# THE EXPANSION JOINTS AND BEARINGS OF THE PORT MANN BRIDGE, VANCOUVER, CANADA

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## ABSTRACT

The new Port Mann Bridge in Vancouver, a truly landmark structure on the Trans-Canada Highway, is currently being constructed to replace an existing bridge at the same location, and will cater for the greatly increased traffic of recent decades. This paper describes the design, manufacture and special features of the bridge's key mechanical parts – its bearings and expansion joints. The disk bearings were designed and delivered by R.J. Watson, Incorporated of the United States in partnership with Mageba of Switzerland, with Mageba manufacturing 28 bearings for the main cable-stayed structure using key materials supplied by RJ Watson, Inc. The expansion joints, of the modular type invented by Mageba, were designed and manufactured by Mageba for 8 bridge axes on the main cable-stayed structure and both the north and south approach structures. Innovations in the design of the joints were necessitated by the predetermined recess dimensions in particular, and a number of the bridge's joints were fitted with noise reducing surface plates to minimise the noise caused by over-rolling traffic. These and other features of these important bridge components are described. The project demonstrates how partnership across borders, while ensuring the highest quality standards imposed by project specifications and the quality control systems of leading manufacturers, can offer optimal solutions to clients in any market.

**Keywords:** bridge bearing, expansion joint, design, manufacture

**Fig. 1-Port Mann Bridge, looking north (artist's impression)**

## INTRODUCTION

The new Port Mann Bridge is currently being constructed in Vancouver, to carry the upgraded Trans-Canada Highway 1 route over the Fraser River in the east of the city. The construction of the bridge is just one element of the major Port Mann Highway 1 project, on which construction began in August 2008 with a budget of over two billion Canadian dollars. The project also encompasses the widening and upgrading of highway and connecting roads between Vancouver and Langley, a distance spanning 37 km, with improved access and safety. The projects to supply the bridge’s expansion joints, and some of its bearings, are described below.

## THE PORT MANN BRIDGE

The original Port Mann Bridge was opened to traffic in 1964, and was recently deemed to require either a major renovation or complete replacement as part of the overall Port Mann Highway 1 project. Considering all factors, including the increased width of the new structure and impact on traffic during construction, the decision was made to replace the existing bridge with a new one, adjacent to the location of the existing one. With its main span of 470m and end spans of 190m each, it will be the second longest cable-stayed bridge in North America, and with its ten traffic lanes and overall width of 65m it will be the widest long-span bridge in the world, when it opens to traffic at the end of 2012[1]. The cable-stayed section of the bridge will be constructed of precast concrete deck panels supported by steel girders, and will consist of two structurally independent parts, side by side. The approaches at each end, however, will consist of concrete box girders, and be continuous across the full width of the bridge.

## SELECTION AND DESIGN OF THE STRUCTURE’S EXPANSION JOINTS

Expansion joints are required at 8 bridge axes, including those at the ends of the cable-stayed structure (850m apart) and at six other locations on the north and south approach structures. The total length of joint at each axis is approximately 45m, with most joints being continuous along this full length. To facilitate transport of the joints to site in 40-foot containers, the joints are being delivered in sections of less than 12m in length, to be welded together on site using a special technique, known as the *Secheron* method, to connect the center beams of the individual joint sections.

### Selection of joint size

The largest longitudinal movement of any joint (that at one end of the main cable-stayed structure) is 870mm, a movement which could be accommodated by a modular expansion joint with 11 gaps, each allowing 80mm movement. The smallest movements, at just 150mm, can be facilitated by a 2-gap joint. The number of gaps required per joint, however, was also influenced by another factor: the requirement to provide the joints in certain noise-sensitive areas with noise-reducing surface plates. The so-called “sinus plates” (named for their sine wave shape) are required at the joints on the more residential south side of the bridge, and will ensure that residents are not disturbed by the noise of traffic crossing the joints at night. An example of a joint with these sinus plates is shown in Fig. 2. The requirement for this feature influenced the determination of how many gaps were required per joint, since a joint with sinus plates can facilitate 100mm of movement per gap (thanks to the bridging of the individual gaps of the joint

