Long Term Evaluation of Unbonded Concrete Overlay Technology: A Municipal Case Study

Aleks K. Kivi, MASc, P.Eng.[1], Susan L. Tighe, PhD, P.Eng.[2],
Rico Fung, P.Eng. LEED® AP[3] and Jozef Grajek, M.Sc., P.Eng.[4]

Abstract
Portland cement concrete (PCC) overlays are growing in popularity as a cost-effective means of pavement preservation or rehabilitation. When properly designed and constructed, concrete overlays are a durable and cost-effective solution. This technology can be an excellent choice for municipal pavements, which are often subjected to heavy, slow moving vehicles. This paper presents an overview of design and construction considerations for unbonded concrete overlays, with an emphasis on details relating to the use of this technology in municipal applications. The included case study presents a synopsis of the City of Toronto's experience with the design and construction of its first unbonded concrete overlay project on Bloor Street. The performance of this trial section and lessons learned from the first twelve years of service are discussed.

Introduction

Functional and effective pavement infrastructure is necessary in urban areas, in order to ensure the continued societal and economic development spurred by the efficient movement of people and goods. However, many municipalities are facing challenges due to aging infrastructure and limited fiscal resources to keep public assets in a state of a good repair. Meanwhile, user demands are increasing. The number of vehicle-miles travelled annually continues to grow, reaching almost 3 trillion in 2009 in the United States (FHWA 2011).

The vast majority of pavements in the United States and Canada are constructed using hot mix asphalt (HMA). 94% of U.S. roads are paved with asphalt (NAPA 2009), including an overwhelming number of local roads. However, the typical urban traffic mix can be very damaging to asphalt pavements. Asphalt, as a viscoelastic material, is particularly susceptible to the severe stresses imparted by braking, standing, accelerating and turning traffic. The stresses induced by static and slow-moving urban vehicles, such as trucks and buses, frequently cause premature distress in asphalt pavements.

Rutting and shoving are most prevalent in intersections, in bus bays and on bus and truck routes (ACPA 1997). The rutting of asphalt pavements creates numerous safety concerns. Pavement rutting can reduce frictional characteristics

[1] Project Engineer, Applied Research Associates, Inc., Toronto, Ontario, Canada, email:akivi@ara.com
[2] Professor and Canada Research Chair, Norman W. McLeod Chair in Sustainable Pavement Engineering, Director, Centre for Pavement and Transportation Technology, Department of Civil and Environmental Engineering, University of Waterloo, Waterloo, Ontario, Canada, email: sltighe@uwaterloo.ca
[3] Director, Markets and Technical Affairs (Ontario Region), Cement Association of Canada, Toronto, Ontario, Canada, email: rfung@cement.ca
[4] Senior Engineer (Retired), Technical Services, City of Toronto, Toronto, Ontario, Canada

due to flushing or water ponding. Lane changes can potentially become dangerous and vehicles can hydroplane and lose control, particularly during periods of poor weather (NRC 2003). The ruts can also make snow removal more difficult. It is recommended that these safety concerns be addressed as soon as possible to mitigate the possible impacts on the safety of drivers, vehicles and pedestrians. These types of pavement failures often become a costly maintenance issue for local transportation department because of their recurring nature.

Despite many municipalities' preference for asphalt, concrete pavement technologies also have a prominent place on city streets and local roads. The selection of pavement materials is one of the more challenging engineering decisions facing transportation agencies and design engineers. The initial construction costs must be compared with the total life-cycle costs, including costs associated with maintenance and rehabilitation activities. Furthermore, the sustainability and social benefits must also be factored into the decision.

This paper presents an overview of unbonded concrete overlay systems as a pavement preservation/rehabilitation alternative in municipal applications. A case study from the City of Toronto, Canada is used to show the benefits achieved to date from the City's first unbonded concrete overlay project.

Overview of Concrete Overlays

Portland cement concrete (PCC) overlays are growing in popularity as a cost-effective means of rehabilitating in-service pavement. When properly designed and constructed, concrete overlays are a durable and cost-effective solution, making them an excellent choice for municipal pavements.

Overlays can be used to improve the quality of the riding surface, as well as increase the load-carrying capacity of the existing pavement (Garber et al. 2011). Practice has shown that overlays can be constructed quickly and economically to renew deteriorated pavement sections without the expense of reconstruction, and the associated user delays (REF). Overlays are a long-life solution: the Federal Highway Administration reports typical service lives of 20 to 30 years for unbonded overlays (FHWA 2002). Furthermore, concrete overlays make use of the existing pavement, eliminating the need for its removal and disposal of the waste materials and build further equity in the original construction (Van Dam et al. 2012).

Concrete overlays fall into two primary categories: bonded and unbonded (Harrington 2008). Both types of overlay can be constructed over existing concrete, asphalt or composite pavements, as shown in Figure 1.

