North Bay Twenty Years Later – A Case Study of Proper Design and Construction of Interlocking Concrete Pavement

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Paper prepared for presentation

at the "Long-Life Pavements – Contributing to Canada's Infrastructure" Session

of the 2003 Annual Conference of the
Transportation Association of Canada
St. John's, Newfoundland and Labrador

Abstract

In 1983, North Bay, Ontario completed construction of over 14,000 square meters (150,000 sq. ft.) of interlocking concrete pavement on a one-kilometre section of downtown Main Street. The project, affectionately known as 'The Big Dig' was completed in seven months of construction at a cost of $3,300,000 (1983$). Based upon a twenty-year design life and an expected traffic volume of 8000 vehicles per day with 5% delivery trucks and buses, the pavement has now reached the intended design life. In addition to these traffic volumes, the pavement is subjected to very severe weather conditions, ranging from - 40 C in the winter to 35 C in the summer.

After 20 years, the pavement continues to perform exceptionally well and there are very minimal signs of distress. Maintenance of the pavement has been virtually non-existent. It is quite possible that the interlocking concrete pavers will perform quite adequately for at least another 20 years. Since the Downtown was renovated, the city has continued to use pavers in public places such as sidewalks, boulevards, and waterfront promenades. Interlocking concrete pavements have not only contributed to a better structural pavement performance, but have been instrumental to the Downtown revitalization of North Bay.

This paper will discuss the original pavement design, pavement evaluation and condition surveys performed in 1991 and 1999, maintenance, and a life cycle cost analysis performed in 2000. The paper will also key on the important lessons learned.

Introduction

More and more, Canadian cities and municipalities are beginning to recognize the asset value of their pavements and the need to protect their investment. As a result, the search for "long life" pavement alternatives is now beginning to be more of a focus for public works and engineering departments. In 1982, the City of North Bay decided to renovate their city centre and expressed an interest for different pavement alternatives. The guiding principles behind the selection of the pavement included 1) speed of construction to minimize interference with business, 2) maintenance of vehicular and pedestrian accesses during construction, and 3) creating an image that would attract more downtown shoppers.

Concrete pavers achieved these criteria, but more importantly, have proven to be a superior choice in terms of maintenance and overall life cycle costs. Since it's construction in 1983, two condition surveys have been completed on the interlocking concrete pavements in North Bay. A study completed in 1991 (1) concluded that the pavements were structurally equivalent to asphalt pavements and showed very little evidence of distress. Another study performed in 1999 (2) again showed little evidence of pavement distress, and moreover demonstrated through lifecycle cost analysis that the cost of interlocking concrete pavement was less than the local experience with asphalt pavements.

Project Site

The reconstruction of Main Street covers an area of 13,935 m^2 (150,000 ft^2), including sidewalks and roadways. In total, it extends just over 1 km (3300 ft). Figure I shows a plan view of the installation along Main Street extending from Sherbrooke Street to Cassells Street and Figure II shows the site before construction in 1982. As part of this major reconstruction, all underground services were replaced and a completely new streetscape was constructed on the full width of the 66' (20.2m) road allowance, which had buildings immediately abutting the property line throughout the entire length of the project.

Figure III is a view of the completed work in 1983. While the two-way traffic on Main Street is approximately 8,000 vehicles per day, the intersection of Algonquin and Main Streets sees approximately 13,000 vehicles per day. Approximately 5% of the traffic consists of buses and trucks. The pavements in North Bay are subjected to severe weather conditions with temperatures ranging from – 40 C to + 35 C. In addition, North Bay receives an average of 990 mm of precipitation each year, and Main Street itself receives approximately 270 tonnes of a rock salt/sand mixture each year (See Figure IV).

