CSA S6:19

Canadian Highway Bridge Design Code

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- **Section 4 –** Seismic Design
- **Section 5 –** Methods of Analysis
- **Section 6 –** Foundations and Geotechnical Systems
- **Section 7 –** Buried Structures
- **Section 8 –** Concrete Structures
- **Section 10 –** Steel Structures

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Canadian Highway Bridge Design Code

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Preface

This is the twelfth edition of CSA S6, *Canadian Highway Bridge Design Code*. It supersedes the previous editions published in 2014, 2006 (including three supplements published in 2010, 2011, and 2013), 2000, 1988, 1978, 1974, 1966, 1952, 1938, 1929, and 1922.

This Code is based on limit states design principles and defines design loadings, load combinations and load factors, criteria for earthquake resistant design, and detailed design criteria for the various materials. This Code has been written to be applicable in all provinces and territories.

There are 17 Sections in this Code:

Section 1 ("General") specifies general requirements for applying the Code and includes definitions and a reference publications clause applicable throughout this Code. It also specifies geometric requirements, based in part on the Transportation Association of Canada's *Geometric Design Guide for Canadian Roads* (2017), and hydraulic design requirements, based in part on the Transportation Association of Canada's *Guide to Bridge Hydraulics* (2004). There are also general provisions covering durability, economics, environmental considerations, aesthetics, safety, maintenance, and maintenance inspection access. The definitions in Clauses 1.3.2 to 1.3.4 apply to those used specifically in this Section, and new to this edition of the Code, also apply to common definitions used in more than one Section in this Code.

Section 2 ("Durability and sustainability") specifies requirements for durability and sustainability that need to be considered during the design process of bridges, culverts, and other structures located in transportation corridors. The durability requirements are based on principles applicable to service life design that consider the environmental exposure conditions, the deterioration mechanisms, the protective measures, and detailing requirements needed to meet the projected service life of structural components. The concept of sustainability considerations has been introduced to alert owners and designers to undertake design and decision-making practices that will help to achieve the context-specific balance of social, environmental, and economic values, and impacts associated with the investment in building new or rehabilitation of existing bridges and other transportation structures included in the scope of this Code. Similarly, local climate change and exposure conditions are brought to the attention of designers and owners.

Section 3 ("Loads") specifies loading requirements for the design of new bridges, including requirements for permanent loads, live loads including special trucks, and special loads (but excluding seismic loads). The 625 kN truck load model and corresponding lane load model are specified as the minima for interprovincial transportation and are based on current Canadian legal loads. Ship collision provisions are also included. Section 3 does not specify limits on the span lengths for application of the truck and lane loads. Accordingly, long-span requirements have been developed and appear in Section 3 and elsewhere in this Code (these requirements, however, should not be considered comprehensive). Section 3 addresses wind tunnel testing for aerodynamic effects.

Section 4 ("Seismic design") specifies seismic design requirements for new bridges and evaluation and rehabilitation requirements for existing bridges. In this edition of the Code, performance-based design (PBD) has been maintained using updated values for damage states in ductile substructures. Additional damage and service definitions have been provided. Minimum performance levels have been revised from three to two seismic hazard levels for all bridges requiring PBD. Force-based design (FBD) remains permitted for a refined set of special cases. Requirements for geotechnical and foundation design have been moved to Section 6. Some provisions for bearing design have been moved to Section 11 with revisions in Section 4 for consistency. Capacity design has been clarified and encouraged for ductile structures using PBD and FBD. Design forces and material properties for PBD, FBD, and capacity design have been clarified. The shear capacity for ductile concrete columns has been revised upwards. Performance-based design and recommended minimum performance targets have been revised for the evaluation and rehabilitation of existing bridges. FBD approaches for existing bridges are discouraged, while guidance on displacement-based methods has been provided.

Section 5 ("Methods of analysis") specifies requirements for analyzing bridge superstructures. Additional guidance related to longitudinally connected beams and integral abutment bridges are provided. This Section presents new methods for the simplified analysis of longitudinally connected concrete box-beam bridges (previously named shear connected beams), curved steel girder bridges, and steel or aluminum pony-truss bridges. Reductions to limitations for when a curved bridge can be analyzed in the same manner as a straight bridge have been introduced. The robustness and accuracy of the simplified method has been verified by conducting thorough analysis using a large database of simply supported and continuous slab-on-girder bridges. This analysis resulted in shear forces being increased by up to 13% at interior supports for slab-on-girder bridges. In collaboration with Section 3, more specific requirements related to traffic loading are provided with the aim of clarifying the use of refined method of analysis. Revised requirements and guidance for the refined method of analysis have therefore been included. Methods for the design of deck slab cantilever overhang have been updated. Finally, a new simplified method of analysis is provided for determining the factored flexural resistance of steel-reinforced concrete barrier to transverse traffic barrier load.

Section 6 ("Foundations and geotechnical systems") adopted a risk-based approach to the design of foundations and geotechnical systems (including bridge approach embankments and retaining systems) in the 2014 edition of the Code. The risk-based design approach involves using a resistance factor, which captures our uncertainty in the ground and in our performance predictions, combined with a consequence factor, which adjusts target reliabilities depending on the severity of failure consequences (i.e., depending on the importance of the supported structure), to produce designs which properly account for the level of site understanding and failure consequences. This edition of the Code provides considerable additional changes, adding Code provisions in four design areas, three of which are entirely new to this Section, as follows:

- Clause 6.14, on seismic design, brings the geotechnical seismic design content originally in Section 4 into Section 6 and adds up-to-date content;
- Clause 6.10, on shallow foundations, has been brought up to date and its application is now much clearer;
- Clause 6.18, on permafrost design, provides new specifications for geotechnical design in cold climates; and
- Clause 6.19, on mechanically stabilized earth (MSE) wall systems, provides code requirements for MSE wall systems within the LRFD framework of Section 6 and addresses issues based on Canadian experience with these systems.

