Development of High Stability and Fuel Resistant Airfield Asphalt Mixture

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captg SWIFT AIRFIELD CONFERENCE/TRADE SHOW

2022 CAPTG Workshop

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ACKNOWLEDGMENT

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Golder Associates

OUTLINE

- Asphalt Mix Challenges at The Pearson Airport
- Need for High Performance and Fuel Resistant Airfield Asphalt Mixtures
- Experimental Work on High Stability and Fuel Resistant Mix
- First in Canada Field Trials at the Pearson Airport
- Final Remarks

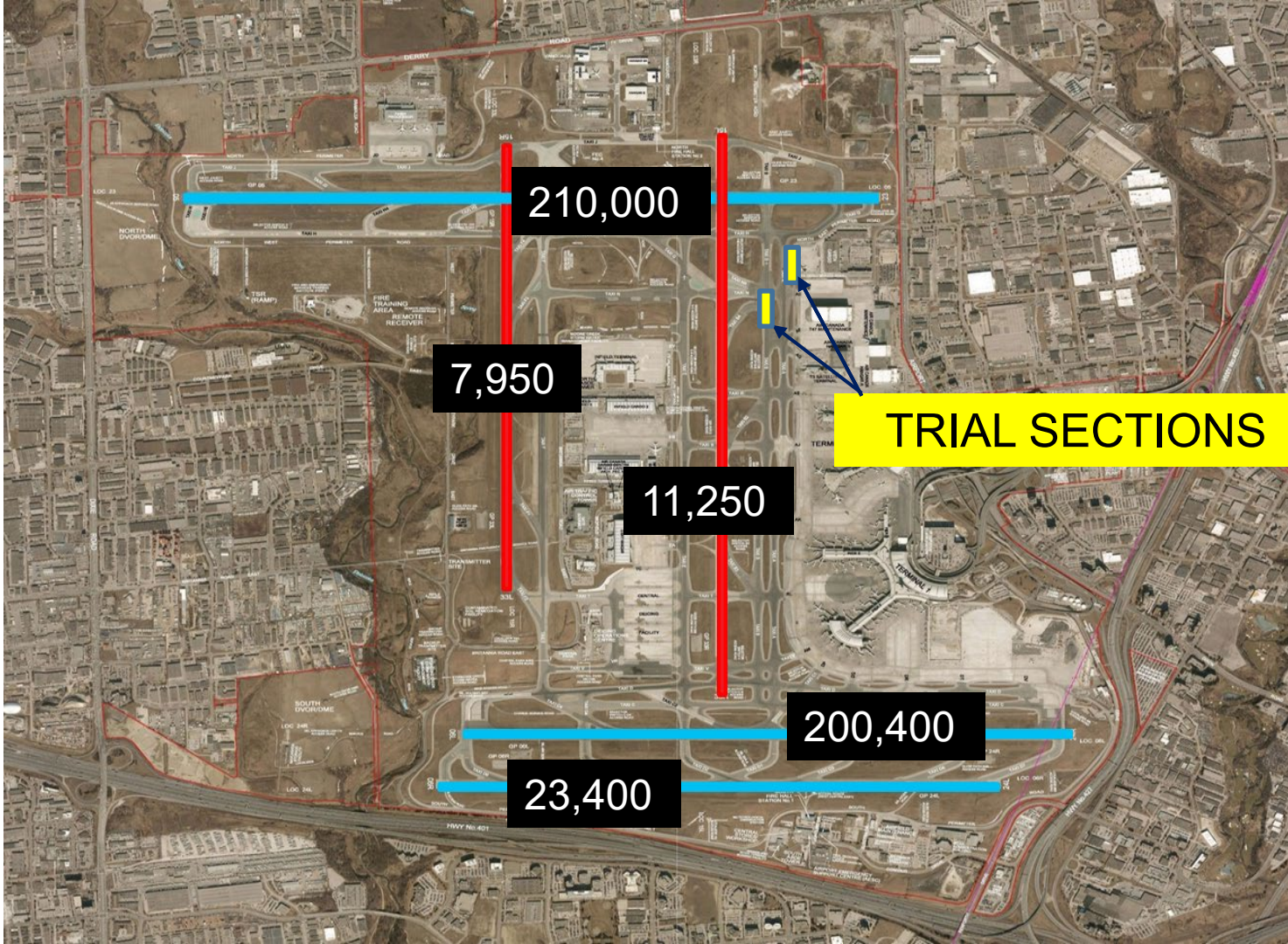
TORONTO PEARSON
CANADA'S LARGEST AIRPORT