Initial Design and Construction

Reconstruction started on Main Street in April of 1983 and was completed in early-November of the same year. The pavement cross-section (See Table I) included 80 mm (3-1/8 inch) thick pavers over 30 mm (1-1/4 inch) bedding sand, 150 mm (6 inch) granular base and 200 mm (8 inch) granular sub base. The base material used was a typical Ontario Granular "A" and the sub base a typical Granular "B", both compacted to 100% modified proctor density. The subgrade soil is a well-drained sandy soil with a design California Bearing Ratio of 10 to 12%.

Substantial rock excavation was encountered over approximately 25% of the project length. Sub-drains were utilized in some locations and surface water was designed to flow to catch basins and storm sewers. The pavers were laid in a 45-degree herringbone pattern (See Figure V) except for cross walks where a running bond was used. The herringbone pattern is the recommended laying pattern for vehicular applications to minimize lateral creep of the pavers. A slight crown in the road for drainage also contributed to interlock, strengthening the pavement as the pavers settled slightly over time from traffic loads.

Edge restraint for the pavement consisted of standard concrete curb and gutter in the longitudinal direction and a 200 mm wide concrete curb laterally at the pedestrian crosswalks. A soldier course pattern was also integrated at some of the pavement edges. The joints between the pavers were filled with fine-graded mortar sand (See Figure VI) as per industry recommendations (3).

1991 Performance Evaluation and Condition Survey

Approximately 8 years after the project completion PCS/Law Consulting Engineers conducted a detailed condition survey along with non-destructive deflection testing. For the deflection testing, a Dynatest model 8002 falling weight deflectometer (FWD) was used to determine the structural capacity of the pavements. This is a trailer-mounted device (See figure VII) capable of applying impulse loads from 13 to 134 KN (3,000 to 30,000 pounds). For this study, however, deflection tests were conducted using nominal impulse loads of 22 to 40 kN.

Back calculation of the deflection testing to determine the pavement layer moduli (See Table II) was done by computer simulation with a program called MODULUS (4). This deflection testing determined that the pavement was stiffer in the intersections than in the streets. This is likely due to the higher traffic volumes and the higher degree of crowning at those locations. Particularly at the intersections, the PCS Law report concludes that full stiffening had most likely already occurred in the pavement. Progressive stiffening (5) is a concept in interlocking concrete pavements that has been noted in many research studies and discussion is not included in this paper. As a result of the progressive stiffening, the intersections showed paver and sand layer moduli very similar to other hot mix asphalt sections tested in North Bay. It was noted that the asphalt moduli were not temperature corrected and would have actually showed a weakening of the load spreading ability of the asphalt if this were the case.

The report also assessed the structural capacity of the pavements using the AASHTO flexible pavement design method (6). Using a terminable serviceability of 2.5 and reliabilities, R, of 50, 85 and 95%, along with the back-calculated layer moduli noted above, a structural number (SN) was determined. Equivalent axle loads to failure were then determined (See Table III).

It is interesting that the report by PCS/Law rightly noted that the structural capacities derived from the FWD testing represent a single point in time. Because of this, it was cautiously noted at the time of the study (8 years) that if the current traffic trends were to continue (10,000 to 20,000 EALS per year), the remaining structural life was predicted to be in excess of 20 years. We now know this to be true, and in fact North Bay Public Works confirms that the pavements are expected to be serviceable for another 15-20 years with only minimal maintenance anticipated.

The pavement condition survey conducted by PCS/Law identified several distress types and the total area affected by each distress type. A total of 5350 m^2 of pavement area was randomly sampled. Table IV shows the results. 230 rut depth measurements were taken from the curb to the centreline along Main Street. The average rut depths were 6mm and are not categorized as severe. It was also noted in the study that the depressions reported (4%) are somewhat misleading since they all occurred in one location or sample unit. Indeed, North Bay Public Works confirmed that this area had been excavated in order to access underground utilities, but the pavers were not re-instated as per industry recommendations (7). In addition, the corner edge spalling was possibly due to incomplete joint filling in one section of pavement that resulted in the pavers losing interlock and the corners touching during traffic loads.

