

Concrete Slabs Provide Overnight Rehab Solution for Busy Ontario Freeways

As Ontario's highway network expands and is subjected to increasing traffic volumes, the Ministry of Transportation Ontario (MTO) is challenged to find new and innovative solutions to preserve and maintain the highway system. The ministry identified highway sections with heavy truck traffic, more than 25,000 trucks per day, at risk of premature deterioration. These asphalt pavements with over 300 mm thickness may experience early rutting failure and /or full depth cracking.

The typical mill and repave treatment at these locations may last only three-to-five years, rather than the expected eight-to-twelve, before the rutting and cracking returns. Since the lifespan of this holding strategy is short, the ministry is investigating an option using overnight mill and inlay of precast concrete to extend the lifecycle of the rehabilitation. The concrete inlay strategy also avoids traffic disruption. Reducing delays to the travelling public on these busy freeways during highway rehabilitation adds to the ministry's challenge. Performing maintenance and rehabilitation work is restricted to only nightly construction closures.

In 2004, MTO successfully carried out its first precast concrete slab repairs on concrete pavements to evaluate construction techniques. The initial trial was conducted on Highway 427, in Toronto. Based on this experience,



a specification was developed and additional precast repair work carried out in the following years. MTO's success with precast concrete repairs on concrete pavement inspired the use of precast concrete slabs to repair flexible pavement in a fall 2016 trial. The benefits in using concrete inlay as a highway rehabilitation method, despite its slightly higher cost, include reduced traffic impacts, but more importantly, extend pavement lifecycle; both factors adding to the cost benefit.

Location

The ministry conducted the 2016 pilot project on the northbound section of Highway 400 between the intersections

of Highways 88 (to the south) and 89 (to the north). A 2013 report indicates the average annual daily traffic in both directions was estimated to be 87,300. Figure 1 below shows the approximate location of the pilot project.

Slab Support Systems

The ministry approached the concrete inlay trial based on [Fort Miller Superslab® System](#), a slab-on-grade approach using fully cured precast concrete slabs for pavement replacement.

Three different slab support systems were evaluated based on factors such as load transfer and ease of construction.

Concrete Slabs Provide Overnight Rehab Solution, continued

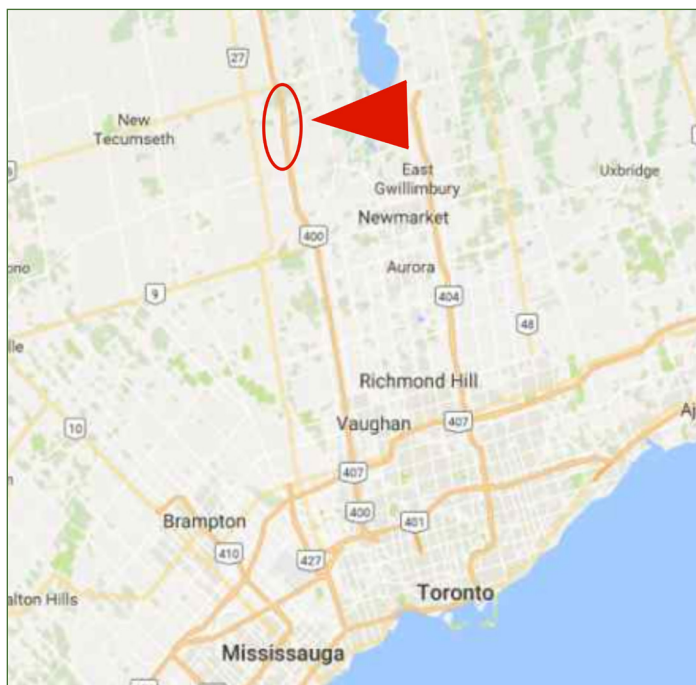


Figure 1: Pilot Project location on Highway 400, between Highway 88 and 89 (Source: Google Maps)

