Assessment of Aged Bridge Bearings: Use of Automated Monitoring Equipment to Complement Traditional Inspection Techniques

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Abstract

Bridges are key components of public transportation networks. Bridge owners need to ensure that proper maintenance programs are executed to maximize the lifespan of their assets safely, while ensuring that fiscal year expenditures are managed efficiently. Detailed structural assessments are typically performed as bridges approach the end of their design service life. The assessment of bridge bearings (which support the superstructure and accommodate thermal movements) is a critical component of the overall condition assessment. Bearing replacements are costly, as the work often requires constructing temporary load-bearing structures to jack and support the superstructure during bearing replacement. The topic of this study pertains to a 57-year-old concrete bridge located in Florenceville NB, which is undergoing a multi-year condition assessment and rehabilitation program. One component of the condition assessment, and the focus of this article, involves the assessment of main span bearings. To complement traditional visual inspections, six vibrating wire deformation gauges were installed to monitor longitudinal displacement of the superstructure and temperature over time using an autonomous data acquisition system. The experimental results from 731 days of monitoring have shown that: 1) observed peak deformations during seasonal temperature changes are found to be in reasonably good agreement with computed theoretical movements, 2) instrumented bearings have returned to near their initial position after the complete calendar year, and 3) the coefficient of thermal expansion of the main span superstructure is shown to be in good agreement with the general design values recommended in the Canadian Highway Bridge Design Code. Based on the results of this detailed assessment, it was determined that the replacement of main span bearings is not warranted at this time, and such outcome led to significant cost savings during rehabilitation of this structure.

Introduction

Bridges are key components of public transportation networks in Canada and around the world. Bridge owners must employ proper maintenance programs to maximize the lifespan of bridge assets safely and to ensure that fiscal year expenditures are managed efficiently. As bridge structures age, their present condition must be accurately quantified to ensure that operation is at an acceptable level of service. Bridge bearings, which support the superstructure and accommodate thermal movements, are vital to the asset and assessment of bridge bearings is a critical component of the overall condition assessment. Bearing replacements are very costly and the work often involves constructing temporary load-bearing elements to jack and support the superstructure.

The topic of this study pertains to a 57-year-old concrete bridge in Florenceville New Brunswick, which is undergoing a multi-year condition assessment and rehabilitation program. The Florenceville Bridge is owned and operated by the New Brunswick Department of Transportation and Infrastructure (NBDTI) and permits NB Route 130 to traverse the Saint John River. The focus of this article pertains to an instrumentation and monitoring program that was developed and deployed at this structure to assess the performance of main span bearings. Based on the results of this detailed assessment, it was determined that the replacement of main span bearings was not warranted at the present time and such outcome led to significant cost savings for the owner during rehabilitations of this structure.

Background

The Florenceville Bridge was constructed during the late 1960's as part of the Trans-Canada Highway Project. The structure is approximately 550 meters in total length and is supported by a traditional abutment at each end and 15 intermediate piers. Figure 1 displays a general plan of the Florenceville Bridge structure.

The Florenceville Bridge superstructure is composed of four distinct sections identified in Figure 1 and listed below:

1. The *North Approach* structure, extending from the north abutment to pier 5a,
2. The *Approach Structure*, extending from pier 5a to pier 8,
3. The *Main Span* structure, extending from pier 8 to pier 14,
4. The *South Approach* structure, extending from pier 14 to the south abutment.

The bridge is approximately 11 meters wide and includes two traffic lanes with curbs and barriers on both sides. The focus of this article pertains to the main span structure. The main span structure is curved horizontally (635.1-meter radius), has an asphalt driving surface (4% superelevation), and is sloped longitudinally at 1.3%. The main span superstructure consists of a single cast-in-place concrete box girder with cantilevered top flanges, which is continuous along its entire length of 383.2 meters, contains longitudinal and transverse post tensioning, and is supported by two pot-bearings at each pier. Note that bearings at Pier 11 are fixed and longitudinal sliding is permitted at all other main span bearings. Figures 2 and 3 display a longitudinal profile and cross section of the main span superstructure, respectively.

Figure 1. Plan of Florenceville Bridge (Basemap: Imagery © 2022 CNWS/Airbus, Maxar Technologies, USDA Farm Service Agency; Map Data © 2022 Google).

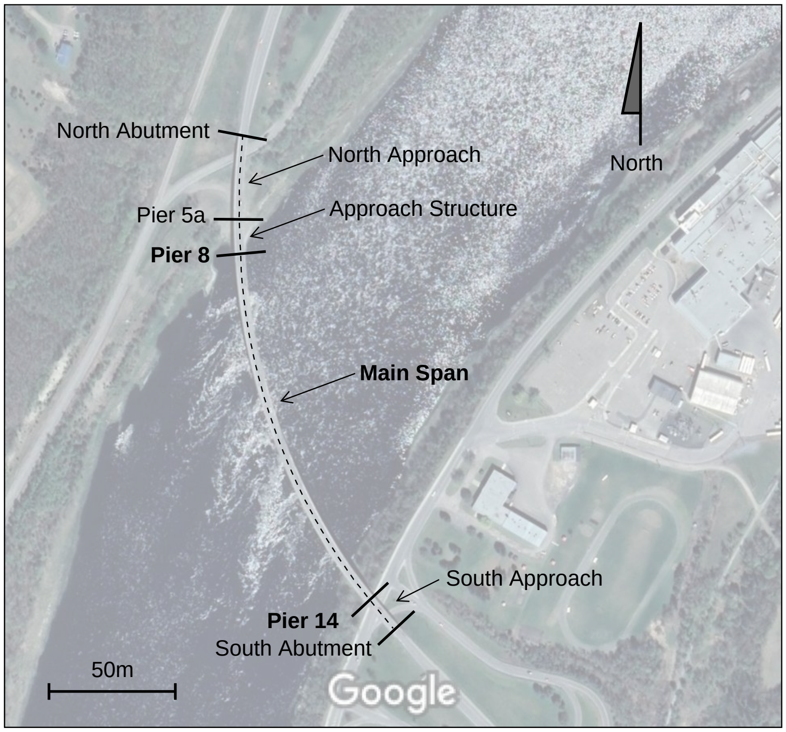
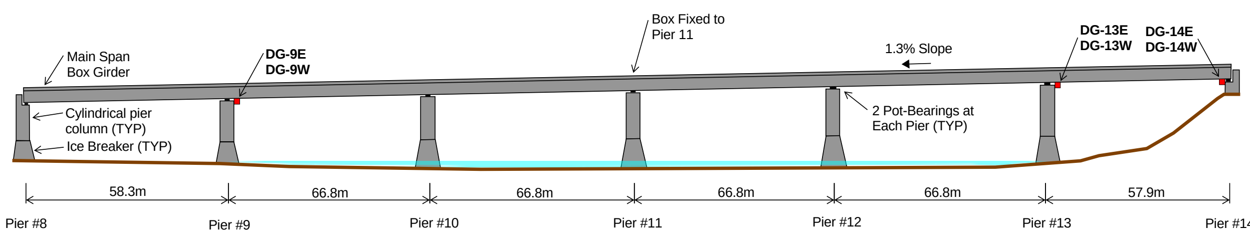