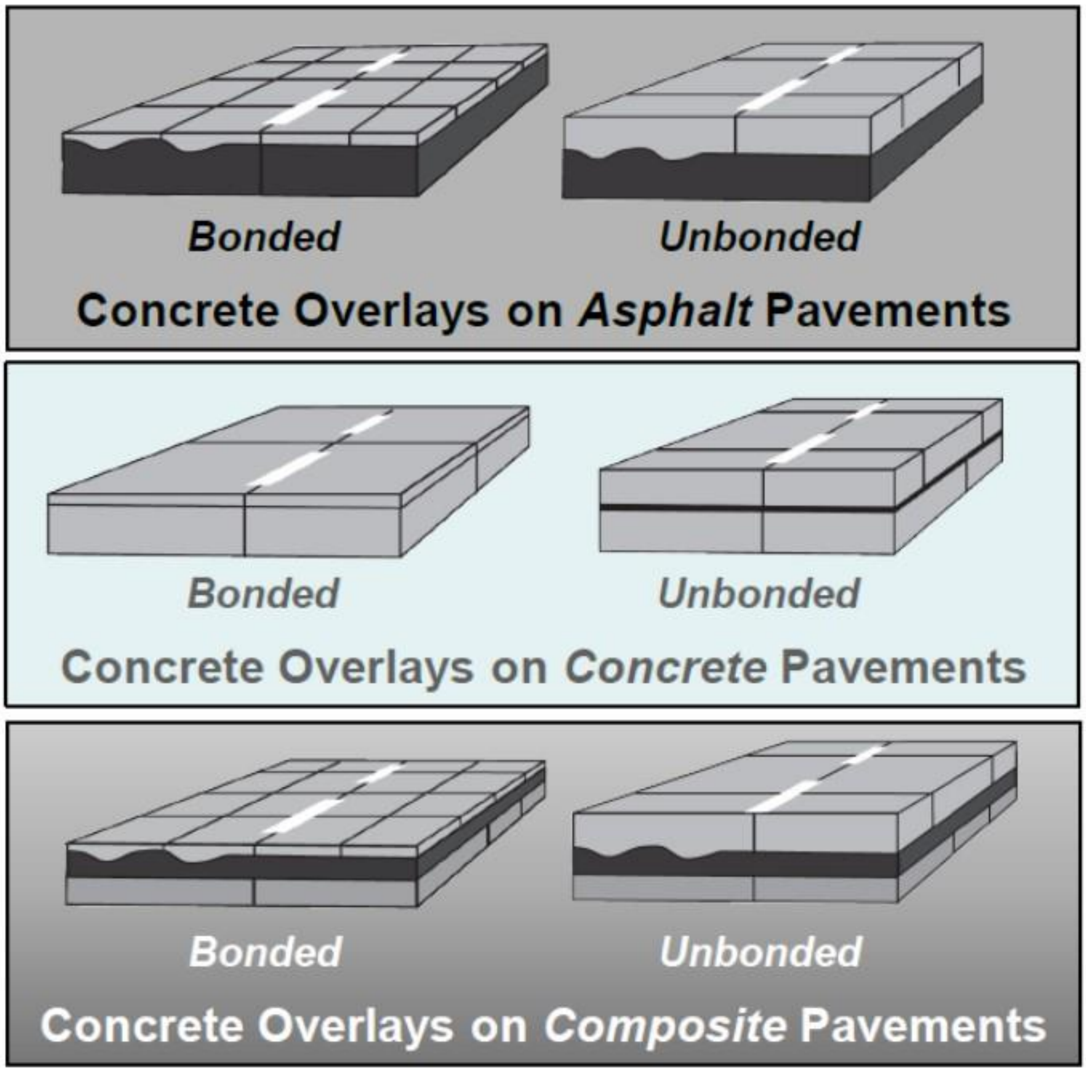

Figure 1. Examples of concrete overlays (Harrington 2008)

Bonded vs. Unbonded. Bonded overlays are generally thinner (50 to 125 mm thick) and typically used as a resurfacing solution on pavement preservation projects. (Harrington 2008). These overlays are designed to have the overlay slab form a solid bond with the existing pavement surface so that the layers act as one monolithic system. Bonded overlays are appropriate in good to fair condition overall. The thin overlay addresses moderate surface distresses, e.g. rutting and shoving, improves ride quality and surface friction, and provides minor pavement strengthening. (Delatte 2008)

Unbonded concrete overlays, are usually thicker and are generally used a rehabilitation method for moderately to severely distressed pavements (Harrington 2008). The existing pavement structure, albeit having some structural deterioration, serves as a solid base layer for the new concrete pavement placed on top. The performance of unbonded overlays requires separation of both layers. The type of concrete overlay restores ride quality and serviceability, while also providing the additional structural capacity required for future traffic loads (ACI 2006). Unbonded typically range from 150 mm to 275 mm thick, but can be as low as 100 mm in areas with low traffic volumes and/or lighter traffic loadings. (Harrington

2008) This paper focuses on the design, construction and performance of unbonded overlay as they apply in urban areas.

Design and Construction of Unbonded Overlays

Design procedures. The design of an unbonded overlay is similar to designing a new concrete pavement over a stabilized subbase. In unbonded overlay design, it is assumed that there is no bond between the bottom surface of the overlay and the top surface of the existing pavement (Smith and Harrington 2014).

