Project Report:
Night Time Paving Project (117-16THP)

Department of Transportation and Works

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ABSTRACT

This report is an analysis of the night time road construction pilot project conducted in Newfoundland and Labrador in summer 2017. Increasing traffic volumes on the Avalon Peninsula, and calls from the travelling public to minimize construction delays led the Provincial Government to undertake the night time paving pilot project.

The location selected for the project was the Trans-Canada Highway, between Salmonier Line and Kenmount Road in St. John's. The purpose of the pilot was to gain knowledge about how night time road projects are conducted, how they differ from day time projects, and ultimately to determine if night time construction is practical and economically feasible.

This report examines the development of a construction specification for night time paving operations and assesses project results based on factors such as safety, quality, productivity and cost effectiveness. Night time construction performance is compared to performance on similar day time paving projects conducted in 2017. A set of conclusions offers a number of summary points for consideration for future night time road construction.

1. INTRODUCTION

In recent years, the Department of Transportation and Works has been receiving an increasing number of complaints from the travelling public regarding traffic delays caused by road construction. Conducting road work at night has been suggested as one way to deal with this problem and is an approach used in other parts of Canada and the United States with some success. As a result, during the summer of 2017 the department conducted a night time paving project as a pilot to learn more about this type of project and, ultimately, to determine if the approach might be feasible for broader application in the future.

Road construction on existing roadways pose unique safety risks relative to most other types of construction. Most types of construction, for example building construction, take place in closed and secured sites that are off limits to the public. Road construction sites however have the public driving through the work zone as a regular occurrence and this introduces a significant variable which must be managed. Whether or not construction work is carried out in peak daylight hours or during lower volumes during the night, the risk created by the motoring public must be appropriately managed.

2. BACKGROUND

The Project

When the decision was made to conduct the night time road construction pilot, the department approached the Heavy Civil Association of Newfoundland and Labrador (HCANL) to inform them of the decision and to solicit input with respect to project design, location, etc. as well as any concerns related to the initiative. HCANL were concerned about future comparisons to day time construction and requested that the tender for night time work be reflective of the processes and requirements of daytime work, to try to ensure that project comparisons were fair and accurate.

The first priority was to identify an appropriate project for night time work. Early on it was recognized that night time work would require special planning, equipment and scheduling and, as such, the project should be large enough to make the endeavor worthwhile but not too large or complex. Additionally, it was noted that for maximum value the project should be conducted on a route that experiences significant traffic volumes and that night time work should not occur in residential areas to avoid disruption due to noise.

The project selected was for paving of multiple sections of the Trans-Canada Highway (TCH) between Salmonier Line and Kenmount Road in St. John's. This part of the TCH was chosen, in part, because it has a range of traffic volumes at different intervals. This would provide an opportunity to study the impacts of night time work on roads subject to different traffic conditions. The table below shows the annual average daily traffic (AADT) for four different road sections between Salmonier Line and Kenmount Road.

Location	AADT (2013)
Kenmount Road to Route 2	33,000
Route 2 to Foxtrap Access Rd	15,900
Foxtrap Access Rd to Holyrood Access Rd	13,500
Holyrood Access Rd to Salmonier Line	12,300

Additionally, choosing this section of the TCH minimized the need for coordination with other stakeholders and municipalities. In all, the project incorporated 17 segments of highway that required cold planing and repaving for a total of approximately 26 lane kilometres.

The public tender for the project was issued by the department on February 10, 2017 and closed on March 31, 2017. The early tender release was intended to enable lower bid prices by contractors and to provide enough lead time for an early project start-up. The intent was to have the work conducted during the months of July and August when there would be longer daylight hours and warmer night time temperatures.

The project was awarded on April 13, 2017 to Concord Paving with a target completion date of August 31, 2017. The actual start date on the project was September 27, 2017 and the project was completed on October 11, 2017.

Project Planning and Specifications – Day Time Work

Work on road construction projects is conducted by contractors with oversight and inspection carried out by department employees for tasks such as project management, surveying, and materials testing. Once a project is awarded, the contractor is responsible for scheduling the work within the stipulated project completion date, in coordination with the department.

Contractors are required to follow pre-defined specifications as published in the Department of Transportation and Works' Specifications Book. These specifications include factors such as the asphalt mix that should be used, standards for the grading of roads, proper installation and management of construction signage, etc.

Before work can begin on a project the contractor must provide the department with a site specific safety plan and traffic control plan.

Project Planning and Specifications – Night Time Pilot

Roles and responsibilities on the night time project were in keeping with day time projects. The department's specifications for road projects were developed with day time projects in mind and, while the majority also apply to night time work, some modifications were required for the pilot project.

During project planning, the department developed a specification for night time work following the model used by the Nova Scotia, along with information from the National Cooperative Highway Research Program.