Figure 2. Longitudinal Profile of Florenceville Bridge Main Span with Locations of Deformation Gauges Identified, not to scale (Bryden et al., 2022).

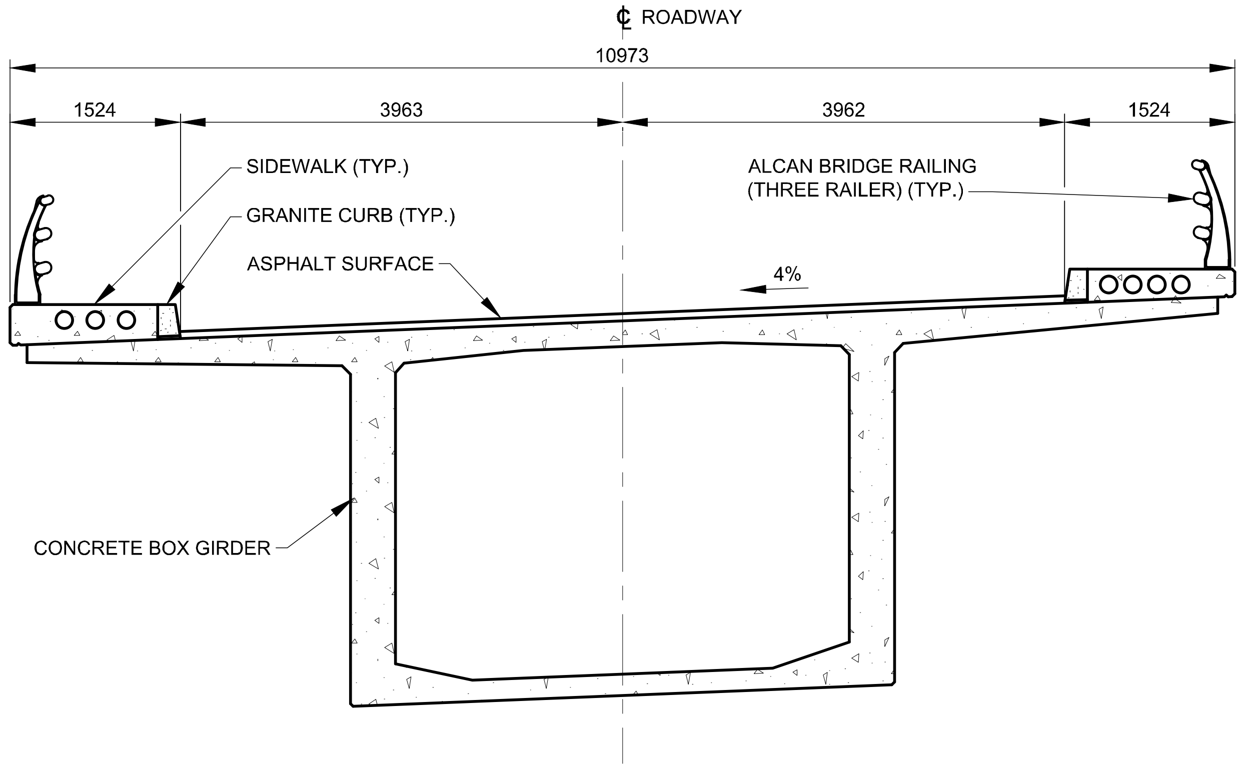


Florenceville Bridge Rehabilitation Program

The Florenceville Bridge recently reached its 50th year in service, which is typically the design service life for structures of this era. The New Brunswick Department of Transportation and Infrastructure (NBDTI) retained a bridge consultant (EXP Services Inc.) to complete a condition assessment of the Florenceville Bridge (EXP, 2016). The findings of this assessment prompted a series of rehabilitation contracts to extend the service life of the structure, including: replacement of expansion joints and bearings, complete removal and replacement of the approach structure, and deck surface/barrier rehabilitations.

One component of the structural rehabilitation, and the focus of this article, involves assessing the condition of the existing (original) bearings that support the main span.

Figure 3: Cross Section of Main Span Box Girder at the Florenceville Bridge (EXP, 2021a).