2000 Condition Survey and Life Cycle Cost Analysis

At a pavement age of 16 years, in December 1999, John Emery Geotechnical Engineers (JEGEL) performed another condition survey as well as a life cycle cost analysis on Main Street. In the absence of standardized distress criteria for segmental concrete pavement street applications, Appendix D of the Interlocking Concrete Pavement Institute (ICPI) *Airfield Pavement Design with Concrete Pavers (Canadian Edition)* (8) was used. Four randomly selected areas were used to evaluate surface distress types and the extent of the severity. These areas ranged from 400 to 567 m^2. A control section of hot mix asphalt pavement was also evaluated. Table V is a summary of the results of the condition survey at 16 years.

Low severity rutting was noted as the predominant distress type in 8 to 13 percent of the areas in question. It was also noted that the rutting was more severe (8 mm) in the outer wheel path compared to the inner wheel path (4mm). However, the inside wheel path rutting in 3 of the 4 areas above does not qualify as rutting according to the ICPI pavement design manual since it is less than 6mm. In addition, the rutting was determined to be a combination of abrasive wearing of the pavers and shear deformation in the base/subbase and/or the subgrade. At 20 years Public Works confirms the chamfer wear on the pavers in the wheel path as significant, but of no major concern. It would, however, be an interesting check to determine thickness of wearing surface that actually remains. As mentioned earlier, the City of North Bay uses a considerable amount of 100% road salt or sand (mixed with 5% salt) for deicing the streets and sidewalks during the winter season. This may be a partial explanation for the concrete wear on the pavers in the wheel paths.

The other distress observed on Main Street was low severity (2 to 3 mm) loss of joint sand. This loss of sand, observed on 3 of the 4 sections surveyed, occurs only in the wheel paths and is probably due to suction created by vehicular tires traveling over the pavement surface. This phenomenon has been confirmed in other segmental pavement research (9).

JEGEL concluded that the pavement condition indexes (PCI) for these four interlocking concrete pavement sections averaged approximately 70. The PCI values were established by the use of the American Public Works Association (APWA) "PAVER" procedures with some adaptation for interlocking pavements (by JEGEL). A 40-year model was used for the concrete paver lifecycle cost analysis whereby rehabilitation would be required at Year 21, in order to maintain a pavement PCI of 60. No other rehabilitation was modeled after that time period. The rehabilitation in the model consisted of replacement of the worn/rutted pavers in a section of 500 mm of outside wheel path for each lane, and included correcting the granular base. North Bay Public Works confirms that some minor rehabilitation is indeed planned at year 21 or 22 in a short section of the first block that was constructed and where there was a known problem with the joint sand.

For a life-cycle cost comparison, a typical asphalt street model for Northern Ontario was used. To maintain a minimum PCI of 60, rehabilitation would correspond to year's 18, 27 and 36 on a 40-year life cycle model. In the model used, the schedule of maintenance and rehabilitation for the typical North Bay asphalt concrete pavement included a 40/50 mm mill/overlay at 18 years, a 90/100 mm mill/overlay at 27 years, and 36-year mill/overlay of 40/50 mm. Periodic routing, sealing, and patching were also included.

The results of the lifecycle costing comparison are shown in Table VI. At a 4% discount rate (corresponding to a secure investment of 6% and inflation of 2%), interlocking concrete pavements are more cost-effective than asphalt pavements. The study also notes, however, that user delay costs were not included in this study. User delay costs reflect the costs to the public in terms of down-time from routine maintenance and repairs. Interlocking concrete pavements can have a significant benefit in terms of reduction of user delay costs since traffic can be restored very quickly compared to alternative pavements and also since there is less scheduled down-time due to less frequent maintenance.

Why Did the City of North Bay Choose Interlocking Concrete Pavers?

The project design team consisted of a landscape architect firm, consulting engineers, City staff and representatives of the Downtown Improvement Area. David Cram & Associates of London, Ontario was the landscape architect and their role related almost entirely to the streetscape. The firm's principal, Mr. David Cram, and his firm, recommended the utilization of interlocking concrete pavers for both the sidewalk and roadway areas.