Significant effort was required before start-up to plan for the unique conditions of night time construction with a heavy focus on safety issues. Department staff conducted a risk assessment and developed new safe work practices to be followed for identified night time risks.

As with a day time project, before work could begin on the project the contractor was required to provide the department with a site specific safety plan and traffic control plan.

Safety planning efforts required development of new work methods, new safe work procedures, improved safety protective gear, and revised execution procedures. This took weeks of planning, risk assessments, and training.

More detailed information is provided below on project planning, the risk assessment and the additional safety measures put in place.

3. PROJECT PLANNING

After the tender was awarded the department, with input from the contractor, commenced execution planning for the project. As this was the first night time project for the department and the contractor, neither had specific work procedures in place for conducting road work at night. As such, the first order of business was to develop these tools and implement them accordingly.

Specifications

In the development of night time road project specifications the department contacted other provincial jurisdictions for input on how night time work is conducted and managed. A night time construction specification from Nova Scotia was particularly useful to inform the department's planning and development work.

The department also referenced guidelines and documents available through the National Cooperative Highway Research Program (NCHRP) including:

- National Cooperative Highway Research Program (NCHRP) 726: A Guidebook for Night time Construction: Impacts on Safety, Quality, and Productivity; http://www.trb.org/Publications/Blurbs/167702.aspx
- National Cooperative Highway Research Program (NCHRP) 475: A Procedure for Assessing and Planning Night time Highway Construction and Maintenance; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_475.pdf
- National Cooperative Highway Research Program (NCHRP) 476: Guidelines for Design and Operation of Night time Traffic Control for Highway Maintenance and Construction; http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_476.pdf
- American Traffic Safety Services Association; http://www.atssa.com/TrainingCertification/CourseInformation/NighttimeTemporaryTrafficControl.aspx
- National Work Zone Safety Information Clearing house; https://www.workzonesafety.org/training-resources/fhwa_wz_grant/atssa_night_lighting_guide/

Risk Assessment/Safety

There are unique safety hazards associated with night work which had to be considered during project planning. The best way to minimize safety risks is to clearly identify them and develop risk mitigation strategies. As such, the department conducted a risk assessment for the project and developed night time Safe Work Practices (SWP).

The risk assessment started by defining the core tasks associated with night time paving work and proceeded to identify the associated safety risks. Some of the more notable risks, along with the mitigation strategies identified, are as follows:

Risk	Safeguards/Actions/Controls
Vehicle/ Pedestrian Collision (getting hit by a car while working)	• Traffic Control: ensure traffic control measures are in place (signage, diversions, and escort vehicles); detour traffic where possible. • Lighting: ensure the contractor has an approved lighting plan in place; perform illuminance checks with photometer (see more below). • Training: ensure all workers have been trained for night time work. • Personal protective equipment (PPE): ensure PPE includes reflective/high visibility markings/material (hardhat with reflective material, minimum Class 2/Level 2 high visibility). • Timing: complete as much work as possible during daylight.
Inadequate Lighting/ Poor Visibility	• Lighting: ensure the contractor has a lighting plan in place that has been approved by an engineer and department; Level 2 illuminance required 15m each side of milling/ shouldering, Level 1 required 120m ahead/ 250m behind milling/ shouldering; perform illuminance checks with photometer. • Traffic Control: ensure traffic control measures are in place (signage, diversions, and escort vehicles); detour traffic where possible.
Mobile equipment collisions/ Toppling over/ Struck by heavy equipment/ Caught under equipment.	• Follow SWP for working near heavy equipment. • Training: ensure all workers have been trained for night time work. • Personal protective equipment: ensure PPE includes reflective/high visibility markings/material (hardhat with reflective material, minimum Class 2/Level 2 high visibility). • Lighting: ensure the contractor has an approved lighting plan in place; perform illuminance checks with photometer. • Timing: if possible, chain out cold planing locations in daylight hours. Working behind the cold planer at night may not be an option as only 250m is required to be illuminated and the grader and rubber tire will be in that area. May have to work within 120m ahead of the cold planer or wait until the paving begins in the area to chain out the road.

As evidenced above, the risk assessment highlighted the need for extra lighting, night time construction training and higher class PPE. It also recommended the use of detours to reduce the risk posed by vehicular traffic. The risk assessment also identified the need for a minimum of eight department employees to be assigned to the project.

The department's project engineer played a major role in safety planning, along with staff in the department's Corporate Safety Division. It was the project engineer who requested night time safe work practices be developed and who initiated the risk assessment process. Additionally, the project engineer developed the SWPs for the survey crews, labourers, technicians, inspectors, as well as the project engineering role.