This type of overlay is typically designed using the same procedures as those for designing new concrete pavements. Established concrete pavement design procedures with provisions for overlays include 1993 American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavements Structures* (AASHTO 1993) or the 1998 AASHTO Supplement procedure (AASHTO 1998). The Mechanistic-Empirical Pavement Design Guide (MEPDG), developed as part of National Cooperative Highway Research Program project 1-37A, also includes design procedures for unbonded overlays (AASHTO 2008).

The AASHTO procedures are based on empirical studies, whereas the MEPDG, which has been implemented in the AASHTOWare PavementME Design software, uses a mechanistic-based approach combined with empirical field performance data to predict key performance indicators, e.g. IRI, transverse cracking and faulting (AASHTO 2008). The MEPDG is still undergoing evaluation, calibration, and implementation by agencies around the world.

All methods take into consideration regular concrete pavement design parameters, such as traffic, and subgrade strength, but also include the condition of existing pavement in some manner. (Torres et al. 2014)

Additionally, the factors that caused the deterioration of the existing pavement must be identified. These factors must be corrected and/or taken into consideration in the design in order to ensure satisfactory performance of the overlay. Pavement distress and failures can be attributed to a number of factors, including age, inadequate drainage, traffic volumes/type, subgrade condition, inadequate thickness, and poor construction quality and/or materials.

Separation layer. Unbonded overlays over existing concrete pavements require an interlayer to separate the concrete overlay from the underlying pavement, which prevents reflective cracking and premature failures (Delatte 2008). The interlayer, commonly a thin lift of asphalt concrete, provides a shear plane for differential movements and prevents the different concrete layers from becoming bonded together, providing stress relief. With the inclusion of the interlayer, only minimal pre-overlay preparation is required (ACI 2006).

Although no bond is assumed in the design, partial bonding between the overlay and the existing asphalt pavement may occur and is acceptable (Rasmussen and Rozycki 2004). The bonding may even improve load-carrying capacity. The interlayer thickness may be increased if the deteriorated pavement shows considerable faulting in order to prevent reflective cracking (McGhee 1994).

Nonwoven geotextiles have also been used to isolate adjacent concrete layers (Harrington et al. 2014). It should be noted that unbonded overlays of asphalt pavements do not require an interlayer (Garber et al. 2011).

Jointing. As with any unreinforced concrete pavement, jointing is required to provide space for thermal expansion and contraction, in order to control cracking.

Joint spacings are designed based on the thickness of the overlay. Usually a joint spacing that is 12 to 18 times the thickness of the slab is recommended (APCA 1999). This provides for joint spacing that shorter than most jointed plain concrete pavements. Short spacing helps reduce curling and warping stresses (Westergaard 1927). The joints should are constructed to a depth of 1/4 to 1/3 of the overlay thickness (Garber et al. 2011).

The most common design procedures generally recommended trying to match the transverse joints in the overlay with those in the existing pavement below, but this is not critical (Garber et al. 2011). The designer should also verify that the expected wheelpath does not fall along any longitudinal joints, when tends to result in corner breaks. It is preferred that the wheelpaths fall into the centre of individual panels. (Rasmussen et al. 2002).

Load transfer. In unbonded overlays, load transfer across joints is commonly provided by aggregate interlock. Small joint openings, resulting from a short joint spacing, help ensure good load transfer (Rasmussen et al. 2002). Furthermore, the joint opening size can be reduced to enhance aggregate interlock by using a concrete mix with low shrinkage characteristics and a low coefficient of thermal expansion (Rasmussen and Rozycki 2004).

On occasion, dowels used in joints when the overlay's design thickness is greater than 200 mm and/or is expected to carry heavy truck traffic (Harrington 2008). The improved load transfer resulting from the use of dowels occasionally allows for the reduction in design slab thickness.

Pre-overlay repairs. On many projects, very few pre-overlay repairs to the existing pavement are required. The concrete overlay itself will fill in or otherwise correct low to medium severity distresses. Some agencies fill potholes and seal cracks prior to placing the overlay, but this is not mandatory (Rasmussen and Rozycki 2004). However, more serious distress, such as localized subgrade failures beneath the existing pavement, should be corrected prior to overlay construction, as they may lead to premature deterioration of the overlay, if left uncorrected. Many agencies use milling in order to prepare the surface of the existing. Milling allows for the elimination of severe rutting and shoving (greater than 50 mm), the smoothing out surface distortions, the adjustment of grades and cross slopes.

Construction. The construction of unbonded overlays follows standard conventional concrete paving practices (Garber et al. 2011). After any repairs, the surface of the existing pavement is first cleaned with a sweeper or compressed air. If the existing pavement is concrete, the bond-breaking interlayer is constructed. The HMA layer is placed and compacted, and needs to cool before concrete paving begins. Concrete placement can be performed using fixed formwork or slipform construction techniques (Smith and Harrington 2014). If dowels are included in the design, the dowel baskets must be secured properly to the existing pavement unless a dowel bar inserter is used (Garber et al. 2011).

Transition details. The detailing of the transition from the concrete overlay to the adjoining pavement is very important. The pavement near the interface is susceptible to damage because of differing material types. For example, because of different coefficients of thermal expansion for asphalt and concrete, horizontal movement of the concrete can cause a settlement or shoving, resulting in a bump or dip, spoiling ride quality (Rasmussen and Rozycki 2004). A common transition detail is to thicken the edge of the slab near the interface. A typical transition includes increasing the slab thickness by 75 mm over a two meter extent. (ACPA 1999).