The City's landscape architect and other Ontario municipalities had very minimal previous experience with interlocking concrete pavers in a full City roadway application. The project's landscape architect nevertheless felt that the goal of transforming the City's dated Downtown appearance needed the impact of a new and more people friendly scale and appearance (See Figure VIII). As part of the transformation, approximately 50% of the on-street parking was recommended for removal and this area was replaced by wider sidewalks, boulevard areas and the addition of trees and planting areas along with additional benches, underground wiring and new street light poles and fixtures.

At the time, the City's Engineering and Public Works Departments were very concerned that this pavement surface had not been adequately proven anywhere else in Ontario or Canada. A primary concern was the performance of the concrete pavers in terms of withstanding the severe frost conditions, which can reach depths of 8' (2.4m), along with the aggressive use of road salt for de-icing. The only experience the City of North Bay had with interlocking concrete pavers was in the extensive public areas surrounding the City's new City Hall (1978) but these areas were not subject to any vehicular traffic.

During the winter months, the City of North Bay Public Works Department uses underbody slushers as well as conventional motor graders and snow plows to clear the considerable snowfall that is received each year. The City uses carbide steel blades on their slushers, graders and plows and there was considerable concern that these blades would chip or break the interlocking pavers.

A full day seminar – *Paving Stone 83*, was held in Toronto in January 1983 – an event jointly sponsored by the Canadian Portland Cement Association (now Cement Association of Canada) and the Ontario Interlocking Concrete Paver Association (now ICPI). This seminar was attended by the City's Project Engineer, Brian R. Baker, P. Eng. and he heard from four world leaders in the utilization of paving stones; Dr. Brian Shackel and C. F. Morrish of Australia, Alan A. Lilley from England and H. Van Leeuwen of The Netherlands (Holland). These speakers made convincing presentations on the extensive research that was ongoing in Australia, South Africa, England and Europe. In addition, their discussions of the various successes around the world with major projects such as container ports, airports as well as roadways convinced the City's Project Engineer that this technology, with proper design, manufacture and installation would withstand the rigours of a heavily trafficked Northern Ontario Main Street.

A recommendation was subsequently made to endorse the landscape architect's proposal for a complete surface utilizing interlocking concrete pavers in both the roadway and sidewalk. The roadway pavers were 80mm thick and were laid in a herringbone pattern. The paver shape was, at that time, called Type 1, which are wavy edged in shape (See figure V). The paver thickness, shape and laying pattern were selected based upon the expert advice provided at the *Paving Stone 83* Seminar. Other key engineering recommendations from the seminar included the need for proper drainage, compaction of the granular base to specification, proper edge restraint and the importance of using a concrete paver manufactured to high standards, particularly to resist freeze-thaw cycles in a salt-laden environment.

Lessons Learned

There were several key lessons learned during the construction portion of the project. The first problem encountered was the cut faces of the roadway pavers at the interface with the concrete gutter. This was also a problem at the interface where the sidewalk pavers met the back of the concrete curb and gutter (or the concrete edge strip) that ran along the frontage of each building. The contractor initially used standard mechanical shear cutters that did not provide a square and uniform face to abut with the concrete edge strips. The contractor was then required to employ diamond blade saws, which gave an excellent tight fitting surface.

The second identified problem was the unsuitability of the joint sand. This material was not specified in the original contract tender and the sub-contractor utilized a material similar to the coarseness of the bedding sand, but more of a 'screenings' material. Within a few days of opening the first block of Main Street to traffic, the pavement quickly became unstable and many of the paver corners touched those of adjacent pavers, and broke off.

This event was terribly disconcerting and embarrassing but further investigation revealed that the joint material was too coarse and angular and the joints were plugged at the top. As a result, the material could not fully penetrate the full height of the joint and establish complete interlock. Interlock is achieved by friction created between the joint sand and the adjacent pavers. Once the paver surface was loaded there was rotational movement of the pavers and the subsequent failure noted above. Replacing the damaged pavers and re-sanding the joints with a clean, mortar sand corrected the problem. There is some minor deterioration of this same problem section 20 years later and in hindsight, it would have been preferable if the entire area of pavers had been removed and re-done with the proper joint sand.

