Runway 05-23 Rehabilitation

at Toronto Pearson International Airport

Presenter: Jessica Hernandez – Englobe, Kevin Chee – GTAA

Date: Sept 21, 2017

Location: 2017 SWIFT - Halifax

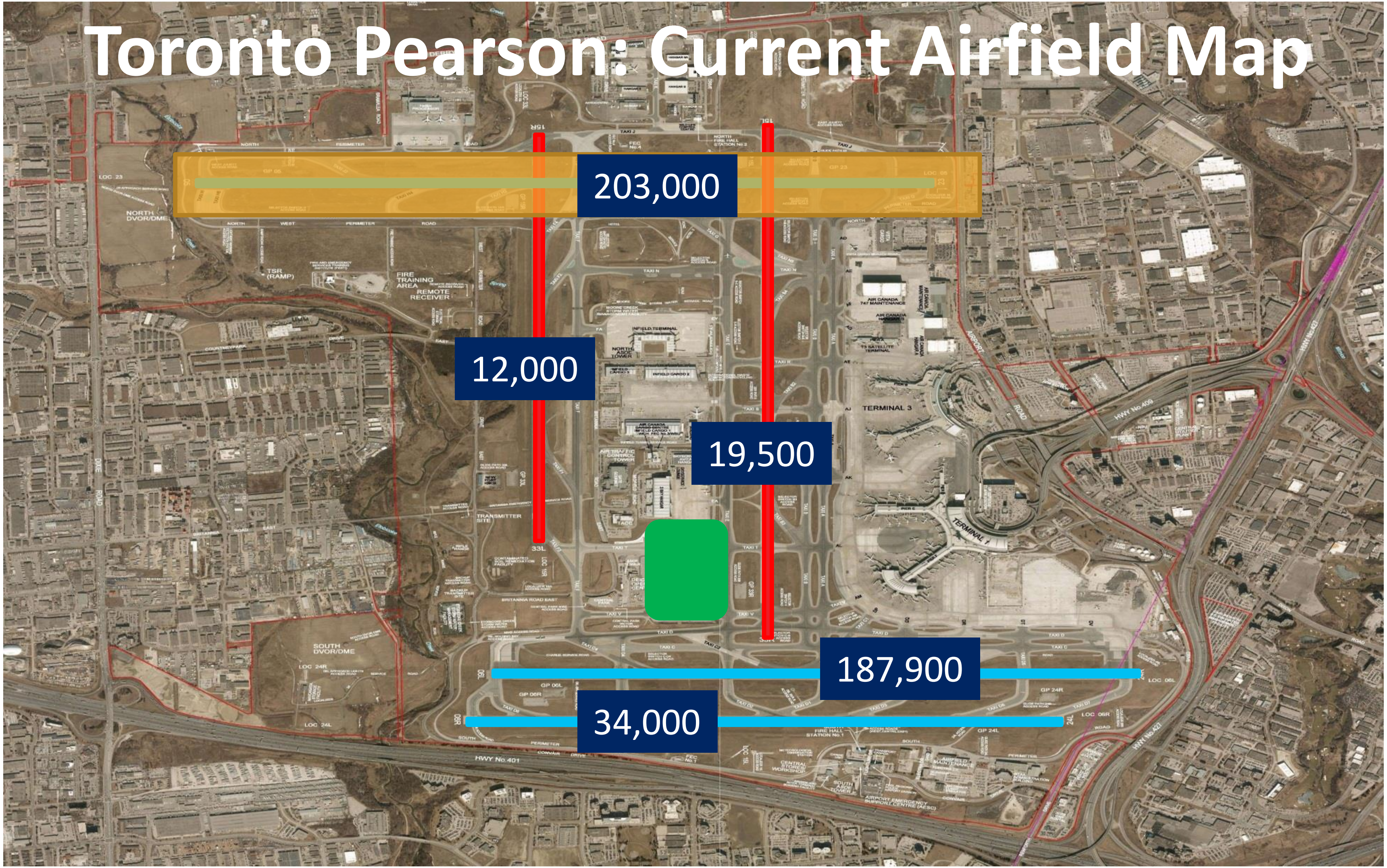
Toronto Pearson

Runway 05-23 Rehabilitation

Overview

- Background Information
- Operational Planning
- Risk Mitigation
- Field Investigation
- Design Alternatives
- Construction/Implementation
- Aircraft Ride Quality Analysis
- Conclusions

Toronto Pearson: Current Airfield Map



Toronto Pearson – Canada's Largest Airport

Toronto Pearson

• 2016 Passenger Volume:	44 Million PAX.
• Ranking in North America:	2^{nd} busiest airport
(in terms of international passengers, 27 Million PAX.)	
• Total airside paved areas:	approx. 5.8 million m^2
(concrete and asphalt)	
• # aircraft movements: annually	approx. 456,400
• Cargo processed:	over 472,000 tonnes
• Direct Jobs created:	49,000
• Jobs facilitated by Pearson:	332,000
• GDP contribution to Ontario	$42 Billion

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A quick comparison of annual Aircraft Movement in 2016 with other Canadian Airports

• Halifax Stanfield	80,500
• Calgary	185,000
• Montreal Trudeau	225,500
• Ottawa	74,500
• Toronto Pearson	456,400
Runway 0523	**203,000**
• Vancouver	280,500

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Background Information

- Originally constructed in the early 50's as a concrete runway
- Extended, widened and overlaid in 1969, 1998 and 2004
- Runway west of 15R – experiencing multiple reflection cracking causing FOD concerns, slab faulting, localized alligator cracking, rutting along the wheel path area and aircraft ride quality issue near the intersection of Runway 15R33L
- Runway east of 15R – experiencing map cracking, transverse and longitudinal cracking, and rutting along the wheel path area

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Background Information con’t

- The existing inset light cans were loose and sinking at various locations throughout the entire length of the runway
- Taxi H west of 15R – experiencing severe slab cracking and soft subgrade issues
- Taxi H east of Alpha taxiway – experiencing severe shoving twice within a year at the same location due to slow moving aircraft with stop and go movement

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Background Information con’t

- All airfield pavements are inspected in detail once every three years following the ASTM D5340 procedure. The calculated Pavement Condition Index (PCI value) and the predicted deterioration rate of each pavement section are used to optimize the timing of repair to stay above a predetermined minimum PCI value for reliability and safety.

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Background Information con't

Based on the consultant Pavement Condition Index (PCI) inspections completed in 2014, the predicated PCI values of the runway overall are as follows:

Runway 05-23	2014	2015	2016	2017	2018
Predicted PCI based on 2014 Inspection data	76	73	71	70	69

and the predicated PCI values west of 15R are as follows:

Runway 05-23 west of 15R	2014	2015	2016	2017	2018
Predicted PCI based on 2014 Inspection data	69	68	67	66	65

According to the U.S. Air Force (USAF) ETL 99-7 Pavement Condition Assessment Standards, the condition of the runway is considered to be Marginal when the PCI is

55 to 70.