Main Span Bearings: Overview and Recent Rehabilitations

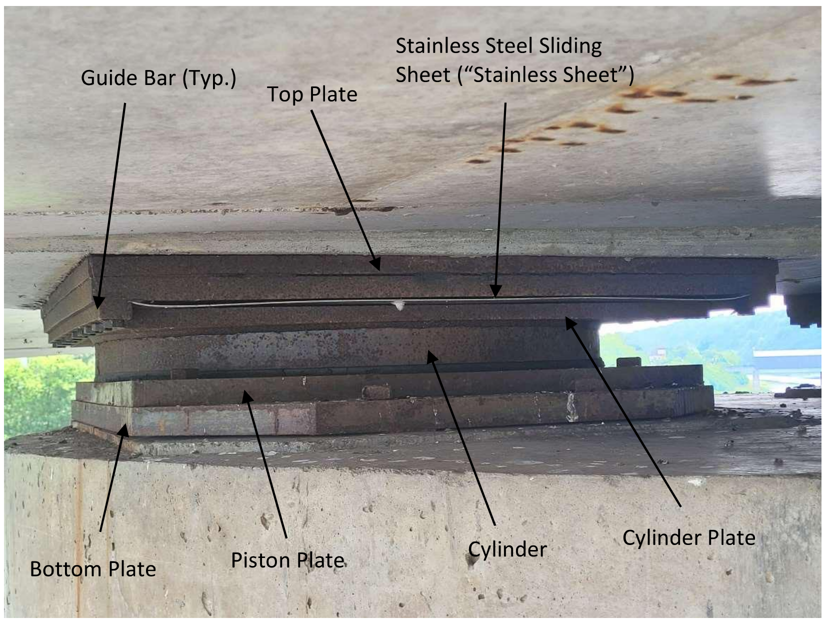
Two pot bearings support the main span box girder at each pier. Pot bearings at the central pier 11 are fixed, and bearings at the remaining main span piers (piers 8, 9, 10, 12, 13 and 14) are unidirectional/guided and permit longitudinal movement. As defined in the original construction drawings, main span bearings are "Rotaflon Structure Bearings" by Andre Rubber Co Ltd. These are guided pot-bearings with a polytetrafluoroethylene (PTFE) sliding surface and stainless-steel mating surface. Andre Rubber reports a coefficient of friction of the sliding surface in the range of 0.018 to 0.026. Figure 4 is a photo of an existing (original) bearing at pier 12 with component terminology noted.

Main span bearings at pier 14 were replaced during rehabilitation work in 2017, and main span bearings at pier 8 were replaced during rehabilitation work in 2022. Note that pier 14 and pier 8 are located at either end of the main span and therefore experience the most movement during temperature fluctuations. Expansion joints are also present at these two locations (pier 8 and pier 14); there is therefore a higher potential for road runoff and chlorides to reach these two terminal bearings compared to the remaining bearings under continuity. Visual inspection of the original bearings at pier 8 and pier 14 revealed that they were in very poor condition, which prompted their replacement.

Replacement of the remaining main span bearings (piers 9-13) was deemed likely, and the timeline for such replacement is dependent on the performance of the bearings. Recall that piers 9-13 are located within the Saint John River watercourse; bearing replacement at these piers is therefore more involved compared to the land piers and is considerably more costly. Visual inspection of these bearings generally revealed corrosion of steel surfaces with little to no section loss, a cracked and brittle rubber seal between the cylinder and piston, and delamination of the stainless-steel sheet at exterior edges. Displacement of the stainless-steel sheet was observed at 3 of the 8 guided bearings ranging in magnitude from 15-35mm (EXP, 2021b).

To further assess the performance of the main span bearings, and to aid in decision making regarding the replacement timeline, an instrumentation and monitoring program was developed and deployed. The objective of this program was to monitor movements and temperatures of these bearings over time, to assess the functionality of these bearings and their ability to accommodate cyclic thermal movements of the superstructure.

Figure 4: Existing (original) Main Span Bearing at Pier 12; Photo Taken August 12, 2021 (EXP, 2021b)



Instrumentation Details

The instrumentation program employed at the Florenceville Bridge involved the installation of six deformation gauges and autonomous data acquisition equipment to monitor longitudinal sliding at select main span bearings. The deformation gauges and data logging system were installed on October 4-5, 2021.

Deformation Gauges

Two deformation gauges were installed at pier 9 (DG-9E and DG-9W), two deformation gauges were installed at pier 13 (DG-13E and DG-13W), and two deformation gauges were installed at pier 14 (DG-14E and DG-14W), as shown in Figure 2. Each deformation gauge was mounted on a steel bracket (on the pier column) and to the underside of the main span box girder; sensors were carefully oriented along the box girder's longitudinal axis to measure longitudinal displacement at the bearing. All deformation gauges consisted of Geokon model 4420 vibrating wire sensors with an operating range of 150mm. The sensors also record temperature (alongside deformation) and are calibrated by the manufacturer and are accurate to within 0.1% of the operating range (Geokon, 2020). The ambient temperature at the time of installation was approximately 10°C; deformation gauges were therefore installed near the mid-range of their operating range to allow adequate capacity during future expansion and contraction events. Figure 5a is a photo displaying the installation process of deformation gauges at pier 13, and Figure 5b is a photo showing the completed installation of sensors at pier 14.

Figure 5: Photos Taken During Installation Showing a) the Installation Process at Pier 13, and b) the Completed Installation at Pier 14 (EXP, 2023).