Section 7 ("Buried structures") deals with structures whose design and performance are heavily influenced by soil-structure interaction. The conduit wall of these buried structures can be fabricated from metal, steel or aluminum, or concrete. For metal structures, the conduit wall is made from corrugated plate which fits one of the three industry categories: shallow, deep, or deeper corrugated plate. For concrete structures the wall is reinforced concrete and can be precast or cast-in-place. Section 7 provides for a wide variety of structure shapes from low profile metal boxes or three-sided concrete boxes to large span metal or concrete arches. Section 7 specifies the use of refined methods of analysis for design although some simplified design equations can be used in smaller structures if specific geometric conditions are met. Section 7 also specifies requirements for determining the properties and dimensions of the engineered soil and non-soil components and addresses construction requirements, geotechnical requirements, and foundation design requirements.

Section 8 ("Concrete structures") covers reinforced, fully prestressed, and partially prestressed concrete components, including deck slabs, made of normal-density, semi-low-density, and high-density concrete of a strength varying from 30 to 80 MPa. Compression field theory is used for proportioning for shear and for torsion combined with flexure. The strut-and-tie approach is used for proportioning regions where the plane sections assumption is not applicable. New to this edition is an informative Annex that provides design provisions for tension softening and tension hardening fibre-reinforced concrete, including ultra-high performance concrete. Other significant changes in this edition include revised provisions relating to the design of slender compression members, the control of cracking, and the use of debonded strands in pretensioned components.

Section 9 ("Wood structures") specifies properties for materials and fastenings that are consistent with CSA O86 *Engineering Design in Wood*. In this edition of the Code, provisions have been reconfigured, and specified strengths revised, to make the application of service condition factors, related to moisture content in members, transparent for the designer. Specified strengths and moduli of elasticity for spruce, lodgepole pine, Jack pine glued-laminated timber have been introduced. Preservative treatments related to durability have been updated to reflect current industry practices, and design values for structural composite lumber have been removed as such products are proprietary and design values can vary between manufacturers. Finally, glued-laminated decks have been introduced.

Section 10 ("Steel structures") specifies the requirements for the design of structural steel bridges and highway accessory supports, including requirements for structural steel components, such as tension and compression members, composite and non-composite straight and horizontally curved girders of I-shape or box shape and their connections. It also covers trusses and arch type bridges. The requirements for structural fatigue and fracture control are outlined in Clauses 10.17 and 10.23, respectively. The construction requirements for steel bridges are specified in Annex A10.1. Provisions for hybrid girders have been re-introduced into Section 10 as Annex A10.2.

Section 11 ("Joints and bearings") specifies the minimum requirements for the design of deck joints and bearings. The design of elastomeric bearings has been updated from previous editions to be consistent with approaches used in other North American and international standards and codes. Alternative sliding materials (as an alternative to PTFE) comprised of ultra-high molecular weight polyethylene are presented. A testing protocol for such materials is also presented.

Section 12 ("Barriers and highway accessory supports") specifies the requirements for the design of permanent bridge barriers and highway accessory supports. New provisions have been added in this edition of the Code to define the extent of the "zone of Intrusion" behind barriers and for the design of noise barriers. Also, new provisions have been added for designing highway accessory supports at the serviceability and fatigue limit states.

Section 13 ("Movable bridges") specifies requirements for the design, construction, and operation of conventional movable bridges, i.e., bascule, swing, and vertical lift. Although the structural design aspects are based on the limit states design approach, the mechanical systems design procedures follow the working stress principle used in North American industry. This Section provides special load combinations and load factors that are specific to movable bridges.

Section 14 ("Evaluation") includes provisions concerning the three-level evaluation system, evaluation of deck slabs, detailed evaluation from bridge testing, and load posting of bridges. An optional probability-based mean load method that uses site-specific load and resistance information for more accurate evaluation is also provided. As in previous editions, an approach to determining material grades from small samples is provided.

Section 15 ("Rehabilitation and repair") specifies minimum design requirements for the rehabilitation of bridges, with particular emphasis on condition assessment, remaining service life, and rehabilitation design life. This Section also provides guidance on the selection of loads and load factors for rehabilitation that is based on the intended use of the bridge following rehabilitation. In this new edition of the Code, this Section introduces a new subsection on rehabilitation of structural steel elements to provide guidance on repair and strengthening of steel components and their connections.

Section 16 ("Fibre-reinforced structures") specifies design requirements for a number of structural components containing high- modulus fibre-reinforced polymers. The high-modulus fibres (aramid, carbon, and glass) are employed in fibre-reinforced polymers (FRPs), which are used for internal reinforcement as replacements for steel bars and tendons or as external reinforcement for retrofit. A new clause also briefly describes the use of the low-modulus fibres which are used for controlling cracks in concrete. This Section covers concrete beams, slabs, columns, concrete deck slabs, barrier walls, and stressed wood decks using FRP. Section 16 also includes design provisions for glass-fibre-reinforced polymers to be used as primary reinforcement and as tendons in concrete. An informative annex is now included to provide guidelines for GFRP composite bridges.