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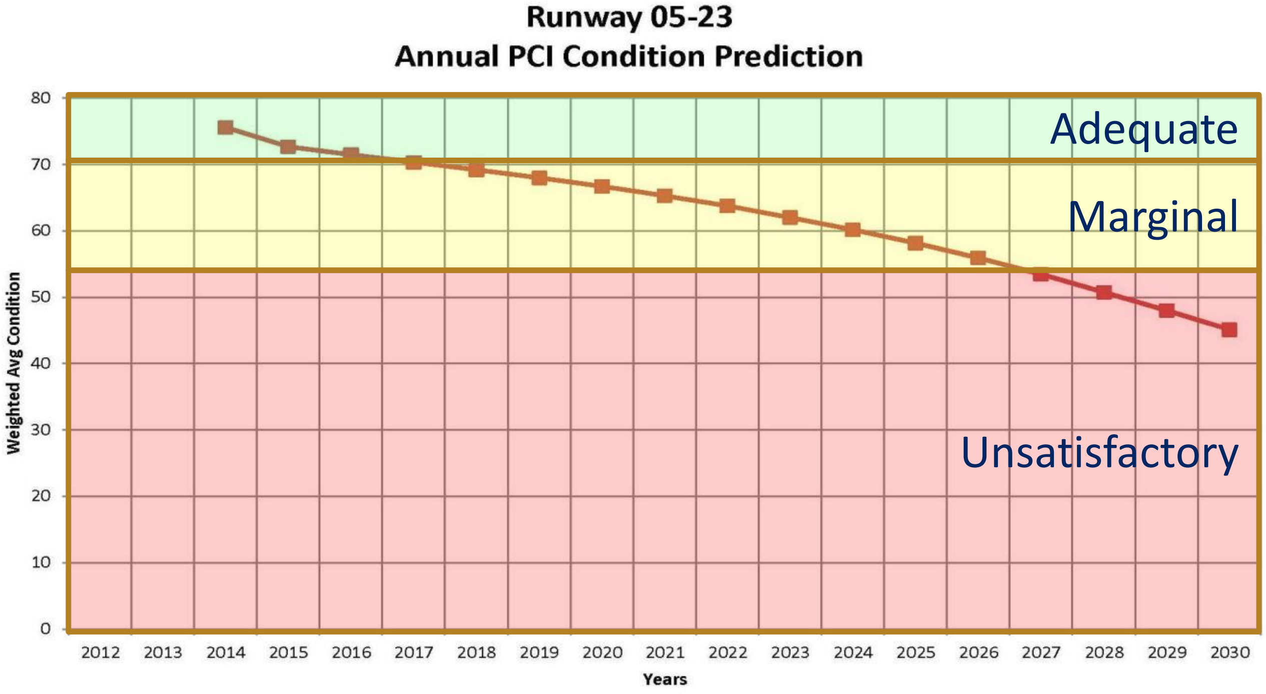
Background Information con’t



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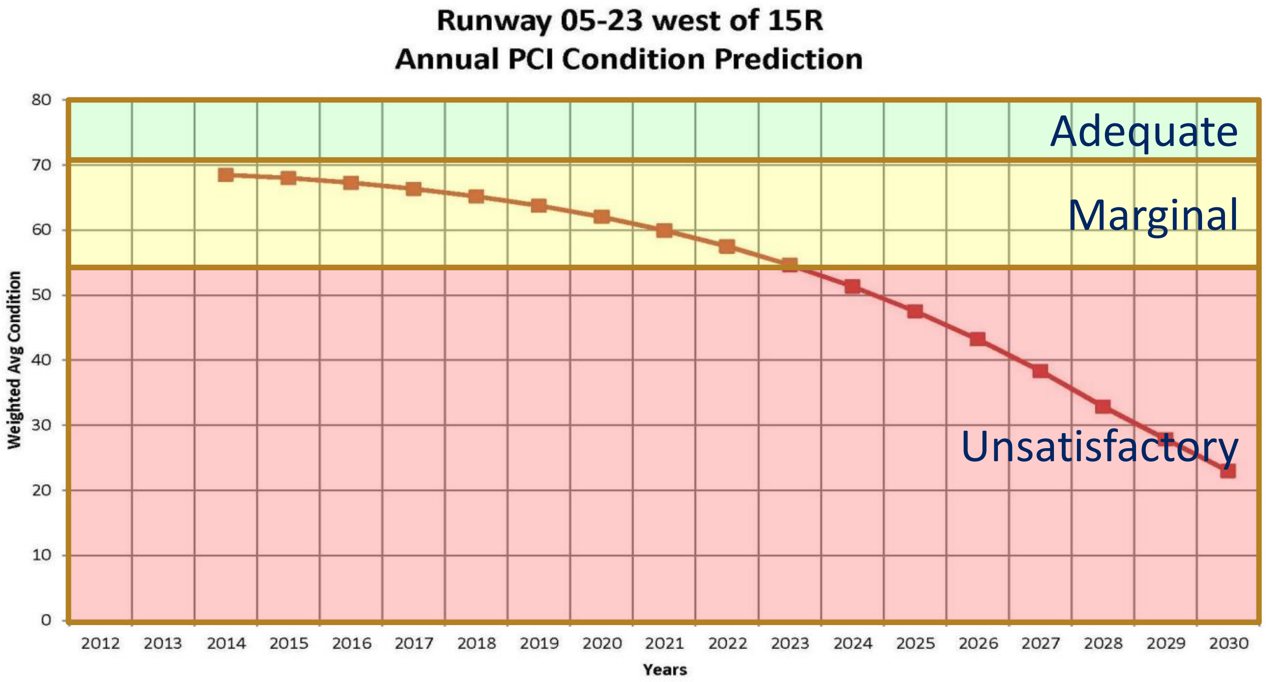
Background Information con’t



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Background Information con't

- Extensive field investigation was carried out to confirm the subsurface pavement condition using HWD and GPR then to determine the rehabilitation alternatives.
- In addition to the above investigation, a site condition review was also carried out by our Engineering and Field Maintenance Departments to verify the above findings.

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Background Information con't

- Maintaining the integrity and safety of the runway daily operations are a must for all travelers and stakeholders, therefore, a fast short-term repair solution to extend pavement life up to 5 years is required until a permanent solution is able to implement.
- Consultation with the Airlines, NavCanada, and internal stakeholders were undertaken over a year prior to any work being done to develop a construction closure schedule which minimized operational disruptions.

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Background Information con’t

- Thorough discussion and risk mitigation with all stakeholders well in advance (min. 5 years or more) including NavCanada, Airlines and all stakeholders including local residents are a must for future permanent reconstruction option on the busiest runway at the airport.

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Background Information con’t

- Existing Pavement Condition Photos

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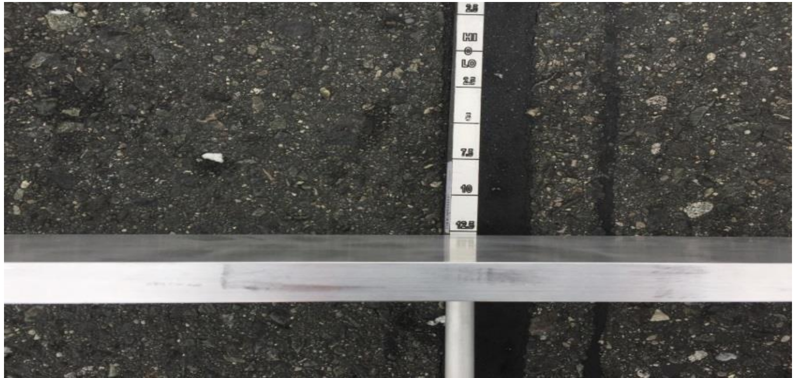
Background Information con’t

- Existing Pavement Condition Photos



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Background Information con’t

- Existing Pavement Condition Photos

Runway 05-23 Rehabilitation

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Background Information con't

- Existing Pavement Condition Photos

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Operational Planning

- Construction start early to avoid summer rush, higher weather risk
- Phasing of works to minimize operational impact
- Temporary restrictions on air traffic
- General/Business aviation flight restriction applied from March 28 to May 16
- Shortened Runway Operation during construction from April 24 to May 16
- Aircraft Arrival Rate assumption of 48 arrival/hour during construction.