Traffic Control

Before construction can begin on any road project the contractor must prepare and submit a Traffic Control Plan (TCP) for approval by the department. Based on the results of the risk assessment, the TCP for the night time project had to reflect the special conditions associated with working at night. In June 2017, the contractor's traffic control consultant approached the department to discuss traffic control options. It was agreed that the safest way to proceed was to break the project up into seven sections of highway and allow for detours around any section being actively worked on. Based on this agreement, and the department's understanding that work would only be conducted in one section at a time, the traffic control layouts were approved.

Illumination

As per tender requirements, the contractor submitted to the department a lighting plan, signed by a professional engineer knowledgeable in the science of photometrics and vision, prior to work beginning. Tender documents provided minimum requirements for illumination in work zones and around equipment and recommended that high-mast lighting to be used instead of portable lighting. The tender did not rule out the use of portable balloon lighting, instead it mentioned balloon lighting as the most common non-glare lighting used in night time construction.

The contractor's lighting plan submission detailed the use of balloon lighting on all equipment, along with the location of pickups during milling/paving operations, to provide the required illumination in front of and behind the operation.

Training

The need for night time construction training had also been identified during tender development and, as such, the tender required the contractor to arrange for training of contractor and department staff who would be working on the project. The standard of acceptance for training on night time work operations was the eight hour classroom course, "Night time Temporary Traffic Control", offered by the American Traffic Safety Services Association (ATSSA). The tender also indicated that flaggers and paving workers receive specific training on night time operations.

The night time training course that was provided by the contractor was an equivalent of the Night time Temporary Traffic Control and taught by an ATSSA recognized trainer. The course however, did not provide specific training on how to perform work duties during the night. The course was broken up into seven modules which included:

1) Factors Affecting the Feasibility of Night Work
2) Night time Temporary Traffic Control
3) Lighting Requirements
4) Installation and Removal
5) Use of Police Services
6) Night time Typical Application
7) Workshop (Develop a traffic control plan)

In addition, department staff who would be working at night were required to take a fatigue management course to address concerns with individual well-being in the adjustment from their normal work schedules. Arrangements were also made to give employees three days off prior to night time work beginning, as well as after it ended, in order to help them adjust to the change in work shifts.

Timing/Hours of Work

As noted above, the intention during tender development was to conduct the night time project during July and/or August when there is more daylight as compared to the autumn months and this was still the goal during the project planning phase. During the risk assessment one of the mitigation measures suggested involved conducting one task in particular during the daylight hours (e.g., chain out cold planing locations). Paving during the summer would also help ensure that night time temperatures did not go too low (i.e., below seven degrees Celsius) for proper asphalt application.

The department did not conduct (or require that the contractor conduct) an analysis of traffic volumes to determine the optimum hours/shifts for carrying out project work. Historically, however, the department has not allowed work on the west bound TCH between the hours of 4:00 p.m. and 6:00 p.m. or on the east bound TCH between the hours of 7:00 a.m. and 9:00 a.m.

Based on this, it was agreed between the contractor and the department that the nightly work shift could be maximized by allowing work between the hours of 7:00 p.m. and 6:00 a.m.

4. PROJECT EXECUTION

Safety

Feedback from the department's project team and the contractor with respect to safety during the project included the following observations:

- Contractor heavy equipment could not be outfitted with balloon lighting making the equipment harder to see/recognize at night as compared to during daylight hours. This was especially problematic for dump trucks which travelled at a relatively higher speed. Other equipment which could not be outfitted with proper lighting included the grader, skid-steer, and rubber tire backhoe.

- There were concerns raised about the speed at which some heavy pieces of equipment travelled through the detours, especially dump trucks.
- There were reports of drivers who missed or ignored signage of the detours and entered the closed construction zones. Because the sites were closed, there was no public traffic control planned in the work zones and errant drivers therefore created an unexpected risk.
- There were reports of drivers who displayed behavior suggesting they were driving while under the influence of drugs or alcohol driving through the closed construction areas.
- There were three reports of close calls for moose-vehicle collisions in the project areas.
- Some workers raised concerns about working alone and there were some who refused to do so.
- The project experienced a high turnover of truck drivers which meant new workers who were not familiar with the worksites were being brought in frequently.
- There were unverified reports of workers skipping or reducing rest periods (e.g., to take care of family obligations) and then working during the night.

These issues were either unique to night time work or were found to be more prevalent on the night time project than in typical day time work and were generally beyond the control of the department.

Prior to another night time project it will be necessary to review the SWPs and revise as necessary to address specific issues that were dealt with in the execution of the work. A full review of specific SWPs is beyond the scope of this report.

Traffic Control

Traffic control measures, including detours and signage, were implemented during road construction based on the pre-approved Traffic Control Plan with some deviations. From the department's point of view, the most significant deviation from plan occurred as a result of work being undertaken on multiple sections of road at the same time. This made traffic control more difficult and created challenges for department staff in terms of providing oversight as the department's staffing complement for the project was based on work at only one section at a time.