(a)

(b)

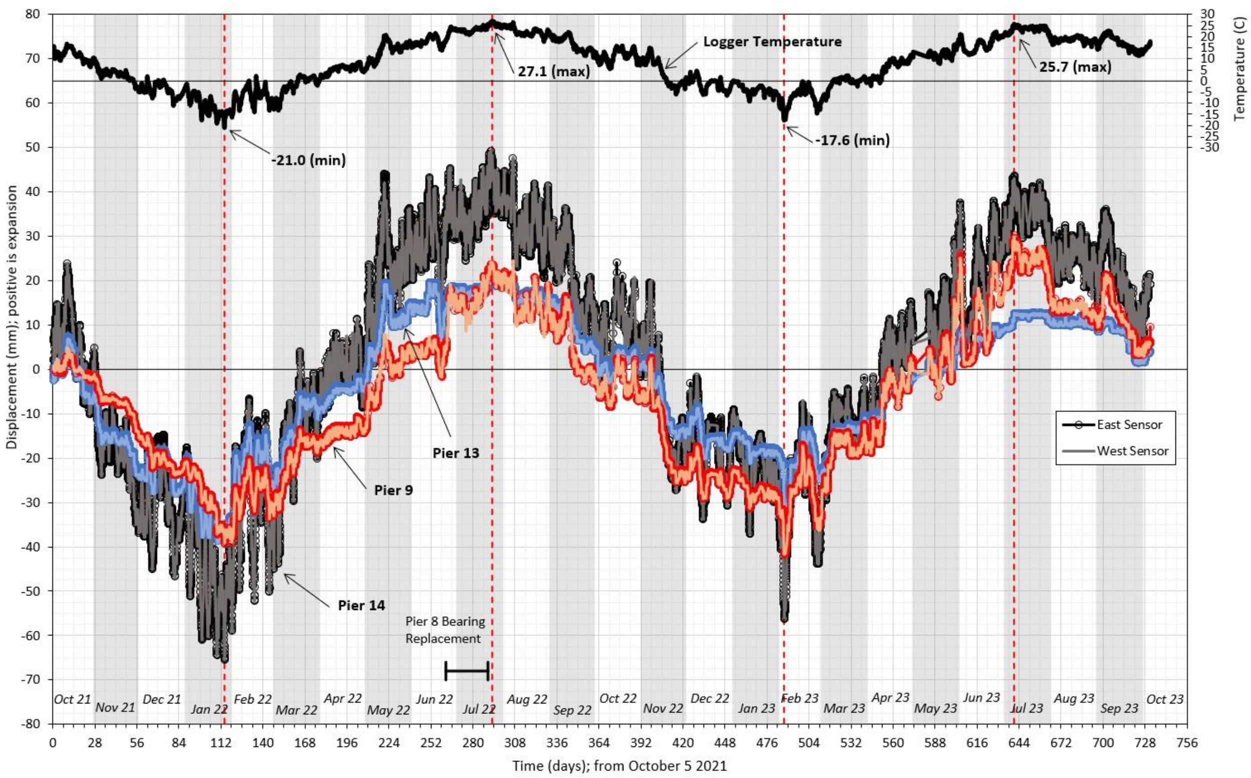
Data Acquisition System

All sensor cables were threaded up into the main span box girder and were routed inside the box to the datalogger located at pier 14. The data acquisition system consists of a 16-channel Geokon LC-2 datalogger (Geokon, 2019) mounted inside the main span box girder at pier 14. The datalogger was configured to read all six sensors at one-hour intervals; each data set includes a deformation reading for each sensor, the temperature of each sensor, and the datalogger temperature (i.e. the temperature inside of the main span box). Data collection began on October 5, 2021.

Experimental Results

The experimental data described in this article is from the monitoring period of October 5, 2021, to October 6, 2023 (731 days). Figure 6 shows the displacement recorded by all six sensors as a function of time over this monitoring period, where such displacements represent longitudinal movement of the bearings relative to the bearing position at the time of sensor installation on October 5, 2021. As shown in Figure 6, the displacements recorded by east and west sensors at each pier are in good agreement. Such result implies that the bearings at each pier are moving together; this is expected given the guide mechanism on these unidirectional pot-bearings and provides confidence regarding the validity of the experimental results.

Figure 6: Measured Displacement (Bearing Longitudinal Movement) as a Function of Time



The results contained in Figure 6 display bearing deformations over 731 days (two full years) and therefore includes two complete thermal cycles. Daily expansion-contraction events are evident throughout. The displacements at pier 14 are greater than those observed at pier 9 and pier 13. This is expected, since the greatest thermal movement is experienced at the terminal piers. The general deformation trends observed over each of the two 12-month periods are observed to be similar and are summarized below:

- Year 1: Oct 5 2021 to Oct 7 2022
  - The general trend of deformation was longitudinal contraction from October 5 2021 to January 27 2022, longitudinal expansion from January 27 2022 to July 24 2022, and longitudinal contraction from July 24 2022 to October 7 2022.
  - With respect to the 'zero' position at the time of sensor installation, the measured contraction at pier 9, 13, and 14 was observed to peak near January 27 2022 at -39.2mm, -38.9mm, and -65.4mm, respectively. The measured expansion at pier 9, 13, and 14 was observed to peak near July 24 2022 at 23.7mm, 20.5mm, and 49.3mm, respectively.
  - At completion of this 12-month period, the structure had experienced one complete thermal cycle and the data shows that all three instrumented bearings returned to near their initial position.

- Year 2: Oct 7 2022 to Oct 6 2023
  - The general trend of deformation was longitudinal contraction from October 7 2022 to February 4 2023, longitudinal expansion from February 4 2023 to July 7 2023, and longitudinal contraction from July 7 2023 to October 6 2023.
  - With respect to the 'zero' position at the time of sensor installation, the measured contraction at pier 9, 13, and 14 was observed to peak near February 4 2023 at -41.7mm, -31.3mm, and -56.1mm, respectively. The measured expansion at pier 9, 13, and 14 was observed to peak near July 7 2023 at 30.0mm, 12.8mm, and 43.3mm, respectively.
  - The data recorded over the second one-year cycle shows that all three instrumented bearings have once-again returned to near their initial position.