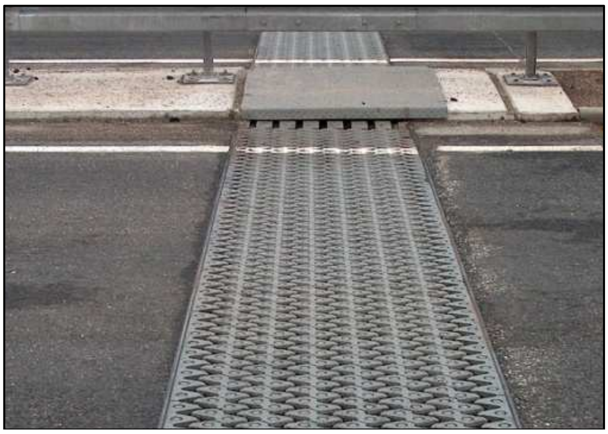

**Fig. 2-A modular joint with noise-reducing “sinus plates”**

by the sinus plates). This meant, for example, that the demands on the joint at the south end of the cable-stayed structure, which must facilitate longitudinal movements of 470mm, could be met by a 6-gap joint *without* sinus plates (since 6 gaps x 80mm > 470mm), or a 5-gap joint *with* sinus plates (since 5 gaps x 100mm > 470mm). The addition of this optional feature requires changes to the design of the joint itself, most notably in relation to the thickness of the top flanges of the beams to which the sinus plates are bolted.

## Design of expansion joints

Following selection of joint type, detailed design of each joint in accordance with the Canadian standard CAN/CSA-S6-06 could commence. A particular challenge was posed by the prior dimensioning of the block-outs of the structure to receive an alternative size of expansion joint, with several difficulties resulting. Most significantly, the height of the standard modular joint had to be reduced – not an easy task given the build-up of a typical joint, as shown in Fig. 3 and Fig. 4. The height of the joint is essentially defined by the height of the center beams which form the driving surface; the height of the support bars beneath, which provide support to the center beams; and the frame which connects the two, allowing the center beam to slide along the support bar.

**Fig. 3-Section through a modular joint, showing its build-up (illustration)**

**Fig. 4-View beneath an installed joint, showing support bars and control springs**

The supplier of the joints, the inventor of the joint type and supplier of such joints to thousands of bridges worldwide, had in the past always used structurally efficient I-profile beams for the support bars, thereby maximizing the bending moment capacity for a given amount of steel. A cross section through a standard support bar, at its connection to a center beam above, is shown in Fig. 5 (left). Given the limited height available in the block-out, the decision was made to develop a new solution for this detail, incorporating a full-section rectangular steel support bar as shown in Fig. 5 (right). A further height saving of 5mm could be made by altering the way in which the sliding bearing (between the center beam and the support bar) is secured, with a thinner steel plate. In total, the height of the joint could be reduced from 472mm to 382mm, a significant and necessary saving.