Section 17 ("Aluminum structures") specifies the requirements for the design, fabrication, and erection of aluminum highway bridges and pedestrian bridges. Where permitted in Section 12, Section 17 may now also be applied to highway accessory structures. In this edition of the Code, Clause 17.19 on aluminum bridge decks has been simplified and generalized recognizing that aluminum deck products may come in a broad variety of forms. Clause 17.20 on fatigue has been updated to add new local stress approaches, and a new Clause 17.26 on performance assessment by testing has been added.

CSA Group acknowledges that the development of this Code was made possible, in part, by the financial support of the governments of Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, the Northwest Territories, Nova Scotia, Nunavut, Ontario, Prince Edward Island, Québec, Saskatchewan, and the Yukon, Public Works and Government Services Canada, the Federal Bridge Corporation Limited, and Les Ponts Jacques Cartier et Champlain Incorporée.

This Code was prepared by the Technical Committee on the Canadian Highway Bridge Design Code, under the jurisdiction of the Strategic Steering Committee on Construction and Civil Infrastructure, and has been formally approved by the Technical Committee.

Notes:

1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
2) *Although the intended primary application of this Code is stated in its Scope, it is important to note that it remains the responsibility of the users of the Code to judge its suitability for their particular purpose.*
3) *This Code was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Code.*
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   b) *provide an explanation of circumstances surrounding the actual field condition; and*
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Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are available on the* Current Standards Activities *page at* ***standardsactivities.csa.ca****.*

5) *This Code is subject to review within five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to* ***inquiries@csagroup.org*** *and include "Proposal for change" in the subject line:*
   a) *Standard designation (number);*
   b) *relevant clause, table, and/or figure number;*
   c) *wording of the proposed change; and*
   d) *rationale for the change.*

Foreword

In Canada, the legal mandate for establishing design and construction requirements for highways, including highway bridges, lies with the provincial and territorial governments. All provinces and territories, with the exception of Manitoba, have mandated this Code for use under their jurisdictions.

Among the benefits associated with undertaking the development of this Code is the opportunity to establish safety and reliability levels for highway bridges that are consistent across Canada. Adoption of a single code makes it easier for the consulting and producer industries to respond to calls for proposals and eliminates the need for familiarity with the details of several codes. The adoption of a single code also supports the implementation of a national highway transportation system with agreed minimum standards and loadings for bridges on interprovincial highways, thereby encouraging consistency of vehicle weights across jurisdictions and supporting the objective of more cost-effective transportation of goods.

Designers need to be aware, however, that although this Code establishes CL-625 loading as the minimum for bridges that are part of the national highway system, it is within the mandate of the provinces and territories to adopt a heavier or lighter live loading based on local traffic conditions. For example, Ontario requires (as specified in Annex A3.4) the use of a CL-625-ONT loading in the design of new bridges; this reflects the higher average regulatory and observed loads for trucks operating in the province. All of the requirements of this Code applicable to CL-W loading also apply to CL-625-ONT loading. Designers should always obtain approval from the regulatory authority when a live loading other than the CL-625 loading is to be used for design, and should check whether any variations from the requirements of this Code are in effect in the jurisdiction, e.g., for evaluation of existing bridges or issuance of overload permits.

This Code was developed by taking into account the different regulatory structures and standards of Canada's provinces and territories. Overall priorities and objectives were established by the Regulatory Authority Committee (RAC), which also monitored the progress of the Code's development. In accordance with CSA procedural requirements, however, responsibility for the technical content of this Code was assigned to the Technical Committee (TC), as were decisions on how to deal with the priorities and objectives identified by the RAC. Because of the breadth and complexity of this Code, subcommittees (which were required to operate and report on a consensus basis) were established to oversee each section. In addition, task forces were established to handle specific aspects of this Code. The subcommittees and task forces reported to the TC through their Chairs. The extensive use of subcommittees permitted the recruitment of experts with the knowledge needed to address the sometimes highly specialized subjects covered by this Code.

This Code is complemented by CSA S6.1:19, *Commentary on CSA S6:19*, Canadian Highway Bridge Design Code, which provides rationale statements and explanatory material for many of the clauses of this Code.

Section 1
General

1.1 Scope

1.1.1 Scope of Code
This Code applies to the design, evaluation, and structural rehabilitation design of fixed and movable highway bridges in Canada. There is no limit on span length, but this Code does not necessarily cover all aspects of design for every type of long-span bridge. This Code also covers the design of pedestrian bridges, bicycle bridges, retaining walls, barriers, and highway accessory supports of a structural nature, e.g., lighting poles and sign support structures.

This Code does not apply to public utility structures or to bridges used solely for railway or rail transit purposes.

This Code does not specify requirements related to coastal effects (e.g., exposure to sea action and icebergs) or to mountainous terrain effects (e.g., avalanches). For structures that can be subject to such effects, specialists need to be retained to review and advise on the design and to ensure that the applicable requirements of other codes are met.

For bridges not entirely within the scope of this Code, the requirements of this Code apply only when appropriate. Necessary additional or alternative design criteria are subject to the approval by the owner.

1.1.2 Scope of this Section
This Section specifies requirements for applying the Code and requirements of a general nature for bridges, culverts, and related works. These requirements govern basic geometry and hydraulic design. General requirements are also specified for subsidiary components, deck drainage, maintenance, and inspection access. Broad guidelines related to economic, aesthetic, and environmental considerations are also provided.