Another problem area that was subsequently experienced was the fairly rapid deterioration of the 'soldier course' pavers in the sidewalk areas as well as the sidewalk areas in the intersections and mid-block pedestrian crossings. The landscape architect desired a 'soldier course' (on each side of the sidewalk) to be a darker brown in colour, in order to distinguish the edge from the lighter tan colour of the sidewalk. A 'mini-cobble' paver was also specified as the 'soldier course' in the 60mm thick non-roadway sidewalk areas.

The 'soldier course' pavers were not available from the supplier of the roadway and sidewalk pavers, whose pavers met the requirements of CSA A231.2 *Concrete Pavers*. The dark brown 'mini-cobble' paver and dark brown standard paver that were subsequently provided for these soldier courses were not in accordance with CSA freeze-thaw specifications. As a result, these pavers have been continually deteriorating for the past 15 years. Most of the soldier courses adjacent to the sidewalk crossings in the roadway have, or shortly will be replaced using a square, suitably sized metric paver. The mini-cobble pavers cannot be conveniently and economically replaced and this is an ongoing, but minor problem.

Drainage (both sub-surface and surface) was well designed by the engineering consultant, Northland Engineering, of North Bay, Ontario. Even 20 years later, there are no signs of surface ponding and there are no signs of frost heaving which is evident throughout most of the City's other roadways during late winter and early spring. Although there have been less than a dozen excavations in the roadway and sidewalk in the past 20 years, the Public Works maintenance staff are always quite amazed as to how very tightly the pavers are interlocked. Unfortunately, the original pavers used in 1983 were of an imperial dimension and although there was some inventory purchased, only metric sized pavers are now available and this can be a minor inconvenience to the restoration process.

Proper compaction of the granular bases was a hallmark of this project. The contractor employed numerous types of compactors in order to achieve the contract specifications, which were identical to conventional road construction. The City utilized frequent testing of the compacted grade using nuclear density machines, which gave immediate feedback as to the suitability of the compacted grade.

The utilization of cast-in-place concrete edge strips (or restraints) on both sides of the sidewalk and roadway surfaces proved to be an essential element in ensuring that the interlock surface generates the tremendous frictional forces that maintain the pavement's structural strength and integrity under years of heavy traffic loading. Although the roadway does not always have a consistent 'crowned' cross-fall (due to differing elevations on opposite sides of the street in some locations), the roadway pavement surface does form a structural arch with the opposite curbs forming the 'abutments' of the arched bridge of interlocking pavers.

In addition to the structural benefit, the back of sidewalk cast-in-place edge restraint at the building interface was beneficial both from a uniform visual appearance and with offering an easy way to set grades for the back of sidewalk (See Figure IX). The project designer's attention to detail and the flexibility of the surface elevation allowed the designers to eliminate dozens of steps and trip hazards that were previously part of the old urban landscape.

Other Revitalization Projects in North Bay

The City has made extensive use of interlocking concrete pavers in a variety of projects over the past 20 years and continues to do so, mostly in sidewalk and boulevard areas. There has been no appropriate roadway project, either municipal or residential development that has come forward in the interim, notwithstanding the excellent success exhibited by concrete interlocking pavers on the City's Main Street.

The City's award winning Waterfront Park (See Figure X) makes extensive use of concrete interlocking pavements and several of the City's recently reconstructed arterial streets (Algonquin Avenue, Cassells Street and Fisher Street) have also made widespread use of pavers for the sidewalk areas. The citizens of North Bay have certainly adopted interlocking pavers in their residences and there are a very high proportion of interlocking concrete driveways in the higher end residential subdivisions.