Longitudinal expansion and contraction of the Florenceville bridge superstructure is a result of thermal strain. During this monitoring period, temperatures were also recorded at the time of each bearing deformation observation. The temperatures recorded by all six sensors and by the datalogger are plotted as a function of time in Figure 7. It is found that there is a considerable difference in temperature between the ambient conditions outside of the box (i.e., at the sensor locations) and conditions inside the box (i.e., at the datalogger location). Temperature differences inside the box structure vs. outside the box structure are observed to differ by up to 10°C during the two-year monitoring period. It is worth noting that all sensors were installed on the underside of the box girder near the bearings and are therefore not exposed to direct sunlight. The general temperature trends observed over each of the two 12-month periods are observed to be similar and are summarized below:

- Year 1: Oct 5 2021 to Oct 7 2022
  - The minimum and maximum temperature recorded by sensors outside the box during the monitoring period was -31.0°C and 32.8°C, respectively.
  - The minimum and maximum temperature recorded by the datalogger inside the box was -21.0°C and 27.1°C, respectively.

- Year 2: Oct 7 2022 to Oct 6 2023
  - The minimum and maximum temperature recorded by sensors outside the box during the monitoring period was -27.8°C and 32.3°C, respectively.
  - The minimum and maximum temperature recorded by the datalogger inside the box was -17.6°C and 25.7°C, respectively.

Figure 7. Temperature Recorded by Deformation Gauges and Datalogger as a Function of Time

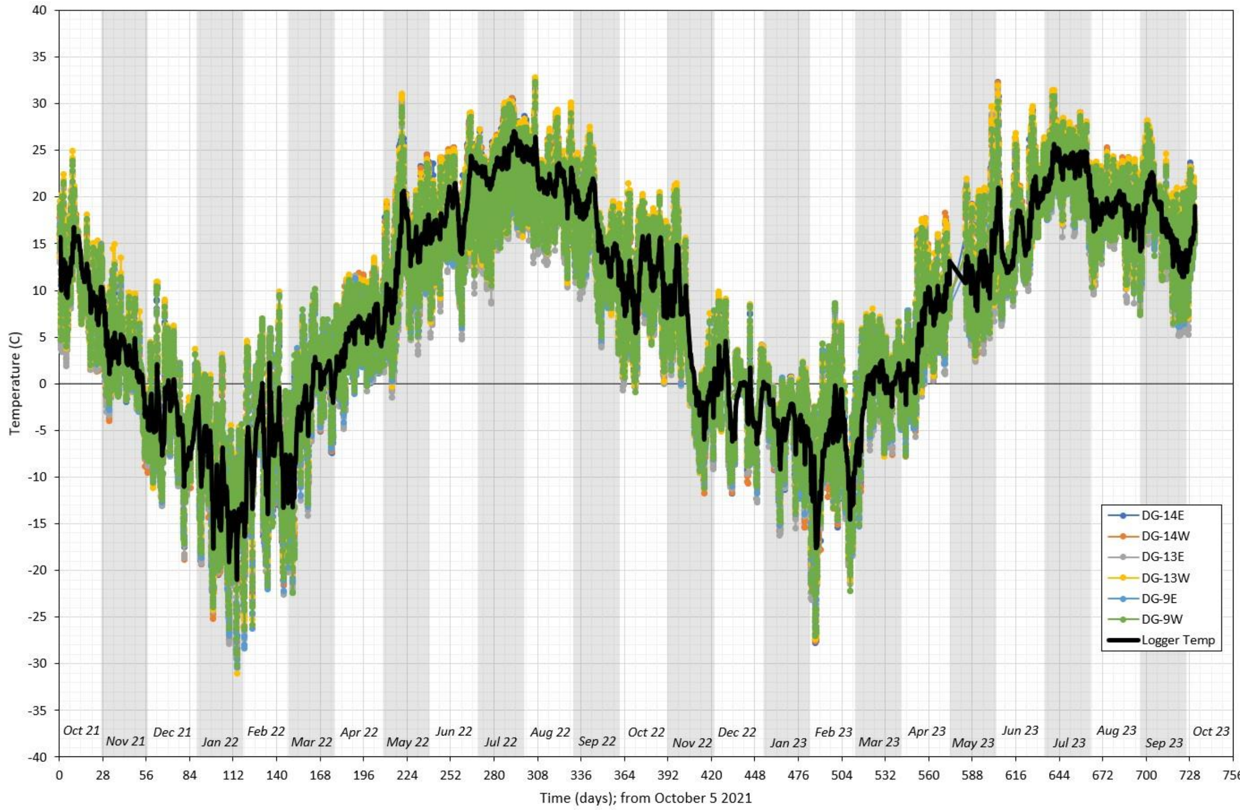


Table 1 contains a summary of the bearing positions recorded at peak contraction and expansion events during the monitoring period, along with the associated internal box temperature. Table 1 also displays the initial position and corresponding temperature (October 5, 2021; position 'zero'), along with the year 1 end position on October 7, 2022, and year 2 end position on October 6, 2023, with the corresponding temperatures. Note that all three instrumented bearings returned to near their initial position after one calendar year, and upon closer inspection of the data contained in Figure 6, it is observed that the bearings all returned to *exactly* their initial position (position 'zero') a few days prior to the 1-year end date of October 7, 2022. The bearings appear to have returned to their initial position when the logger temperature reached approximately 10°C, which is also noted to be the logger temperature in the days following installation in October 2021. Similar observations are noted at the end of year 2.

