Construction of Three Precast Concrete Slab Repair Trials in Ontario, Canada

by

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Outline

- Construction of 3 precast concrete pavement slabs trials
- FWD Analysis
- Conclusions

Introduction

- In 2004, Ontario Ministry of Transportation (MTO) carried out a demonstration/trial project to evaluate the construction techniques for precast concrete slab repair in concrete pavement.
- It was carried out on Highway 427, in Toronto, Canada.
- The project consisted of three precast full depth repair methods:
  1. The Michigan DOT Method,
  2. The Fort Miller Super-Slab™ Intermittent Method,
  3. The Fort Miller Super-Slab™ Continuous Method.

Why Precast Concrete?

- Heavy traffic volumes on Highway 427 dictate that repairs to the roadway are carried out overnight, typically with a fast-track concrete repair.
- Fast-track concrete mixes are problematic and their long term durability is questionable.
- The advantages of precast repairs are:
  - better quality concrete, better curing conditions, minimal weather restrictions on placement, and reduced delay prior to opening to traffic.

Location

- Highway 427 is a major urban freeway running north-south through the city of Toronto.
- 12-lane core-collector divided freeway, originally constructed between 1968-71.
- Existing pavement structure consists of 230 mm of dowelled jointed plain concrete pavement over 150 mm of cement treated base and 150 mm of crushed granular base.

The 2002 Annual Average Daily Traffic (AADT) was 313,000 with 12% commercial vehicles.

Hwy 427 Pavement Condition

- The concrete pavement has not been rehabilitated since it's original construction.
- Major distresses include: joint-stepping, joint failures, joint and crack spalling & severe cracking.
- Since construction, reactive (unscheduled) maintenance activities have included full and partial depth concrete pavement repairs, asphalt pavement repairs, and diamond grinding.







Pre-Cast Concrete Pavement Trials

Construction of the 3 trials was carried out in mid November, 2004:

1. Michigan Method – 3 full depth precast concrete slab repairs, 2 m x 3.65 m in size.
2. Fort Miller Intermittent Method – 3 full depth precast concrete slabs, 2 m x 3.65 m in size.
3. Fort Miller Continuous Method – a continuous 25 m x 3.65 m trial section, consisting of 6 individual slabs.

Construction - Removals

- Removal of the deteriorated concrete pavement was carried out in the same manner for each method.
- The previous night, the outer limits of the removal area were sawcut full depth.
- Dual cuts were made for ease of removal.
- The Contractor first removed the double sawcut sections with a small backhoe machine.
- The removal of this small section allowed the Contractor to place a large grappling bucket into the removal area and lift the existing concrete slab out.

Removal of CTB...

- On this project, the Contractor precast the slabs 230 mm thick.
- Contract coring revealed that the existing concrete pavement ranged in thickness from 200 – 230 mm.
- It became apparent that the CTB would need to be partially excavated to allow for placement of the required levelling material and the precast slabs.
- The Contractor used a large backhoe with a welded plate to scrape off the CTB to the required depth.

Michigan Method

- The Michigan Method was the first precast concrete method tried, 3 slabs were placed on November 16, from 10:00 pm to 3:00 am.
- The weather was cool and damp with a temperature of 8ºC (46ºF) and intermittent light rain.

Dowel Bar Slots

- In the Michigan Method, dowel bars were cast into the precast concrete slabs, 3 bars per wheel path.
- To accommodate the dowel bars, slots are cut into the existing concrete pavement.
- The dowel bar slots were marked out and sawcut the previous night.
- The dowel bar slots were chipped out using small jackhammers and blown out with compressed air.

Base Preparation

- The Michigan Method uses a flowable fill as a levelling material over the existing CTB base.
- The flowable fill was meant to be self-levelling, however, the mix that arrived on site had the consistency of cake icing.
- The flowable fill was placed in the excavation, raked evenly into all areas, then screeded off to a depth of 230 mm using a full lane width levelling screed.

Slab Placement

The precast slabs were lowered by crane onto the flowable fill, with the 12 cast-in dowel bars fitting into the sawcut slots.


MID-EXTEND

Grouting

- Once the precast slabs were in place, the dowel bar slots were grouted.
- The grout was mixed on site and poured manually into the slots from the small mixing unit.
- The grout required 3 hours to set.
- The Contractor cast grout cubes and carried out strength testing before opening to traffic - strength test results were 21 MPa in 3 hours.

Observations

- All three Michigan Method slabs were placed between 10:00 pm and 3:00 am.
- The second slab was the best of the three slabs, being flush with the existing concrete pavement - the other two slabs sat slightly high and will require diamond grinding to meet surface tolerances.
- Excavation of the dowel bar slots was problematic:
  - Dowel bars were not centered in the dowel slots
  - Slots were over cut and some were spalled or cracked.
- This method requires good workmanship to ensure that the removal area is precisely delineated & the dowel bars slots are carefully chipped out without damaging the existing concrete.