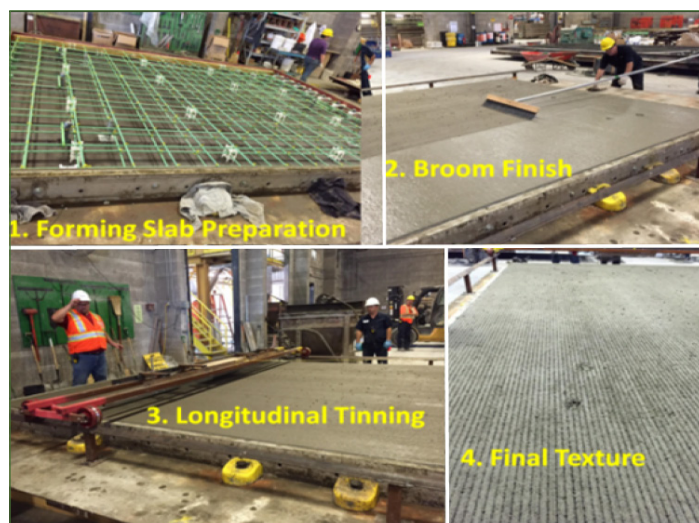


Figure 2: Precast Slab Production

Consideration was also given to the challenges of construction staging within an eight hour work window, with adaptations of horizontal and longitudinal joint details for the anticipated temporary and permanent work. The three slab support methods used for this pilot study include:

- Asphalt Supported Slab
- Grade Supported Slab
- Grout Supported Slab

Long-term monitoring instrumentation was also installed in partnership with the [University of Waterloo, Centre for Pavement and Transportation Technology \(CPATT\)](#).

Slab Fabrication

Twenty-two reinforced precast slabs were required for the pilot. They were fabricated in late summer 2016 at the [Armtec](#) production facility located in Mitchell, Ontario. To ensure good friction, sufficient micro and macro surface texture was mandatory on the precast slabs. Several methods were applied to the precast concrete surface to produce an acceptable surface texture. The final surface texture was a broom finish, followed by longitudinal tining. Constant pressure was applied during the brooming and longitudinal tining processes to provide the required texture. Figure 2 below shows the precast concrete slab production.

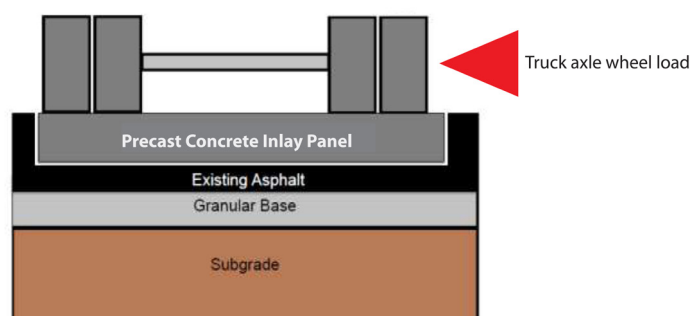


Figure 3: Cross-section of Precast Concrete Slab Repair Rehabilitation on Asphalt Pavement (displaying an axle of dual tires running on top of the pavement)

Concrete Slabs Provide Overnight Rehab Solution, continued

Design Considerations

Core samples were taken at the pilot site to ensure sufficient asphalt depth was available to provide uniform support of the precast slabs. Three northbound lane cores indicated the asphalt thicknesses at 355, 375 and 375 mm. Since the precast concrete slabs are 205 mm, the core samples indicated sufficient asphalt thickness to mill down and place the precast concrete inlay slab, with roughly 150 mm of asphalt remaining as the base support. Figure 3 is the schematic of the precast concrete slab inlay repair of the flexible pavement.

The 205 mm thick precast concrete slabs are a lane-width wide (3.7 m) and 4.6 m

long. Epoxy-coated dowels at 300 mm centres were embedded at the transverse joints. The strength of concrete is rated using megapascals (MPa). The precast concrete used in the slabs was designed for 30 MPa at 28 days with 3 per cent air void. The precast slab was reinforced by two mats of 15M epoxy coated steel bars at 300 mm spacing.

The trial slabs were installed over three consecutive nights to mitigate traffic delays. A temporary 1.0 metre longitudinal slab (sleeper slab) was used to facilitate a transition to the next night's operations. During the day, a temporary slab was placed over the exposed dowels to support traffic during the un-

grouted condition. The temporary slab was removed for the next night's slab placement.

