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CSA S7, A New Design Guideline for Pedestrian, Cycling, and Multiuse Bridges

Azita Azarnejad, Ph.D., P.Eng., FCSCE - Jacobs

Agenda

- **Technical subcommittee structure**
- **Development timeline**
- **Scope**
- **Section summary and main developments**

1. General
2. Geometric design, accessibility, and safety Considerations
3. Loads
4. Design for pedestrian and wind induced vibrations
5. Methods of analysis
6. Material specific design provisions
7. Foundations and seismic design
8. Durability and sustainability
9. Evaluation, inspection, maintenance, and rehabilitation

Annex A – Commentary

Annex B – Aesthetic considerations

Technical Subcommittee Structure

- CSA Project Manager – Mark Braiter (CSA)
- Chair – Jianping Jiang (WSP)
- Vice Chair – Scott Walbridge (University of Waterloo)

- Working Groups leads:
  - Section 1 (owners) – Evan Fer (City of Calgary)
  - Section 2 – Saidur Rahman (City of Toronto)
  - Sections 3 and 4 – Guy Larose (RWDI)
  - Section 5 – Kent Larose (Parsons)
  - Section 6 – Azita Azarnejad (Jacobs)
  - Section 7 – Jianping Jiang (WSP)
  - Section 8 – Etienne Cantin Bellemare (T.Y. Lin International)
  - Section 9 – Maurice Mansfield (WSP)
  - Annex B – Mark Langridge (DTAH) and Juan Sobrino (Pedelta)

- Other members:
  - Pampa Day (University of Laval)
  - Mario Fafard (AluQuebec)
  - Pascale Germain (MTQ)
  - George Josi (Dialogue)
  - Sadegh Kazemi (Morriosn Hershfield)
  - Joshua Schembrie (City of Whitby)
  - Nicholas Spence (Algonquin Bridge)
  - Cristian Zanfir (CWB)
  - Cory Zurell (University of Waterloo)

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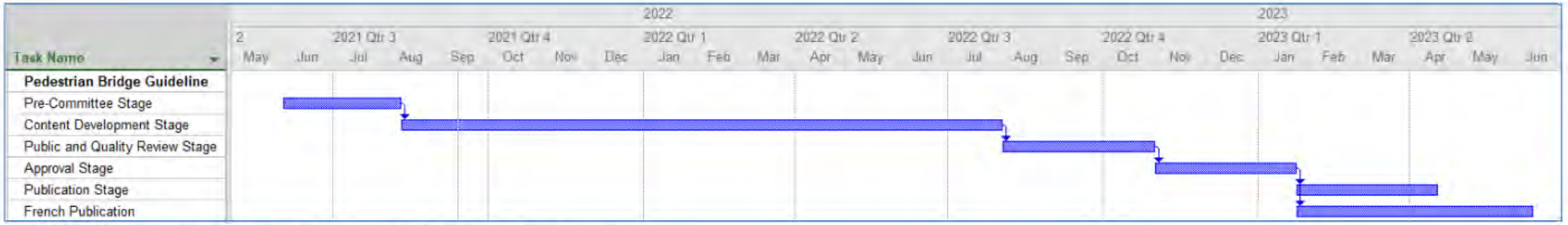
Development Timeline

- First discussed in TAC Structural Committee
- Seed document prepared in summer 2021
- Kickoff meeting - Sep. 09, 2021
- Public review - Aug. 17 to Oct. 16, 2022
- Presentation to CHBDC Technical Committee – Jan. 16, 2023



* Note this schedule has been updated since the meeting

The new guideline is intended to be published in time for consideration to be referenced in the 2025 edition of the Canadian Highway Bridge Design Code

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Scope

- Applies to the design, evaluation, and structural rehabilitation of standalone pedestrian, cycling, and multiuse bridges in Canada
- To be used in conjunction with CSA S6 (not a standalone design document)
- A guideline, but written in mandatory language so that it could be used as necessary by the jurisdictions and in contract documents
- Terminology:
  - Shall – Mandatory (requirement to comply with the guideline)
  - Should – Recommended but not mandatory
  - May - Permissible