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Operational Planning con’t

- At the initial planning stage, three different closure arrangements for construction (12 hours a day, 5 days a week operation) were identified and listed as follows:

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Operational Planning con’t

- One-Phase Full Closure Option

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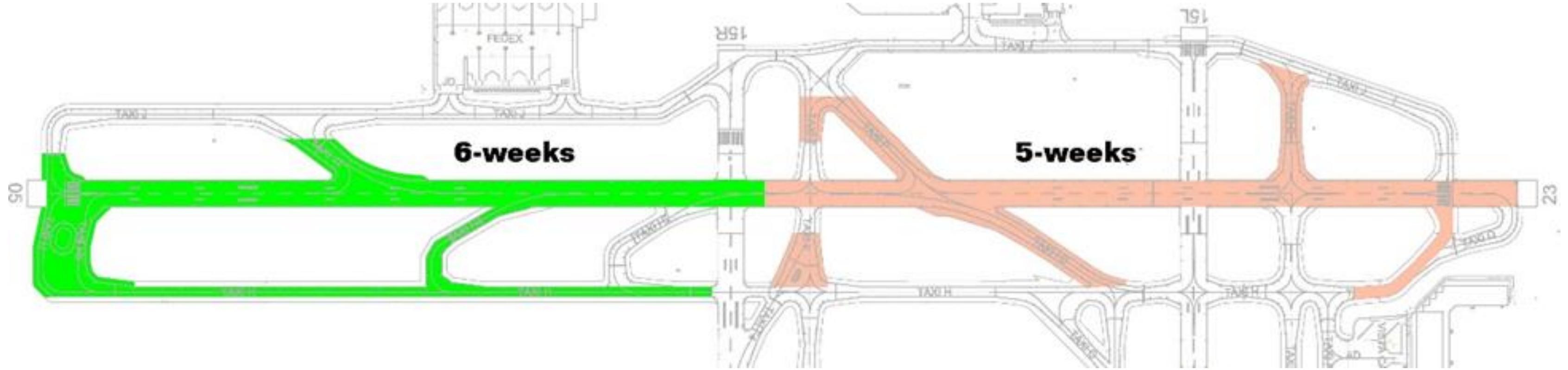
Operational Planning con't

- Two-Phase Option



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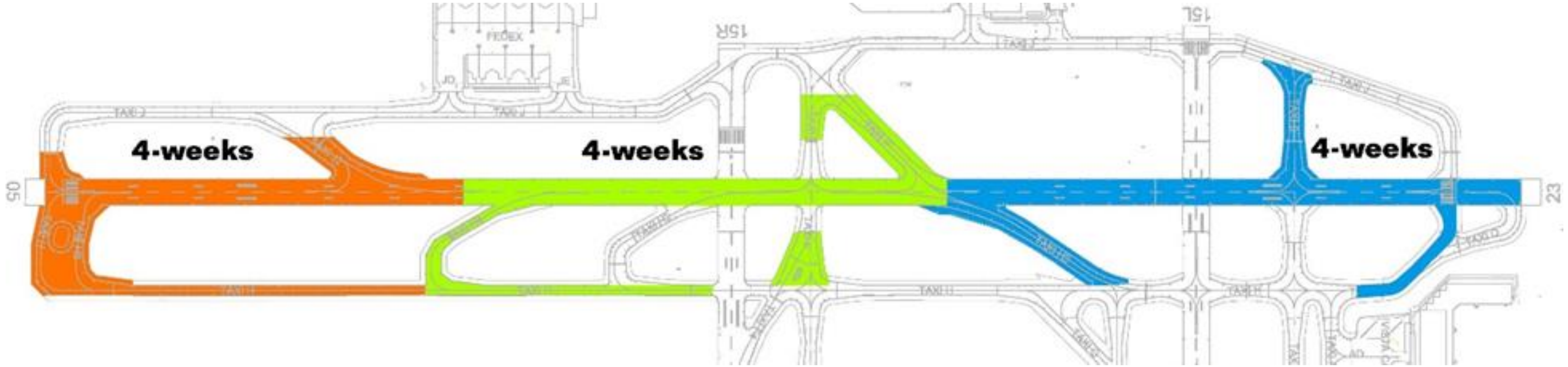
Operational Planning con’t

- Three-Phase Option



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Operational Planning con't

- During initial review with different stakeholders about the preliminary closure schedules, the airlines were concerned about the work extending into peak travel season (i.e. Mid-June to Mid-September). After discussion and commitment from the JV contractor, we were able to reduce the closure schedule significantly by operating 24 hours a day and 7 days a week to avoid the peak travel season concern.

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Operational Planning con't

- At the end, a Four-Phase runway restoration option was selected collaboratively between Airlines, NavCanada, JV contractor and GTAA with the possibility to complete Phase 3 and Phase 4 in conjunction with Phase 2 and Phase 1 respectively if weather and site conditions cooperated. The schedule dates were strategically selected to avoid all peak travel seasons. The closure dates were finalized as follows:

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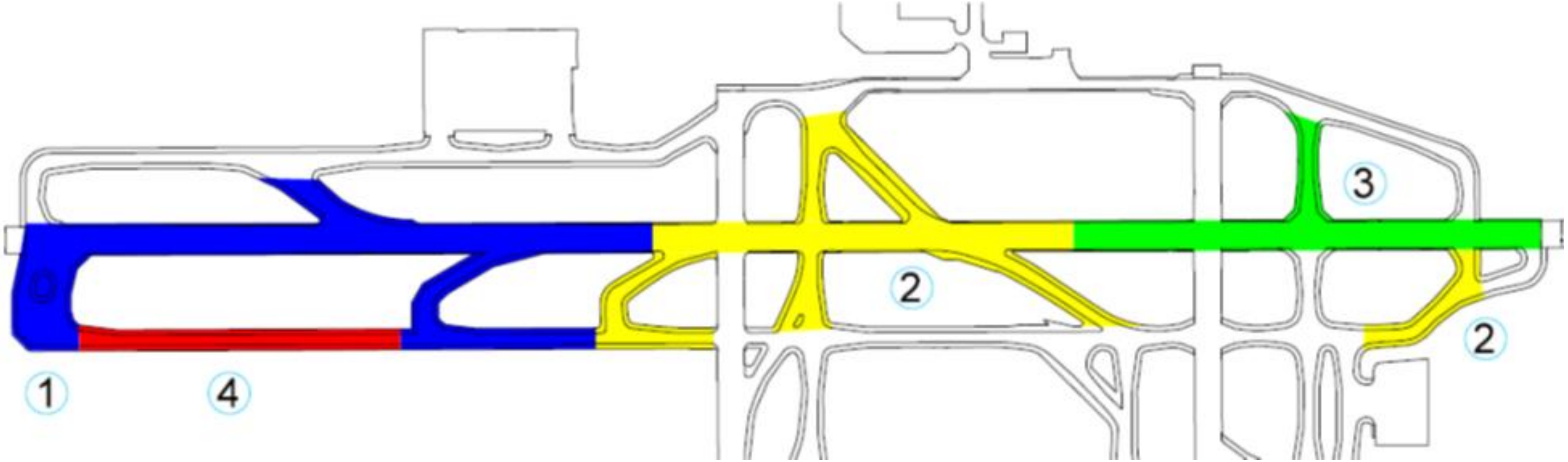
Operational Planning con’t



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Operational Planning con't

- Phase 1 – Runway between 05 and west of H2 including H/H2 area: March 28 – April 23 (4 weeks)
- Phase 2 – Runway between west of H2 and east of H3 including H/Q area: April 24 – May 16 (3 weeks)
- Phase 3 – Runway between east of H3 and 23: October 10 – November 3 (4 weeks), which may be completed in conjunction with Phase 2.
- Phase 4 – Taxi H between 05 and west of H4: April – May 2018, which may be completed in conjunction with Phase 1.