1.1.3 Terminology
In this Code, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the Code; “should” is used to express a recommendation or that which is advised but not required; and “may” is used to express an option or that which is permissible within the limits of the Code.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

Section 2
Durability and sustainability

2.1 Scope

This Section specifies requirements for durability and sustainability that shall be implemented during the design process in addition to this Code's requirements for strength and serviceability. The requirements of this Section apply to the design of new bridges as well as to rehabilitation and replacement work.

2.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Durability — the capability of a component, product, or structure to satisfy, with planned maintenance, the design performance requirements over a specific period of time under the influence of the environmental actions, or as a result of a self-ageing process.

Glass transition temperature — the midpoint of the temperature range over which an amorphous material changes from a brittle and vitreous state to a plastic state, or vice versa.

Inspection — conformity evaluation by observation and judgment accompanied as appropriate by measurement, testing, or gauging (ISO 9000).

Maintenance — a set of activities that are planned to take place during the service life of a structure, in order to fulfil the requirements for durability.

Major repair — activities performed to preserve or restore the function of a structure, that fall outside of the definition of planned or reasonably foreseen maintenance or rehabilitation.

Predicted service life — an estimated period of time for the service life of a component or system of components based on actual choice of materials, detailing, construction data, environmental characterization, or experience.

Qualified person — as a minimum, a person with sufficient experience and credentials as required by the owner based on the requirements of the projects. This should apply to site supervisors, contract administration and inspection staff, contractor's supervisory staff, and anyone responsible for oversight during construction on behalf of the owner or contractor.

Quality assurance — as part of quality plan, a set of quality checking and verification procedures applied to confirm engineering design or construction of a structure completed in accordance with relevant codes and standards, and approved project criteria by the owner.

Quality plan — the document specifying which procedures and associated resources are to be applied by whom and when to meet the requirements of the specific project.

Remaining service life — the remaining period of time for which a structure or a component is to be used for its intended purpose with appropriate maintenance activities and planned rehabilitation, but without major repair. The assessment of the remaining service life of a structure or a component should

Section 3
Loads

3.1 Scope

This Section specifies loads, load factors, and load combinations to be used in calculating load effects for design. Resistance factors required to check ultimate limit states criteria in accordance with Clause 3.4.2 are specified elsewhere in this Code. Loadings provisions for evaluation of existing structures are covered in Section 14 and for rehabilitation in Section 15.

This Section includes requirements related to the vibration of highway and pedestrian bridges. It also includes requirements related to construction loads and temporary structures; these apply to partially completed structures and structures necessary for construction purposes. Snow loads are not specified because in normal circumstances the occurrence of a considerable snow load will cause a compensating reduction in traffic load.

3.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Acceptance criterion — the acceptable frequency of collapse due to the design vessel collision.

Axle unit — any single-axle, tandem, or tridem.

Buffeting — the loads induced in a structure by the turbulence in the natural wind.

Critical or essential bridges — an operational classification for bridges that must continue to function after a vessel collision.

Damping — the dissipation of energy in a structure oscillating in one of its natural modes of vibration. It is normally expressed as a ratio of the actual value of damping to the critical value of damping. The critical value of damping is the lowest value at which an initial motion decays without oscillation.

Dead load — the load from material that is supported by the structure and is not subject to movement.

Debris torrent — a mass movement that involves water-charged inorganic and organic material flowing rapidly down a steep confined channel.

Design lane — a longitudinal strip that is a fraction of the deck width and within which a truck or Lane load is placed for the purpose of design or evaluation.

Divergence — an aerodynamic instability in torsion that usually occurs at wind speeds higher than those normally considered in design.

Drag — the load in the direction of the wind, induced by an airstream acting on a body.

Effective temperature — the temperature that governs the thermally induced expansion and contraction of a superstructure.

Section 4
Seismic design

4.1 Scope

This Section specifies minimum requirements for

a) the seismic analysis and design of new bridge structures; and

b) the seismic evaluation (Clause 4.11) and rehabilitation (Clause 4.12) of existing bridge structures.

4.2 Definitions

The following definitions shall apply to this Section of the Code. For common definitions used throughout the Code, refer to Clause 1.3.

Capacity design — a method of seismic design that allows the designer to prevent damage in certain components by making them strong enough to resist loads generated when adjacent components reach their probable resistance.

Capacity-protected element — a structural component that is being protected from damage by designing its capacity to be greater than the loads generated when adjacent ductile or force-limiting elements reach their probable resistance.

Concentrically braced frame with nominal ductility — a braced frame with concentric bracing designed and detailed to absorb limited amounts of energy through inelastic bending or extension of bracing members.

Connectors — mechanical devices, including bearing components and shear keys, that provide transverse or longitudinal restraint of movement of the superstructure relative to the substructure.

Note: *Connectors do not include moment connections, monolithic joints, or longitudinal restrainers at expansion bearings (see Clause 4.4.10.4.2).*

Damping — the dissipation of energy of a structure oscillating in one of its natural modes of vibration.

Note: *It is normally expressed as a ratio of the actual value of damping to the critical value of damping. The critical value of damping is the minimum damping at which an initial motion decays without oscillation.*

Design displacement — for bridges without isolation or supplemental damping, the displacement predicted from analysis.

Note: *For the design of isolation or supplemental damping, see Clause 4.10.6.*

Ductile concentrically braced frame — a braced frame with concentric bracing designed and detailed to absorb energy through yielding of the braces.

Ductile substructure element — an element of a substructure that is expected to undergo reversed-cyclic inelastic deformations without significant loss of strength and is detailed to develop the appropriate level of ductility while remaining stable.