The use of detours in the night time construction required more complicated sign plans (e.g., detours involving multiple interchanges). While these took considerable time to develop during the development of the TCP, feedback indicates that more detailed signage would have been helpful. As noted above, there were numerous reports of motorists getting through the detours into the work areas, which pose significant safety concerns.

It is of interest to note that the use of detours was a pivotal piece of the traffic control plan for the pilot project in an attempt to minimize risk created by motorists in a construction zone, and in turn help offset other risks created by working at night. However, the nature of the provincial road network does not provide many opportunities for traffic detours to facilitate road closures. Furthermore, in areas where detours are possible, consideration can be given to utilizing this as a solution to keep traffic flowing, increase productivity, and improve safety for typical day time construction work as well as night time work.

Illumination

The contractor's lighting plan detailed the use of balloon lighting on all of its equipment and the location of pickups during milling/paving operations to provide the required illumination in front of and behind the operation. In practice, however, some heavy equipment could not be outfitted with balloon lighting, including dump trucks, the grader, the skid-steer, and the rubber tire backhoe. As a result, it was more difficult for workers to distinguish these pieces of equipment at night. This posed a safety concern as this equipment is constantly maneuvering inside work zones and comes in close proximity to workers. As noted above, the dump trucks in particular, were a concern as they were travelling through the detours.

Lighting on the project was provided by mobile equipment. As work proceeded forward, however, the lighting behind the operations was not maintained, making inspection of the asphalt difficult for department employees. This resulted in some errors/problems in the paving work. For example, early in the project the new asphalt "mat" was laid too thick which meant it was higher than the adjacent lane. Where possible, lighting adjustments were made as the project progressed to help address issues encountered, with varying results. For the issue with the asphalt mat, for example, lighting was installed lower on the paver to provide the operator with better visibility. This helped but did not completely solve the issue.

While illumination levels were checked by both the contractor and Transportation and Works, multiple simultaneous operations made it difficult to ensure that specified illumination was being maintained at all work locations for all tasks at all times.

As per the risk assessment, workers were required to wear a minimum of Class 2 personal PPE for higher visibility and have a minimum of 80 cm^2 of reflective material added to each side of their hard hats. In the interest of safety, higher visibility Class 3 PPE was used.

During the execution of the work, it was also observed that while specified lighting levels were provided for specific work areas (mounted on mobile equipment for the execution of specific tasks) the broader construction site consisting of a stretch of unlit highway with near zero ambient light, was still "dark". This is in contrast to work sites within communities, for example, which have considerable background light provided by municipal street lighting.

Training

As noted above, the night time training course provided by the contractor was an equivalent of the Night time Temporary Traffic Control and taught by an ATSSA recognized trainer. The course however, did not provide specific training on how to perform work duties during the night.

Most of the course modules would not be applicable to the employees actually working on the project, but more so tailored towards designers/planners. There was nothing offered in the course that informed each employee how to perform their job duties differently than in the day time, or how to identify and avoid night time hazards.

Further, there was no mechanism in place whereby the department could ensure that all of the contract workers attended the night time training course. It became known during construction that a number of the truck drivers and cold planing crew did not attend the training.

Timing/Hours of Work

Work on the project took place between September 27 and October 11, 2017. Working late in the year presented challenges with respect to lighting, as there were fewer daylight hours to work with. Weather conditions at this time were also more challenging, with night time temperatures starting to dip lower. The department's specifications state that there shall be no paving when the temperature is below seven degrees Celsius. Due to timing, there were deviations from the specification with some asphalt laid in temperatures below seven degrees. No asphalt was placed in temperatures below five degrees and wind chill was monitored closely.

As noted above, the hours of work on the project were between 7:00 p.m. and 6:00 a.m., however, some problems were encountered in coordinating the work schedule with the contractor. The contractor had a daytime project that would be going on at the same time that the night time paving would be taking place. As such, the contractor notified the department that they intended to implement a 12:00 p.m. to 12:00 a.m. shift that would enable them to work from 12:00 p.m. to 6:00 p.m. on their daytime project, and 7:00 p.m. to 12:00 a.m. on the night time project.

Departmental Impacts

Eight departmental employees were assigned to this project as per recommendations arising out of the risk assessment. In general, this was found to be insufficient as a larger proportion of work time (i.e., as compared with day time projects), at least for some positions, was found to be necessary to deal with safety matters as well as complaints from the travelling public.

Both the project manager and project engineer were required to devote a great deal of attention to safety related planning, monitoring and issue management; so much so, that they reported that there was little time to ensure the actual paving work met tender requirements and project specifications.