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Risk Mitigation

The following are the difficult aspects of civil construction practices:

- Poor Weather
- Construction Delay
- Availability of Materials
- Reliability of Equipment

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Risk Mitigation con't

In order to overcome the above concerns, the contractor had planned and done the following:

- Reviewed, determined and included rainy days based on the historical weather data between late-March to mid-May into the project schedule.
- Serviced asphalt plant in advance (during winter months) to ensure smooth production in the spring.
- Supplied asphalt from two asphalt plants with a combined capacity of 9,000 tonnes per day versus only one plant for a regular paving job.
- Paved in echelon with 6 pavers to improve productivity and smoothness, to minimize cold paving joints and to reduce future maintenance costs.

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Risk Mitigation con't

In order to overcome the above concerns, the contractor had planned and done the following: con't

- Hauled premium aggregate to asphalt plant in early spring, stockpiled for use to avoid supply shortage during construction.
- Pre-ordered all long lead items in advance to avoid delay during construction.
- Serviced all critical equipment in advance and provided standby equipment for all critical tasks such as telebelts for concreting, breakers for concrete removal, pavers and rollers for asphalt paving.

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Risk Mitigation con't

In order to overcome the above concerns, the contractor had planned and done the following: con't

- Water pumps, vacuum excavator trucks, and poly tarps were made available as needed in case of rain to protect excavated area or subgrade to minimize water damage, and to shelter areas under construction.
- Excavation crews with 5 backhoes, 16 trucks; Grading crews with 2 dozers, 16 trucks, and Concrete crews with 2 telebelts, 20 trucks worked 24/7 on Hotel taxiway.

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Risk Mitigation con’t

In order to overcome the above concerns, the contractor had planned and done the following: con’t

- Worked 24/7 whenever possible in addition to the above-mentioned tasks.
- Monitored weather forecast on an hourly basis, maintained good communication to all subcontractors and workers, and scheduled weather sensitive tasks such as concrete paving, asphalt paving only under favourable conditions to ensure the quality of the project is not compromised and to minimize any lost days due to weather.

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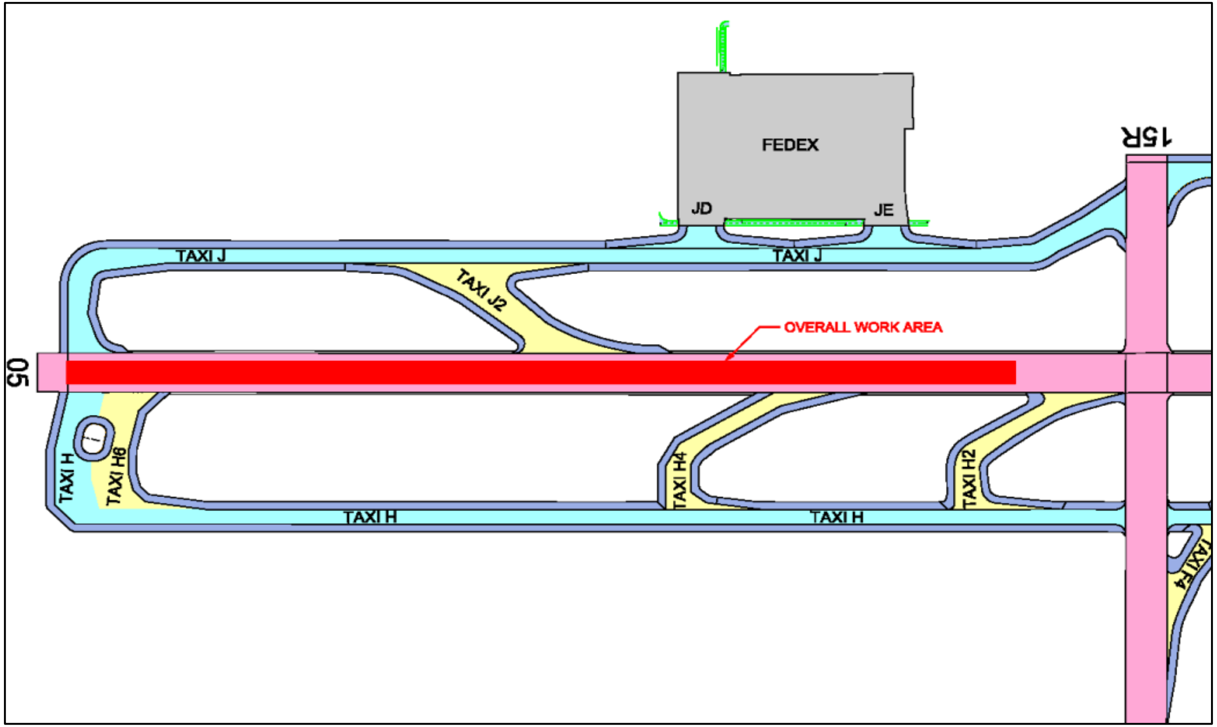
Risk Mitigation con’t

In order to overcome the above concerns, the contractor had planned and done the following: con’t

- Over 400 workers on site to work on the project at the peak level.
- Work schedule and progress were reviewed on an ongoing basis to ensure the project would be completed on time. Extra crews or resources would be deployed if needed.