The View From Public Works and the General Public

Public Works staff and the general citizens were initially very sceptical about the strength and longevity of the interlock paver roadway, particularly with the harsh winters of deep frost and heavy salt use. Twenty years later, the same staff and citizens are marvelling at the longevity of the Main Street pavement surface and wondering how long the surface can continue to perform with such a high degree of strength and integrity. Initially, there were minor complaints from some women who wore spiked heels and felt that they were catching their heels in the joints, but this was a short lived complaint. Handicapped persons utilizing wheelchairs continue to praise the smoothness of the interlock sidewalks in contrast to the bumpy ride encountered with the traditional 1.5 meter (5 foot) joints found in conventional poured concrete sidewalks.

The best example of the quality of the pavement surface is to drive the roadway at night after a heavy rain. Under the low-angle of vehicle headlights, every pavement distortion is easily seen but North Bay's Main Street exhibits virtually no wheel rutting or ponding of any kind. This is truly a credit to the quality of the surface as well as the excellent design and construction of the road base and installation of high quality, CSA specified pavers.

Conclusion

Research on interlocking concrete pavements continues both in North America and Internationally. The 7th International Conference on Concrete Block Paving, a conference held every three years, is scheduled from October 12th to 15th, 2003 in Sun City, South Africa. The keynote address by Dr. Brian Shackel recognizes the growing acceptance of interlocking concrete pavements worldwide and is appropriately entitled "The Challenges of Concrete Block Paving as a Mature Technology". The conference paper themes range from Environmental/Tactile considerations to Construction, Structural Design, Performance and Maintenance, Industrial Pavements, and Material Properties. In 2006, North America and the ICPI will host the 8th International Conference.

Main Street North Bay is an excellent case study in the proper design and construction of interlocking concrete pavements. The lessons learned have been valuable to the City of North Bay and to the industry. Further, the experience in North Bay supports the consideration of interlocking concrete pavements as an alternative design method for "long-life pavements".

References

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Tables

Table I
Main Street, North Bay
Pavement Design

LAYER	THICKNESS, inches (mm)
Concrete Pavers	3.2 (80)
Bedding Sand	1.2 (30)
Granular A Base	6 (150)
Granular B Subbase	8 (200)

Table II
Average Pavement Layer Elastic Moduli
1991 – North Bay Main Street

Pavement Section	Streets	Intersections
Pavers and Bedding Sand	8568 Mpa	12, 704 Mpa
Aggregate Base and Sub base	898 Mpa	652 Mpa
Subgrade Soil	339 Mpa	407 Mpa

Table III
Summary of EALS to Failure
North Bay Main Street
Source: PCS/Law

Pavement Category	AASHTO Structural Number	EALS to Failure R=50%	EALS to Failure R=85%	EALS to Failure R=95%
Roadways	3.9	> 10 million	> 10 million	7.1 million
Intersections	3.94	> 10 million	> 10 million	> 10 million

Table IV
Summary of Visual Distress At 8 Years
North Bay Main Street

Distress Type	Percent of Area affected
Surface Irregularities	
Rutting (extreme)	0
Swell/Heave	0
Depression	4.17
Transition to utility	0.07
Transition to Curb	0.09
Paver Distress	
Corner of edge spalling	3.59
Cracked pavers	0.12
Snow plow damage	0
Joint Distress	
Deformed Joints	0.07

TABLE V
SUMMARY OF VISUAL DISTRESS SURVEY
North Bay – 16 Years
Source: JEGEL

SAMPLE UNIT	DISTRESS TYPE/SEVERITY	EXTENT (% Of Area)	REMARKS (Average Values)
Main Street – Cassells to Algonquin	Low severity rutting (both wheel paths)	13	5/16 inches (8 mm) in outside wheel path 1/4 inches (6 mm) in inside wheel path
Main Street – Fraser to Civic 170	Low severity rutting (Outside wheel path only)	8.3	5/16 inches (8 mm) in outside wheel path 1/8 inches (3 mm) in inside wheel path
	Low severity loss of joint sand	14	1/8 inches (2 to 3 mm) depth of loss
Main Street – Wyld towards Ferguson	Low severity rutting (outside wheel paths only)	8.3	1/4 inch (7 mm) in outside wheel path 1/8 inch (3 mm) in inside wheel path
	Low severity loss of joint sand in wheel paths	14	1/8 inch (2 to 3 mm) depth of loss
Algonquin Avenue – Main to Oak (Control)	Low severity longitudinal and transverse cracking.	18	
	Medium severity transverse cracking	0.1	