Ductility — the ability of a structural member to deform without significant loss of load-carrying capacity after yielding.

Section 5
Methods of analysis

5.1 Scope

This Section specifies the methods of analysis for the design and evaluation of bridge superstructures.

5.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Beam analogy method — a simplified method applicable to bridges satisfying the requirements of Clause 5.6.2 in which the bridge superstructure can be treated as a group of parallel beams equally distributed across the bridge width and on which the longitudinal load effects due to CL-W loading in longitudinal beams are determined using simple statics or prescribed distribution factors.

Bearing unit — a group of structural devices forming a line of support on a substructure unit (pier or abutment).

Bridge width — the distance between the unsupported edges along a line perpendicular to the centreline of the bridge.

Cantilever slab — in the transverse direction, the section of the deck slab that lies outside the centreline of the outermost girder or web; in the longitudinal direction, the section of the deck slab that lies outside the outermost lines of support.

Cross-frame — a transverse truss framework connecting adjacent longitudinal flexural components to provide stability to the compression flanges, sometimes synonymous with the term diaphragm.

Deck-on-girder bridge — a bridge superstructure made of longitudinal girders supporting a deck that is composite or not with the underlying girders.

Diaphragm — transverse structural element that spans between longitudinal main girders to provide lateral stability to these elements while adding to the transverse rigidity of the bridge and to distribute vertical and lateral loads.

Distortion — change of the cross-section shape in its own plane due to torsion.

Divergence — an aerodynamic instability in torsion that is analogous to column buckling and usually occurs at wind speeds beyond the range normally considered in the design.

Effective width — a reduced width of a flange or deck that enables a member to be proportioned on the basis of uniform stress.

Exterior portion of a slab bridge —

a) for a solid slab bridge, the outermost strip of the transverse cross-section on either side of the bridge equal to the slab depth but not less than 0.6 m nor more than 2.0 m; and

Section 6
Foundations and geotechnical systems

6.1 Scope

This Section specifies minimum requirements for the design of foundations and geotechnical systems (including highway embankments) under static loading conditions and for requirements pertaining to geotechnical investigations and design reports. This Section includes requirements for investigation to support seismic design, specifies minimum requirements to evaluate seismic resistance of foundations, and provides seismic performance requirements for geotechnical systems. This Section also includes requirements for investigation to support design of buried structures, although design of buried structures falls within the scope of Section 7.

Where conflict occurs between requirements in references to other Standards or Codes and Section 6, the requirements of Section 6 shall take precedence.

6.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Abutments — the end foundations upon which the bridge superstructure rests.

> **False abutment** — an abutment that consists of a wall where the bridge is actually supported on piles or columns behind the wall face.
>
> **Flexible abutment** — an abutment supported on a single row of steel H-piles or steel tubular unfilled piles not exceeding 302 mm in diameter.
>
> **Integral abutment bridges** — single or multispan continuous deck bridges with the superstructure integrally connected to flexible abutments. A cyclic joint is provided at the end of the approach slabs that are integrally connected to the deck.
>
> **Self-supporting abutment** — an abutment not requiring lateral support from the deck for stability.
>
> **Semi-integral abutment bridges** — single or multispan continuous deck bridges where the superstructure is supported on self-supporting abutments separated by bearings and as such is not integrally connected to the abutments. A cyclic joint is provided at the end of approach slabs that are integrally connected to the deck.
>
> **True abutment** — an abutment that consists of a wall where the bridge is supported directly by the fill through a spread footing.

Active layer — the top layer of the ground above the permafrost that is subject to annual thawing and freezing in areas underlain by permafrost.

Active pressure — the lateral earth pressure exerted on a structure or geotechnical system, or both, when the system is able to move away from the backfill by an amount sufficient to fully mobilize the ground strength.

Section 7
Buried structures

7.1 Scope

This Section specifies requirements for the analysis and design of buried structures of the following types:
a) soil-metal structures;
b) metal box structures; and
c) reinforced concrete structures.

This Section also specifies construction procedures, properties and dimensions of engineered fill components, and requirements for construction supervision.

7.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Arch — a soil-metal or reinforced concrete structure in which the structure wall is not continuous around the perimeter of the bridged opening and the structure wall is supported on footings.

Arching — the transfer of pressure or load between the soil masses adjacent to and above a buried structure that move relative to one another. Positive arching results in the transfer of loads away from the buried structure; negative arching produces the opposite effect.

Aufeis — sheet-like mass of layered ice that forms from successive flows of groundwater during freezing temperatures.

Backfill — the fill around and above a buried structure or retained by a structure, including fill approved for use as engineering fill.

Bedding — the prepared portion of engineered fill on which the base of a closed buried structure wall is placed.

Bevel — the termination of the wall of a buried structure, cut at a plane inclined to the horizontal.

Buried structure — a structure that has one or more buried structures and is designed by taking account of the interaction between the structure wall and engineered fill.

Camber — a deliberate adjustment required in the longitudinal profile of bedding to compensate for post-construction settlement along the longitudinal axis of the structure.

Closed buried structure — a structure with a continuous perimeter.

Cold region — those land masses characterized by sub-zero average annual temperatures.
Note: *Examples include Yukon, the Northwest Territories, Nunavut, and the northern portions of many Canadian provinces.*

Section 8
Concrete structures

8.1 Scope

This Section specifies requirements for the design of structural components that are made of precast or cast-in-place normal-density, low-density, or semi-low-density concrete and reinforced with prestressed or non-prestressed steel. The components covered by this Section can be prestressed with pretensioned steel, grouted post-tensioned steel, or both.