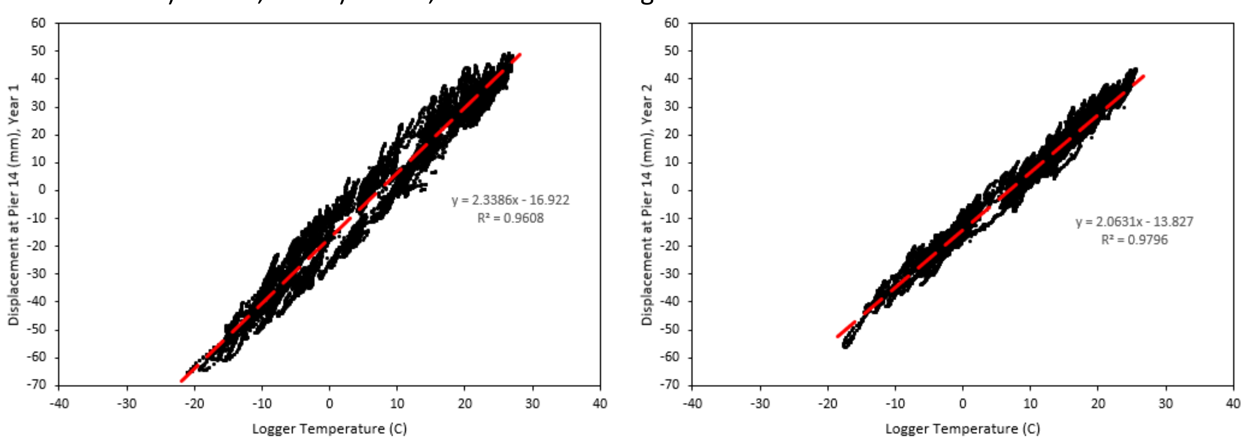
Table 1: Summary of Bearing Positions at Min/Max Temperature Events During the Monitoring Period

Date	Bearing Position			Logger Temperature
	Pier 9	Pier 13	Pier 14	
October 5, 2021	0.0 mm	0.0 mm	0.0 mm	12.6°C
January 27, 2022	-39.2 mm	-38.9 mm	-65.4 mm	-21.0°C
July 24, 2022	23.7 mm	20.5 mm	49.3 mm	27.1°C
October 7, 2022	-4.5 mm	0.9 mm	7.3 mm	13.0°C
February 4, 2023	-41.7 mm	-31.3 mm	-56.1 mm	-17.6°C
July 7, 2023	30.0 mm	12.8 mm	43.3 mm	25.7°C
October 6, 2023	6.0 mm	4.0 mm	19.2 mm	16.4°C

Temperature-Deformation Relationship

To assess bearing movement, all deformation data recorded throughout the monitoring period is plotted as a function of temperature. Note that results of an earlier study found that bearing deformation data can be better correlated with box internal temperature (i.e., logger temperature) than with external ambient air temperature (i.e., sensor temperature); refer to Bryden et al. (2022) for details. Figures 8a and 8b display pier 14 displacement readings as a function of logger temperature in year 1 and year 2, respectively.

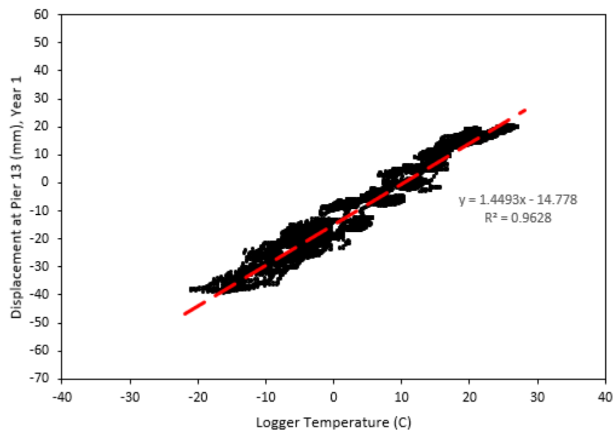
Figure 8. Pier 14 Displacement Readings Plotted as a Function of Box Internal (datalogger) Temperature for: a) Year 1, and b) Year 2, of the Monitoring Period.



As shown in Figure 8, the deformation data is well correlated with box internal temperature for data collected over both years. The slope of the best fit line through the deformation/logger-temperature data is 2.3386 mm/°C in year 1 and 2.0631 mm/°C in year 2. This suggests that, on average, bearings at pier 14 experienced longitudinal displacement at a rate of 2.3 mm per degree temperature change (box internal temperature) in year 1, and at a rate of 2.1 mm per degree temperature change in year 2.

Displacement readings at pier 13 and at pier 9 are plotted as a function of box internal (datalogger) temperature in Figures 9 and 10, respectively.

Figure 9. Pier 13 Displacement Readings Plotted as a Function of Box Internal (datalogger) Temperature for: a) Year 1, and b) Year 2, of the Monitoring Period.



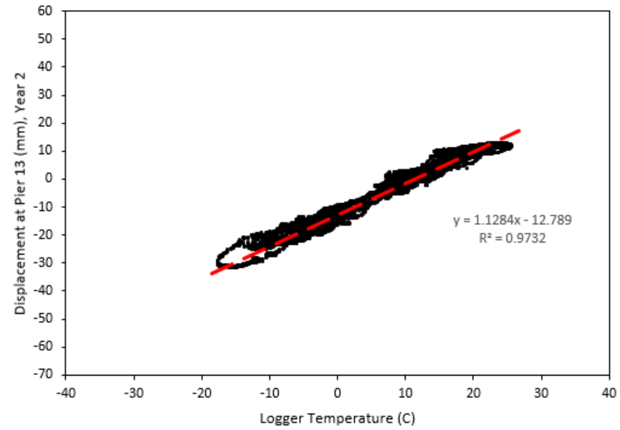
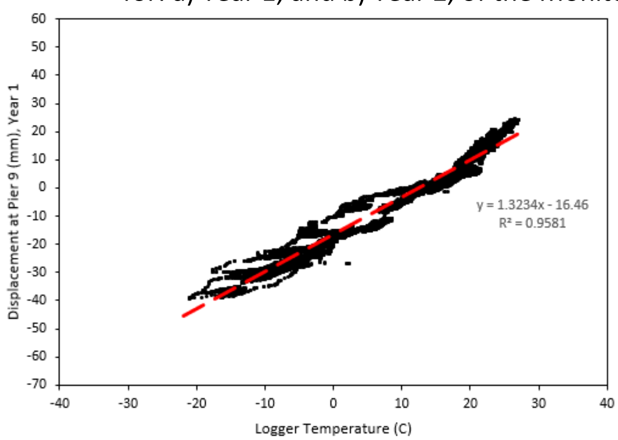
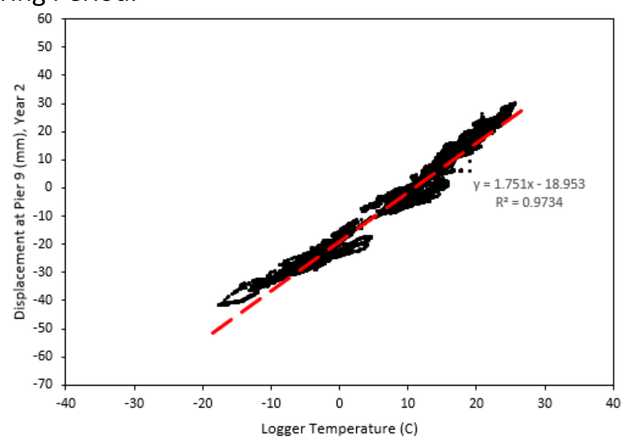