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Section 1 - General

Owner’s working group

Chair: Evan Fer

Working group members:

Alireza Ahmadnia, Laura Archila, Karen Esarte, Cheryl Faraday, Pascal Germain, Saidur Rahman, John Stephensen, Walter Kenedi

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Summary and Main Developments

- Provides scope and applicability of the guideline
- Defines bridge users, bridge components and types, and exclusion
- Guideline references
- General requirements
  - Design philosophy
  - Environment and climate change
  - Aesthetics considerations (Annex B)
  - Conceptual design
- Expansion joints and bearings
- Construction
- Utilities

Flora Footbridge, Ottawa – CSA S7 Annex B

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Section 2 – Geometric Design, Accessibility, and Safety Considerations

Chair: Saidur Rahman

Working group members:

Tom Baumgartner, Sergui Bagrianski, Karen Esarte, Pascale Germain, Peter Phillips, Joshua Schembri, David Woodford

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Summary and Main Developments

- Geometry – Grades, clearances, cross slope, requirements for cyclists
- Stairways, walkways, and ramps
- Barriers, hand rails, and curbs
- Deck surface – Functionality and characteristics for different surfacing materials
- Lighting – Illumination, fixtures, and systems
- Deterring undesirable use – Principles of CPTED, Maintenance and access control
- Traffic Control – Signage, bollards, and pavement marking

East Hamilton Pedestrian Bridge – CSA S7 Annex B

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Section 3 – Loads

Chair: Guy Larose

Working group members:

Azita Azarnejad, Benoit Cusson, Pampa Day, Darrel Gagnon, Sadegh Kazemi, Kent LaRose, Ryan O'Connell, Scott Walbridge

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Summary and Main Developments

- Limit States, load factors, and load combinations
- Pedestrian loads
- Maintenance vehicle, snowmobile, equestrian, wind, and snow loads
- Handrail and barrier loads
- Wind induced fatigue loads
  - Natural wind gust
  - Truck-induced gust
- Collision loads for superstructure
- Longitudinal horizontal force

Garrison Crossing, Toronto – CSA S7 Annex B

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Section 4 – Design for Pedestrian and Wind-induced Vibration

Chair: Guy Larose

Working group members:

Azita Azarnejad, Benoit Cusson, Pampa Day, Darrel Gagnon, Sadegh Kazemi, Kent LaRose, Ryan O'Connell, Scott Walbridge

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Summary and Main Developments

- Damping ratios (service and limit states)
- Pedestrian-induced vibration design – includes a design flowchart
  - Stage 1 – Frequency evaluation
  - Stage 2 – Vibration evaluation
  - Stage 3 – Measures for vibration control or improved vibration performance (if necessary)
- Structural verification under pedestrian induced dynamic loads
- Wind induced vibration design

Pottery Road Bridge, Toronto – CSA S7 Annex B

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Section 5 – Methods of Analysis

Chair: Kent LaRose

Working group members:

Benoit Cusson, Mecky El Sharnouby, Matthew Galloway, Lauren Gerin, David Hubbell, Georg Josi, Geoff Kallweit, Radhouane Masmoudi, Ryan O'Connell, Michael Paulsen, Sameh Salib, Khaled Sennah, Kevin Serre, John Stephensen, David Woolford

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Summary and Main Developments

- Barriers – Consideration of their stiffness
- Beam Type bridges – uplift of bearing for curved bridges
- Simplified analysis of pony trusses
- Arch bridges
- Cable supported structures
  - Suspension bridges
  - Cable-stay bridges
  - Stress-ribbon bridges
- Buried Structures

Terwillegar Bridge, Edmonton – CSA S7 Annex B

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Section 6 – Material Specific Design Provisions

Chair: Azita Azarnejad

Vice-chair: Sadegh Kazemi

Secretary: Nick Spence

Working group members:

