Harwood Avenue and Bayly Street (Reg. Rd. 22)
A Concrete Pavement Urban Intersection Pilot Project
The Regional Municipality of Durham

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1 ABSTRACT

Located immediately east of Toronto, Ontario, the Regional Municipality of Durham includes 7 area municipalities with a total geographical area of approximately 2,590 square kilometres and a combined population of approximately 650,000 people. Situated in the highly developed and populated economic centre of Ontario, known as the Golden Horseshoe, Durham Region is expected to grow to an estimated population target of 970,000 by the year 2031. This growth will bring higher traffic volumes including buses and heavy trucks, which should be designed for in today's road reconstruction projects.

As part of its commitment to continually improve its service excellence, Durham Region is exploring innovative approaches to pavement design and road rehabilitation that could extend the life of its roadways and reduce overall lifecycle costs of the network. In line with this initiative, a pilot project was undertaken to reconstruct the intersection of Harwood Avenue and Bayly Street (Regional Road 22) in the Town of Ajax using a jointed plain concrete pavement design instead of a conventional asphalt pavement design.

This paper provides an overview of the pilot project, highlighting key differences between concrete pavement design and traditional asphalt pavement design, and discusses construction considerations and lessons learned. This paper also outlines the construction staging that was followed and a traffic impact assessment undertaken by the Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo.

2 INTRODUCTION

Located immediately east of Toronto, Ontario, the Regional Municipality of Durham is situated in the highly developed and populated economic centre of Ontario known as the Golden Horseshoe. Durham Region includes 7 area municipalities with a total geographical area of approximately 2,590 square kilometres and a combined population of approximately 650,000 people. Residential development is expanding and the Region is expected to grow to an estimated population target of 970,000 by the year 2031.

With the growth in population, traffic volumes are increasing throughout the Region and the effects are especially evident in denser urban areas which experience heavier bus and truck traffic. Early onset asphalt distresses including varying degrees of rutting and shoving are prominent at most arterial intersections in these urban areas. In an effort to provide more resilient intersections and a lower life-cycle cost, the Region is exploring alternative pavement designs that may hold up better over time to higher traffic loads. As part of this initiative, the Region implemented a concrete pavement pilot project at the intersection of Harwood Avenue and Bayly Street (Regional Road 22) in the Town of Ajax.

3 BACKGROUND

Bayly Street is a five-lane Type A arterial Regional road with an approximate annual average daily traffic (AADT) volume of 25,000. Harwood Avenue is an arterial Town of Ajax road with similar traffic volumes. The intersection is located in the heart of downtown Ajax and is surrounded by commercial plazas, medium-rise apartment buildings, two schools and a church. Pat Bayly Square is currently being constructed at the southwest corner of the intersection which will be one of the largest urban developments in Durham Region. The development is expected to provide residency for an estimated 3,200 people and provide commercial space for 200 jobs. A high volume of pedestrian traffic traverse the intersection, especially during the school months, and this is expected to increase upon completion of Pat Bayly Square. The intersection contains channelized left turn lanes with median islands which increases the complexity of construction traffic staging.

3.1 Previous construction

The asphalt pavement at the intersection of Harwood Avenue and Bayly Street was placed in 1999 when the intersection was widened and the slotted left turn lanes were constructed on Harwood Avenue. The pavement design consisted of 40mm HL1 asphalt, 100mm of HL8 asphalt, 150mm of Granular A base and 600mm of Granular B subbase.

Soon after construction, the pavement experienced extensive, moderate to severe wheel path rutting and shoving and was in need of rehabilitation. These types of distresses can be attributed to a combination of factors including high truck and bus traffic, rounded or poorly graded aggregates used in the asphalt mixes, poor quality asphalt mixes (i.e. too many impurities), poor construction methods (i.e. overheating) and low asphalt Performance Grades (PG) [1]. Over time, wheel path rutting is common to some degree at most arterial intersections throughout the Region. However, the magnitude and severity of these distresses at this intersection were greater than other typical intersections, and the distresses became evident within 12-18 months of construction. The asphalt failures were most obvious at the locations of the stop bars and crosswalks where the transverse pavement markings deformed with the shoving and rutting asphalt.

Figure 1 – Asphalt distresses at the intersection approaches (photos from 2014)

3.2 Concrete pavement pilot project

At the onset of the project, different pavement designs were considered including composite asphalt/concrete, steel fibre reinforced concrete, roller compacted concrete, and jointed plain concrete. Durham Region consulted with a number of external agencies including other road authorities in the Greater Toronto Area (GTA), Concrete Ontario, the Cement Association of Canada (CAC), the Ontario Ministry of Transportation (MTO) and the Washington Department of Transportation (WxDOT) all of which have extensive experience with concrete and composite pavements. After considering the various alternatives in terms of construction costs and life cycle costs, construction duration, construction staging, and contractor availability, the Region decided to move forward with a jointed plain concrete pavement design at the intersection of Harwood Avenue and Bayly Street with construction planned for 2016.

4 GEOTECHNICAL ENGINEERING AND PRELIMINARY DESIGN

4.1 Field investigation and laboratory testing

Durham Region retained Golder Associates to conduct a geotechnical borehole investigation at the subject intersection and provide analyses and recommendations for reconstruction with a plain jointed concrete pavement. A total of 12 boreholes were advanced to a depth of 1.5m at the locations shown in Table 1.

Table 1 Summary of borehole locations

Location		**Number of Boreholes**
Bayly Street	Eastbound Lane	2
	Westbound Lane	2
Harwood Avenue	Northbound Lane	2
	Northbound Left Turn Lane	1
	Southbound Lane	3
	Southbound Left Turn Lane[1]	–
	Intersection	2
	Total	12

Notes: 1. A core was taken in place of a borehole at this location due to the presence of underground utilities.