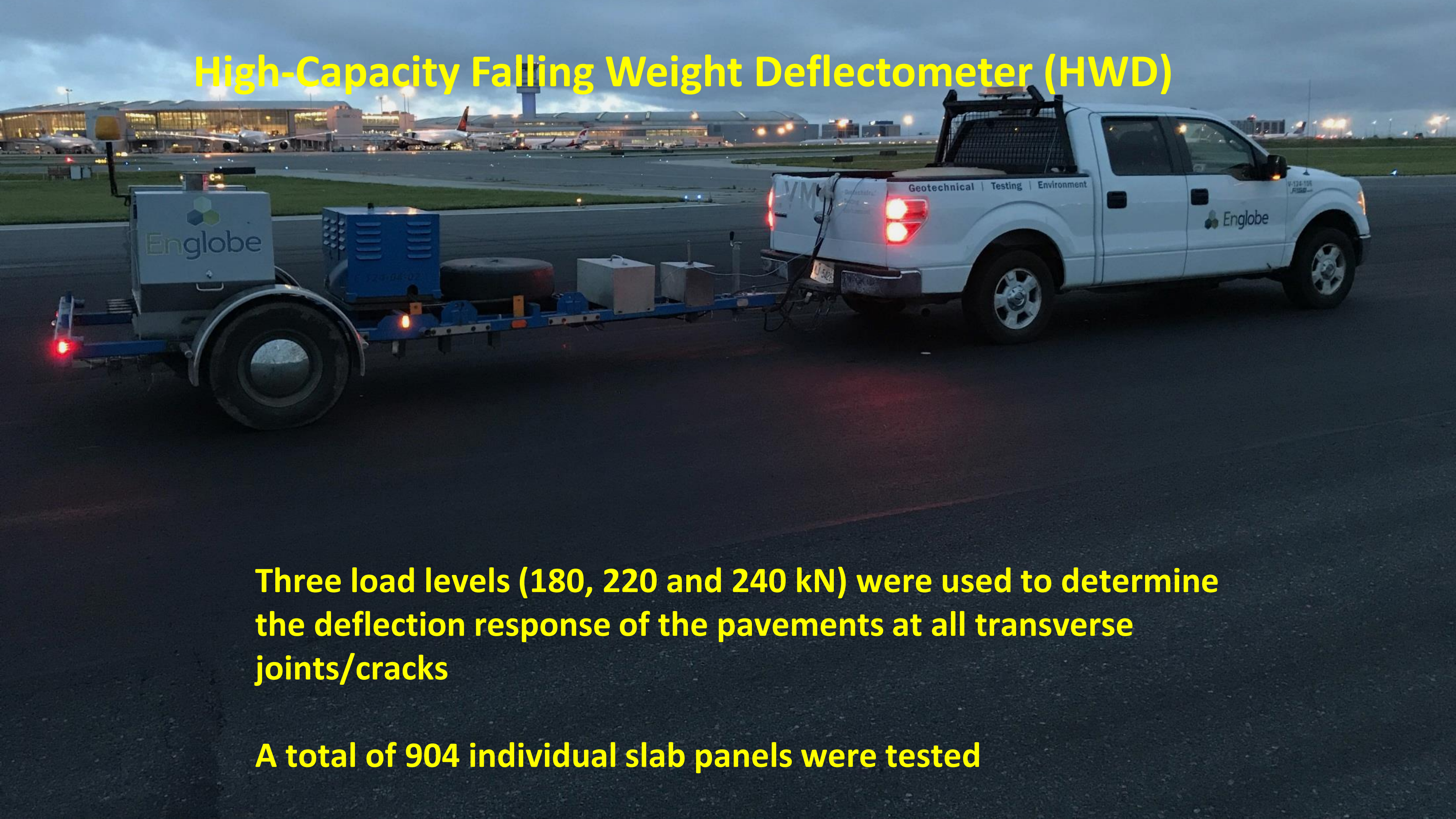
Field Investigation



Field Investigation

- Non-destructive High-Capacity Falling Weight Deflectometer (HWD);
- Limited coring of the existing asphalt concrete and portland cement concrete at selected locations (7 cores);
- Supplementary Ground-Penetrating Radar (GPR) survey to determine the extent of voids; and
- Preparation of a report.

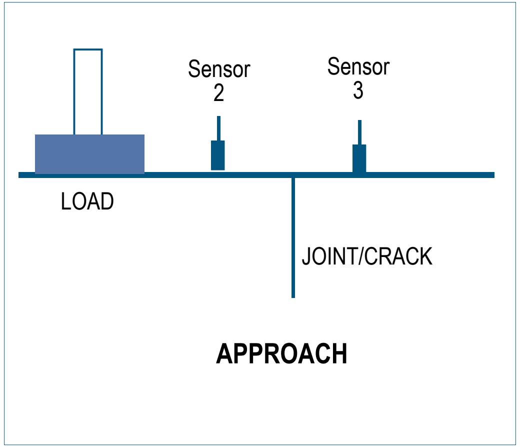
High-Capacity Falling Weight Deflectometer (HWD)

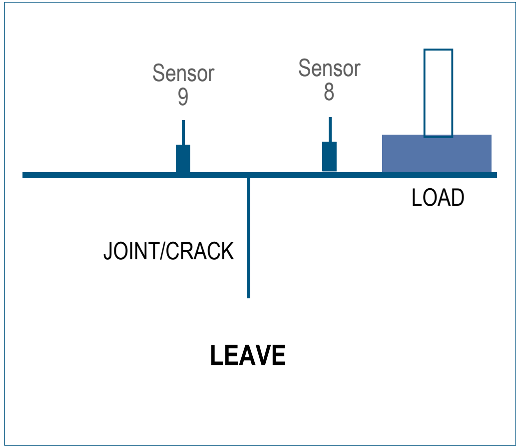


Three load levels (180, 220 and 240 kN) were used to determine the deflection response of the pavements at all transverse joints/cracks

A total of 904 individual slab panels were tested

HWD Testing





CONDITION	LTE, PERCENT
Acceptable	70 to 100
Fair	50 to 70
Poor	Less than 50

FAA 150/5370-11B - *Use of Nondestructive Testing in the Evaluation of Airport Pavements*

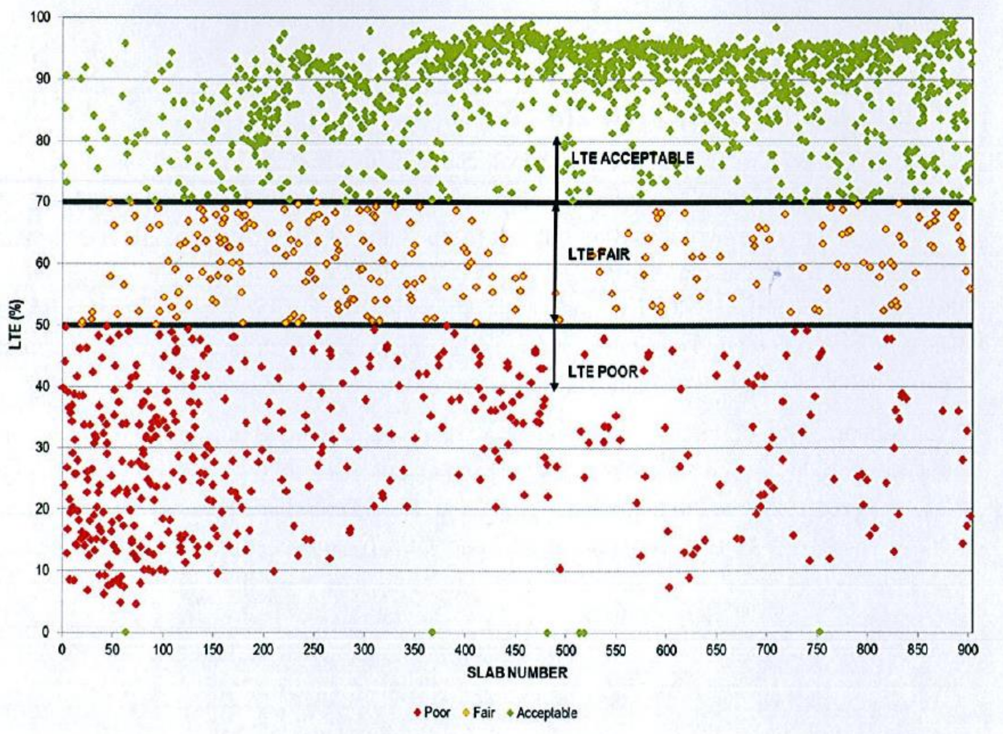
HWD Testing

LTE CONDITION	NUMBER OF TRANSVERSE JOINTS	PERCENTAGE (%)
Acceptable	1,135	62.8
Fair	235	13.0
Poor	432	23.9
Not Estimated	6	0.3
TOTAL	1,808	100

- The void detection analysis indicated the presence of voids or soft spots under some slab panels (101 of 904 slab panels tested, or 11 percent)

HWD Testing

Figure 4 Load Transfer Efficiency at transverse Joints



Coring

- Core advanced through a transverse joint, located in a Poor Load Transfer Efficiency (LTE) Slab Panel
- No intact cement stabilized base was observed/recovered during coring operations