• 2019 Passenger Volume	50.5 Million PAX.
• Ranking in North America*	2nd busiest airport
• Total airside paved areas (concrete and asphalt)	approx. 5.8 million m^2
• # aircraft movements:	approx. 453,000 annually
• Cargo processed:	513,000 tonnes
• Direct Jobs created:	51,000
• GDP contribution to Ontario	$42 Billion

**In terms of international passengers, 32.4 Million PAX.*

Toronto Pearson
International Airport | Aéroport International

2019 TRAFFIC MOVEMENT



ASPHALT MIX CHALLENGES AT GTAA

- Effects of new large aircraft with higher tire pressure and higher maximum takeoff weight.
- Slow moving aircraft with stop and go movement prior to or at the holding bay areas, stop bar areas, etc.
- Global warming leading to unusual severe hot weather in the summer.
- Maintaining the integrity and safety of the airport’s daily operation is a must for all travellers and stakeholders.

ASPHALT MIX CHALLENGES AT GTAA

GTAA's Proactive Approach:

- Innovative opportunities such as Jet Fuel Resistant mix, fiber and wax additive, warm mix asphalt technology, dual layer asphalt paving equipment, perpetual pavement design, etc. to improve mix design to provide durable pavement and to minimize operational impacts due to planned/unplanned shutdown.
- Using premium materials for better durability and frictional properties.
- More collaboration with contractors, suppliers and experts in paving design and paving technology.
- More collaboration with airframe manufacturers to ensure that aircraft design for future large aircraft will have no negative impact to current/existing pavement due to load, tire pressure, gear configuration, etc.
- More collaboration with other airports and universities (i.e. Canadian Airfield Pavement Technical Group (CAPTG) and University of Waterloo Centre for Pavement and Transportation Technology (CPATT)).

ASPHALT MIX CHALLENGES AT GTAA

Slippage of asphalt away from the inset light

Pavement shoved at the hold line position

ASPHALT MIX CHALLENGES AT GTAA cont'd

Asphalt Sliding between layers due to braking and turning

Shoving in asphalt due to heavy braking of fully loaded aircraft

STUDY OBJECTIVES

- Collaborative work between GTAA, SNC-Lavalin, and McAsphalt Industries
- Development of FAA P-404 Airfield Asphalt Mixture using locally available premium materials
- Completion of a field trial
- 5-year field monitoring

EXPERIMENTAL MATERIALS

	Sieve Size (mm)	Trap Rock	Diabase	Gabbro	P-404 Specification
Gradation % Passing	16	100	100	100	100
	12.5	99.2	98.5	99	100
	9.5	93	91.2	91.2	90 – 100
	4.75	61.1	61.3	62.4	58 – 78
	2.36	41.1	50.1	42.8	40 – 60
	1.18	32.3	32.5	28.1	28 – 48
	0.6	25.2	20.5	18.9	18 – 28
	0.3	11.8	12.4	12.2	11 – 27
	0.15	7.5	7.3	6.6	6 – 18
	0.075	6	4.5	3.6	3 – 6

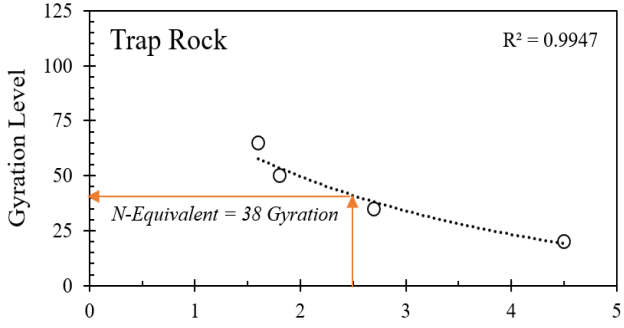
NOTES:

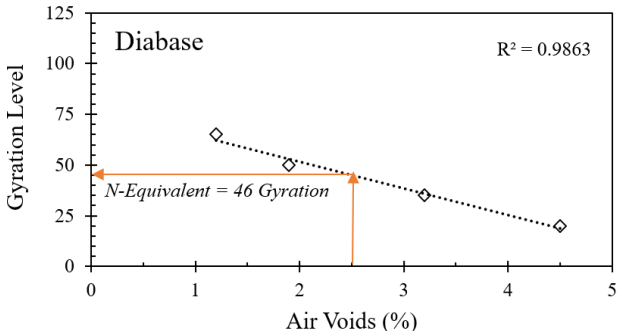
1. *P-404 is Federal Aviation Administration (FAA) Specification, under AC 150/5370-10H Section: 404-2.1*
2. *The binder was formulated to also ensure P-404 Section 404-2.3 (meeting ASTM D6373 for performance grade PG 82-28FR)*