The boreholes were advanced to determine the type and thickness of individual pavement layers (asphalt, granular base/subbase, etc.), assess the type of subgrade soils and ground water conditions, and obtain material samples for laboratory testing.

Based on the information from the borehole investigation, the existing pavement structure within the project limits is summarized in Table 2.

Table 2 Summary of existing pavement structures

Pavement Component	Pavement Thickness (mm)			
	Harwood Avenue		Bayly Street (RR 22)	
	Range (mm)	Typical (mm)[1]	Range (mm)	Typical (mm)[1]
Hot Mix Asphalt	140 – 230	175	100 – 220	165
Granular Base	290 – 460	320	390 – 450	405
Granular Subbase	0	0	190 – 440	290
Total Pavement Thickness	460 – 640	495	600 – 1,000	860
Subgrade Soils	Clayey Silt / Silty Clay		Silty Sand / Clayey Silt	
Notes: [1] The 65th percentile value was used as the typical thickness.				

A sub-angular, sub-rounded gravelly sand base layer was encountered at each of the 12 boreholes advanced throughout the intersection. A sandy subbase layer was only encountered at three of the boreholes on Bayly Street and was not encountered along Harwood Avenue.

Gradation testing results for the gravelly sand layer indicated that the material did not satisfy current Region requirements for granular base due to a higher percentage of material passing some of the sieve sizes (i.e. the material was too fine). Similarly, the gradation testing results on the sandy subbase layer, where encountered, indicated that the material did not satisfy current Region specifications due to a slightly higher percentage of material passing the 0.75 µm sieve size.

The in-situ water contents of the base and subbase materials were in the range of 2 to 5 percent, indicating that the materials were generally in a dry to moist condition.

The subgrade soils were variable and consisted of silty sand, clayey silt and silty clay. The in-situ water contents of the silty sand, clayey silt and silty clay materials were 10%, 12% and 25%, respectively. Based on the results of the gradation testing, the subgrade soils tested were considered to have a low susceptibility to frost heave.

4.2 Geotechnical findings and recommendations

The results of the geotechnical investigation identified that the existing pavement structures on Harwood Avenue and Bayly Street varied from the original 1999 design drawings which specified 140mm of asphalt, 150mm of granular base and 600mm of granular subbase. Further, as measured by the laboratory testing, the quality of the granular materials was determined to be variable, typically finer in gradation when compared to current Region standards.

For lifecycle costing analysis, Golder presented asphalt rehabilitation options along with the concrete pavement option. The existing pavement structure and variable quality of the in-situ materials, along with the observed distresses (most notably the severe rutting), were considered when evaluating pavement rehabilitation options. The following criteria were also taken into consideration when evaluating options:

- The intersection needed to retain its urban cross-section with curb and gutter sub-drainage system following rehabilitation;
- Rehabilitation strategies that resulted in a minor grade raise were suitable, provided the curb face was still available to support positive drainage;
- Minimizing the extent of removal of existing pavement materials off site in line with the Region's desire to minimize waste generation and maximize sustainability.

Based on these constraints, the following options were considered:

1. Flexible pavement overlay
2. Full Depth Reclamation (FDR) and placement of new granular materials and hot mix asphalt
3. Full depth asphalt removal and partial depth granular removal and re-pave
4. Rigid (concrete) pavement construction

The severe rutting distresses observed in the pavement were considered to be occurring mainly in the asphalt binder courses. Therefore, an asphalt overlay would not prevent future rutting, nor would an overlay strategy address the structural deficiency, given the grade raise constraints.

An FDR or pulverizing strategy would have permitted an improvement in the pavement structure and would remove all existing asphalt distresses; however, it would have resulted in a significant grade raise, and as such was not considered feasible.

Full depth removal of the existing asphalt and partial depth removal of the existing granular base, followed by replacement with new granular base and three lifts of new asphalt, would provide a rehabilitated pavement with a 20-year design life. The existing granular subbase thickness would still be deficient, however this strategy would remove all existing rut-prone asphalt and permit placement of new high stability, rut-resistant mixes. This strategy could be achieved without a grade raise and would have addressed the existing pavement distresses. In addition, the new granular base would improve site drainage and with the selection of appropriate asphalt mixes would also address the historic rutting problems.

A rigid concrete pavement design alternative to replace the conventional asphalt design was evaluated which would eliminate the rutting and maintain the exiting grades. This option was ideal to address the slow moving/turning and frequent stopping/starting of the heavy truck and bus traffic.

Initial construction cost, life cycle cost and constructability comparisons were made of the two viable options, namely asphalt and partial granular base removal and replacement with new materials, and the concrete pavement option. Although the initial construction cost of concrete was more than the asphalt option, the life cycle cost over a 30-year analysis period demonstrated that in this instance, the concrete option provided better value for money considering maintenance costs, lower maintenance interventions and level of service.

Based on a detailed review of the alternatives and considering the history of pavement performance problems at this intersection, the Region selected the rigid pavement design alternative for this contract.

4.3 Concrete pavement design

The American Concrete Pavement Association's (ACPA's) StreetPave 12 Software was used for the design of the concrete pavement section. StreetPave 12 is recognized software used throughout North America for concrete pavement thickness designs on municipal roadways.

The design parameters selected to carry out the rigid pavement concrete design analysis are presented in Table 3.