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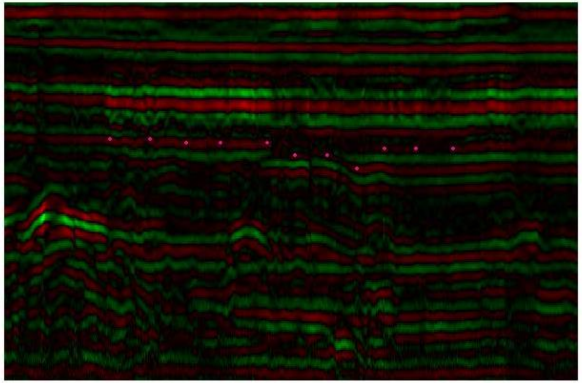
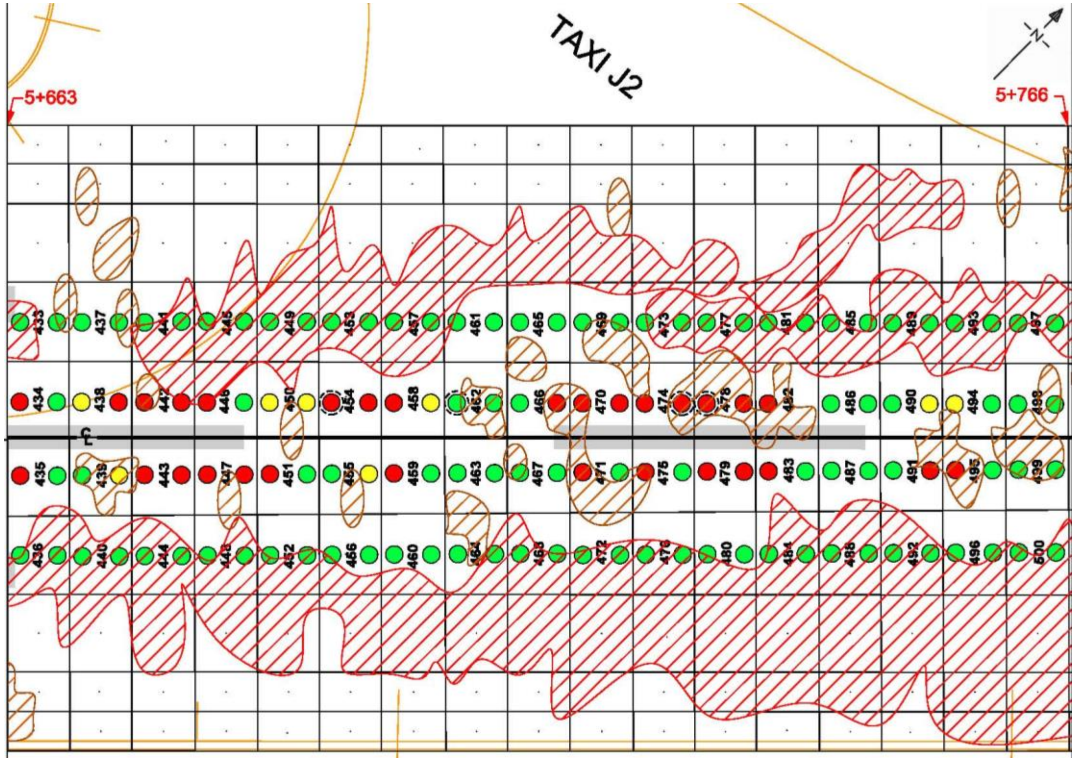
GPR Testing

- A supplementary survey/voids investigation of the project area was carried out using GPR equipment (using a 70 MHz antenna).
- The purpose of the GPR testing was to assess the extent of possible voids (or deteriorated CSB) beneath the thick runway composite pavement.