Special consideration for urban areas. Urban environments often have features that makes overlay construction more challenging. There features dictate pavement grades and may include curb and gutter, catchbasins, manholes, sidewalks and utilities. (Harrington et al. 2014) The grades associated with these features can have a profound impact on the overlay design and will often need to be modified in some way to accommodate the overlay. For example, curb and gutter may need to be removed and replaced at the correct grade, partially milled to accommodate the placement of the new slab or overlaid entirely with a new curb and gutter at the correct elevation. Catchbasins, manholes and other in-pavement structures will need to be adjusted to the final overlay elevation. Unfortunately, most of these treatments comes at additional expense.

CASE STUDY BACKGROUND

The intersection of Bloor Street and Aukland Road, located in west Toronto, is subjected to high traffic volumes and a large number of heavy vehicles. Bloor Street is a major four-lane east-west arterial road with an Average Annual Daily Traffic (AADT) of over 30,000 vehicles and high peak hourly volumes (approximately 1000 vehicles and in excess of 15 buses per hour). It meets Aukland Road, a short north-south collector road, at a T-intersection. Aukland Road leads directly into the nearby Toronto Transit Commission's (TTC) Kipling subway station, located approximately 500 metres south, as shown in Figure 2. Many TTC and MiWay (the adjacent City of Mississauga's transit service) bus routes travel along Bloor St. and turn onto Aukland Rd to travel to and from the subway station.

Frequent, rapid deterioration of the asphalt at this busy urban intersection was being noted by City of Toronto's Transportation Services staff. Rutting and shoving was reoccurring at regular frequencies, particularly near the stop bars, where traffic slows to turn or stops for the traffic signal. These distresses were creating safety concerns, forcing the City of Toronto to intervene with "mill and inlay" treatments at 2-3 year intervals, removing and replacing the damaged asphalt. City staff noted that that traditional maintenance and rehabilitation treatments were not addressing the underlying issues and a more permanent solution was required. The high volumes of heavy, slow moving bus traffic were increasing the pavement deterioration rate above acceptable levels.

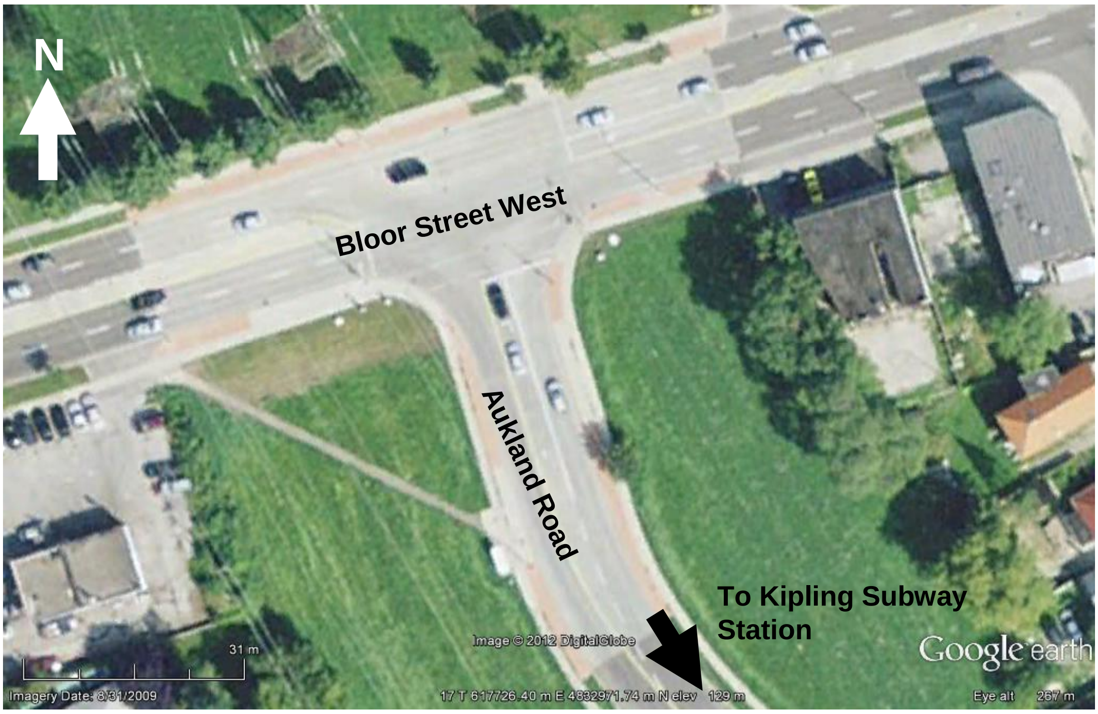

Figure 2. Plan of Bloor and Aukland intersection (Google 2012**).**

In collaboration with the Cement Association of Canada, the City of Toronto elected to rehabilitate the high traffic intersection of Bloor Street and Aukland Road using Portland cement concrete materials in attempt to mitigate the recurring issues. As part of this project, the city constructed its first unbonded concrete overlay on Bloor Street West and placed a full depth Jointed Plain Concrete Pavement (JPCP) inlay on the adjacent area on Aukland Road (Tighe et al. 2005). This rehabilitation work was completed in the summer of 2003. This case study focuses on the design, construction and performance of the unbonded concrete overlay along Bloor Street.