Table 3 StreetPave rigid pavement design parameters

Design Years	**20 Years**
ESALs – Harwood Avenue (20 Year Design Life)	1.26 Million
ESALs – Bayly Street (20 Year Design Life)	3.15 Million
GLOBAL DESIGN DETAILS	
Terminal Serviceability Index	2.2
Desired Reliability	85%
Estimated Elastic Modulus for Subgrade Soil (MPa)	25
CONCRETE DESIGN DETAILS	
Percent of Slabs Cracked at End of Design Life	15%
Composite Modulus of Subgrade Reaction – Harwood Street	78 MPa/m
Composite Modulus of Subgrade Reaction – Bayly Street	90 MPa/m
28-Day Flexural Strength	4.2 MPa
Modulus of Elasticity	28,350 MPa
Macrofibres in Concrete	No
Edge Support – Tied curb and gutter	Yes

In addition to the design parameters summarized in Table 3, the following additional design and construction considerations were also incorporated into the design solution:

- Tie bars to be installed along all abutting curbs;
- Load transfer devices installed at all transverse joints;
- Transverse joints to be provided with joint spacing at regular intervals;
- As far as possible, the joints were to be laid out to form approximately square concrete panels;
- To minimize cracking, all joints were to be cut as soon as the concrete reached a non-plastic state;

- Longitudinal joints to be cut to one-third of the pavement thickness and transverse joints cut to one-quarter of the pavement thickness;
- For sealed joints, joint sealants should be capable of withstanding repeated extension and compression compatible with the joint spacing and the sealant reservoir dimensions were specified; and
- The concrete surface was to have a standard broom or tined finish to provide adequate frictional resistance.

After evaluating various designs using the StreetPave software, the final rigid pavement design for the intersection reconstruction was as follows:

- 200 mm Jointed Plain 32MPa Concrete Pavement (M_R = 5,000 kPa)
- 100 mm Granular A Base
- Existing prepared and compacted granular base

5 DETAILED DESIGN

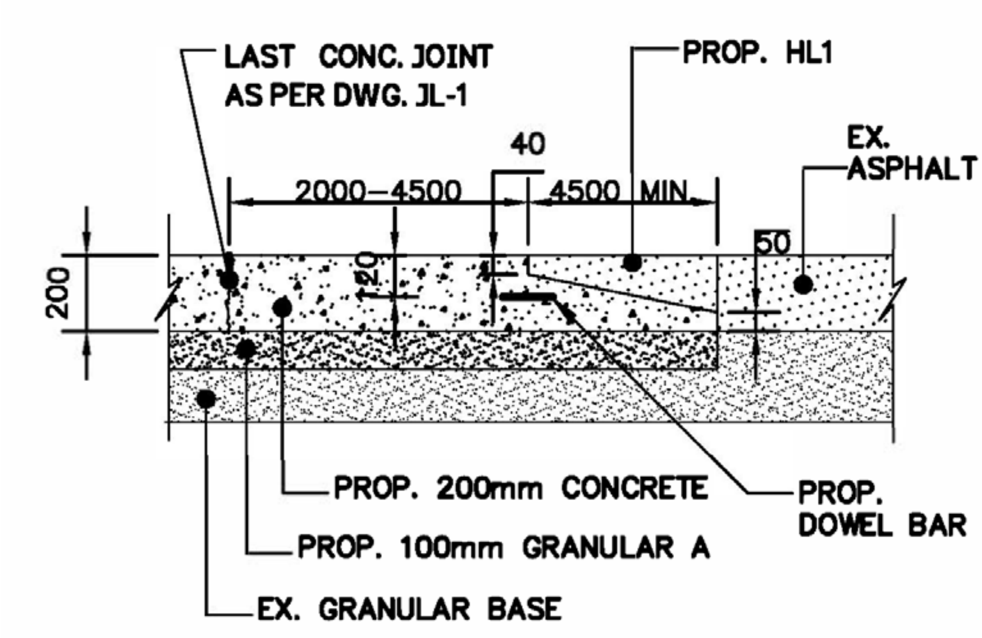
The intersection design drawings and contract specifications were prepared by Durham Region transportation design staff. Based on recommendations provided by the geotechnical engineer, and with input from Concrete Ontario and the CAC, the design included the full-depth removal of existing asphalt pavement (+/-150-250mm thick), placement and compaction of 100mm of Granular A and paving of 200mm of 32MPa Portland Cement Concrete. It is important that concrete pavement is constructed on a solid, well-draining compacted granular base to provide uniform support and reduce the potential for standing water and frost heave [3]. The pavement design included the use of deformed tie bars and smooth dowels to provide edge support and resistance to faulting and separating of the concrete slabs, as discussed further in Section 5.2. It should be noted that the concrete pavement design did not include steel reinforcement or steel fibres, based on the traffic volumes and 20-year design life.

This project also included new curb and gutter, the replacement of a deficient 300mm diameter watermain along the south half of the intersection, and the installation of new traffic signal loops.

5.1 Concrete/asphalt transition joints

At the outer limits of the concrete paving, on each approach to the intersection, special concrete-to-asphalt joints were constructed to transition between the two pavement materials. It is important to construct properly designed transition joints to prevent differential settlement and vertical faulting at the asphalt/concrete interface. The transition joint used for this project was designed with input from the ACPA [3] and includes a buried concrete impact slab that tapers down in transition to the existing asphalt. This impact slab is doweled into the concrete paving slab and is designed to provide support at the transition for vehicle loads, particularly from heavier trucks. The joint detail is shown in Figure 2 below.

Figure 2 - Concrete-to-asphalt transition joint (cross section)



5.2 Joints, dowels and tie bars

Transverse and longitudinal sawcut joints are necessary to control cracking by providing an avenue for the concrete to shrink and expand. The ACPA recommends a maximum joint spacing of 4.5m to prevent shrinkage cracks from forming between sawcuts [2]. For straightforward paving of linear highways, it is common practice for the joint layout to be left up to the contractor. However due to the complexities of the curbs and median islands at this intersection, the Region opted to include a joint layout drawing as part of the design package to ensure that the proper joint spacing was achieved and to allow contractors to more accurately bid the work. The actual joint layout did not vary significantly from the design; however minor field adjustments were required as expected to accommodate the construction staging. Proper joint construction is a critical component of concrete pavements and misplacing a joint or delaying the cut could result in uncontrolled cracking and damage to the concrete surface. For these reasons, the Region took extra effort to plan the joint layout and ensure that the contractor would be well equipped to mark and cut the joints timely and accurately.

