be submitted to and approved by the Owner of this Standard.

3.1.2.3 Continuous or cantilevered spans shall not be permitted over the rail corridor, unless technical justification of no other alternative is provided, subject to approval by the Owner of this Standard.

3.1.2.4 The connection between an Enclosed Pedestrian Bridge and adjacent structures shall accommodate relative/differential movements such as thermal expansion/contraction, settlement, and wind loads, etc. Expansion joints, bearings, and other suitable mechanisms shall be utilized, as needed, to allow for adequate flexibility and minimize stress concentrations, while ensuring the safety and stability of each structure.

3.1.3 Geotechnical Requirements

3.1.3.1 The structural design shall be supported by geotechnical field investigation and testing, as well as geotechnical data and interpretive design reports, which shall provide sufficient information such as the soil stratigraphy, soil and/or bedrock design parameters and bearing capacity, estimated soil settlement (immediate, consolidated, and creep), groundwater depth and seasonal fluctuations, soil contaminants/aggressive environments and any other geotechnical factors needed to support the design of the bridge, as determined by the geotechnical engineer.

3.1.3.2 Geo-structural assessments, such as a Construction Impact Assessment Report (CIAR) and a Geotechnical Instrumentation and Monitoring Plan (GIMP), shall be

conducted to mitigate and monitor potential adverse impacts of constructing the enclosed pedestrian bridge.

3.1.3.3 Geotechnical investigation and design scopes, including a minimum number of geotechnical boreholes or test pits, shall be in accordance with the requirements of the current edition of applicable standards and guidelines, including but not limited to Metrolinx Standards, Direction for Conducting Site Investigations, the Canadian Foundation Engineering Manual and when/if applicable, TTC Geotechnical Standards.

3.1.4 Geometry-Level of Service

3.1.4.1 The interior dimensions of enclosed pedestrian bridges shall comply with the requirements outlined in associated/respective Metrolinx Architectural Design Standards and the Universal Design Standard. The minimum interior clear height and clear width shall be 3500 mm.

3.1.4.2 All elements (e.g., corridors, staircases, and others) of a pedestrian bridge shall be sized to satisfy the LOS required at their associated station, and it shall provide the required egress capacity. Passenger flow modelling shall be carried out in accordance with Pedestrian Flow Modelling Design Standard (DS-12).

3.1.5 Durability-Corrosion Mitigation

3.1.5.1 Galvanic Corrosion: all structural elements shall be designed to prevent galvanic corrosion, by either selecting metals with similar corrosion potentials, or separating the two metals to avoid direct contact using distance, insulation, or coatings.

3.1.5.2 Atmospheric Corrosion: all structural steel elements exposed to the external environment, whether exterior or interior members, shall be treated or coated to be resistant to atmospheric corrosion.

3.1.5.3 Chloride-Induced Corrosion:

a) For reinforced concrete decks without architectural finishes, the design shall include a pedestrian-grade elastomeric traffic topping system or approved equivalent on the top surface.

b) For reinforced concrete with architectural finishes (e.g., tiles, stone), the design shall incorporate a compatible protective membrane or approved equivalent beneath the architectural finishes.

c) For composite decks (e.g., corrugated steel deck with a concrete topping), the design shall include a vapour-permeable protective sealer or approved equivalent on the top surface.

d) For metal decks, the design shall include the use of corrosion-resistant materials or materials treated with a corrosion-resistant coating.

3.1.5.4 Epoxy-coated embedded steel reinforcements shall not be utilized.

3.1.5.5 Mass timber elements shall not be utilized in pedestrian bridges spanning across the rail corridor.

3.1.6 Anti-Slip

3.1.6.1 Anti-slip and colour-contrasting nosings shall be provided at the edges of each staircase step in accordance with the OBC, CSA B651 and AODA.

3.1.6.2 Bridge decks, in conjunction with any coatings applied to their top surface, shall be slip-resistant and provide an adequate coefficient of friction in dry and wet conditions (minimum Pendulum Test Value of 36). Pendulum test shall be performed in accordance with ASTM E303 Standard Test Method for Measuring Surface Friction Properties using the British Pendulum Tester to confirm slip resistance.