Planning and Installation

Together, the ministry, CPATT, the Design Consultant and the Contractor, Dufferin Construction, decided the final site location and the layout for the three installation methods. Figure 4 below shows the planned layout of the installation methods.

Installation of the precast concrete slabs began on Sept 20th, 2016. The contractor installed seven to eight slabs, over three nights, for each of the three methods. Installation activities were planned in advance to adhere to the tight timeline and avoid any possible construction delays. Figure 5 below is the nightly construction activity schedule.

Methods

Option 1: Asphalt Supported Slab Method – the fastest method

This method requires the precast concrete slabs to be supported directly on a precisely milled asphalt base and then grouted in place the following night.

A Wirtgen Model W120 CFI milling machine with a 1.2 m-wide milling head was used to achieve the required width.

Since the Asphalt Supported Slab method requires a precise milling depth of the asphalt (tolerance of ± 3 mm), the Fort Miller grade check apparatus was adopted to ensure milled surface tolerances were achieved prior to placing the slab (Figure 7).

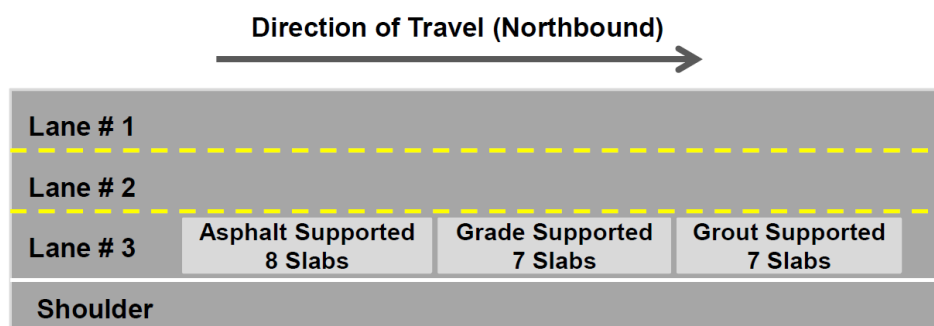


Figure 4: Site Layout of the Three Support Methods

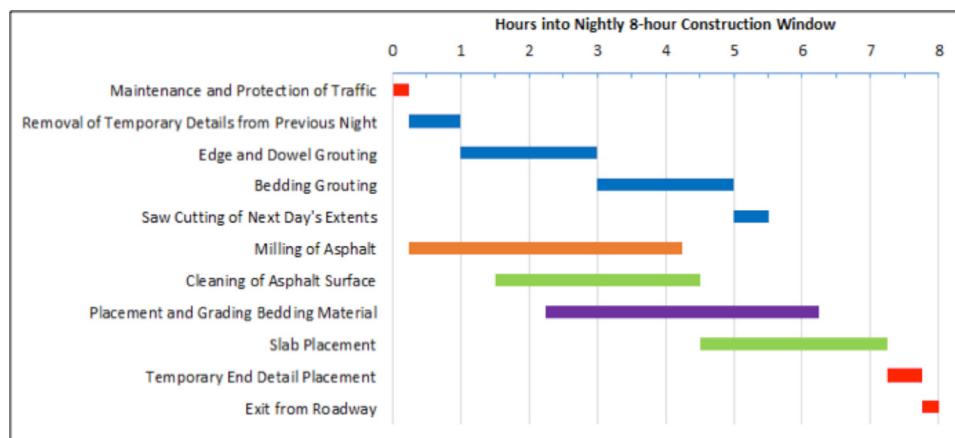


Figure 5: Precast Concrete Trial Activity Schedule

Concrete Slabs Provide Overnight Rehab Solution, continued



Figure 6: Wirtgen Milling Machine



Figure 7: Fort Miller Grade Check Apparatus

After the first slab placement, measurements indicated the surface differential between the adjacent lane surface and the precast slab surface differed by approximately 9 mm. This was adjusted by removing the slab and milling an additional 12 mm, based on Fort Miller's grade check readings. The surface differential between adjacent slabs was small (within ± 3 mm tolerance as required in the specification) for the remainder of the slabs. The CPATT instrumentation was installed beneath the fourth and eighth asphalt supported slabs. Figure 8 shows the installation of a precast concrete slab.