Isolation joints and construction joints were constructed as per the MTO Concrete Pavement Joint Details (OPSD 552.010, 2008). There is industry debate over whether or not concrete pavement joints should be sealed [5] and with consideration toward future maintenance, the Region opted to construct unsealed joints. Therefore, the contraction joints were constructed as per a modified MTO detail using a 3.5mm wide cut instead of the wider 10-13mm sealed joint.

The dowel and tie bar design was driven by traffic volumes, design life and expected failure criteria. Deformed 15mm diameter epoxy-coated tie bars were installed across the longitudinal joints, which were generally sawcut along the lane lines. The tie bars, which are positioned perpendicular to the flow of traffic, serve to prevent the lateral separation of adjacent slabs. Tie bars were also used to secure the slabs to the concrete curbs, providing edge support.

Smooth 32mm diameter epoxy coated dowels were installed across the transverse joints, which were sawcut every 4.0-4.25m. The dowels, which are positioned parallel to the flow of traffic, serve to prevent vertical faulting of adjacent joints. Typical tie bar and dowel bar locations are shown in

Figure 3. Within the middle of the intersection, dowel bars were used exclusively for both longitudinal and transverse joints. Tying more than three or four adjacent slabs together can increase internal stresses and lead to cracking.

Figure 3 - Dowel and tie bar details (plan view)

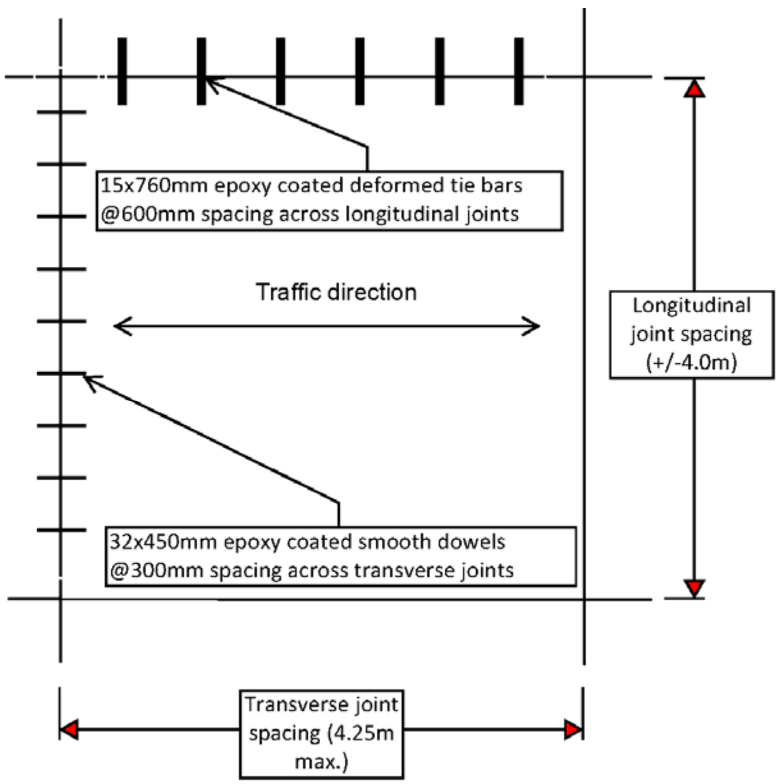


Figure 4 - Dowel baskets and tie bars in place

5.3 Pavement markings

On urban asphalt pavements throughout Durham Region, permanent pavement markings are generally applied using thermoplastic or field reacted polymeric materials. Thermoplastic materials rely on a thermal bond between the pavement marking and the pavement surface which is usually well established when placed on asphalt pavements [4]. Concrete surfaces are generally more porous and the thermal bond is therefore not as strong. For these reasons MTO does not recommend using thermoplastic materials on concrete pavements and for this project, methyl methacrylate was specified as the pavement marking material. Methyl Methacrylate is a type of field reacted polymeric material that is listed on the MTO Designated Sources of Materials (DSM) approved products list and recommended for concrete surface applications. Prior to placement of the material, the concrete surface was mechanically blast cleaned to ensure that all surface accumulations of hardened concrete layers or laitances and any trowel finishes were completely removed. Efforts were made to place the markings on the bare concrete surface with exposed upper fascia of the aggregate for optimal bonding. To improve the visibility of white markings on grey concrete, the design included a wider black marking to be placed behind the standard white lines for all cross walks and left turn skip lines.

Figure 5 - Methyl methacrylate pavement markings with black backing on new concrete

5.4 Concrete paving specifications

Since the Region did not have a standard specification for concrete paving, the MTO specification was used (OPSS 350, 1998) with some modifications to suit an urban, municipal environment. The concrete material was 32MPa Class C-2 and the paving was measured and paid per square metre of paving with the dowels and tie bars also measured and paid per square metre of paving. The contractor determined the number of dowels and tie bars required based on the joint layout drawing and the joint details provided in the contract drawings.