3.1.7 Handrails and Guardrails

3.1.7.1 Handrails and guardrails (if required) shall be provided on both sides of bridge interior spaces (e.g., corridors, staircases, etc.) in accordance with the OBC, CSA B651 Accessible Design for the Built Environment, Accessibility for Ontarians with Disabilities Act (AODA) and Architectural Materials and Finishes Design Standard (DS-24). All handrails and guardrails constructed of metal or other conductive materials shall be electrically grounded or bonded to the grounding system.

3.1.8 Drainage

3.1.8.1 Floor area drains shall be designed at both ends of an enclosed bridge. Bridge decks shall incorporate a minimum 2% slope near each drain to direct water flow and prevent ponding.

3.1.8.2 Roof level drains shall be provided in accordance with the Low-Slope Roofing Standard. Roof scuppers are not permitted to discharge onto the rail corridor or pedestrian pathways.

3.1.8.3 Drains and drainage pipes are not permitted above or within the rail corridor. Drainage pipes in unconditioned spaces shall be heat-traced.

3.1.8.4 When required, all drainage pipes, elevator sump pumps, hydrants and hose bibs shall comply with the DRM.

3.2 Asset Specific Requirements

3.2.1 Bridge Envelope Requirements

3.2.1.1 An enclosed pedestrian bridge shall provide clear sight lines to the exterior with vision glazing, transparent fibreglass reinforced plastic (FRP) panels or approved equivalent systems.

3.2.1.2 Expansion joints shall be designed to accommodate the bridge's maximum anticipated movements. Joints shall also be designed to be watertight and corrosion-resistant as per the requirements outlined in the Waterproofing Standard. Sealant joints intended for expansion/contraction shall not be wider than 25 mm. Joints on a bridge deck shall be designed to safely accommodate high volumes of pedestrian traffic with a cover or protective system, secured to one side, to prevent trip hazards and damage to the joint.

3.2.1.3 The roof of an enclosed pedestrian bridge shall be insulated. Conditioned spaces shall meet a minimum RSI value of 7 m^2 K/W (R-value of 40 ft^2 °F h/BTU), and unconditioned spaces shall meet a minimum RSI value of 3.5 m^2 K/W (R-value of 20 ft^2 °F h/BTU). Low-slope roofs of enclosed pedestrian bridges shall also comply with the Low-Slope Roofing Standard.

3.2.1.4 If wind scoops are incorporated into the roof of an enclosed passively ventilated pedestrian bridge, they shall possess a uniform design with the bridge envelope and be designed to prevent the intrusion of rain and snow into the bridge.

3.2.1.5 The design shall incorporate features to prevent thermal bridging (e.g., curtain wall system, mullions, slab edges, and so on). Mullions shall possess a high albedo finish and be insulated where possible.

3.2.1.6 The design shall reduce solar heat gains in the summer and increase solar heat gains in the winter by maximizing the use of natural light. Example methods may include, but are not limited to, utilizing interior light shelves, roof overhangs, vertical or horizontal shading devices, or secondary exterior facades.

3.2.1.7 Operable windows shall not be utilized over the rail corridor or roads.

3.2.1.8 Exterior cladding and soffit materials shall follow GO Station Architecture Design Standard (DS-04) to provide a consistent, cohesive, and uniform appearance.

3.2.2 Glazing

3.2.2.1 Glazing shall either be heat-strengthened laminated or tempered glass. Laminated glass is required at bridges spanning over rail corridors and shall be designed not to dislodge from its frame support in the event of a breakage.

3.2.2.2 Enclosed pedestrian bridges with a conditioned space shall either utilize double-glazed or triple-glazed insulating glass units that are IGMAC certified and follow the requirements outlined in the Curtain Wall Standard (pending).

3.2.2.3 Bird-friendly frit (dots) shall be installed on all pedestrian bridge glazing and/or transparent panels in accordance with CAN/CSA A460 Bird-Friendly Building Design, to prevent birds from colliding with the bridge.

3.2.3 Thermal Comfort Requirements

3.2.3.1 Conditioned spaces: Enclosed pedestrian bridges that require year-round temperature regulation for comfort or regulatory reasons shall meet the requirements of a corridor outlined in ANSI/ASHRAE 55-Thermal Environmental Conditions for Human Occupancy and the DRM.

3.2.3.2 Unconditioned spaces: Where temperature control is not necessary, unconditioned bridges shall meet the following:

a) Interior temperatures shall not exceed 35 °C/95 °F DBT or 32.5 °C/90.5 °F WBGT, for more than 1% of all annual operating hours; and

b) Interior temperatures shall remain a minimum of 2 °C above outdoor ambient temperatures in colder months/seasons.