A total of eight asphalt supported slabs were placed in approximately 1 hour 10 minutes, for an average placement time of approximately nine minutes per slab, followed by the temporary end slab (Figure 9). Fast-setting bedding grout, dowel grout and edge grout for longitudinal joints were applied the following night (Figure 10).

Option 2: Grade Supported Slab Method

The Grade Supported Slabs were placed on the second night, September 21st, 2016. This method involved milling the asphalt, followed by placement, grading, and wetting the cement-treated bedding material (CTBM) prior to placing the precast concrete slab on top.

The same milling machine (Figure 6) and Fort Miller Grade Check Apparatus (Figure 7) were used as in the Asphalt Supported Slab method. The CPATT instrumentation was installed underneath the second and fourth slabs prior to placement of the CTBM. The CTBM was graded using a manual leveling screed and compacted using the plate tamper to the correct elevation. The material was wetted to begin hydration and the slabs were placed directly on this bedding layer (Figure 11).

A total of seven grade supported slabs and the temporary end slab were placed in approximately 90 minutes, for an average of approximately 13 minutes per slab. The edge grout for longitudinal joints was again applied the following night.

Option 3: Grout Supported Slab Method

The Grout Supported Slabs were placed on night three. This method used built-in leveling screws (or jacking bolts) which rested on the milled asphalt surface. These leveling screws have the capability to adjust the level of the concrete slab to the required elevation. Quick setting bedding grout was then injected to support the slab.

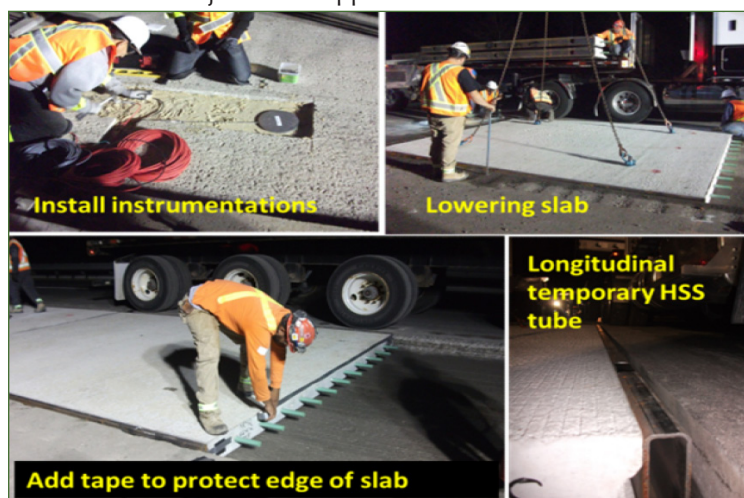


Figure 8: Precast Concrete Slab Installation for the Asphalt Supported Slab

Concrete Slabs Provide Overnight Rehab Solution, continued



Figure 9: Asphalt Supported Slab and Temporary End Slab



Figure 10: Pumping the Dowel Grout

The same milling machine was again used to remove the asphalt for this support method, and the CPATT instrumentation was installed prior to slab placement. Three grout mixers were used to produce the increased amount of bedding grout required to fill the void beneath the Grout Supported Slab. Figure 12 below shows the adjustment of the levelling screws for this method.

A total of seven grout supported slabs were placed in approximately 85 minutes, for an average placement time of approximately 12 minutes per slab.

Post-Construction Data Analysis

The post construction data collected immediately after construction included Falling Weight Deflectometer (FWD) - a testing device used to evaluate the physical properties of pavement and to determine if a pavement is being overloaded. Friction and roughness testing data were also collected.



Figure 11: Compaction of the CTBM Grade Supported Slab Method

Out of the 22 slabs placed, only one slab did not meet the 3 mm tolerance and needed to be diamond ground as per the specification.

Falling Weight Deflectometer

The ministry retained a consultant to carry out the load transfer testing using the FWD at the transverse joints of the precast slabs. Testing was completed in October 2016. A total of 23 joints were tested for load transfer efficiency (LTE %) and void detection.