6 CONSTRUCTION

6.1 Staging and traffic control

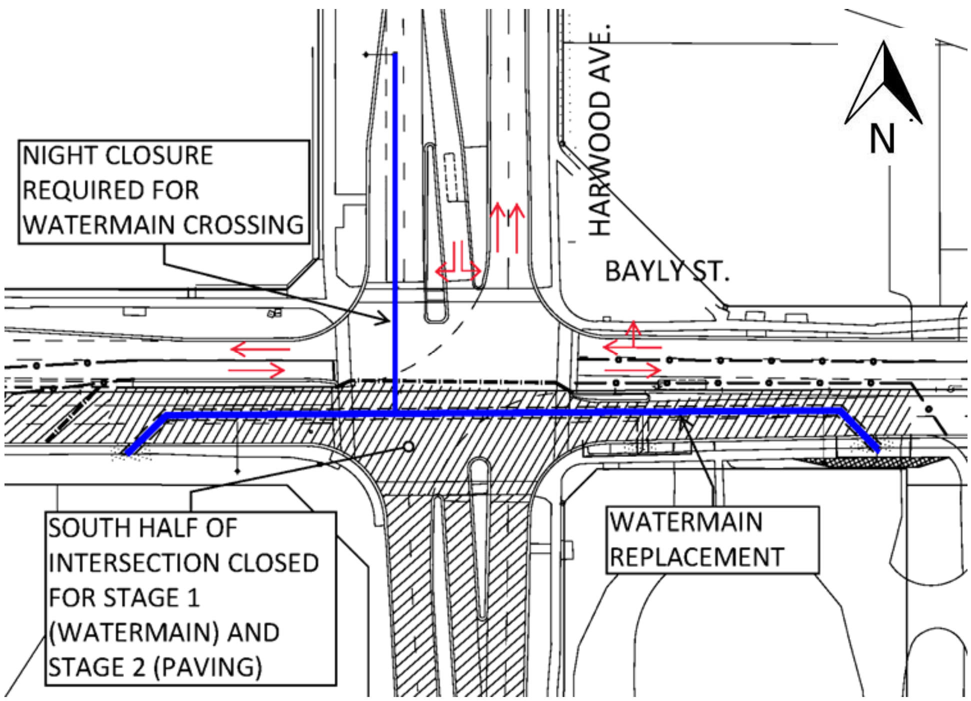
Due to the nature of the work, in particular the 200m long watermain replacement along Bayly Street, it was anticipated that the intersection would be closed in stages to facilitate construction. The Region considered closing the intersection in quadrants and completing the work in four stages. However, quadrant construction was not considered feasible since the watermain replacement would span three of the quadrants and should be completed in a continuous operation for efficiency. It was decided to close the intersection in halves (north/south) to provide more room for the contractor and allow for more efficient construction.

Bayly Street was reduced to one lane in each direction through the intersection and traffic was shifted north or south to accommodate the construction stages, with one leg of Harwood Avenue being closed for each stage. The Region prepared detailed construction staging plans as part of the contract drawing package and provided guidance in the contract documents with respect to lane restrictions and peak traffic times. The three stages are described below.

6.1.1 South half - Watermain works (Stage 1) and paving (Stage 2)

Stage 1 consisted of asphalt pavement removals and the watermain replacement along the eastbound lanes of Bayly Street. To provide a safe working area, the south leg of Harwood Avenue was closed to traffic in both directions. Traffic on Bayly Street was shifted to the north and reduced to a single lane in each direction; left turns onto Harwood Avenue were prohibited. Existing asphalt pavement was removed within the work area and the 300mm diameter watermain replacement was completed. A full closure of the intersection was required for one night to construct a section of watermain across the intersection and up Harwood Avenue. Stage 1 took approximately 2 weeks to complete.

Figure 6 - Stage 1 and Stage 2 closures



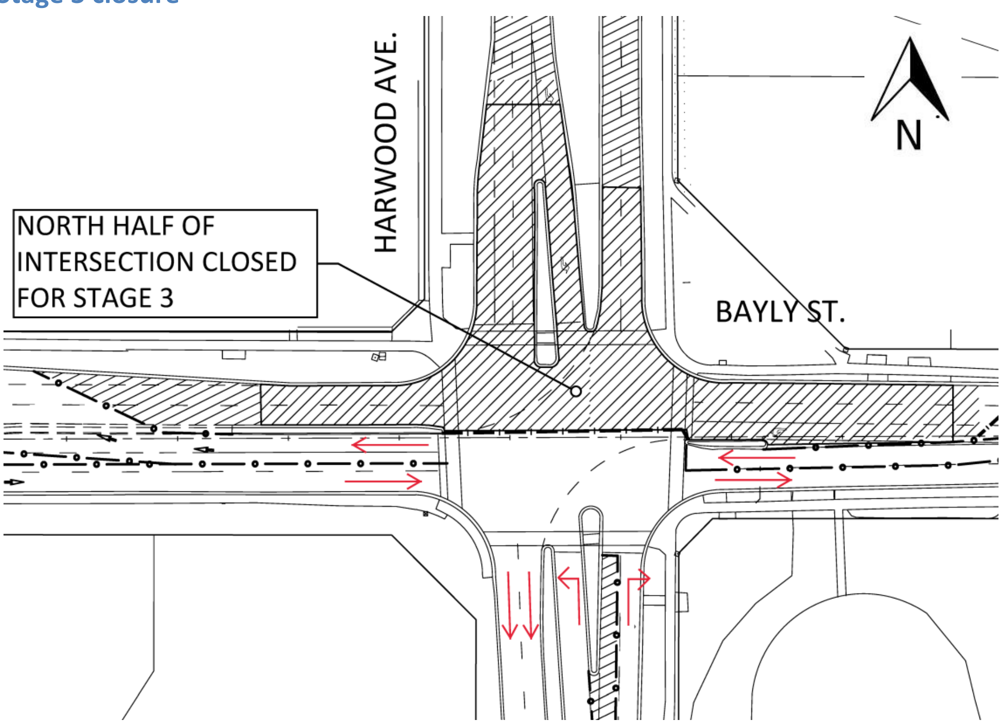
Stage 2 maintained the same partial intersection closure for the road works in the south half of the intersection. After removal of the existing asphalt and curb, the underlying granular material was proof rolled and new Granular A was placed and compacted. The preformed traffic loops were placed on the new granular base and the dowel baskets and tie bars were laid out along the proposed joint locations. For the paving operations, the contractor opted to use fixed forms and a vibratory roller screed paver. Strategic sequencing of the concrete slab construction minimized the total number of pour-days by ensuring that adjacent slabs were cured in time to serve as formwork for new pours. This saved time and allowed the contractor to efficiently work around the slotted left turn lanes and median islands. Once the concrete paving was completed, curing compound was applied immediately and the joints were sawcut within the first two hours of curing using early-entry saws. Following the concrete paving, the new curbs were constructed. Since the pavement was connected to the new curbs with tie bars, the sawcuts in the curb were aligned with the sawcut locations in the concrete pavement to prevent uncontrolled cracking. Stage 2 took approximately one month to complete.