8.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Adhesive anchor — an anchor inserted into a hole drilled in hardened concrete and held in place by epoxy resin or another adhesive.

Anchor — a bolt, stud, or reinforcing bar embedded in concrete.

Anchorage —

a) in post-tensioning, a device used to anchor a tendon to a concrete member;
b) in pretensioning, a device used to anchor a tendon until the concrete has reached a predetermined strength; and
c) for reinforcing bars, a length of reinforcement, mechanical anchor, or hook, or a length of reinforcement combined with a mechanical anchor or a hook.

Anchorage blister — a protrusion in a web, flange, or flange-web junction for placement of tendon anchorage fittings.

Anchorage system — an anchor or assemblage of anchors.

At jacking — at the time of tensioning tendons.

Attachment — a structure external to concrete that transmits loads to an anchor.

At transfer — at the time immediately after transfer.

Bonded tendon — a tendon that is bonded to concrete directly or by grouting.

Cast-in-place anchor — an anchor that is in its final location at the time of placing of concrete.

Closure — a cast-in-place concrete segment used to complete a span in segmental construction.

Concrete cover — the least distance between the surface of reinforcing bars, strands, post-tensioning ducts, anchorages, or connections and the surface of concrete.

Creep — time-dependent deformation of concrete under sustained load.

Deep beam — a member with a span-to-depth ratio of less than 2.0, where for continuous spans an effective span is taken as the distance between points of contraflexure due to dead load.

Section 9
Wood structures

9.1 Scope

This Section applies to structural wood components and their connections.

9.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Beam and stringer (grading term) — sawn wood with a smaller dimension of at least 114 mm and a larger dimension more than 51 mm greater than the smaller dimension, graded for use in bending with the load applied to the narrow face.

Bearing block — a short wood block with its grain parallel to the applied post-tensioning force, used to distribute the forces in a stress-laminated wood bridge with an external post-tensioning system.

Butt joint — the discontinuities in a laminated wood deck where the ends of two laminates meet.

Crib — a configuration of horizontal members with alternating layers (usually perpendicular to one another) connected to form a closed box.

Dimension lumber — sawn wood 38 to 102 mm thick.

Direct bearing area — the area of outside lamination over which the post-tensioning is assumed to be applied.

Direct bearing pressure — the average pressure that is assumed to be applied to the direct bearing area by the post-tensioning force.

Distribution bulkhead — a steel section used to distribute the post-tensioning force.

Drift pin — a steel pin used to connect wood members.

Duration of load — a period of continuous application of a specified load or the summation of the time periods of intermittent applications of the same load.

External post-tensioning system — a system that transversely post-tensions a longitudinally laminated wood deck using two bars at each anchorage, one above and one below the deck.

Framed bent — a line of wood columns suitably braced.

Glued-laminated timber (Glulam) — structural wood that is manufactured in accordance with CAN/CSA-O122 and is produced by gluing together a number of laminates with essentially parallel grains.

Grade — the designation of the quality of a wood element.

Section 10
Steel structures

10.1 Scope

This Section specifies requirements for the design of structural steel bridges and highway accessory support structures, including requirements for structural steel components, welds, bolts, and other fasteners required in fabrication and erection. Requirements related to the repeated application of loads and to fracture control and fracture toughness for primary tension and fracture-critical members are also specified. Construction requirements for structural steel are also provided.

10.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Brittle fracture — a type of fracture in structural materials without prior plastic deformation that usually occurs suddenly.

Buckling load — the load at which a member or element reaches a condition of instability.

Camber — the built-in deviation of a bridge member from straight, when viewed in elevation.

Class — a designation of structural sections with regard to the width-to-thickness ratios of their constituent elements and their flexural-compressive behaviour.

Coating — an owner-approved protective system for steel, e.g., galvanizing, metallizing, a paint system, or coal tar epoxy.

Composite beam or girder — a steel beam or girder structurally connected to a concrete slab so that the beam and slab respond to loads as a unit.

Composite column — a column consisting of a steel tube filled with concrete, with or without internal reinforcement.

Connection — a weld or arrangement of bolts that transfers normal and/or shear stresses from one element to another.

Critical net area — the area with the least tensile or tensile-shear resistance.

Erection diagrams — drawings that show the layout and dimensions of a steel structure and from which shop details are made. They also correlate the fabricator’s piece marks with locations on the structure.

Fatigue — initiation of microscopic cracks and propagation of such cracks into macroscopic cracks caused by the repeated application of load.

Fatigue limit — the level of stress range below which no fatigue crack growth is assumed to occur.

Firm contact — the condition that exists on a faying surface when plies are solidly seated against each other but not necessarily in continuous contact.

Section 11
Joints and bearings

11.1 Scope

This Section specifies minimum requirements for the design, selection, and detailing of joints and bearings.

11.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Armour — an edging to the deck joint comprising a steel angle or a steel plate permanently attached to the concrete dam corners.

Bridging plate — a structurally integral cantilever plate, e.g., a finger plate, that is rigidly fastened to one side of a joint and permits free movement of the joint.

Concrete dam — the area adjacent to the joint that anchors the joint assembly or mechanism. It also provides protection against dynamic impact effects resulting from direct wheel traffic loading.

Cover plate — a plate that is not necessarily structurally integral with the joint but covers the joint to provide a safe riding surface.