Design. A local Toronto engineering consultant was retained to carry out a pavement investigation and develop pavement designs for the intersection rehabilitation project. The consultant's visual condition survey indicated moderate rutting and shoving, concentrated in the curb lanes on Bloor Street, near the stop bars. Frequent, severe reflective cracking from the underlying concrete was also observed. Furthermore, the pavement evaluated noted a large quantity of asphalt patches (utility cuts) along Bloor Street that had deteriorated and were negatively impacting ride quality (Tighe et al. 2005).

The borehole investigation revealed that the existing pavement on Bloor Street consisted of a composite structure (asphalt over concrete). It generally comprised of 80 mm of HL1 hot mix asphalt, 200 mm of Portland cement concrete (PCC) base and 100-150 mm of granular base over a poorly draining silty clay subgrade.

Based on the field data and the anticipated traffic loadings, the resulting rehabilitation design recommendation was a 150 mm unbonded concrete overlay of the existing concrete base along an 85 metre long section of Bloor Street. The existing and new pavement designs are illustrated in Figure 3.

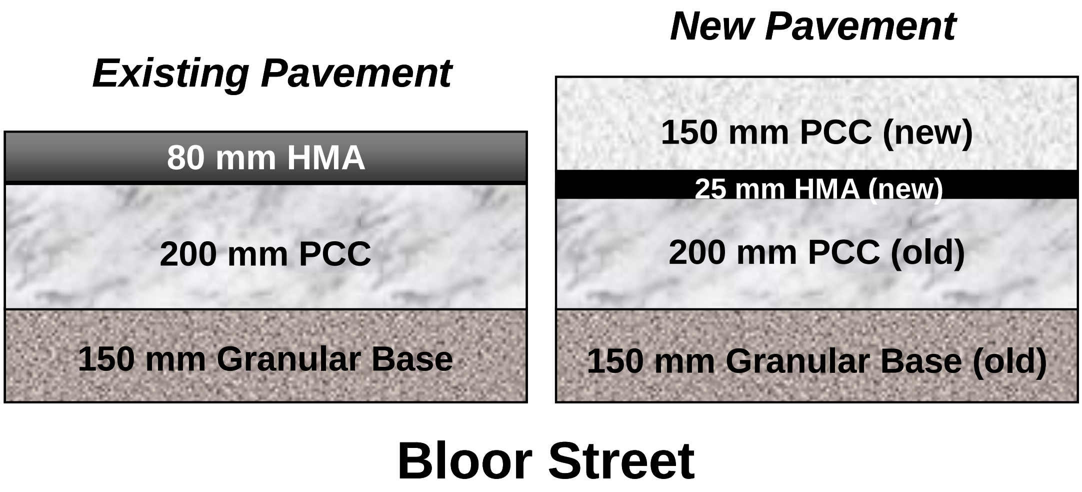

Figure 3. Existing and new pavement designs.

Construction. The City of Toronto required that the contractor stage the work such that partial access to traffic through the busy intersection is maintained at all times. In order to minimize delays to the travelling public, the majority of construction activities, including the placement of the concrete pavement, took place over the course of two consecutive weekend closures, when traffic volumes are lower.

The damaged asphalt layer was first removed from the composite pavement by milling. Cracks in the concrete base were routed and sealed and the deteriorated utility cuts were repaired with full depth concrete patches. Once the existing concrete base has been prepared, a slow-setting asphalt emulsion tack coat was placed, followed by a 25 mm thick lift of high stability HL3 asphalt concrete as a separator layer. This was followed by the placement of the new concrete overlay once the asphalt had sufficiently cooled.

Contraction joints were sawcut as soon as the concrete had set (within twelve hours of concrete placement) to a depth of one-fourth of the thickness of the new concrete slab. A short joint spacing of 1.5 metres was used in both direction, laying out a grid pattern.

Dowel bars (25 mm in diameter by 400 mm long) were placed in turning locations and stopping areas to minimize the potential for faulting. The first 25 meters west of the centreline of Aukland Road were doweled. Dowel baskets, spaced at 300 mm intervals, were installed on the asphalt interlayer prior to the placement of the concrete.

During the first weekend closure, the eastbound lanes of Bloor Street West were paved. This stage was constructed using fast track methods using high early strength concrete (24 MPa in 72 hours). The newly constructed lanes were re-opened to traffic on Monday morning. The following weekend, the westbound lanes of Bloor Street West were constructed using conventional concrete with a minimum strength of 32 MPa.

Instrumentation. As part of a collaborative research partnership with the City of Toronto, researchers from the University of Waterloo's Department of Civil and Environmental Engineering embedded instrumentation in the new pavement layers to monitor the long-term performance of the trial unbonded overlay rehabilitation project.