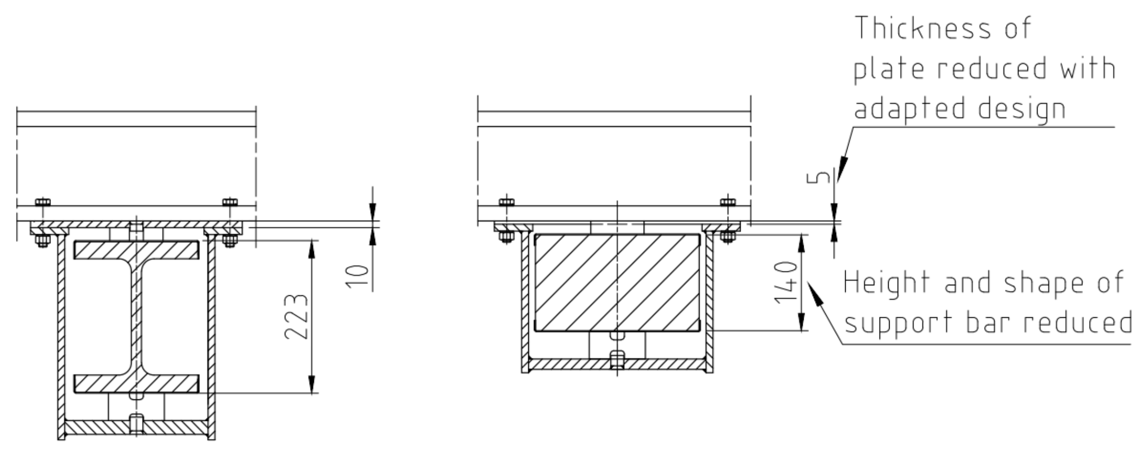

**Fig. 5-Sections through a standard I-beam support bar (at center beam connection), and through a rectangular support bar as specially developed for this project**

## TESTING OF EXPANSION JOINTS

Prequalification testing of the joints has been successfully carried out in accordance with project requirements. An Opening Movement & Vibration (OMV) test (Fig. 6), conducted in accordance with AASHTO LRFD Bridge Construction Specifications Appendix A19, simulated the opening/closing movements resulting from daily temperature cycles, and the vibrations from traffic, of a 100-year life (i.e. 33% more than the 75-year life specified by the standard). A Seal Push Out (SPO) test (Fig. 7) then verified the resistance of the elastomeric seals of the same tested joint to being pushed out of the recesses in the steel beams which hold them in place.

**Fig. 6-Opening Movement & Vibration (OMV) test of an 11-gap modular joint**

**Fig. 7-Seal Push Out (SPO) test**

## SUPPLY OF DISK BEARINGS – THROUGH INTERNATIONAL COOPERATION

The disk bearings of the bridge have already been supplied by R.J. Watson, Inc., with the fabrication of the first batch, for the first critical delivery of 28 bearings for the main cable-stayed structure, being carried out at Mageba's factory in Shanghai in order to make the tight delivery program possible. The key component of a disk bearing is the disc at its center (shown red in Fig. 8), which

**Fig. 8-The structure of a typical disk bearing**

carries the load of the structure above and allows rotations about any horizontal axis. The disc is molded from high-strength Polyether Urethane (PU), an aromatic thermoplastic with excellent mechanical properties. The allowable compressive stress on the disc is as high as 35 MPa, and it does not require confinement, as does, for example, the elastomeric pad at the heart of a pot bearing. The disc is also highly resistant to environmental impacts, and remains effective at a very wide range of temperatures (from -70 degrees to +121 degrees Celsius). Further parts of the bearing allow fixing to the structure, and resist horizontal loading or permit sliding movements as necessary. The structure of a typical disc bearing is illustrated in Figure 9. The fabrication of the bearings, in accordance with the designs of R.J. Watson, Inc., is shown in Figures 9 to 12. Key materials, most notably the rotation discs, were also supplied by R.J. Watson, Inc.

**Fig. 9-Quality control during the production of a disk bearing**

**Fig. 10-A completed single-disk bearing**

**Fig. 11-Completed double-disk bearings - each containing two discs**

**Fig. 12-Packing of bearings for transport**

Following fabrication and inspection in the factory, most bearings were immediately sent to site to meet the demanding bridge construction schedule, while the rest were submitted to testing at a specialist testing facility in South Korea, to confirm performance in accordance with the design and specification.

## CONCLUSIONS

The expansion joints and disk bearings of the Port Mann Bridge are the result of decades of product development by leading suppliers in their respective fields, and collaboration between them where this could assist in the speedy delivery of the manufactured product without any impact on the high quality expected according to stringent project requirements. Adaptations to standard designs, as necessitated in this case for the bridge's expansion joints, can always be accommodated by experienced suppliers, enabling landmark structures such as the Port Mann Bridge to be equipped with the best bearing and expansion joint products on the market.

## REFERENCES

1. "Construction Update: Building the new Port Mann Bridge ", Summer 2010. Ministry of Transportation of British Columbia.