Figure 7 - Stage 2 paving

6.1.2 North half - paving (Stage 3)

After completion of Stage 2, the south leg of Harwood Avenue was opened to traffic and Bayly Street traffic was shifted onto the south side of the intersection. The north leg of Harwood Avenue was closed and the road works for the north half of the intersection were completed. Concrete paving was then completed in a similar fashion to Stage 2.

Figure 8 - Stage 3 closure



As discussed in Section 4.2, a conventional asphalt pavement design would have required full depth replacement of the existing asphalt and partial depth replacement of the underlying granular material. Asphalt pavement reconstruction, paired with the watermain replacement and the curb reconstruction, would have required similar lane restrictions and a partial intersection closure.

Figure 9 - Vibratory roller screed

Figure 10 - Curing compound

7 UNIVERSITY OF WATERLOO STUDY

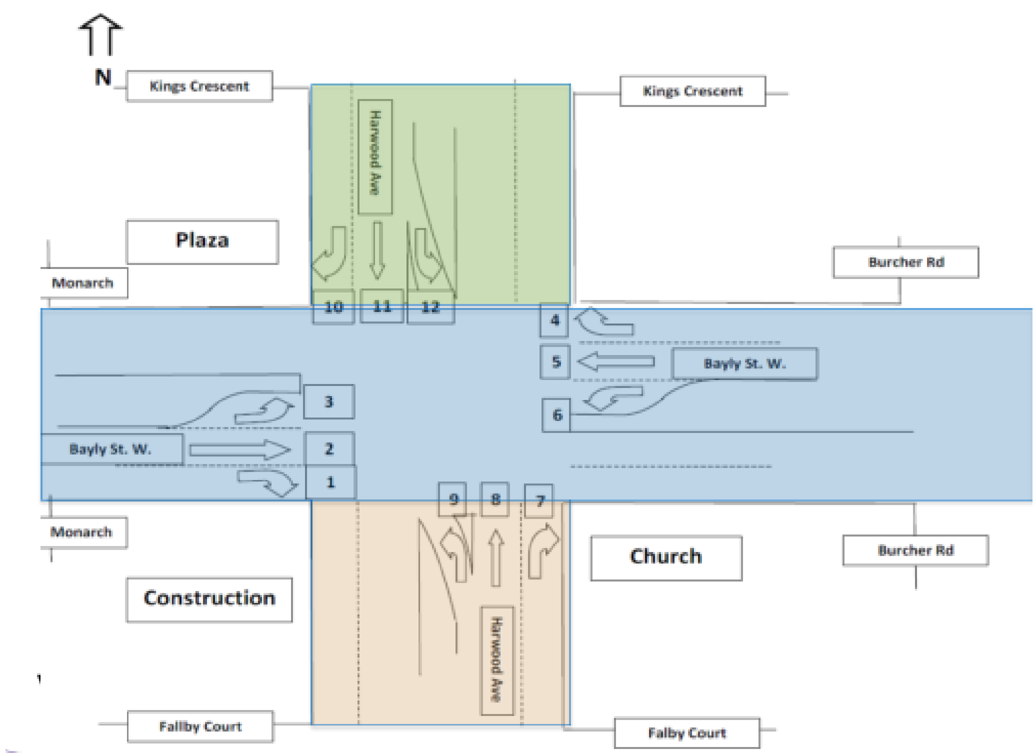
The Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo completed a traffic impact assessment during construction of the concrete intersection. The study comprised several field assessments to evaluate traffic flow through the work zone.

To assess the impact of construction on traffic flow and to optimize traffic management at the site, driving tests were conducted during the 3 stages of construction for 12 possible routes with 5 times of driving on each route. The different Stages were considered as follows:

Stage 1: Aug 3-Aug 15, 2016
Stage 2: Aug 15- Sep 12, 2016
Stage 3: After Sep 12, 2016 and onward

The tested 12 routes cover all the possible directions at the intersection as shown in Figure 11.

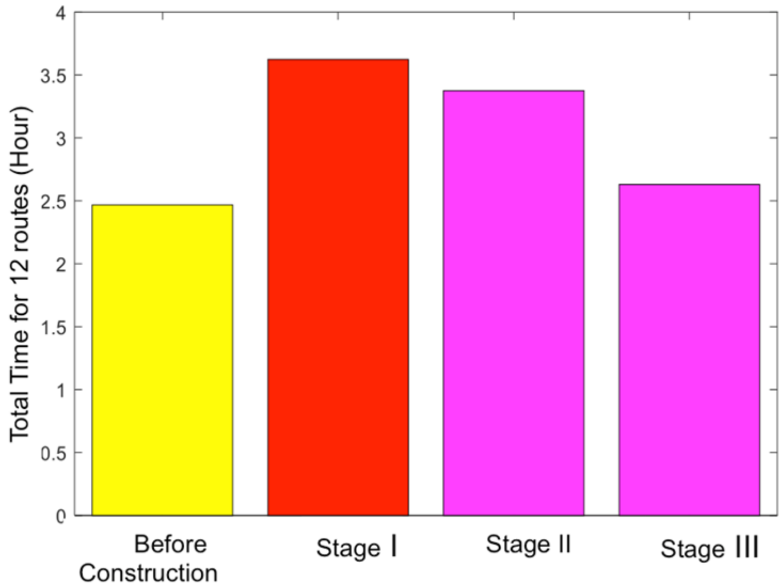
Figure 11 - Tested routes at the intersection



The cumulated travel time for all the 12 routes was plotted as shown in Figure 11. The most significant traffic delay was found to be in Stage 1, the watermain reconstruction along Bayly Street and north leg of Harwood Avenue, as expected due to the following reasons:

1. Works in Stage 1 cover signal works, removing the existing pavement, excavating and installing watermain.
2. It takes time for roadway users to get used to the traffic detour plan.