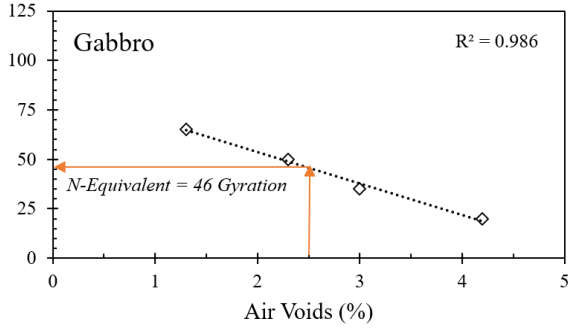
EXPERIMENTAL MATERIALS

Properties	Trap Rock	Diabase	Gabbro	P-404 Specification
Binder Content, %	6.9	6.9	6.5	5.5 – 8.0
Design Air Voids, %	2.5	2.5	2.5	2.5
Design VMA, %	18.6	19.4	18.2	14%
Stability, N	14,289	15,543	14,127	9,564
Flow (0.25 mm)	26.0	23.0	19.0	
Bulk Relative Density (Gmb)	2.515	2.515	2.532	
Maximum Specific Gravity (Gmm)	2.579	2.580	2.595	
Asphalt Film Thickness (AFT), µm	13.2	15.7	16.3	
Tensile Strength Ratio (TSR), %	92.7	97.6	90.6	Minimum 80

N-equivalency (Superpave Gyratory Vs. Marshall)



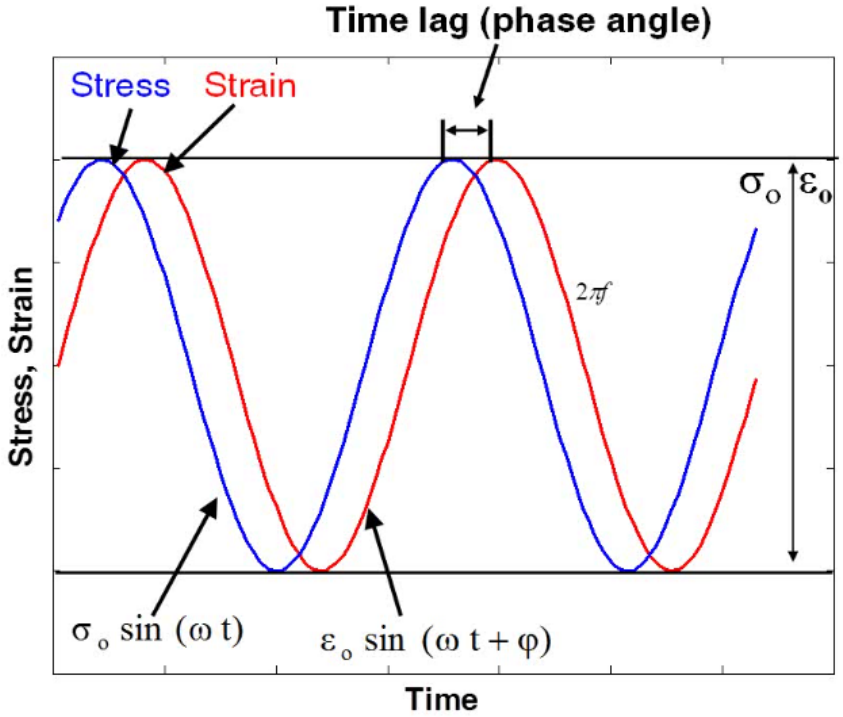




ASSESSMENT OF MIXTURES PERFORMANCE

Distress Target	Test
Overall Stiffness	AMPT – Dynamic Modulus
Rutting/Shoving	AMPT – Flow Number
	Asphalt Pavement Analyzer (APA)
	Hamburg Wheel Tracking Device
Fatigue Cracking	Semi-Circular Bending (SCB)
Fuel Damage	Fuel Immersion Test