Figure 10. Pier 9 Displacement Readings Plotted as a Function of Box Internal (datalogger) Temperature for: a) Year 1, and b) Year 2, of the Monitoring Period.





The deformation data recorded at pier 13 and pier 9 are also shown to be well correlated with box internal temperature for both years of data collection. The slope of the best fit line through the pier 13 deformation/logger-temperature data in year 1 is 1.4493 mm/°C, while the slope of the best fit line through the pier 13 data in year 2 is 1.1284 mm/°C. These results suggests that, on average, bearings at pier 13 experience longitudinal displacement at a rate of 1.4 mm per degree temperature change in year 1 and 1.1 mm per degree temperature change in year 2. The slope of the best fit line through the pier 9 deformation/logger-temperature data in year 1 is 1.3234 mm/°C, while the slope of the best fit line through the pier 9 data in year 2 is 1.7510 mm/°C. These results suggests that, on average, bearings at pier 9 experience longitudinal displacement at a rate of 1.3 mm per degree temperature change in year 1 and 1.7 mm per degree temperature change in year 2.

Coefficient of Thermal Expansion

The coefficient of thermal expansion for the main span box girder can be approximated by interpretation of the recorded temperature-deformation data. Pier 9 and pier 13 are located 133.6m on opposing sides of the fixed pier (pier 11); the rate of bearing displacement observed at pier 9 and pier 13 are therefore superimposed and the girder coefficient of thermal expansion is approximated as 10.4 με/°C based on the year 1 data and 10.8 με/°C based on the year 2 data. Note that these values are based on the measured bearing displacement only and does not capture girder strains occurring before mobilization of bearing slippage (i.e., assumes bearings to be frictionless). Curvature of the superstructure is also ignored.

Pier 14 had new bearings installed in 2017 and is approximately 40 times stiffer than the other main span piers. Bearing displacements at pier 14 can therefore be considered equivalent to girder deformations at this location. The total girder length between pier 9 and pier 14 is 325.1 meters; when the rate of bearing displacement at these two piers are considered, the girder coefficient of thermal expansion is approximated as 11.3 με/°C based on the year 1 data and 11.7 με/°C based on the year 2 data. These values are greater than those computed from the pier 9 / pier 13 data and are thought to be a more accurate representation of the box girder's response (since pre-slip strains are presumed negligible at pier 14).

Note that the coefficient of expansion values described herein are in good agreement with the generalized design value of 10με/°C recommended in the Canadian Highway Bridge Design Code (CSA, 2019) for concrete structures.

Comparison of Experimental Results with Expected Theoretical Displacement

The theoretical amount of displacement that is expected at each bearing can be computed based on an assumed coefficient of thermal expansion for the superstructure and the effective length subject to thermal strain. Such an approach is simplistic in that curvature of the structure and bearing friction are assumed negligible; however, it is often implemented to approximate the expected amount of displacement at bridge bearings. Based on the assumption that the main span superstructure is fixed at the central pier 11, and that the coefficient of thermal expansion for the concrete superstructure is 10με/°C as recommended in the Canadian Highway Bridge Design Code (CSA, 2019), the expected thermal movement at each instrumented bearing is computed. Note the effective length subject to thermal strain from the fixed pier 11 to pier 9, pier 13, and pier 14 is equal to 133.6m, 133.6m, and 191.5m, respectively. Table 2 displays the expected theoretical displacement at each instrumented bearing (computed from box internal temperatures) compared to the measured experimental values at peak temperature events.

The results in Table 2 show that theoretical displacements are in reasonably good agreement with the experimental observations (the only exception is the displacement at pier 14 at peak expansion, which is underestimated by approximately 20mm). These results suggest that the bearings are in general moving as expected.

Table 2: Expected Theoretical Displacement at Each Instrumented Bearing Compared to Experimental Results (theoretical result computed based on internal box temperature)

Period	Internal Box Temperature (°C)			Pier 9 Displacement (mm)		Pier 13 Displacement (mm)		Pier 14 Displacement (mm)	
	Period Start	Period End	Change	Theory	Experim.	Theory	Experim.	Theory	Experim.
October 5 2021 to January 27 2022	12.6	-21.0	-33.6	-44.9	-39.2	-44.9	-38.9	-64.3	-65.4
January 27 2022 to July 24 2022	-21.0	27.1	48.1	19.4	23.7	19.4	20.5	27.8	49.3
July 24 2022 to October 7 2022	27.1	13.0	-14.1	0.5	-4.5	0.5	0.9	0.8	7.3
October 7 2022 to February 4 2023	13.0	-17.6	-30.6	-40.3	-41.7	-40.3	-31.3	-57.8	-56.1
February 4 2023 to July 7 2023	-17.6	25.7	43.3	17.5	30.0	17.5	12.8	25.1	43.3
July 7 2023 to October 6 2023	25.7	16.4	-9.3	5.1	6.0	5.1	4.0	7.3	19.2