Deck joint — a structural discontinuity between two elements, at least one of which is a deck element, that is designed to permit relative translation or rotation, or both, of abutting structural elements.
Note: *Also called "expansion joint".*

Disc bearing — a bearing consisting of a restrained single moulded disc of unreinforced elastomer confined by upper and lower metal-bearing plates and prevented from moving horizontally by a shear-restricting mechanism.

Effective elastomer thickness — the sum of the thicknesses of all of the elastomeric layers in a bearing, excluding the outer layers.

Elastomer — a compound containing
a) virgin natural polyisoprene (natural rubber) (when used in pot bearings and plain or laminated elastomeric bearings);
b) polyether-urethane polymer (when used in disc bearings).

Elastomeric concrete — a viscous mixture of elastomer, chemical additives, and aggregates that, after being placed as an end expansion-joint dam and cured, retains the joint assembly while providing a resilient transition in the riding surface.

Fixed bearing — a bearing that prevents differential translation while permitting rotation of abutting structural elements.

Integral abutment bridge — a bridge whose superstructure and abutments are connected monolithically.

Section 12
Barriers and highway accessory supports

12.1 Scope

This Section specifies requirements for the design of permanent bridge barriers and highway accessory supports.

12.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Anchorage — a bolt, stud, reinforcing bar, or assembly that is installed in concrete to anchor a structure or a component.

Barrier clearance — the clearance between the outside edge of the traffic lanes and the roadway face of a barrier.

Barrier exposure index — an index that reflects traffic volumes and bridge site characteristics and is used for determining barrier test levels.

Barrier joint — a discontinuity in a barrier that permits relative rotation or translation between barrier components on opposite sides of the discontinuity.

Bikeway — part of a highway designated for the movement of bicycles.

Breakaway support — a support designed to fail in such a way that, when struck by a vehicle, damage to the vehicle and injury to its occupants does not exceed a specified level.

Cantilevered support — a support that cantilevers out over a roadway.

Crash cushion — a barrier used for protecting vehicles from a roadside hazard and designed to fail in such a way that, when struck by a vehicle, damage to the vehicle and injury to its occupants does not exceed a specified level.

Crash test — a test of a barrier or highway accessory support carried out by crashing a vehicle into it and monitoring the vehicle-barrier or vehicle-highway accessory support interaction.

Design speed — the speed for which a highway at a bridge site is designed.

Double-nut anchor bolt anchorage — an anchorage consisting of a highway accessory support transverse base plate located above the top of the concrete foundation with the transverse base plate connected to the concrete foundation by anchor bolts having nuts both above and below the transverse base plate.

Highway accessory — a component required for the operation of a highway, e.g., a sign, luminaire, traffic signal, surveillance installation, noise barrier, or privacy barrier.

Highway accessory support — a structure (including supporting brackets, maintenance walkways, and mechanical devices, where present) that is designed to support highway accessories.

Section 13
Movable bridges

13.1 Scope
This Section specifies requirements for the design of conventional movable highway bridges, i.e., bascule (including rolling lift), swing, and vertical lift bridges and deals primarily with the components involved in the operation of such bridges. The requirements for fixed span bridges, as given in other sections of the Code, shall apply to movable bridges, except as otherwise provided.

13.2 Definitions
The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Acceleration torque — torque produced by prime mover at any time between the initial start condition and full load speed.

Note: *This is a variable as the torque value will vary with the speed.*

Accumulator — an energy storage device for storing hydraulic fluid under pressure.

Note: *The energy absorbing mechanism may be a spring, an external weight, or an inert gas with a precharge pressure.*

Actual speeds — velocity at which machinery will move or rotate under the actual load or resistance, which is dependent upon the speed versus torque characteristics of the prime mover or the power-limiting settings of a hydraulic pump.

Addendum — the portion of gear tooth outside (greater than) the pitch radius.

Allowable static design stress — the permissible value of stress for calculations involving components subjected to static loading.

Average (mean) stress — one-half of the sum of the maximum and minimum stress.

Backlash — the smallest amount of space between the faces of mating gears.

Beta ratio — a measure of the effectiveness of filters.

Bevel gear — the type of gear that is commonly used when shafts intersect and that utilizes the concept of rolling cones.

Bridge closed or in closed position or in seated position or in fixed position — the bridge is in a position that permits highway traffic to use it.

Bridge open or in open position — the bridge is in a position that allows navigation to proceed.

Brittle —
a) materials designed against ultimate strength for which failure means fracture; or
b) easily broken, snapped, or cracked.

Section 14
Evaluation

14.1 Scope

This Section specifies methods of evaluating an existing bridge to determine whether it will carry a particular load or set of loads.

14.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Capacity — the unfactored nominal resistance of an element or joint.

Evaluation — determination of a bridge's capacity to carry traffic loads.

> **Evaluation Level 1** — evaluation of a bridge to determine its load-carrying capacity for vehicle trains (in normal traffic).
>
> **Evaluation Level 2** — evaluation of a bridge to determine its load-carrying capacity for two-unit vehicles (in normal traffic).
>
> **Evaluation Level 3** — evaluation of a bridge to determine its load-carrying capacity for single-unit vehicles (in normal traffic).

Evaluator — a qualified engineer responsible for evaluating a bridge.

Posting — signing of a bridge for load restrictions in accordance with regulations.

Single-unit vehicles — trucks, buses, cars, and other vehicles consisting of a single unit.

Two-unit vehicles — tractor–semi-trailers, car-trailers, truck-trailers, and other vehicles consisting of two units.

Vehicle trains — tractor-trailer-trailers, tractor–semi-trailer–trailers, tractor–semi-trailer–semi-trailers, and other vehicles consisting of three units.