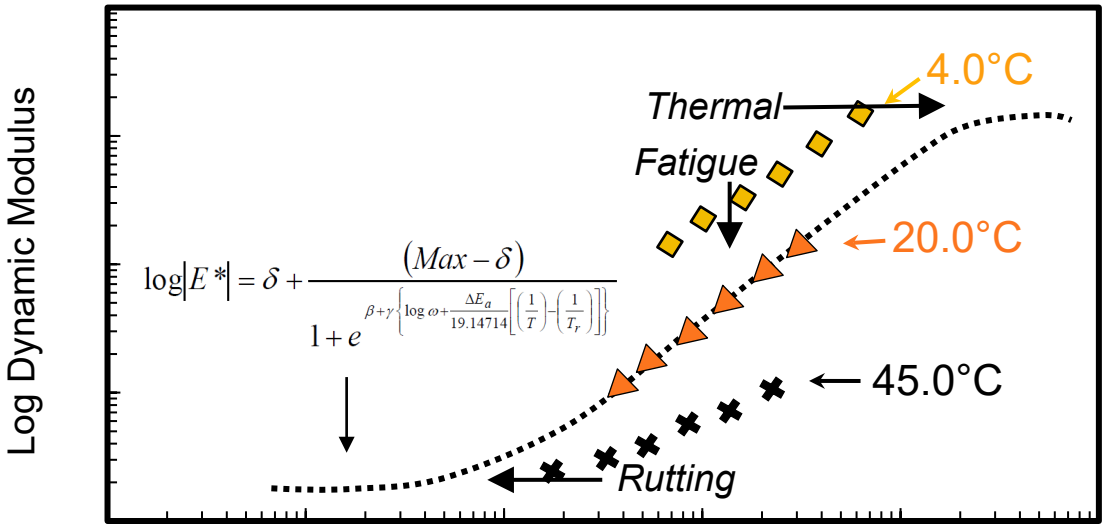
AMPT DYNAMIC MODULUS TEST



$$|E^*| = \frac{\sigma_o}{\varepsilon_o}$$

ASPHALT MIXTURE PERFORMANCE TESTER (AMPT) AASHTO TP 79

DYNAMIC MODULUS AND MASTER-CURVES



Temp. (°C)	Freq. (Hz)
4.0 (Low Temp Cracking)	0.01 (Very Slow)
20.0 (Fatigue Cracking)	0.10
45.0 (Rutting)	0.50
	1.0
	5.0
	10.0 (Moderate)
	25.0 (High Speed)

OVERALL STIFFNESS – DYNAMIC MODULUS

Mix Name	Dynamic Modulus, E*, ksi at 10 Hz			Phase Angle (Degrees)		
	Testing Temperature, ºC			Testing Temperature, ºC		
	4ºC	20ºC	40ºC	4ºC	20ºC	40ºC
Trap Rock	1066.4	433.9	56.9	15.4	24.1	34.8
Diabase	1170.7	372.3	58.9	17.5	28.3	34.5
Gabbro	987.5	321.5	52.5	18.0	28.8	33.9

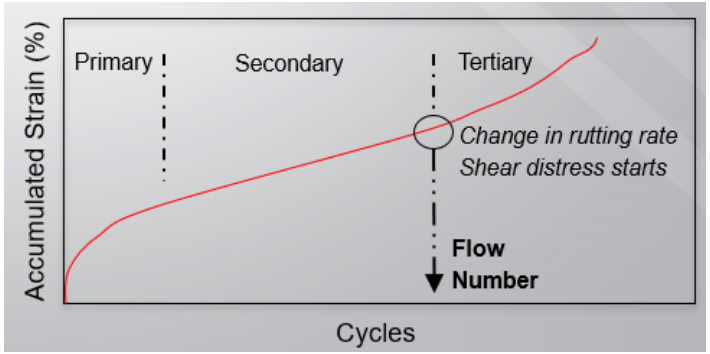
Notes: Stiffness value was predicted for the conditions of 20°C using a frequency of 10 Hz.

HIGH TEMPERATURE SUSCEPTIBILITY

» APA & HWT rutting

- Simulative Testing
- APA - 100 lb (45.5 kg) wheel load over 100 psi (690 kPa) pressurized hose, 8,000 cycles at 64˚C
- HWT - Tracking 705 N Steel Wheel, 20,000 passes

» Flow Number



HIGH TEMPERATURE SUSCEPTIBILITY
FLOW NUMBER (FN)

Mix Name	Franken Model Curve Flow Number
Trap Rock	7,929
Diabase	2,990
Gabbro	3,448