As a general practice, the load transfer is considered to be acceptable when LTE is greater than 70 per cent. The average LTE for all 23 joints was 80.3 per cent, which indicates a relatively good load transfer for these precast concrete slab placements

Friction

Roadway friction is the interaction between the roadway surface with the wheels of a vehicle. Frictional resistance testing was performed using a locked

Concrete Slabs Provide Overnight Rehab Solution, continued

wheel Friction Tester unit per ASTM E-274 with ASTM E 501 standard ribbed tire. The tined longitudinal texture provided friction numbers in excess of FN30.

Roughness

Roughness was assessed by measuring the International Roughness Index (IRI) using the Automated Road Analyzer (ARAN). IRI is a roughness index with 0 mm/m representing a perfectly smooth pavement, and as the IRI increases, the measure represents a less smooth/rougher pavement. Typical IRI values for a concrete surface are higher than a hot mix asphalt surface because the longitudinal profile measurement will capture the timing of the concrete surface resulting in a higher reading. The average IRI summarized in 10 m intervals for all the precast concrete inlay slabs was 2.14 mm/m and for the adjacent asphalt pavement was 0.76 mm/m.

Lessons Learned

Precast concrete slabs require a uniform base for support. This pilot required precise asphalt milling to a specific depth, including the provision of a uniform surface for precast slab installation. Therefore, precise surface measurement and milling head control is critical to the success of this process.

Based on this pilot project experience, milling slightly deeper is better than under milling. The specialized milling machine was able to meet the specified grade requirement of ± 3 mm and provide a uniform milled surface texture.

Manual chipping of localized high spots and chipping of the asphalt rounding from the milling head delayed installation by about 1 hour. It is recommended that Bobcat mounted chipping equipment be used to significantly reduce chipping time.

Slabs should be broom finished at the plant, then diamond ground or grooved on site, as a post installation process.

Saw cutting of longitudinal joints prior to milling is not needed; however, transverse end joints should be saw-cut.

The milling width dimension required over-milling by 75 mm to accommodate the precast slab. However, the installation process shows a need for only 25 mm of over-milling. With the narrower gap, the temporary longitudinal steel channel is not required.

In addition, the use of the temporary one metre long end slab was a success to facilitate the next night's start up.

In order to achieve full production speed, two crews with separate grout mixing equipment are required for the production of dowel grout and bedding grout as the two grouts have different mixing consistency. Grouting slabs the night before opening to traffic provided sufficient set time to achieve the required grout strength.



Figure 12: Grout Supported Slab Levelling Screw and Adjustment

Concrete Slabs Provide Overnight Rehab Solution, continued

Conclusion and Recommendations

The precast concrete inlay slab trial was a success. Twenty-two precast concrete slabs using three different slab support systems were successfully placed on three consecutive nights, within the scheduled time-line. When the base support was prepared, each slab placement took about ten minutes. At full production speed, 30 to 40 slabs could be placed in an eight hour construction window.

Based on the post construction data collected to date, the Grout Supported Slab method is slightly superior in terms of load transfer and roughness. However, the ministry prefers the Asphalt Supported Slab method based on a constructability/cost perspective. This method was constructed the quickest during the pilot, adding to the cost/

benefit ratio. Precision milling achieves the final grading and it does not require additional bedding grout. The Asphalt Supported method is recommended for future projects incorporating embedded leveling screws in the precast slab as a contingency to correct any grade issues. The ministry will carry out the ongoing performance monitoring. Instrumentation installed beneath all trial inlay slabs will be monitored by CPATT in partnership with MTO. Based on lessons learned, revisions to the specification, and installation method standardization are required prior to full implementation. •

For more information, please contact:

Stephen Lee, P.Eng. Head,
Pavements and Foundations Section,
Materials Engineering and Research
Office at (416) 235-3732 or
at Stephen.Lee@ontario.ca

More *Road Talk* issues can be found on the Ontario Ministry of Transportation website:
<http://www.mto.gov.on.ca/english/publications/road-talk.shtml>

Subscribe to Road Talk: roadtalk@ontario.ca