TABLE VI
LIFE-CYCLE COST SUMMARY
TOTAL PRESENT WORTH OF COSTS ($/Lane-Km)
(Calculations based on 40-year analysis period and 4 percent discount rate)

INTERLOCKING CONCRETE PAVEMENT COSTS			ALTERNATIVE PAVEMENT COSTS ASPHALT		
Initial $/lane-km	Maintenance $/lane-km	Total $/lane-km	Initial $/lane-km	Maintenance $/lane-km	Total $/lane-km
159,465.	9072	**168,537**	94,256	84,861	**179,117**

Figures

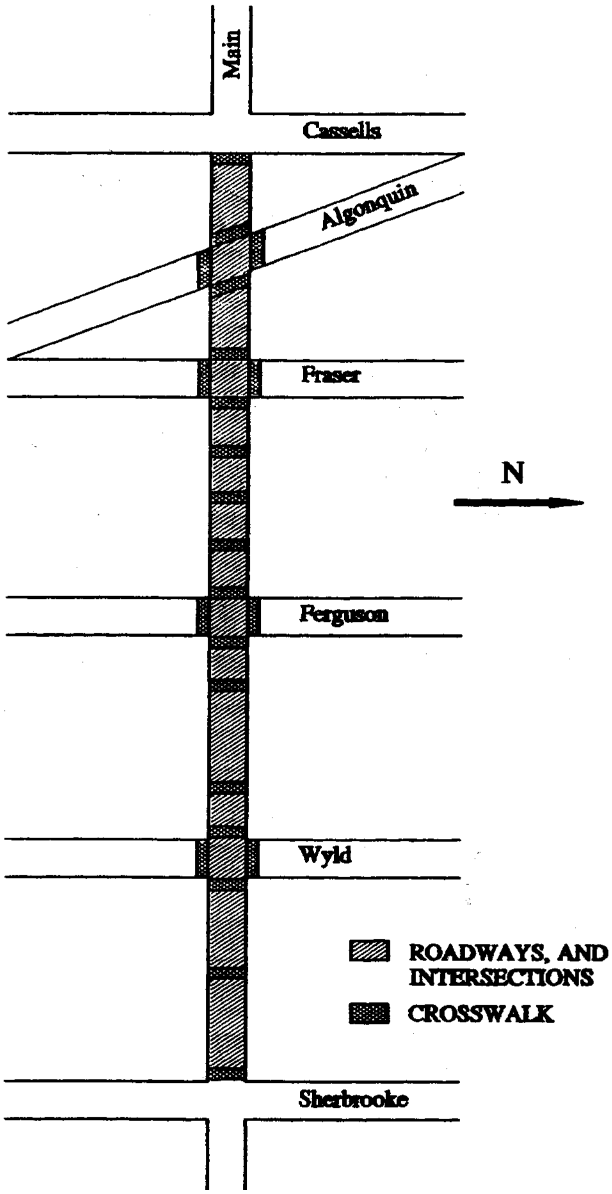

Figure I: Site layout of the reconstruction of Main Street North Bay – 1983
Source: PCS/Law Engineering