Andrew Crosby, Benoit Cusson, Mehdi Dastfan, Mario Fafard, Bradley Fletcher, Matthew Galloway, Laurent Gerin, Tim Harris, Amir Jamshidi, Geoff Kallweit, Radhouane Masmoudi, Sameh Salib, Michael Samuels, Khaled Sennah, John Stephensen, Jack Tarrell, Scott Walbridge, Christian Zanfir, Corey Zurell

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6.1 - Scope

- Limited to special requirements for pedestrian, cycling, and multiuse bridges.
- Not intended to be used as a stand-alone document and should be used together with CSA S6 with this section having the higher hierarchy.
- In most cases, this guideline will relax requirements of CSA S6 for economical reasons. There are clauses that focus on requirements that might not be common in highway bridges but are common in pedestrian bridges.
- Materials other than those specified in this Section may be used if approved by the owner. In this case, the designer shall take the responsibility.

6.2 Steel

Group leads: Amir Jamshidi, Jack Tarrell, Mehdi Dastfan

Working group members:

Bradley Fletcher, Geoff Kallweit, Sameh Salib, Michael Samuels, John Stephensen, Jack Tarrell, Scott Walbridge, Christian Zanfir

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Main Developments

- Materials – Expansion of permitted materials
- Slenderness – relaxed compared to CSA S6
- Durability – minimum thickness requirement
- Structural fatigue – different nature of fatigue loading
- Fracture control and fracture toughness – relaxed compared to S6
- Wearing surface on flexible steel deck
- Identification and traceability
- Inspection

GTI Bridge over Crowchild Tr., Calgary, AB – CSA S7 Annex B

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6.3 Aluminum

Group lead: Mario Fafard

Working group members:

Benoit Cusson, Scott Walbridge, Cristian Zanfir

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Main Developments

- Minimum plate thickness
- A method to verify if an aluminum bridge is significantly affected by fatigue loading and therefore must be designed/detailed as a “cyclically loaded structure”
- References to relevant existing standards for tubular connection design
- Special requirements for non-destructive evaluation of welds in aluminum pedestrian bridges

Arbour Stone Rise, AB – CSA S7 Annex B

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6.4 Concrete Structures

Group lead: Tim Harris

Working group members:

Azita Azarnejad, Matthew Galloway, Geoff Kallweit, Sadegh Kazemi, Radhouane Masmoudi

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Main Developments

- Reduced cover for stainless steel
- Deck slab
  - Minimum slab thickness
  - Deck slabs with only two layers of reinforcement are permitted
  - Additional thickness for wear not required for exposed concrete decks

Corktown Footbridge, Ottawa – CSA S7 Annex B

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6.5 Wood

Group lead: Cory Zurell

Working group members:

Sadegh Kazemi, Khaled Sennah, John Stephensen

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Main Developments

- Relaxation of CSA S6 requirements and additional materials
- Alternate materials include CLT and other wood species (hardwood) or treatments (Accoya) not included in CSA S6 which are commonly used for pedestrian bridges
- Service life/preservative treatment requirements are relaxed when approved by owner
  - Pressure-treated wood planks will not last 75 years, but could be replaced several times

Fifth Bridge, Jasper, AB, Cable stay footbridge with gluelam timber girders – CSA S7 Annex B

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6.6 FRP Structures

Group lead: Khaled Sennah

Working group members:

Sadegh Kazemi, Radhouane Masmoudi, Sameh Salib

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Main Developments

- Reference to other CSA standards (CSA S806, CSA S807 or CSA S808) to determine relevant properties and manufacturing requirements of FRP materials by tests.
- *Minimum concrete cover to GFRP, non-prestressed, reinforcement in concrete members*
- References for the design of concrete-filled FRP tube bridge components
- FRP structural shapes
- Cl. 6.6.6 - GFRP composite bridges made of structural shapes manufactured through pultrusion (Previously Annex A16.3 in CSA S6).