Waterloo researchers devised an instrumentation plan to monitor pavement responses of interest. Seven vibrating wire strain gauges were placed at various locations in the unbonded overlay, in order to measure pavement responses associated with the bus traffic loadings and environmental effects. The vibrating wire type strain gauges, identical to the one shown in Figure 4, reliably capture the long-term effects of environmental loads, e.g. thermal expansion/contraction, shrinkage, curling and warping, as well as the cumulative effects of repeated traffic loadings.

The sensor locations were strategically selected to capture the effects of accelerating, slowing and turning traffic, as well as the overall effects due to environmental changes. Sensors were placed both at the top and bottom of the slab. The sensor layout on Bloor Street is shown in Figure 5.

Pavement strain information has been collected hourly since the completion of construction in 2003. The data collection equipment was finally removed in the summer of 2015, after twelve years of continuous monitoring. At the time of decommissioning, only four of the seven gauges originally installed were providing reliable data.

Nevertheless, the embedded instrumentation continued to provide valuable information relating to the behaviour of the concrete under environmental and vehicular loadings, and assisted with validating the pavement designs.

Figure 4. Typical vibrating wire strain gauge used.

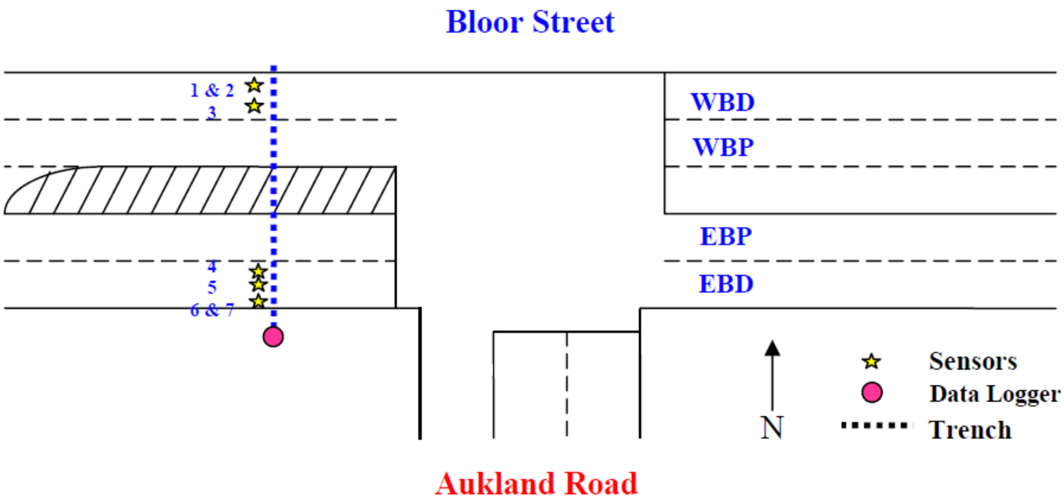

Figure 5. Sensor layout on Bloor Street.

Performance Evaluation

Strain Data Analysis and Evaluation. Over the course of the twelve year monitoring period, the most obvious trend observed in the strain data is a daily variation in strain, corresponding with a daily temperature cycle. The measured strains increase as the concrete heats up and expands with rising temperatures and exposure to solar radiation during the day and decrease as the pavement cools and contracts overnight.

Seasonal trends have been observed from year to year as well. The largest strains are observed in the winter season, which is likely due to the drastic changes in temperatures. Although Toronto's average daily temperature in January is -4.5ºC, the city can experience temperatures ranging from -33ºC to 16 ºC (City of Toronto, n.d.). The measured strains continue to decrease throughout the year, with the lowest strains being observed in the fall.

A general trend of increasing compressive strains has been observed in the wheelpaths of the unbonded overlay over time. This holds true for the data obtained from the sensors at the top of the overlay layer, as well as the bottom. This trend is illustrated in Figures 6 and 7, which compare strain data from the first, third and ninth years following construction. A similar number of datapoints from each year, collected equally across all twelve months, has been used in the analysis.

The boxplots present the maximum, third quartile, median, first quartile and minimum strain values for each year. Strain values greater than zero are tensile; those less than zero are compressive.

The trend of increasing compression at the top surface is no surprise; however, the bottom sensors are expected to be measuring tensile strains under the thermal loadings and vehicular loadings being measured. Unbonded overlays are designed to have the overlay slab and existing slab bend separately under traffic and environmental loads due to the placement of a separation layer, shown in Figure 8.