Given that this was a night time project, arrangements had not been made for any daytime duties. With the department's offices closed at night, however, virtually all complaints and inquiries were received during the day. With no assigned staff available to address these complaints/inquiries the project manager was required to spent a great deal of time addressing these issues at night. This also resulted in less time available for the management of technical aspects of the paving project. The project team recognized during construction that more department resources were needed but none were available due to other ongoing daytime projects.

5. Outcomes

Quality

Quality assurance (QA) data from the night time paving project was compared to other similar projects completed in 2017. The purpose of this exercise was to evaluate materials and performance properties. The comparison projects were chosen as they all followed End Product Specification (EPS) and consisted of milling and filling with Hot Mix Asphalt (HMA).

Overall, all QA results for the night time project were within the departments allowable tolerances. The asphalt plant was formulating and mixing the HMA on a consistent basis and did not affect the quality of the HMA product.

Smoothness data collected for the night time project showed some issues, however, one of the comparison projects showed comparable results. It is not possible to determine the root cause for these smoothness issues for either project based on the data available.

Visibility concerns may have affected other quality issues such as tack coat application uniformity as well as longitudinal joint milling adjustments that were missed.

Refer to Appendix 1 for the full Night Time Paving Quality Report.

Costs

Unit costs on any project will vary due to factors such as location, size, time of tender, and market conditions at the time of tender. It is therefore difficult to compare the cost of the single night time project to other similar projects and simply determine the cost premium for night time construction. However, the cost of the night time project was compared to the cost of four other TCH paving projects from the west coast to the Avalon Peninsula and it showed that the night time project was 33 per cent to 97 per cent higher than the comparison projects. Discussions with other jurisdictions in Canada validate the general conclusion that night time work is significantly more costly than daytime.

While it is difficult to compare productivity of different projects and different contractors, the productivity during the night time was lower than the productivity of a day time project with the same contractor. This is in contrast to the theory that productivity during night time construction could be higher due to lower traffic volumes or in the case of a detour, zero traffic. It should be noted however that productivity levels could also be increased on day time projects if traffic is eliminated through the use of detours and road closures.

It is possible that costs and productivity could improve once more experience is gained with night time paving, however, it is not possible to predict what this improvement could be with the data from this project.

Public Perception/Satisfaction

In general, the project appears to have been deemed by the travelling public as a success as majority of feedback was positive. There were initially some issues with detours including problems with signage and the lack of clarity on the detour route. These issues were addressed and were reduced as the project progressed.

6. CONCLUSIONS AND RECOMMENDATIONS

Overall, the night time project resulted in the delivery of a quality paving product (i.e., within acceptable tolerances) and received mostly positive feedback from the travelling public. Costs, however, were substantially higher than comparable day time projects, productivity was lower and there were unique safety hazards that persisted even after a significant amount of mitigation planning was conducted. In addition, the project had a negative impact on the department's ability to execute some of its day time projects due to a reduced pool of resources available for day time work.

However, definitive conclusions cannot be drawn from a single project, particularly the first project of this kind undertaken. It is almost certain that with time and experience, project performance would improve in most if not all areas (i.e., cost, resourcing, safety, etc.). Based on information gathered from other jurisdictions, however, it seems reasonable to expect that night time work may continue to be more costly than day time projects but it is impossible to say by how much. As such, decisions to proceed with night time in future will need to balance the various advantages and disadvantages of this type of work.

Should the province decide to engage in night time road work in future, a number of observations and/or lessons learned from this project should be considered in project planning and execution.

Planning

- For this project, the department consulted with the Department of Transportation and Public Works in Nova Scotia and conducted some research to inform the development of project specifications. Additional time and broader jurisdictional research into tendering requirements, project specifications, resource planning, etc. would be beneficial to ensure the department's night time road work methodology reflects best practices.
- The risk assessment process was very informative and helped in the development of night time safe work practices. Even so, once in the field some of the SWPs had to be revised in order to accomplish the work. As such, it would be advisable to conduct risk assessments again in future that incorporate the practical experience gained on the job.
- Organization management and human resourcing issues are more difficult for night time work. Project scheduling, durations, magnitude and collective agreements all must be reviewed and planned accordingly when determining the feasibility and ability to properly staff a night time project. Organization planning must consider the need for contingency

resources to deal with challenges and project execution risks. Prior to sanctioning a night time project the organization plan/resource plan should be developed and approved. As part of this, consideration should be given to assigning a dedicated department safety officer and/or additional safety resources, as well as resources for stakeholder communications/public issues resolution.

- Until night time road construction becomes more commonplace project planning will require several months, especially with contractors that are not familiar with night time work. Project selection, planning, and tendering must recognize the need for this length of time to ensure a solid plan is developed.

