Review of Confederation Bridge Ice Forces: Winter 2008-2010

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ABSTRACT

Ice interactions with the Confederation Bridge for the winters 2008, 2009 and 2010 have been studied. Ice conditions for these winters were characterized by two average and one very mild. Tilt data from piers P23 and P24 in response to ice and wind actions were recorded by a data acquisition system. Video records of ice interactions with pier P23 and overall ice conditions adjacent to piers P23 and P24 allowed ice conditions and interaction processes to be related to tilt measurements. Wind data were analysed to correct for the tilt caused by wind actions on the bridge. Limit stress and limit force events were identified. An ice loading scenario that transitioned from limit force to limit stress resulted in the highest ice forces measured over the three years of monitoring, with forces of 3.1 MN and 4.3 MN at P23 and P24, respectively. This loading event corresponded to a likely adfreeze condition.

KEY WORDS: Ice forces, ice failure, measurement systems, conical structures, bridge piers.

INTRODUCTION

The forces which floating ice can exert on structures have been an area of investigation for decades. The Confederation Bridge is in an area of active sea ice movement and is an ideal platform for ice force measurements. The Bridge, a 13 km long structure, spans the Northumberland Strait, connecting Prince Edward Island (PEI) and New Brunswick (NB) in Canada. The duration of the ice season in the area is about 3 months long with a maximum level ice thickness reaching 1 m. The Strait is subject to reversing tidal currents that result in about 3000 km of total ice movement past the bridge each winter. These dynamic ice conditions produce ice ridges and numerous ice loading events on the piers supporting the bridge.

Because of this combination of environmental conditions and the uniqueness of the structure, an extensive monitoring and research program was initiated with the opening of the bridge. A part of the program is the Confederation Bridge Ice Monitoring Program, which has been measuring ice forces on two piers towards the NB end of the bridge starting in 1997 (Brown, 2001). In 1999 a complimentary program of ice force measurements was initiated on two piers near the central navigation span of the bridge by the National Research Council-Canadian Hydraulics Centre (NRC-CHC) (Kubat and Frederking, 2000). Thus a total of 4 piers are being used to measure response to ice loading. Ongoing measurements have been reported from time to time (Frederking et al, 2006, Tibbo et al, 2009), adding to our understanding of ice forces on conical structures. This paper will summarize and select some salient results of three recent winters of ice force measurements by NRC-CHC (Li et al, 2010).

BRIDGE DESCRIPTION AND INSTRUMENTATION

The bridge and instrumentation have been described in earlier papers (Brown, 2001; Kubat and Frederking, 2001), so will not be described in detail here. The general layout of the Bridge is shown in Fig. 1. The pier numbering starts on the PEI side and progresses across to the NB side, in a south-westerly direction. The main piers are spaced 250 m apart, and each pair is fixed to each other to form a frame, for example piers P23 and P24. Frames are separated by a drop in span, which allows relative movement between frames. The navigation channel between piers P21 and P22 provides a minimum clearance of 48 m. Total pier length, from foundation to top of pier, varied from 25 m at P1 to 72 m at P21.

Fig. 1 Profile of Confederation Bridge pier height, water depth and foundation depth.