3.2.4 Passive Ventilation Requirements

3.2.4.1 Passive ventilation is appropriate for unconditioned spaces where natural airflow can maintain interior temperatures within acceptable limits. Specific criteria include:

a) Use of stationary and/or adjustable louvres shall be designed to prevent the intrusion of wind-driven rain and snow into the pedestrian bridge, and incorporate vandalism-resistant elements, adhering to CPTED principles;

b) For passively ventilated bridges, design openings appropriately to achieve a minimum target ventilation rate of 0.3 L/s/m^2 for ninety percent (90%) of annual hours;

c) Orient the bridge using local and microclimate wind patterns to take advantage of cross ventilation; and

d) The designer shall submit a report outlining the internal conditions within the bridge (e.g., ventilation rates, internal temperatures, etc.) for the Owner of this Standard to review.

3.2.5 Stationary/Fixed Louvres

3.2.5.1 If louvres are utilized, they shall be on both sides of an enclosed passively ventilated pedestrian bridge.

3.2.5.2 Louvres shall be oriented on the top and bottom portions of the façade in a continuous or staggered pattern to promote better air ventilation.

3.2.5.3 Louvres shall bear the AMCA Worldwide Certified Ratings seal, and be rated for Water Penetration, Air Performance, and Wind Driven Rain. Louvres shall also be self-draining.

3.2.5.4 Louvres shall be rated Class-A at 50 mph (80 kph) in accordance with ANSI/AMCA 500-L.

3.2.5.5 Non-flammable and removable snow stoppers or insect/bird screens shall be installed on the interior side of louvres. Insect/bird screens shall comply with the requirements outlined in Architectural Material and Finishes Design Standard (DS-24).

3.2.6 Mechanical Ventilation Requirements

3.2.6.1 Mechanical ventilation rates shall meet the minimum ventilation rates of a corridor outlined in ANSI/ASHRAE 62.1-Ventilation and Acceptable Indoor Air Quality.

a) Unconditioned Space: Where estimated ventilation rates are less than 0.3 L/s/m^2 for more than ten percent (10%) of annual hours or if the maximum estimated internal temperature exceeds 35 °C (95 °F) DBT, a supplemental sensor-activated mechanical ventilation system is required.

b) Conditioned Space: For ventilation requirements, refer to the DRM.

3.2.7 Maintenance and Access Requirements

3.2.7.1 External catwalk systems with guardrails shall be provided on both sides of an enclosed pedestrian bridge. Catwalk systems shall also incorporate an Electrification Protection Barrier when/if required by the project.

3.2.7.2 Fall arrest roof anchors shall be provided on the roof of an enclosed pedestrian bridge.

3.2.7.3 Consider the use of interior glazed fenestration systems for ease of maintenance and glazing replacement.

3.3 Quality Assurance and Quality Control (QA/QC)

3.3.1 The following QA/QC activities shall be included in the project agreement to ensure proper documentation and certification by the Professional Engineer responsible for the design throughout construction. At project completion, all QA/QC documentation shall be submitted to the Owner of this Standard for review and approval.

a) Structural Design: Provide record drawings and structural calculations signed and sealed by two (2) Professional Engineers demonstrating compliance with relevant codes and standards;

b) Signed and sealed architectural, mechanical and electrical record drawings. Drawings and associated specification packages shall include details for the bridge envelope, including glazing specifications, insulation details, thermal bridging prevention measures, and drainage system plans, ensuring compliance with Waterproofing and Roofing Standards and no discharge within the rail corridor;

c) Technical Reports: Reports and calculations demonstrating that thermal comfort and ventilation requirements have been thoroughly considered and met, including compliance with relevant standards; and

d) Testing and Inspection for Roof Anchors and Catwalks: Ensure project requirements include roof anchors to be visually inspected annually and load tested every 5 years, as required by the Occupational Health and Safety Act (OHSA) Regulation 859. Project requirements shall specify intervals for when exterior catwalks are required to be visually inspected.

e) Testing and Inspection for Bridge: Visual inspection, non-destructive testing, and sampling shall be done in the fabrication shop and in the field to confirm the supplied materials, fabrication, and erection have been done as specified in the Contract Documents.