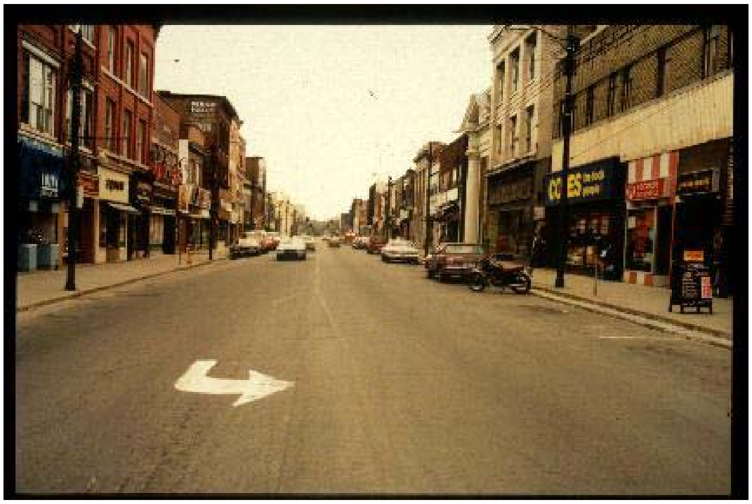

Figure II: Main Street North Bay before 1983 re-construction

Figure III: Main Street North Bay immediately after re-construction – 1983
Overhead wiring was removed in 1984

Figure IV: Typical winter conditions in North Bay

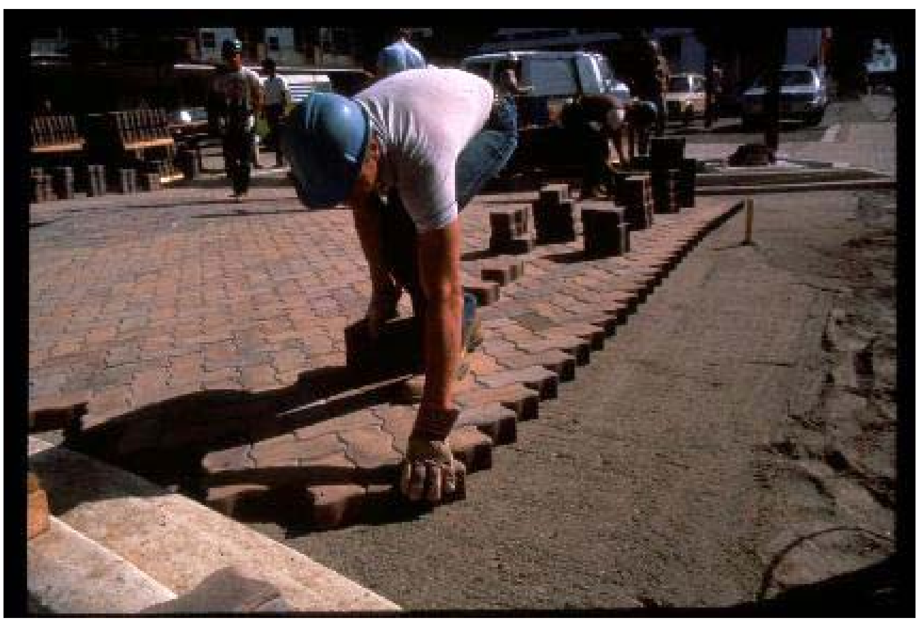

Figure V: Installation of the pavers on Main Street, North Bay – Note the 45-degree herringbone pattern utilizing Type 1 – wavy edged, 80 mm thick concrete pavers.

Figure VI: Joint Sand is spread on the pavement. Also of note is the soldier course used on pedestrian areas adjacent to the cast-in-place concrete edge restraint.

Figure VII: FWD testing utilized a Dynatest Model 8002 similar to the one pictured above

Figure VIII: The choice of Interlocking Concrete Pavements for Main Street North Bay has proven to meet the original intent of the project’s landscape architect – transformation of the City’s dated Downtown appearance into a “people friendly” place.

Figure IX: The back of sidewalk cast-in-place edge restraint at the building interface was beneficial both from a uniform visual appearance and with offering an easy way to set grades for the back of sidewalk

Figure X: The award winning North Bay Waterfront Park has utilized interlocking concrete pavers extensively