Bridge over Elbow River, AB – CSA S7 Annex B

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6.7 Glass Elements in Barriers

Group lead: Geoff Kallweit

Working group members:

Andrew Crosby

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Main Developments

- Glass is a new material to Canadian bridge structural design
- Capacity calculations based on European research and standards
- Currently applies to barriers only
- Addresses the post-breakage limit state
- Inclusion of deck panels for next CSA S7 edition

Mimico Bridge, Toronto –
CSA S7 Annex B

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Section 7 – Foundations and Seismic Design

Chair: Jianping Jiang

Working group members:

Alireza Ahmadnia, Sepideh Ashtari, Meckkey El Sharnouby, Masoud Manzini, Nicholas Spence

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Summary and Main Developments

- Foundation design – Some updates to suit pedestrian bridges
- Seismic analysis and design for new bridges
  - Reclassification of Importance Categories (Critical, Essential, and Other)
  - Single hazard level design 2% (2475 years)
  - Seismic analysis requirements (Elastic Static Analysis not permitted in general)
  - Earthquake load cases (vertical ground motion effects to be considered)
- Seismic evaluation and rehabilitation

Humber Bridge, Toronto, ON – CSA S7 Annex B

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Section 8 – Durability and Sustainability

Chair: Etienne Bellemare

Working group members:

Yves Archambault, Sylvie Boulanger, Guillaume Bedard Blachet, Allison Halpern, Ahmed Kouba, Jamie McIntyre, Radhouane Masmoudi, Nick Spence, Jianping Jiang

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Summary and Main Developments

- Design for durability
  - Steel – detailing
  - Aluminum – surface finishing
  - Concrete – protective measures
  - Wood – design details, material choice, preservative treatments, replaceable elements
  - Fibre Reinforced Polymers (FRP) – protective measures
  - Cables – Protection, detailing, replaceability, anti-vandalism
  - Glass – design, maintenance, impact damage
- Walkway surface – Deck surface, drainage
- Design for sustainability
  - Social responsibility
  - Economic effectiveness
  - Environmental protection

An example of wood decking - CSA S7 Section 2

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Section 9 – Evaluation, Inspection, Maintenance, and Rehabilitation

Chair: Maurice Mansfield

Working group members:

Laura Archila, Karen Esarte, Evan Fer, Darrel Gagnon, Matthew Galloway, Michael Paulsen, Kevin Serre, Jaime Vandenburg

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Summary and Main Developments

- Evaluation
  - Mainly follows CSA S6
  - Live load dependent on the owner's desired use of the bridge
- Inspection and maintenance
  - Access requirements
  - Planning for winter operations
  - Inspection program, maintenance strategy, and component replaceability
- Rehabilitation
  - Conversion of highway bridges to pedestrian bridges
  - Reuse of structural components for new pedestrian bridges
  - Loads and load factors
  - Fatigue and seismic rehabilitation

Montmorency Falls Crossing, QC – CSA S7 Annex B

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Annex A (informative) – Commentary

- Written by Technical Sub Committee
- Explains the intent of various clauses
- Provides additional background information

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Annex B (informative) – Aesthetic Considerations

Chair: Mark Langridge and Juan Sobrino

Working group members:

Azita Azarnejad, Laura Archila, John Stepensen, Karen Esarte, Pascale Germain, Peter Phillips, Saidur Rahman, Serguei Bagrianski, Walter Kenedi

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Summary and Main Developments

- High level of aesthetic consideration required for pedestrian bridges
  - Importance of conceptual design
- Understanding the context
  - Functional parameters, built and natural environment, history, views
- 3D visualization
- Bridge form for different structure types
  - Girder bridges, rigid frames, arches, trusses, cable-supported, stress ribbon, special conditions (trail bridges, landscaped bridges)
- Pedestrian needs – walking, safety, universal access,…
- Integrating the approaches
- Guards and railings
- Material quality and detailing
- Lighting
- Interpretive layers
- Ultimate Goal: A “Special Sense of Place”

Curved approach pathways - CSA S7 Annex B

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Questions?

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