14.3 Symbols

The following symbols shall apply in this Section:

A = force effects due to additional loads (including wind, creep, shrinkage, temperature, and differential settlement) that may be considered in the evaluation

A_r = nominal area of a rivet, mm^2

$A_{s\ell}$ = area of longitudinal tensile reinforcing steel in the bottom of concrete deck slabs, mm^2

A_{st} = area of transverse tensile reinforcing steel in the bottom of concrete deck slabs, mm^2

A_v = area of transverse shear reinforcement perpendicular to the axis of a member within a distance s, mm^2

Section 15
Rehabilitation and repair

15.1 Scope

This Section specifies minimum requirements for the rehabilitation of bridges but is not applicable to the resolution of construction deficiencies of new structures. The requirements specified in this Section relate only to condition assessment, loads, load factors, resistances, and other design criteria relevant to the rehabilitation of bridges, including required remaining service life and assessment of ongoing deterioration and its impact on structural integrity. Material specifications, rehabilitation procedures, and maintenance procedures are not covered in this Section.

15.2 Definitions and symbols

15.2.1 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Fastener — a generic term for bolts, rivets, or other connecting devices, excluding welds.

15.2.2 Symbols

In addition to the symbols listed in this Clause, the symbols in Clause 14.3 shall apply in this Section.

$V_{friction}$ = plate friction resistance component (see Clause 15.8.4.1)

$V_{r,bolt}$ = bolt shear resistance component (see Clause 15.8.4.1)

V_{rjoint} = factored shear resistance of a connection that includes both fasteners and welds in the same shear plane and loaded concentrically

$V_{r,trans}$ = transverse weld resistance component (see Clause 15.8.4.1)

$V_{r,long}$ = longitudinal weld resistance component (see Clause 15.8.4.1)

15.3 General requirements

15.3.1 General

The requirements of Section 1 shall apply in addition to the content of this Section.

Note: *See Clause 15.4 for particular considerations.*

15.3.2 Limit states

Unless otherwise specified by the Owner or required by this Section, all rehabilitated members shall satisfy the ultimate limit state and serviceability limit state requirements specified as part of the design requirements of Sections 1 to 13 and 16 and 17, except that if the purpose of the rehabilitation is to allow passage of a controlled vehicle, the only load combination that shall be considered is permanent loads plus the control vehicle, with the load factors specified in Section 14.

Section 16
Fibre-reinforced structures

16.1 Scope

16.1.1 Components

The requirements of this Section apply to the following components containing fibre reinforcement:
a) fully or partially prestressed concrete beams and slabs;
b) non-prestressed concrete beams, slabs, columns, and deck slabs;
c) externally and internally restrained deck slabs;
d) stressed wood decks;
e) barrier walls;
f) existing concrete elements with externally bonded fibre-reinforced polymer (FRP) systems and near-surface-mounted reinforcement (NSMR); and
g) existing timber elements with externally or internally bonded glass-fibre-reinforced polymer systems (GFRP) and NSMR.

A non-mandatory Annex is also included on GFRP composite bridges (see Annex A16.3).

16.1.2 Fibres

This Section covers fibre reinforcement in which the fibre comprises one or more of the following:
a) glass;
b) carbon;
c) aramid;
d) a low modulus polymer or polymers; and
e) steel.

16.1.3 Matrices

This Section covers fibre-reinforced composites in which the matrix comprises one or more of the following:
a) epoxy resin;
b) saturated polyester resin;
c) unsaturated polyester resin;
d) vinylester resin;
e) polyurethane; and
f) Portland-cement-based mortar or concrete.

16.1.4 Uses requiring approval

Uses of fibre-reinforced polymers in structures or strengthening schemes that do not meet the requirements of this Section require approval by the owner.

16.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Section 17
Aluminum structures

17.1 Scope

This Section specifies requirements for the design, fabrication, and erection of aluminum highway and pedestrian bridges. Where permitted in Section 12, the contents of this Section may also be applied to highway accessory structures.

17.2 Definitions

The following definitions shall apply in this Section. For common definitions used throughout the Code, refer to Clause 1.3.

Brittle fracture — a type of fracture in structural materials without prior plastic deformation that usually occurs suddenly.

Buckling load — the load at which a member or element reaches a condition of instability.

Buckling stress, F_c — the compressive stress that causes buckling.

Camber — the built-in deviation of a bridge member from straight, when viewed in elevation.

Characteristic resistance, R_k — the maximum force, moment, or torque that a component can be assumed to be capable of sustaining.

Coating — an owner-approved protective system for aluminum, e.g., galvanizing, metallizing, a paint system, or coal tar epoxy.

Composite beam or girder — an aluminum beam or girder structurally connected to a concrete slab so that the beam and slab respond to loads as a unit.

Critical net area — the net cross-sectional area with the least tensile or tensile-shear resistance.

Detail category — a category that establishes the level of stress range permitted in accordance with the classification of the detail and the number of design stress cycles.

Effective section — a section in which elements, because of welding or local buckling, are reduced to their effective thicknesses.

Effective strength, F_m — the reduced strength of an element, at the ultimate limit state, to account for the influence of local buckling or welding.

Elastic buckling stress, F_e — the theoretical stress that initiates elastic buckling.

Element — any flat or curved component of a section, such as the web of an I-beam.

Erection diagrams — drawings that show the layout and dimensions of an aluminum structure and from which shop details are made. They also correlate the fabricator’s piece marks with locations on the structure.