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CASE STUDY: THE STRUCTURAL HEALTH MONITORING SYSTEM AND EXPANSION JOINTS OF MONTREAL'S NEW CHAMPLAIN BRIDGE

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1 Introduction

The construction of the new Champlain Bridge in Montreal, to carry approximately 160,000 vehicles per day across the St. Lawrence River, is a key element of one of Canada's largest current infrastructure projects. The expansion joints and structural health monitoring (SHM) system selected for use in the bridge's construction and maintenance shall be described.

Figure 1: Construction of the new Champlain Bridge, Montreal

2 The bridge's expansion joints

Modular joints are required at eight bridge axes, including both the west and east abutments. The number of gaps and longitudinal movement capacities of the joints are summarized in Table 1. Local Partners, GoodCo Z-Tech, helped supply WA, EA and E07.

Table 1: Overview of modular joints required

Axis	No. of gaps	Nominal SLS movement *
WA	4	320 mm
W21	8	640 mm
W15	9	720 mm
W09	10	800 mm
W02	10	800 mm
E02	9	720 mm
E07	7	560 mm
EA	3	240 mm

* Note: This nominal SLS movement capacity of 80 mm per gap (per seal) exceeds the actual SLS movement requirement at each axis, as the joints will be installed with a presetting to enable them to facilitate larger ULS closing movements.

The Tensa-Modular expansion joint (Figure 2) selected for use can facilitate very large longitudinal movements, and offers great flexibility, being also able to accommodate transverse and vertical movements, and rotations about all axes. Modular expansion joints divide the total movement requirement of the superstructure among individual, smaller gaps. The gaps are separated by centerbeams, which create the driving surface and which are supported at regular intervals by support bars underneath. The gaps are made watertight by means of rubber seals. Tensa-Modular is a modular joint of the single support bar type (with every support bar supporting all centerbeams), with pre-stressed, free-sliding, bolted stirrup connections between centerbeams and support bars (see Figures 3 and 4). Rubber control springs, positioned in sets below the centerbeams, coordinate the movements of the centerbeams. This elastic system avoids constraint forces and reduces the effects of loading on the joint, extending its service life.

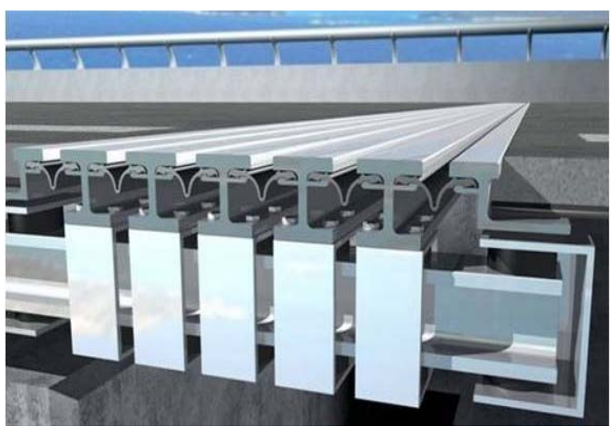

Figure 2: A Tensa-Modular expansion joint (cross section at a support bar), showing stirrup connections to centerbeams

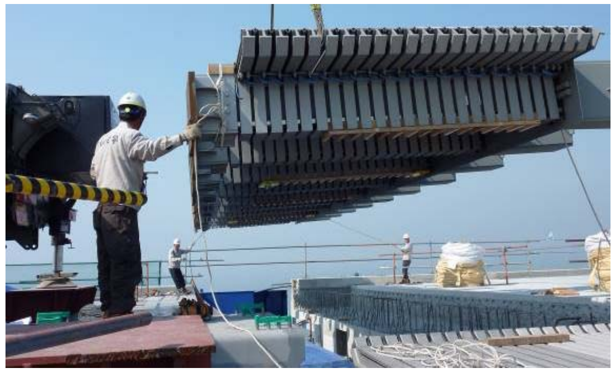

Figure 3: Installation of a Tensa-Modular expansion joint in a concrete bridge deck

Figure 4: An installed Tensa-Modular expansion joint, viewed from below

Since the bridge is being constructed with separate superstructures for eastbound and westbound road traffic, two expansion joints will be installed at each axis, one per carriageway. The lengths of the individual expansion joints range between 17.5 m and 26.8 m.

3 The bridge's SHM system

A permanent Robo-Control SHM system is currently being installed, covering both the new Champlain Bridge and the new Île-des-Soeurs Bridge. This system will provide, on an ongoing basis, instant data which will enable the bridge's performance, maintenance and rehabilitation to be optimized and its service life to the extended. When fully installed, in accordance with a schedule that is dictated by the bridge's construction process, it will incorporate over 200 sensors, as follows:

- 138 strain gauges (54 embedded and 84 glued)
- 36 displacement sensors (28 at expansion joints, 8 at bearings)
- 13 tri-axial accelerometers (on tower columns, piers and superstructures)
- 6 tilt meters (on tower columns and piers)
- 18 corrosion sensors
- Global Positioning System (GPS) units (one at tower base, two at tops of tower columns, one at base station)
- 2 weather stations (top of tower and superstructure of main span)
- 2 pyranometers (tower columns)
- 18 temperature sensors (8 for pavement, 10 for structure)

Figure 5 shows a corrosion sensor as installed on the steel reinforcement of one of the structure's columns, prior to its being embedded in concrete.

Figure 5: Corrosion sensor (embedded)

A user interface on a secure server provides authorized users with remote access to system data, requiring only an internet connection and a password. An example of the data that can be provided by such systems (in this case, correlating temperature to bridge deck movements, both absolute and accumulated) is shown in Figure 6. All data can also be exported in tabular form for evaluation and analysis.

Figure 6: Graphical presentation of typical measured data

Analysis of the recorded data can include, for example, the use of histograms showing the distribution of measurements (number of times each value arose during a given period), and regression models showing the time evolution of movements or other data, both before and after the elimination of environmental effects.

As a result, with durable and dependable expansion joints installed and an efficient SHM system providing comprehensive monitoring data on an ongoing basis, the owner can have great confidence in these aspects of the bridge's condition and performance for many years to come.