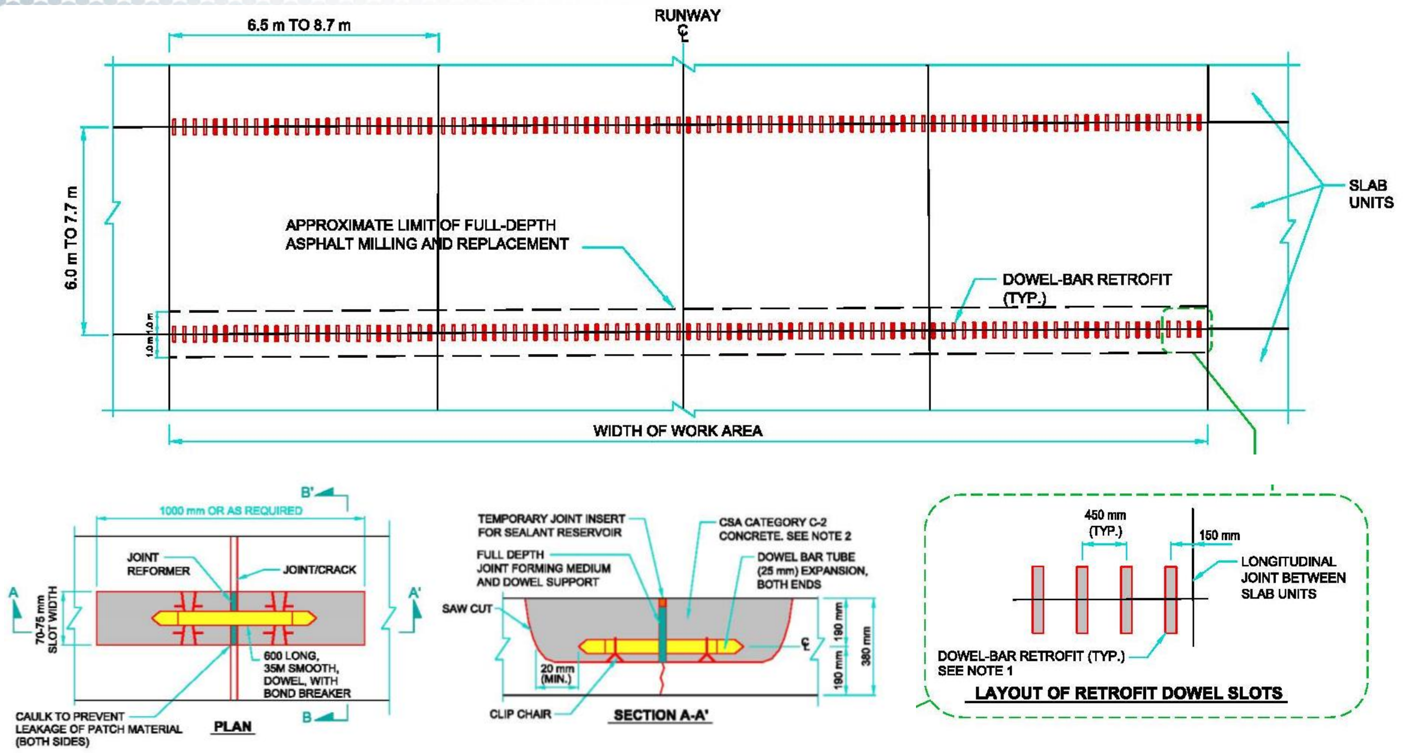
HWD/GPR Testing Results



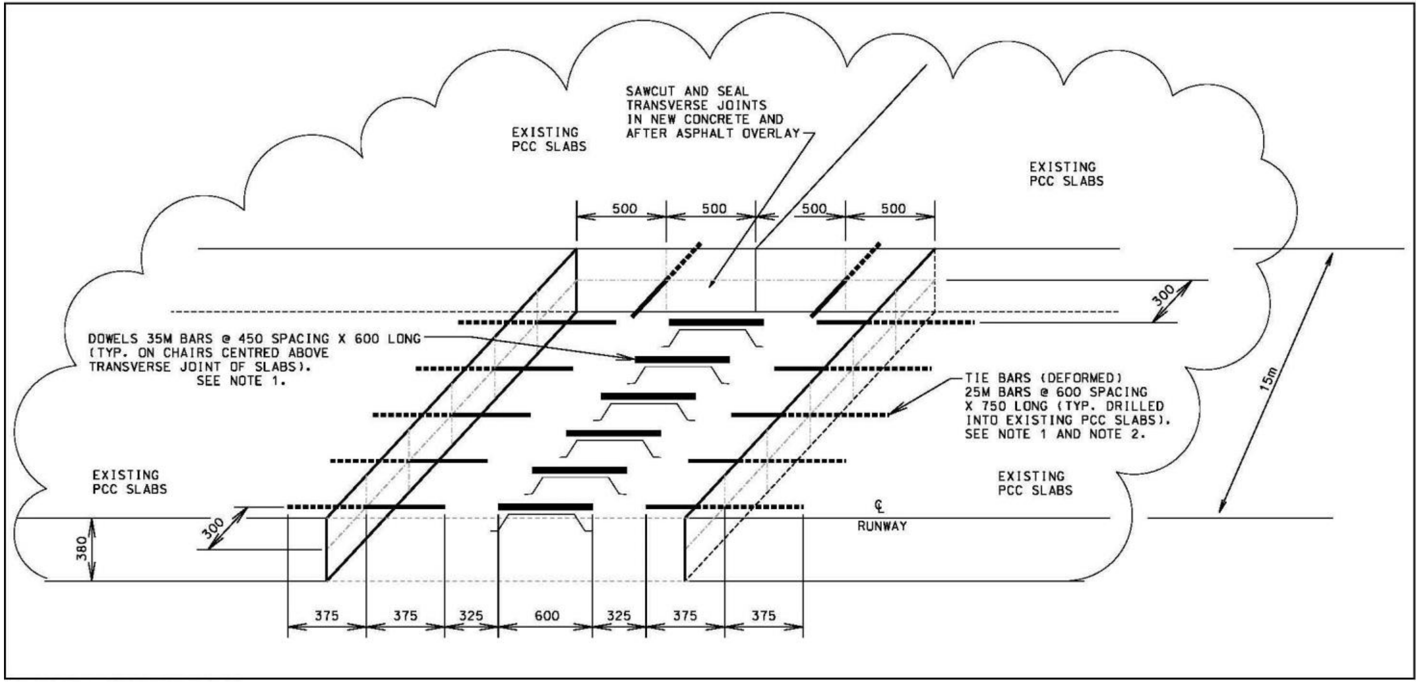
Recommendations – Option 1a Grout Injection

- **Joints where voids/soft spots were identified:** Underslab grouting (to fill voids under the slabs and in the CSB)
- **Joints with Load Transfer Efficiency (LTE) less than 60%:** Load transfer restoration techniques (dowel bar retrofit using 35 mm diameter, 600 mm long dowels at 450 mm spacing)

Recommendations – Option 1b Dowel Bar Retrofit



Recommendations – Option 2 Full Depth Trench Repair



Construction

- The major elements of work consisted of:
  - Pumping grout under pressure below existing concrete based on location of voids established by GPR
  - Cutting slots into concrete to re-establish load transfer where HWD testing established unacceptable load transfer capability
  - Removal of cracked Slabs on Taxiway ‘H’
  - Milling of asphalt and repaving
  - Installation of new concrete slabs on Taxiway ‘H’ west using smaller slab size

Construction

- The major elements of work consisted of:
  - Conversion of a section of asphalt pavement to concrete pavement on Taxiway ‘H’ east of Alpha
  - Removal and refurbishment of inset lighting
  - Repairs to damaged subdrains
  - Regrading of areas to improve drainage off the pavement
  - Reprofiling of the runway to provide improved ride quality
  - New line painting and thermoplastic markings at hold lines

Construction

Construction

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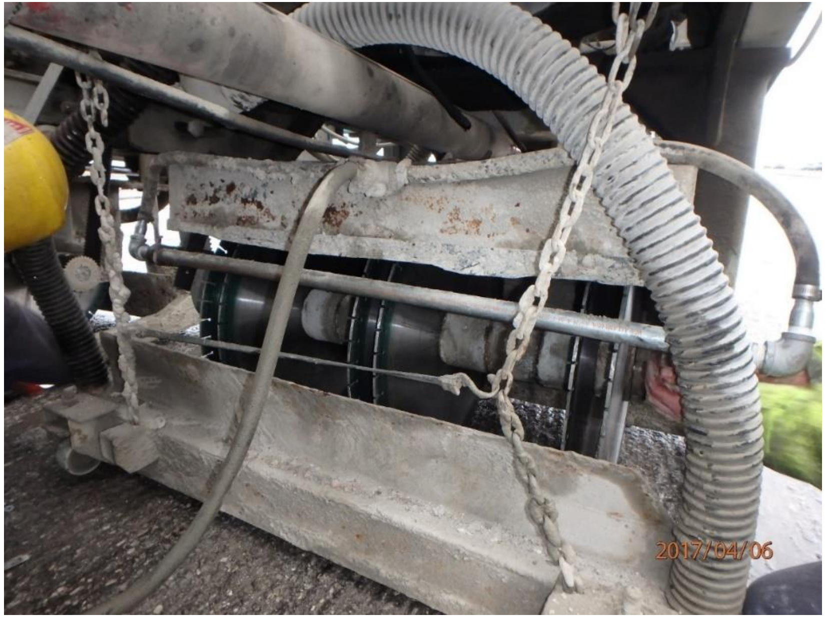
Construction

Construction



Construction

Construction

Construction

DBR Machine Video – 6 Slots

Construction

Construction

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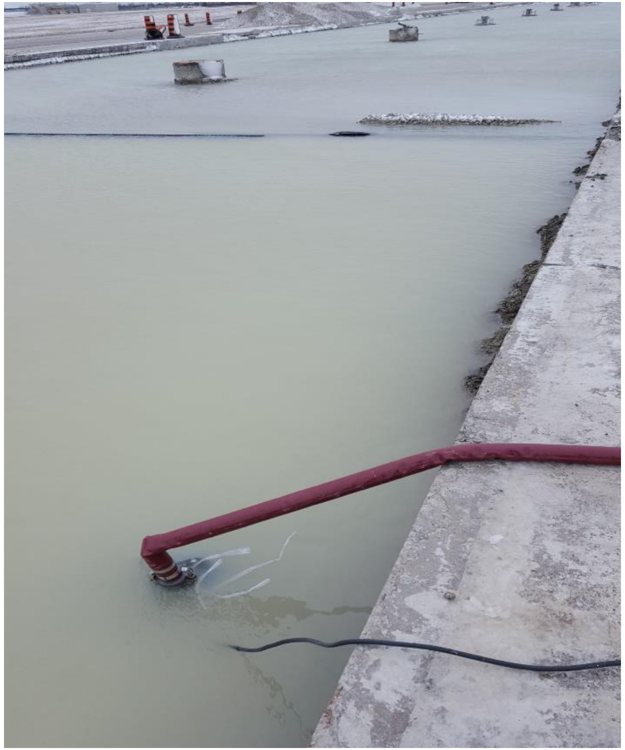
Construction