Safety

- Contractor organization/ management must be considered for night time projects. Contractor personnel were sometimes working on day time work when night time work was delayed. This situation can be avoided in the future by insisting that any contractor with multiple government projects must have staff dedicated to night time projects only until they are completed. This decreases safety concerns by mitigating fatigue issues that occur when workers are frequently changing from dayshift to nightshift.

Traffic Control

- The extra detours and night time specifics required more detailed traffic signage than typical daytime projects. This requirement should be addressed in more detail in future tenders.
- It is also recommended that the signage requirements be more detailed in future tenders. The development of the traffic control plans may need to be developed in-house
- For road construction projects the development of the Traffic Control Plan is the contractor's responsibility. Given that the detour and signage requirements for night time work are more complex, however, the department may wish to consider another process. For example, the TCP could be developed in-house and/or in consultation with the department's Traffic Engineer and other engineering representatives knowledgeable in construction planning and traffic control.
- The use of detours and road closures should also be considered as a traffic control solution generally and not just for night time construction.

Illumination

- A number of safety and quality issues were experienced on this project as a result of inadequate illumination. These issues could be addressed with a better illumination specification. The specification, for example, should require the contractor to provide illumination behind the operation for a set distance and/or length of time after a section is milled and/or paved to give inspectors proper lighting and some time to conduct their inspections.

Training

- While training was required for department and contractor staff and was undoubtedly beneficial to some extent, it did not provide much in the way of practical knowledge for workers in terms of how to complete their duties at night. As such, it is recommended that the department be more specific in terms of the requirements for a night time course syllabus.
- The department should put measures in place such that they can confirm that the agreed upon training has been completed by all workers on night time projects (e.g., proof of course completion).

Timing/Hours of Work

- Specific requirements, when they exist, regarding when project work can take place and at what locations should be clearly communicated and agreed upon in a formal manner with contractors.
- The department should consider reinforcing the requirement for completion of night time projects in periods of longer daylight and warmer temperatures. For example, contract conditions could be included that stipulate night time work must be completed prior to August 31 with associated penalties if that is not achieved.

Quality

- While end quality was adequate there were some challenges with installation of the final product. Some findings to consider for future work include:
    - Inspection of the tack coat was difficult and sometimes inconclusive; more lighting likely required for tack coat inspection and milling operations.
    - Closer monitoring of smoothness workmanship may be required to determine if construction practices are affected by working at night.
    - Once the asphalt was laid it was difficult to see if the asphalt was segregated, bleeding, too thick, or too thin to make necessary adjustments at night.
    - It was difficult to repair long sections of guiderail where good lines of sight are required. The problems were only visible the next day, by daytime staff. Further consideration is necessary to determine the appropriate solution.
    - Early on in the project the new asphalt “mat” was laid too thick which meant it was higher than the adjacent lane. To solve this problem, lighting was installed lower on the paver to provide better visibility for the operator. This measure did not fully solve the issue. Application rates also could be monitored for potential improvement.
    - It was difficult to supervise the placement of the contractor’s millings. At times, millings were dumped in locations without supervision which resulted in a number of complaints after the project was completed.

Public Perception/Satisfaction

- The primary reason to perform road construction at night is to reduce impacts to the travelling public. Further analysis should be conducted on what should be considered acceptable in terms of travel delays caused by road construction delays (i.e. a service standard). This type of analysis would help the department determine when night time projects may be more worthwhile.
- Typical traffic delays are often less than 30 minutes but can be higher in abnormal and unexpected situations. There have been reports, on occasion, of delays exceeding 30 minutes and public feedback suggesting delays as high as two hours in some areas.
- The department may want to consider potential solutions to traffic delays other than night time construction. For example, the department could work with industry on the use of alternative approaches to construction such as working only on weekends and/or full road closure/detours in off-peak times. To put this in context, the night time pilot project was completed in nine days which would translate into only four to five weekends of impact.

Appendix 1: Night Time Paving Quality Report

Executive Summary

Quality Assurance data from the night time paving project (117-17 THP) was compared to other similar EPS projects. The purpose of this review was to evaluate materials and performance properties. It does not address safety or other construction issues.

All QA results for the night time project were within the department's allowable tolerances

For this project the asphalt plant was formulating and mixing the HMA on a consistent basis and did not affect the quality of the HMA product.

It would appear from the smoothness data for the night time project had a variety of bump dip cost reductions applied. However, project 127-17 THP had comparable smoothness issues with somewhat comparable results. It is not possible to determine the root cause for these smoothness issues for either project based on the data.

Visibility concerns may have affected other quality issues such as tack coat application uniformity as well as longitudinal joint milling adjustments that were missed.

Introduction

A review of the Quality Assurance (QA) results for project 117-16 THP was completed and compared to similar projects that were paved in 2017. These projects were chosen as they all followed End Product Specification (EPS) and consisted of milling and filling with Hot Mix Asphalt (HMA). Detailed in the subsequent sections are the performance based results that were used to adjust payments for Hot Mix Asphalt as set out in the Departments Hot Mix Asphalt Concrete specifications. Other potential quality issues are also outlined.