Figure 12 - Cumulated travel time for all the tested routes at different stages



7.1 Challenges for traffic control

7.1.1 Prohibited left turns

Left turns were prohibited during construction to facilitate traffic flow through the intersection. Left turns were made at almost every route although "No left turn" was in place as shown in Figure 13. These prohibited left turns not only delayed the traffic, but also posed a safety concern for workers, pedestrians and other vehicles.

Figure 13 "No left turn" sign and left turns

7.1.2 Right turns run over the curb

To facilitate the watermain construction, the southbound right turn lane on Harwood Avenue was closed in Stage 1. A temporary right turn lane was designated in the southbound slotted left turn lane as shown in Figure 14. Due to the geometry of the existing median island, a number of right turns were observed to run over the curb. An appropriate warning sign or temporary asphalt ramping may have prevented cars and trucks from running over the curb.

Figure 14 - Marks on the median island due to right turning vehicles

7.1.3 Traffic camera

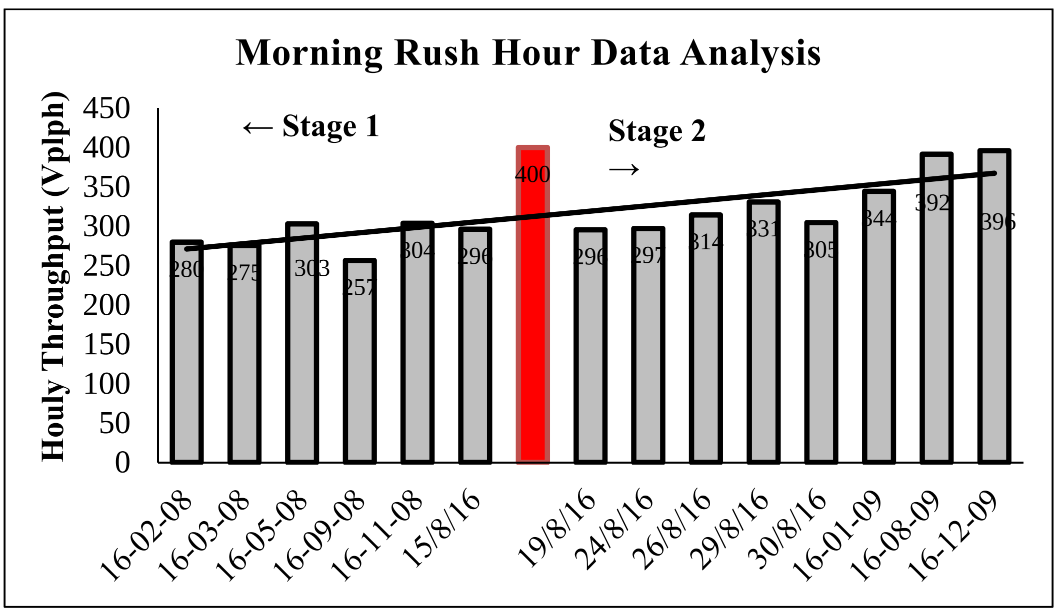
As shown in Figure 15, the existing traffic signal camera was used to record construction sequences and traffic flow over the course of the project. The majority of the construction works were captured on video and all traffic movement through the site was also recorded. Following completion of the project, the video was spliced and sped up to provide a time-lapsed video of the construction works. The traffic data was ultimately used to determine the impact of construction and lane closures on traffic, which is described in the following section.

Figure 15 Traffic camera installed

7.1.4 Traffic data analysis

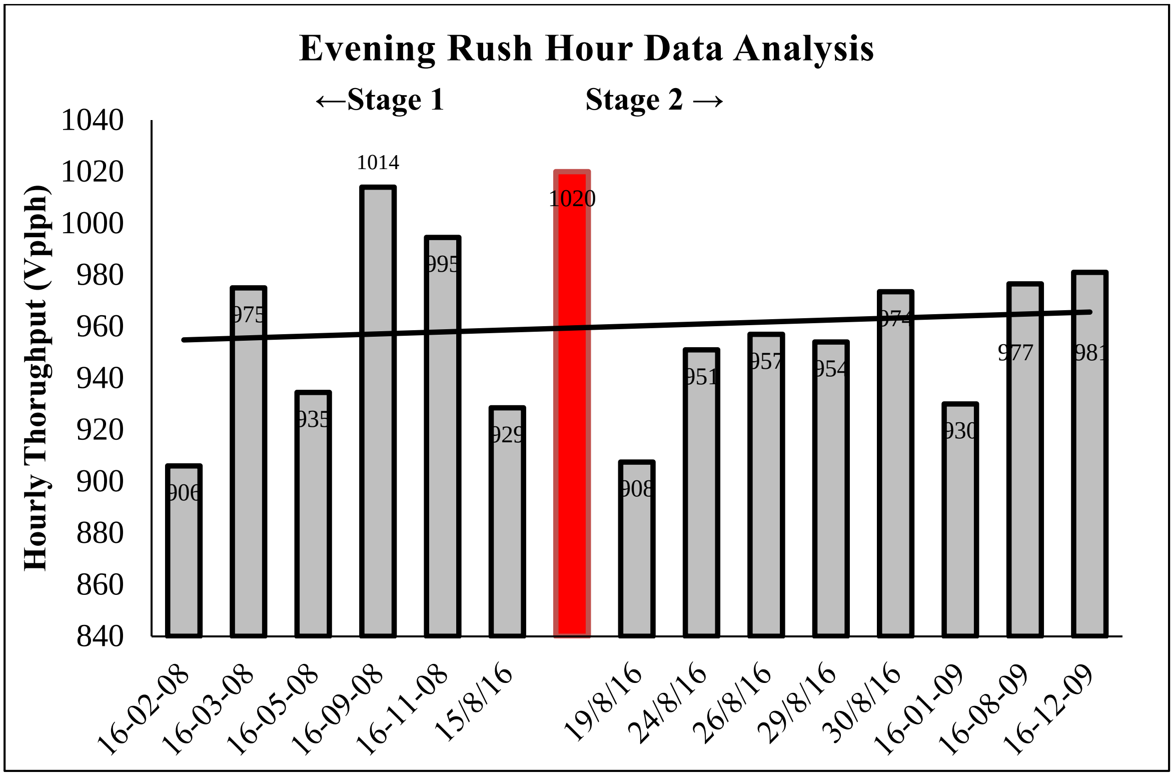
From the available videos, 6 days from Stage 1 and 8 days from Stage 2 were randomly chosen for traffic flow calculation and to determine if there was any trend of change in traffic flow depending on the road closures in different Stages. The actual hourly traffic throughput was calculated from the recorded videos for morning rush hour and evening rush hour on the chosen dates. Figure 16 and 17 present the hourly throughput in Stage 1 and Stage 2 in the morning rush hour and evening rush hour respectively.

