The New Canadian Bridge Code - Design, Evaluation, Rehabilitation

Roger DORTON
Consultant
Buckland & Taylor Ltd.
Toronto, ON, Canada

Roger Dorton, born 1929, received his civil engineering degree and doctorate from the University of Nottingham. After twenty years with the Ministry of Transportation, Ontario, he joined Buckland &Taylor Ltd. in 1993.

Ranjit REEL
Senior Project Engineer
Delcan Corporation
Toronto, ON, Canada

Ranjit Reel, born 1939, received his civil civil engineering degree from the University of Glasgow. After 32 years with the Ministry of Transportation, Ontario, he joined Delcan Corporation in 1998.

Darrel GAGNON
Senior Engineer
Buckland & Taylor Ltd.
N. Vancouver, BC, Canada

Darrel Gagnon, born 1961, received his master of structural engineering degree from the University of Alberta. He has specialized in bridges and is a member of the team developing the evaluation requirements for the CHBDC.

Summary

The first edition of the Canadian Highway Bridge Design Code will be published in 1999 by the Canadian Standards Association for immediate adoption across the country. The code not only addresses the design of new bridges, but also covers the evaluation and rehabilitation of existing bridges, all in a consistent limit states format in one document. The code has been calibrated to a target safety index of 3.5 for new bridges, with a service life of 75 years. For the evaluation of an existing bridge the material conditions may be assessed by inspection, and operational conditions are known, hence different safety index options and load factors are given in the code, reflecting these various conditions. The durability requirements for all structural materials are addressed in order to improve quality. The code will be issued in both English and French and will be accompanied by a commentary and calibration report.

1. Introduction

At present two bridge codes are in use in Canada, the Ontario Highway Bridge Design Code (OHBDC) and the CAN/CSA-S6-88 Design of Highway Bridges (CSA-S6). Both are now in limit states format, calibrated to a target safety index of 3.5. Although each of the ten Provinces is responsible for its own legal vehicle weights and bridge codes there is an agreement on inter-provincial vehicle weights and a proposed National Highway Policy. With the need to have a single bridge code, the Canadian Highway Bridge Code (CHBDC) has been developed and will replace the OHBDC and CSA-S6. The 1991 OHBDC was selected as the model for the development of the CHBDC. The CSA-S6 Clause 12 on evaluation had been successfully used in several jurisdictions, however, and the Clause 12 approach was maintained for the development of the CHBDC evaluation section. The CHBDC aimed to expand and update the existing Canadian codes in a number of areas, including; eliminating the span length limit of 150 m so the code would address long span bridges, developing a new live load model to represent national traffic loads and to extend its application to long spans, carrying out new calibration studies, expanding the coverage of seismic design to include evaluation and retrofit, including movable bridges, including design provisions for some advanced composite materials, and emphasizing the importance of durability issues by having a separate durability section.

2. Design

The consensus of the Provincial bridge engineers was that the design truck should represent the regulatory loads, based on the inter-provincial transportation agreement. The selected truck, known as CL-625, consists of a gross load of 625 kN, on a 5-axle configuration with an 18 m wheel base, with successive axle loads of 50, 125, 125, 175, and 150 kN. Calibration of load factors, load combinations and resistance factors were based on the CL-625 truck, and for a target safety index of 3.5 and a service life of 75 years produced a live load factor of 1.7 for the ULS combination of live load plus permanent loads. The CL-625 truck and its various axle sub-configurations govern the design of short span bridges and elements and were selected so they would be suitable as the basis for bridge evaluation and load posting as well as design.

For spans over about 50 m the lane loading governs, and long spans, over about 100 m are governed by stationary bumper to bumper traffic. The objective was to have one live load factor of 1.7 applicable to the truck load and the lane load which would produce the target safety level of 3.5 over the full range of spans, short, medium and long. Long span bridges have much higher dead to live load ratios than shorter spans, and this aspect was investigated before arriving at the lane load, which consists of a uniform load of 9 kN/m superimposed on a CL-500 truck (the CL-625 truck with axle loads reduced to 80%). Calibration for permanent loads plus live load was carried out by reliability analysis using Provincial truck survey data, and by design checks on 31 representative bridges using the new CHBDC, the OHBDC and the CSA-S6. Further calibration was carried out for permanent loads plus wind as this is of importance on long span bridges, and produced a wind load factor of 1.65, well above the typical 1.3 value used in North America. To address durability in a consistent manner, the CHBDC identifies the deterioration mechanisms and specifies the protective measures and detailing for durability for each material, based on the deterioration mechanisms and the environmental exposure to which the material is subjected.

3. Bridge Evaluation and Rehabilitation

Bridges are evaluated when either the loads are increasing or the bridge is deteriorating. However, it is often inappropriate to use load and resistance factors from the design sections of a code when evaluating a bridge. The bridge evaluation section of the CHBDC was developed to allow the evaluation to benefit from desirable structural behaviour and the results of bridge inspections. Values of the target safety index β, based on a consistent level of life safety, are tabulated allowing for behaviour of the structural system (e.g. multiple or single load paths), behaviour of the element (e.g. gradual or sudden failure) and level of inspection the bridge has received. Consistency is maintained between bridge design and evaluation by tying the β values to the safety index required by the design sections of the code. For each value of β, load factors were calibrated and shown for various dead loads and live loads for evaluation purposes.

When rehabilitating a bridge, the CHBDC recommends that the bridge be rehabilitated to meet the requirements of the design sections. However, if this proves physically or economically unfeasible the evaluation requirements can be used as a minimum rehabilitation standard.