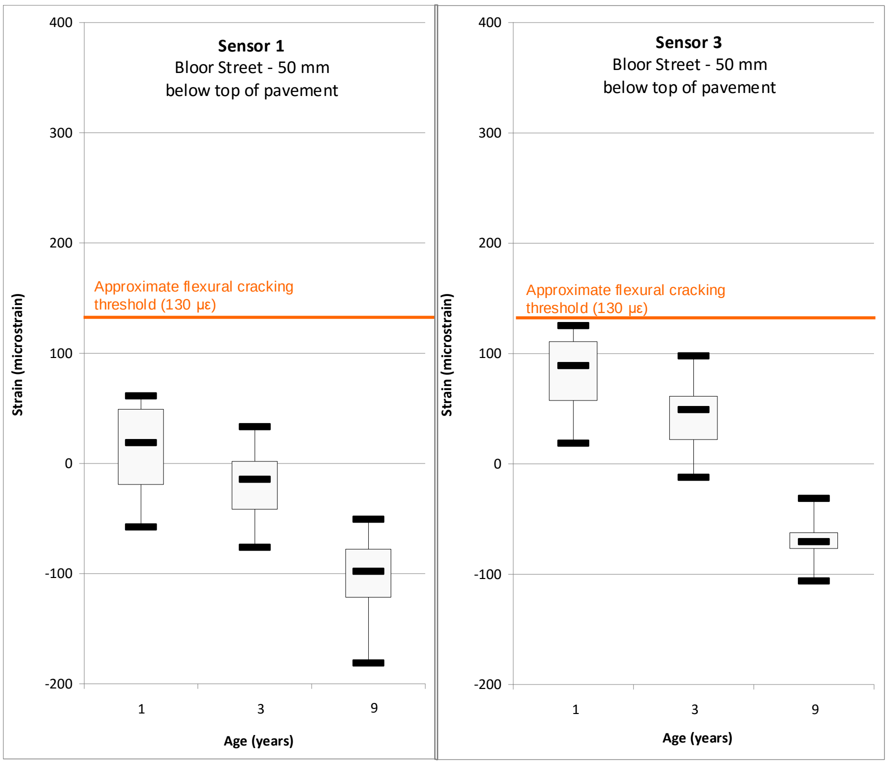

Figure 6. Comparison of strains in unbonded overlay after 1, 3 and 9 years of service at top of concrete.

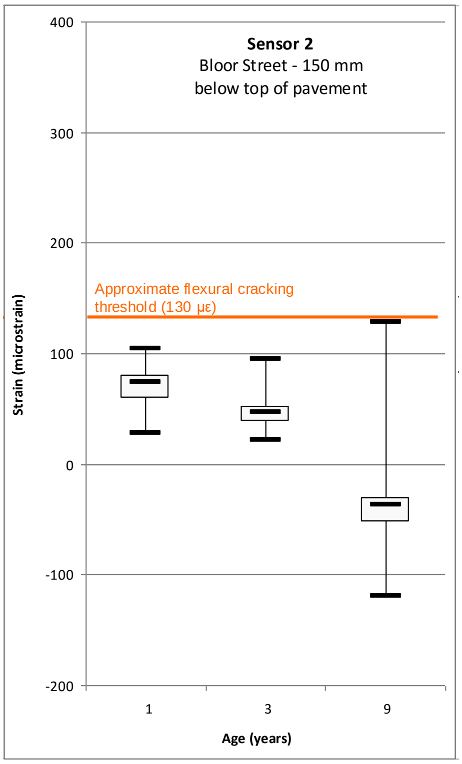

Figure 7. Comparison of strains in unbonded overlay after 1, 3 and 9 years of service at bottom of concrete.

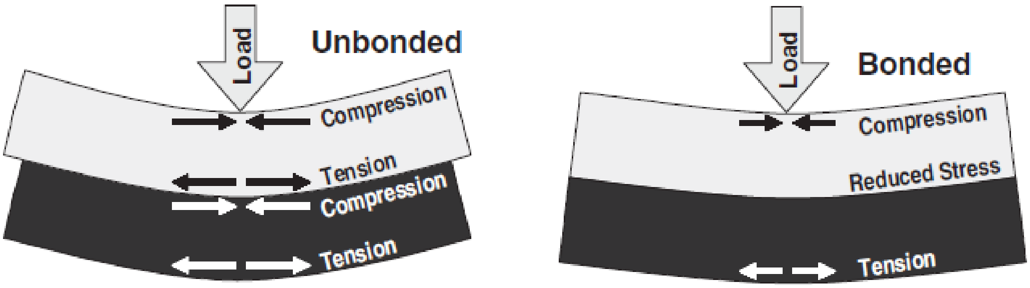

Figure 8. Comparison of theoretical unbonded and bonded overlay strain profiles (Rasmussen and Rozycki 2004).

Nevertheless, it is possible that partial bonding has occurred between the original concrete slab and the overlay concrete slab. The evidence of compressive strains throughout the thickness of the overlay suggest that both slabs may behaving monolithically, In this case, a single neutral axis is found in the both slabs, lying in the old slab. The bonding of the concrete layers effectively adds additional structural capacity to the pavement, since the bottom slab is serving as more than a high quality base layer. Studies have shown that partial bonding may enhance overlay performance (Rasmussen and Rozycki 2004). However, bonding in an overlay that has been designed as unbonded is generally undesirable because it may allow reflective cracking to occur, particularly if the overlaid slab was well deteriorated (Harrington 2008).

Although the measured strains are generally compressive in nature, tensile strains are occasionally captured. The measured tensile strains in the unbonded overlay layer remain low, i.e. well below cracking thresholds. The threshold for flexural (tensile) crack formation in a 30 MPa concrete is approximately 130 microstrain (Neville 1995). The collected data indicates that considerable remaining pavement service life can be expected.