Project Descriptions

The following table describes each of the projects that were used in the quality assurance comparison.

Number	Project Description	Start Date	End Date
117-16 THP	Cold plane and repave various sections of the TCH from Kenmount Road to Salmonier Line	September 27, 2017	October 10, 2017
127-16 THP	Cold planing and repaving various sections of: Route 1 Trans-Canada Highway in the Avalon Region including the Outer Ring Road, Route 75 Veteran's Memorial Drive, Route 2 Pitt's Memorial Drive, and Route 3 Robert E. Howlett Memorial Drive.	August 3, 2017	October 21, 2017
114-16 THP	Mill and Fill various sections of Route 1, Trans-Canada Highway, between Whitbourne and Goobies	August 22, 2017	September 27, 2017

Table 1: Project Descriptions

Asphalt Content

The allowable asphalt binder content tolerance/deviation from the mix design set out in the department's specifications is ± 0.3% measured on a lot bases. If the mix contains too much binder the pavement can experience bleeding, in which a film of asphalt appears on the surface causing decreased friction resistance. In addition, pavements with too much asphalt binder can experience shoving and plastic deformation. Pavements that do not contain enough binder can prematurely crack and lose strength as there is not enough coating on the aggregate to hold the structure together. Also, aggregate can easily be dislodged from the pavement surface causing the road to have a rough texture and age faster. See table below for a comparison of lot deviations for various EPS projects.

Project Number	Number of Lots	Average Deviation	Minimum Lot Deviation	Maximum Lot Deviation	Cost reductions
117-16 THP	4	0.16	0.11	0.22	None
127-16 THP	10	0.17	0.08	0.23	None
114-16 THP	21	0.08	0.01	0.18	None

Table 2: Asphalt Content Percentage

Gradation

The sieves identified below are monitored closely to ensure conformance with mix design gradation properties. Both these sieve sizes have associated performance measures under EPS projects.

Percent Passing the 4.75 mm Sieve

As per the department's specification, if the average deviation per lot exceeds 5.0 % cost reductions will be applied. See table below for project results.

Project Number	Number of Lots	Average Deviation	Minimum Lot Deviation	Maximum Lot Deviation	Cost reductions
117-16 THP	4	2.2	1.6	2.7	None
127-16 THP	10	1.6	1.0	2.9	None
114-16 THP	21	2.9	1.8	4.1	None

Table 3: 4.75 mm Sieve Gradation Percentage

Percent Passing the 0.075 mm Sieve

As per the department's specification, if the average deviation per lot exceeds 0.5 % cost reductions will be applied. See table below for project results.

Project Number	Number of Lots	Average Deviation	Minimum Lot Deviation	Maximum Lot Deviation	Cost reductions
117-16 THP	4	0.31	0.23	0.41	None
127-16 THP	10	0.26	0.13	0.50	None
114-16 THP	21	0.29	0.07	0.50	None

Table 4: 0.075 mm Sieve Gradation Percentage

Marshall Air Voids

These voids are required in a mix to allow for additional compaction from the traffic on the road. Without adequate airs voids within the mix traffic will push out the asphalt binder causing it to flush, bleed and/or shove. In addition, voids allow for the expansion of the asphalt binder due to temperature increases. Mixtures with air void contents that are too high can cause a multitude of problems including decreased stiffness, accelerated aging, raveling, and increased moisture damage. Outlined in the subsequent table are the average Marshall air void contents and minimum and maximum values.

Project Number	Number of Lots	Average air voids of the lots	Minimum Air Void Content	Maximum Air Void Content
117-16 THP	4	2.60	2.41	2.85
127-16 THP	10	2.75	1.50	4.09
114-16 THP	21	2.66	2.06	3.32

Table 5: Air Void Content

Percent In-Place Density

Density values are another performance measure that is tested by the department to ensure proper compaction is achieved in the field. Poorly compacted roadways are more permeable, allowing water and air to enter the structure. The air can prematurely age the pavement causing it to become brittle and crack when subjected to traffic loading. The water that penetrates can lead to stripping and can cause damage when it becomes frozen. If the mixture is over compacted the pavement is susceptible to rutting and deformation. The bonus/penalty adjustment encourages contractors to provide optimal densities. If the values for compaction are less than 94.0%, cost reductions are applied. If below 90.0% it is a basis for rejection. In addition, if the percent compaction is above 97.5% or between 94.0-94.5% there is neither a bonus nor penalty. The table below summarizes the average percent density for each EPS project and the total bonus/cost reductions received.