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Construction

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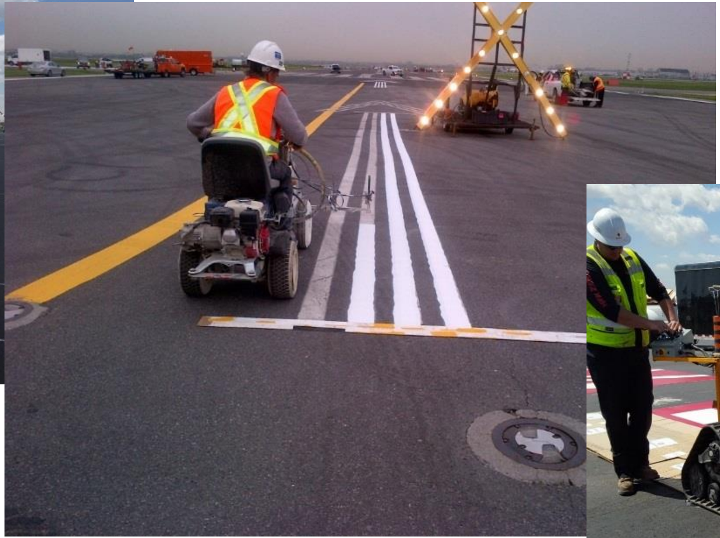
Echelon Paving Video – 6 Pavers

Construction



Construction

Construction

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Construction

Construction

Project Completion

Aircraft Ride Quality Analysis Prior to Paving

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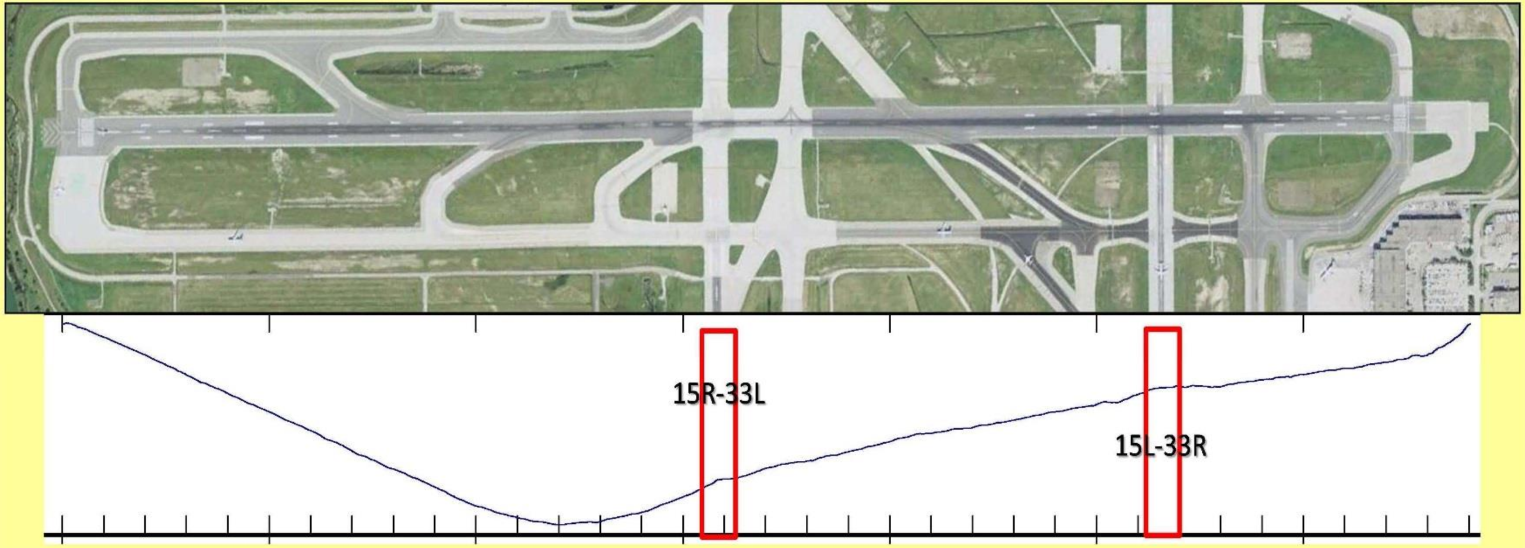
YYZ Runway 05-23

5																								23
Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Distance	0 - 150	150 - 300	300 - 450	450 - 600	600 - 750	750 - 900	900 - 1050	1050 - 1200	1200 - 1350	1350 - 1500	1500 - 1650	1650 - 1800	1800 - 1950	1950 - 2100	2100 - 2250	2250 - 2400	2400 - 2550	2550 - 2700	2700 - 2850	2850 - 3000	3000 - 3150	3150 - 3300	3300 - 3400	

YYZ Runway 05-23



Aircraft Ride Quality Analysis after Paving

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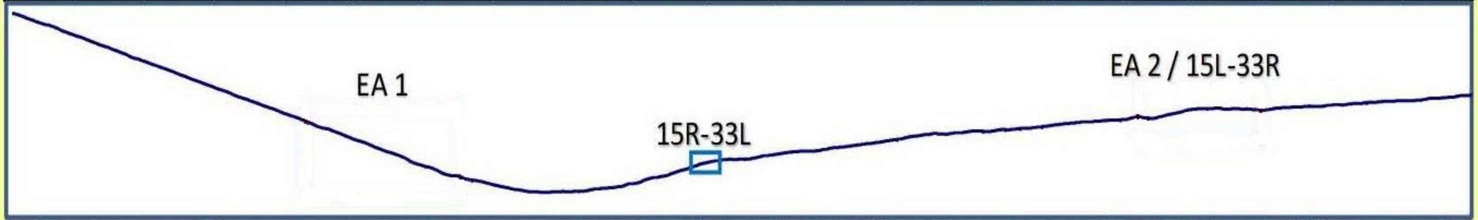
YYZ Runway 05-23

	5																				23
PSI	71	72	71	64	66	65	70	73	70	70	73	74	72	71	76	80	66	67	75	77	84
Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Chainage	0 - 150	150 - 300	300 - 450	450 - 600	600 - 750	750 - 900	900 - 1050	1050 - 1200	1200 - 1350	1350 - 1500	1500 - 1650	1650 - 1800	1800 - 1950	1950 - 2100	2100 - 2250	2250 - 2400	2400 - 2550	2550 - 2700	2700 - 2850	2850 - 3000	3000 - 3161



PSI Number		Comments	Recommended Action
70-100	Green	Smooth	Survey Perodically
60-69	Yellow	Mildly Rough	Survey Within Two Years
40-59	Brown	Moderately Rough	Consider Repairs
20-39	Red	Significant to Severe Roughness	Immediate Repairs Should be Considered
0-19	Black	Severe Roughness	Cease Aircraft Operations Until Repaired

Cake Celebration

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Conclusions

<u>Project Facts:</u> Construction started on March 28 and was Completed on May 16 (7 weeks faster than original schedule)

Concrete Pavement Removal/Installation	59,500 m^2
Dowel/Tie Bars Installation	10,600 unit
Asphalt Milling	300,900 m^2
Dowel Bar Retrofit (DBR)	6,900 units
Gout Injection	5,250 m
HMAC Surface	50,000 t
HMAC Base	23,500 t
Inset Lights	900 units

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Conclusions con't

Lessons Learned

→Develop and initiate a comprehensive communication protocol prior to and throughout the construction duration. All passengers, airlines, stakeholders and local residents will be updated on a regular basis.

→All stakeholders must follow the established plan during construction and should not change it without prior approval from all stakeholders.

→Experienced Contractor with good airfield construction experience is a must.

→Aircraft Arrival Rate should be reduced during construction to minimize delay.

Runway 05-23 Rehabilitation

Conclusions con't

Lessons Learned

→To ensure a sustainable future, long lasting pavement and LED lighting are viable options when compared with convention pavement and traditional lighting.

→The success was thanks to all the hard work and effort from the JV contractor, Subcontractors, Geotechnical consultant, In-House design team and Airport Operations so that the project was able to complete on budget and ahead of schedule.

Thank You

Presenter: Jessica Hernandez – Englobe, Kevin Chee - GTAA

Date: Sept 21, 2017

Location: 2017 SWIFT - Halifax

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