Structural Evaluation. Falling Weight Deflectometer (FWD) testing has been performed to evaluate the structural condition of the concrete overlay section. Applied Research Associates, Inc. (ARA) was retained by the City of Toronto to carry out FWD testing on the unbonded concrete overlay and adjacent concrete inlay. The testing was completed in November 2013. Deflection measurements were taken at the slab corners, the slab edges and the middle of the slab. Load transfer testing was also performed.

Backcalculation methods were used to determine the in-situ properties of the in-service pavement materials of the Bloor Street unbonded overlay. A summary of the determined properties is shown in Table 1. An average resilient modulus of 44 MPa was determined for the silty clay subgrade. The average dynamic modulus of subgrade reaction was found to be 97 MPa/m, and the average static k-value was 49 MPa/m.

Table 1. Summary of Pavement Material Properties.

	Bloor Street West			
	Resilient Modulus (MPa)	Elastic Pavement Modulus (MPa)	Dynamic K (MPa/m)	Static K (MPa/m)
Average	44	3,516	97	49
Std. Dev.	10	1,330	24	12
Min	24	1,386	57	29
Max	70	7,704	166	83

The normalized deflection is a good indicator of overall pavement stiffness. The midslab, corner and edge deflections were compared to review the impact of the panel size on deflection measurements. These results are presented in Table 2. As anticipated, the slab corner observes the greatest deflection with lower deflections observed at the middle of the slab. For the Bloor Street West overlay, the average deflection values for each test location are statistically similar. Curling/warping effects appear to be minimal. Also, the rigidity of the existing concrete base layer likely makes a significant contribution to the greater stiffness as well.

Table 2. Summary of Normalized Deflection Results (*in microns*)

Location within Slab	Bloor Street West			
	Average	Std. Dev.	Min	Max
Midslab	109	30	62	167
Corner	122	26	75	181
Edge	111	31	62	168

The load transfer efficiency (LTE) results presented in Table 3, indicate that the pavement provides very good load transfer across joints. The LTE values range from 75 to 100 percent, with an average of 87 percent. Generally, load transfer values greater than 70 percent indicates good joint load transfer capability. The load transfer was found to be comparable in both the dowelled and undowelled areas.

Table 3. Summary of Load Transfer Results (percent)

Location	Bloor Street West			
	Average	Std. Dev.	Min	Max
Corner Approach	89	6	79	99
Corner Leave	88	4	79	97
Edge Approach	86	5	75	96
Edge Leave	87	4	78	95
Overall	87	5	75	99

Visual Pavement Evaluation. Visual condition surveys of the overlay section have been performed regularly. The results of the most recent condition survey, performed in July 2015, show that both rehabilitated pavements remain in very good condition after twelve years of service. Distresses are infrequent and generally low in severity.

On Bloor Street, a few of the contraction joints exhibit ravelling and minor spalling. The joints between the overlay layer and the curb and gutter display occasional spalling, as well as at the interface between the overlay and the adjacent composite pavement. This damage is likely attributable to restraint effects from materials with dissimilar coefficients of thermal expansion.

Less than optimal joint detailing and isolation of the drainage appurtenances has resulted in minor cracking the adjacent concrete near catchbasins and manholes, as shown in Figure 9. The most severe distress in the overlay section is two cracked slabs near the north-south crosswalk on the east side of the intersection, seen in Figure 10.

Overall ride quality of this section remains excellent. The narrow width of the sawcuts in the overlay prevents the occurrence of "joint slap" noise. Although the overlaid concrete base was in marginal condition prior to rehabilitation, none of the pre-existing cracks or other distresses have reflected upwards into the overlay layer to-date.

Figure 9. Cracking near catchbasin.


Figure 10. Cracked slabs in crosswalk area.

Most significantly, it must be noted that the recurring rutting and shoving problems that were being observed prior to rehabilitation have been mitigated. The rigid concrete overlay has succeeded in eliminating their recurrence.

The City of Toronto notes that no maintenance or rehabilitation has been performed on the overlay section since it was constructed.

Summary and Conclusions

The results of this study demonstrate that unbonded concrete overlays are a technically feasible and economically viable rehabilitation alternative for high volume urban roadways. The Bloor Street overlay, earning the distinction of the first unbonded overlay in Toronto, has proven itself as an effective solution for the rehabilitation of distressed concrete/composite pavements. The overlay section has shown excellent performance in its first twelve years of service, with no issues of note to date. The recurring issues prior to rehabilitation, i.e. frequent rutting and shoving under bus and truck traffic, have also been mitigated, and the regular associated maintenance expenses have been eliminated.

With anticipated service lives of greater than 20 years and low maintenance needs, concrete overlays have the potential to be a reliable, long-term pavement rehabilitation solution for municipal pavements. These are proven, cost-effective technologies with long service lives. Solid research and technology transfer efforts are leading to greater implementation of these solutions. The performance of the concrete overlay pilot project on Bloor Street has exceeded the City's expectations and the City is actively seeking new candidate projects for rehabilitation with concrete overlays. Other Canadian municipalities are also taking advantage of the City of Toronto’s experience and seeking projects where they can apply these solutions.

Although data collection from the embedded sensors has ceased, the City of Toronto and the University of Waterloo will continue monitoring the Bloor Street unbonded concrete overlay section in order to continue gathering valuable performance data about concrete overlay performance in municipal applications in Canada.

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