Project Number	Number of Lots	Average Value	Total Bonus	Total Penalty	Total Bonus/Penalty	Average Bonus/Penalty per Lot
117-16 THP	4	96.1	$13,166.10	$0	$13,166.10	$3,291.53
127-16 THP	10	96.2	$27,248.00	-$300.00	$26,948.00	$2,694.80
114-16 THP	21	96.4	$40,183.55	-$1,200.00	$38,983.55	$1,856.36

Table 6: In-Place Density Bonus/Penalty

Smoothness

While there are many factors that affect pavement life, evidence has shown that smoother roads last longer. When constructed properly, smooth roads tend to stay smoother longer, require less maintenance and decrease the fuel consumption for roadway users. Conversely, increased

roughness results in a higher friction loss and results in more dynamic loading, subjecting pavements to heavier loads.

The smoothness of the finished surface of the pavement structure is determined after final rolling with an inertial laser profiler. The outer wheel paths of all lanes are measured in the longitudinal direction in 100 m sections. The resulting measurements are compiled to produce a Profile Index (PI), which is a cumulative profile reading. If the cumulative PI exceeds 15.1 mm/100 m the contractor is penalized and shall repair the sections or pay a price adjustment based on the Profile Index. However, if the contractor's workmanship is below a PI of 10.1 mm/100 m they are awarded a bonus. Below is a summarized table of the smoothness bonus and cost reductions applied to the EPS projects.

In addition to the PI, individual bumps and dips shall not exceed 8 mm vertically over 7.6 m in length. Where individual bumps and dips exceed 8 mm cost reductions are applied.

Project Number	Lane Kms*	Total Bonus/Penalty for PI	Total Bump Dip Penalty	Total Bonus/Penalty	Total Bonus/Penalty per Lane Km
117-16 THP	21.2	$13,965.49	-$14,200.00	-$234.51	-$11.06
127-16 THP	46.5	$35,835.77	-$29,400.00	$6,435.77	$138.40
114-16 THP	95.8	$81,933.20	-$9,200.00	$72,733.20	$759.22

* Lane Kms only include the length where smoothness performance measures applied

Table 7: Smoothness Bonus/Penalty

Other Potential Quality Issues

Application Rates

HMA is monitored to ensure relative consistency of application. Daily HMA tonnage divided by the laydown area is determined and bonuses/cost reductions are applied based on the department specification. Table 8 below outlines the bonus/cost reductions applied per lane kilometer paved. The 114-16 THP project was excluded as it was required to make many adjustments to the lane widths and thickness to ensure that surface distresses were addressed. Due to this variability application rates were not applied by the region.

Project Number	Lane Kms*	Total Bonus	Total Penalty	Total Bonus/Penalty	Total Bonus/Penalty per Lane Km
117-16 THP	22.7	$2,758.70	-$38,901.00	-$36,142.30	-$1,592.17
127-16 THP	54.3	$7,567.00	-$29,464.06	-$21,897.06	-$403.26

* Lane Kms only include the length where Application performance measures applied

Table 8: Application Rate Bonus/Penalty

Tack Coat

The application of a tack coat is important to ensure that the new asphalt layer bonds to the existing roadway. If the two pavement layers remain unbonded they act as independent layers and will not withstand the stresses resulting in pavement distresses such as fatigue cracking and longitudinal cracking. Insufficient bonding can result in delamination (process in which the top layer separates from the bottom). In addition, if the layers are not bonded the interface can act as a corridor for water to enter the structure which can result in stripping and increased damage from freeze thaw cycles. Construction at night made it difficult to visually determine how much tack coat was being applied and to visually assess uniformity and identify any areas that were insufficiently covered.

Joint Surface Distresses

Typical practice dictates if a surface distress is apparent and adjacent to the opposite side of the longitudinal joint, than the width of the miller should be increased to mill out that distress. This practice helps to extend the life of the pavement as it prevents the surface distresses from increasing in size or potentially affecting the new pavement structure. During the night time work multiple surface distresses were not visually identified and missed by the milling machine.

Summary

After reviewing the Quality Assurance data and performing this comparison, the mixture properties (asphalt content, gradation and air voids) appear consistent to the other EPS projects. Results were also within the allowable tolerances set out by the department. This would indicate the asphalt plant is formulating and mixing the HMA on a consistent basis and would appear day to night time work is not affecting the quality of the HMA product. It would appear from the smoothness data for the night time project had a variety of bump dip cost reductions applied. However, project 127-17 THP had comparable smoothness issues with somewhat comparable results. It is not possible to determine the root cause for these smoothness issues for either project based on the data. Consideration of increased due diligence in future night time work could potentially improve smoothness quality, however, this is not definitive. In addition, the other quality issues need to be addressed to ensure tack coat can be visually examined to confirm uniformity and that joint surface distresses are not missed during milling.