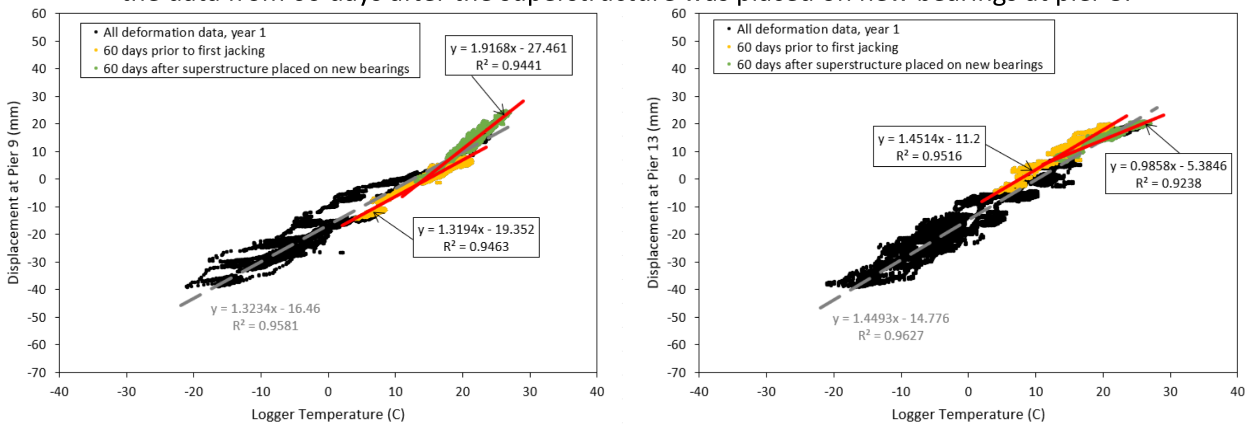
Effect of 2022 Bearing Replacement at Pier 8

The original main span bearings at pier 8 were replaced during rehabilitation works in the summer of 2022. Key stages of the bearing replacement work occurred on the following dates:

- June 24, 2022: First jacking operation with use of temporary bearings
- July 4, 2022: Structure was lowered to the original elevation for grouting of new bearings
- July 22, 2022: Superstructure load was successfully transferred to the new bearings

This work therefore occurred during the first year of the monitoring period described in this article. The main span structure at pier 8 was placed on new (temporary) bearings on day 262 of the monitoring period and was placed on new permanent bearings on day 290 of the monitoring period. To assess whether replacement of bearings at pier 8 influenced the bearing movements at adjacent piers, the pier 9 year 1 displacement readings as a function of temperature are highlighted in Figure 11a for: 1) the period 60 days prior to the first pier 8 jacking operations, and 2) the period 60 days after the superstructure was placed on new bearings at pier 8. Pier 13 displacement year 1 readings for the same 60-day periods are highlighted in Figure 11b for discussion purposes. Best-fit lines are shown in Figure 11 for each 60-day period.

Figure 11. a) Pier 9 and b) Pier 13 Displacement Readings Plotted Against Box Internal (datalogger) Temperature highlighting 1) the data from 60 days prior to the first jacking operation, and 2) the data from 60 days after the superstructure was placed on new bearings at pier 8.



(a) (b)

As shown in Figure 11a, the slope of the best fit line through the deformation/temperature data is considerably steeper during the 60-day period after pier 8 bearing replacement compared to the 60-day period before the bearing replacement. Similar observations are evident at pier 13 as shown in Figure 11b; the slope of the best fit line through the deformation/temperature data is considerably less steep during the 60-day period after pier 8 bearing replacement compared to the 60-day period before the bearing replacement. These results suggest that replacement of the pier 8 bearings may have relieved some restraint at this end of the structure and therefore allowed more thermal expansion at pier 9 in the period immediately following the pier 8 bearing replacement.

Summary and Conclusions

This article describes details of the bearing instrumentation and monitoring program employed at the Florenceville Bridge. Experimental data recorded during the monitoring period from October 5, 2021, to October 6, 2023 (731 days) are presented. It is shown that:

- Existing (original) bearings on the Florenceville Bridge main span structure were successfully instrumented to monitor longitudinal displacement and temperature over time.
- The coefficient of thermal expansion of the main span box girder is approximated as 11.3 με/°C based on the year 1 data and 11.7 με/°C based on the year 2 data. These values are in good agreement with the general design value of 10με/°C recommended in the Canadian Highway Bridge Design Code (CSA, 2019) for concrete structures.
- All three instrumented bearings returned to near their initial position after each of the two years of monitoring described herein, and the observed peak deformation values are in reasonably good agreement with computed theoretical movements.
- The original bearings at pier 8 were replaced during 2022 rehabilitation work, which took place during the monitoring period. Interpretation of the deformation data suggests that replacement of the pier 8 bearings may have relieved some restraint at this end of the structure and therefore allowed more thermal expansion at pier 9 in the period following the pier 8 bearing replacement. However, additional observations are required.

Results of this instrumentation and monitoring program suggested that the original main span bearings were operating within reasonable parameters. Based on these experimental observations and results of visual inspections, the bridge consultant and NBDTI determined that replacement of main span bearings was not warranted at this time (EXP, 2023). It was concluded in 2023 that the need for replacement would be re-evaluated on an on-going basis as the bearings continue to age. Monitoring of bearing deformations as a function of temperature would continue at the Florenceville Bridge to further assess the performance of these bearing. With the data collected in year 1 acting as a baseline, future deviations from this baseline could be used as a trigger to prompt remedial actions if/when required. It was concluded that the condition of main span bearings would be re-evaluated in 5 years with a follow up visual inspection.

Given the results of this detailed instrumentation and monitoring program, the owner (NBDTI) was confidently able to postpone the main-span bearing replacement scope of work, which was originally to be a significant portion of the overall structural rehabilitation program. Such outcome led to significant cost savings for the rehabilitation program and efficient allocation of fiscal year expenditures.

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