Fort Miller Intermittent Method

- The Fort Miller Intermittent Method was carried out on November 17, from 10:30 pm to 3:00 am.
- The weather was cool, clear, windy and 9ºC (48ºF).

Base Preparation

- The contractor used crusher screenings for the levelling material beneath the precast slabs.
- Screenings were placed on the excavated CTB, graded and compacted using a plate packer.
- The screenings were then fine graded with the contractor's levelling screed prior to setting the precast slabs.

Installation of Dowel Bars

- In the Fort Miller Intermittent Method, block-outs are cast into the precast slabs, to accommodate 4 dowel bars in the wheel paths.
- Once the existing concrete was removed, four dowel bars per wheel path were drilled into the adjacent concrete pavement.
- The location of the dowel bars was accurately marked with a template and a gang-drill was used to drill the dowel bar holes.


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Slab Placement

Precast slabs were lowered by crane and sat flush with the existing concrete pavement.


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Grouting

- Once the slabs were set, the dowel bars were grouted through injection ports in the precast concrete slabs.
- Grouting of the dowel bars was carried out with a manually operated grout pump.
- The grouting operation was slow (45 minutes per slab) – on-site staff from the Fort Miller Company indicated that grouting should only take 10 minutes per slab.


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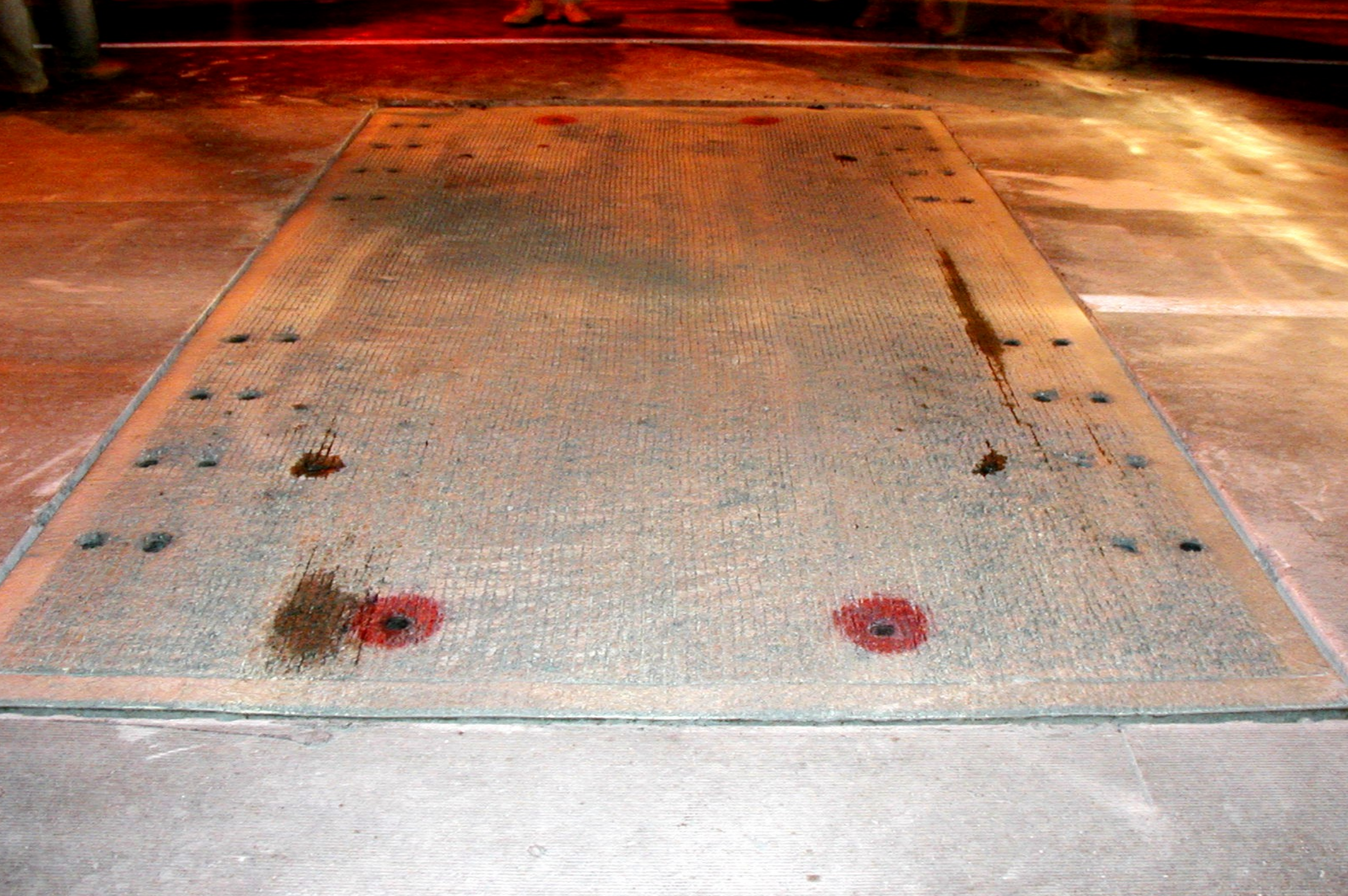
Observations

- Crusher screenings were easy to place and compact.
- Gang drilling and installation of dowel bars went well.
- Grouting was a problem:
  - Use of a manual pump was very slow.
  - Only the dowel bar grouting was carried out the first night.
  - Bedding grout, required to ensure that there are no voids beneath the slab, was injected the next night.
- The ride over all three Fort Miller Intermittent slabs was acceptable.