Figure 16 - Morning rush hour traffic throughput in Stage 1 and Stage 2



As demonstrated in Figure 16, an increasing trend in number of throughput was observed from the beginning of Stage 1 until the end of Stage 2 especially in the morning rush hour. The possible reason might be during the Stage 2, this route was favorable to many drivers, which increases the throughput value.

Figure 17 - Evening rush hour traffic throughput in Stage 1 and Stage 2



A significant difference was captured between morning throughput and evening throughput. Evening throughput was much higher than morning throughput in both Stage 1 and Stage 2.

8 LESSONS LEARNED AND FUTURE STEPS

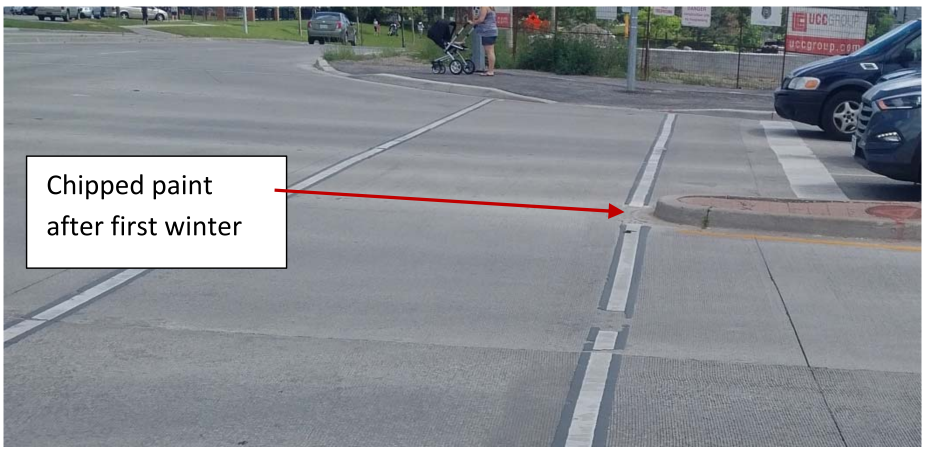
The physical constraints of this urban intersection provided limitations on the size of the paving equipment and the method of construction. Unlike conventional concrete paving for highway construction, the contractor did not have room to operate and manoeuver a large slip-form paver. With only +/-4m of clear width between curbs in the slotted left turn lanes, the contractor opted to use fixed forms and a vibratory screed roller which allowed for more mobility and smaller equipment staging areas. For projects where the existing curb is to remain, other equipment may be required to ensure that the new concrete pavement can abut up to the existing curb.

Like any paving operation, concrete paving may be more efficient in situations where the road or intersection can be closed or partially closed as was done for this project. One advantage of concrete paving is that it could be placed earlier in the year prior to asphalt plants opening, and at night with less concern for lower ambient temperatures.

It is anticipated that utility cuts and repairs to buried services will be required at this intersection at some point in the future. Reinstatement of the concrete pavement following these works should be properly performed to reduce the potential for differential settlement and pavement failure. The Region is working to produce standard guidelines for utility cuts through concrete pavement and reinstatement following excavations for buried services.

The white-on-black methyl methacrylate pavement markings discussed in Section 5.3 were thicker than a single layer or thermoplastic that the Region typically uses. These thicker markings may not hold up as well over time (especially from snow plow wear) and may need to be reapplied more often.

Figure 18 - Cross walk pavement markings (photo from 2017)



Construction was originally planned to occur during the summer months while school was out. Scheduling delays caused the work to continue into the school year and so pedestrian volumes were higher than anticipated. Additional crossing guards were utilized to facilitate pedestrian crossing through the intersection and around the construction area. As shown in Figure 19, concrete barriers were installed to provide better protection for pedestrians than the traffic barrels that were originally implemented.

Figure 19 Traffic cones vs. concrete barriers

The Region along with researchers at the Centre for Pavement and Transportation Technology at the University of Waterloo will continue to monitor the performance of the pavement at this intersection over time. In addition, modelling associated with the traffic construction closures will be evaluated.

In addition to the lower long term maintenance costs of concrete, there is a cost benefit to encouraging competition between the asphalt and concrete industries. The Region will continue to explore the use of concrete pavement designs on future projects, where appropriate.

9 ACKNOWLEDGEMENTS

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