Fort Miller Continuous Method

- The Fort Miller Continuous Method was carried out on November 18, 2004, from 12:00 midnight to 6:00 am.
- Six interlocking precast slabs formed the 25 m long continuous repair.
- The weather was 6ºC (43ºF) with light rain.

Removals & Base Preparation

- Sawcutting of the 25 m long removal area was done the previous night.
- Removal began at 12:00 midnight, and full removal of the 25 m section was carried out in less than an hour.
- By 1:00 am, partial excavation of the CTB was underway.
- Screenings were then placed on the existing base, graded, compacted and fine graded using the contractor's levelling screed.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Installing Dowel Bar & Tie Bars

- In the Fort Miller Continuous Method, dowel bars and block-outs were cast alternately into a set of six pre-cast concrete slabs, which fit together like puzzle pieces.
- The first slab and last slab placed were dowelled into the existing pavement at each end of the excavation - in between, the slabs were connected to each other by dowel bars.
- All slabs in the continuous repair were tied into the adjacent lane with drilled and epoxy-grouted tie bars.


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Slab Placement

- The six precast slabs which formed the 25 m long continuous slab replacement were lowered by crane between 2:45 and 4:25 am.


FULL-EXTEND

Grouting

- Once the slabs were set, the dowel bars and tie bars were grouted through ports in the slabs.
- This time, an automatic grout pump was used, thank God.
- The grout flowed well and the grouting operation proceeded quickly - the grouting of the dowel bars and tie bars at the first slab took only 5 minutes.
- Test results on the grout gave 28.8 MPa at 3 hours (20 MPa at 2 hours).


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Observations

- The contractor's own leveling screed for base preparation was not as effective for the 25 m long replacement area – Fort Miller's patented Super-grader was offered and not used.
- As a result, the slabs do not match flush with each other and do not meet surface tolerance requirements.
- The resulting ride over the six Fort Miller Continuous slabs is uneven - it is recommended that diamond grinding be carried out to improve the ride.
- The Contractor had also over-excavated the removal area.

Falling Weight Deflectometer Testing

- FWD testing was carried out on November 22, 2004, at each precast slab to determine the load transfer efficiency across the transverse joints.
- FWD measurements were taken at the approach and leave joint of each slab, in the left wheel path and between wheel paths (12 tests per slab).
- Contract Documents required a minimum of 70% LTE.

FWD Results

Method	Slab	LWP	CL
		LTE (avg)	LTE (avg)
Michigan Method	slab 1	90	66
	slab 2	92	73
	slab 3	94	70
	avg	92	70
Fort Miller Intermittent Method	slab 1	82	76
	slab 2	91	85
	slab 3	83	76
	avg	85	79
Fort Miller Continuous Method	slab 1	78	74
	slab 2	86	84
	slab 3	87	87
	slab 4	83	76
	slab 5	76	68
	slab 6	91	90
	avg	83	80

FWD Results

- All the precast slabs met the minimum requirement of 70% LTE in the wheel path.
- The Michigan Method had lower load transfer between wheel paths - the Michigan Method used only three dowel bars per wheel path, whereas the Fort Miller Method used 4 bars in each wheel path.
- The Fort Miller Intermittent slabs gave slightly better LTE than the Fort Miller Continuous slabs - the intermittent slabs are tied into existing concrete on either side, whereas the continuous slabs are connected to each other.

Conclusions

- The precast trials were a success:
  - the precast slabs did not crack, spall or rock.
  - the FWD results met the minimum requirement of 70% LTE.
  - the work was carried out within the required timeframes
  - the precast repairs are similar in both ride and appearance to fast-track repairs along the same section of highway.
- The surface tolerances were not met, and diamond grinding will improve the ride.
- Workmanship was an issue, however this work was undertaken by a Contractor carrying out precast repairs for the first time and under difficult conditions, including night work, in cold, wet weather, with a 6-hour work window.

Conclusions

- The Fort Miller Method was easier to construct than the Michigan Method and less prone to damaging the existing concrete pavement.
- The Ministry will continue to monitor the field performance of these innovative precast technologies and assess the cost effectiveness of this alternative to full depth fast-track concrete repairs.

Any Questions?