Mix Name	Flow Number Micro-strain
Trap Rock	30,117
Diabase	35,589
Gabbro	28,702

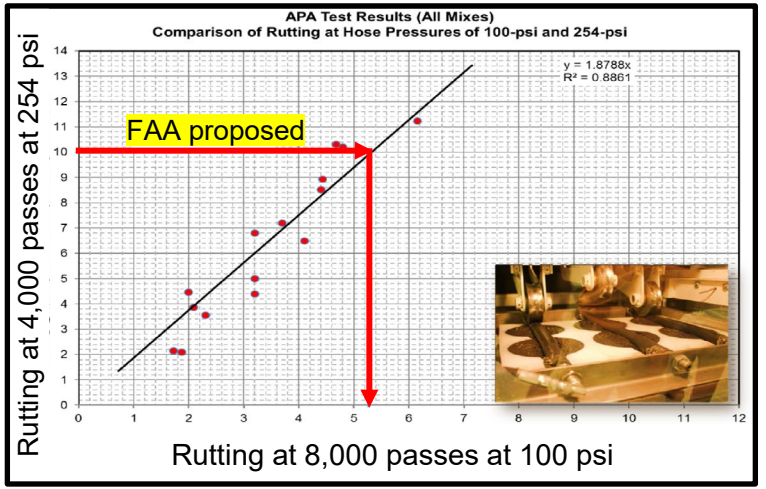
HWY Traffic Level (Million ESALs)	Minimum Flow Number (cycles)	General Rut Resistance
< 3	--	Poor to Fair
3 to < 10	53	Good
10 to < 30	190	Very Good
≥ 30	740	Excellent

NCHRP Report No.673 (Project 9-33)
(A Manual for Design of Hot-Mix Asphalt)

HIGH TEMPERATURE SUSCEPTIBILITY
APA & HWT

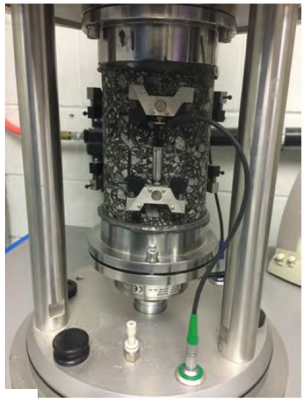
Mix Name	Average APA Rut Depth (mm)	FAA P-404 Requirement
Trap Rock	2.57	Less than 5 mm at 8,000 passes
Diabase	2.59	
Gabbro	2.55	

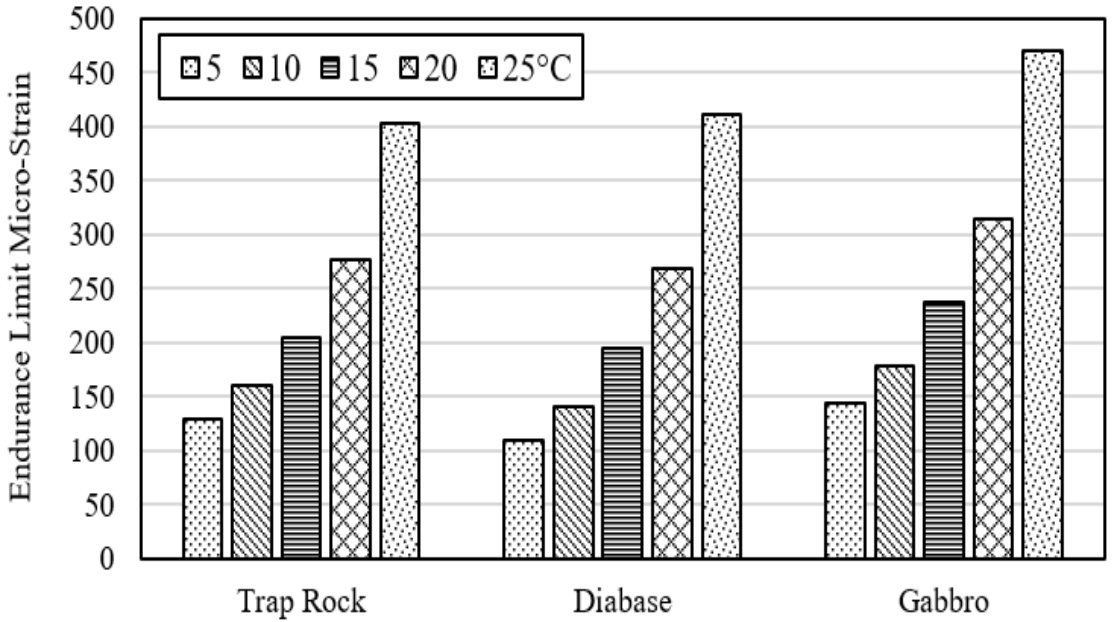
Mix Name	Average Hamburg Rut Depth (mm)	FAA P-404 Requirement
Trap Rock	1.86	Less than 10 mm at 20,000 passes
Diabase	2.05	
Gabbro	1.92	



Garg N. "HMA Design for Airport Pavements: Current State of the Practice and Future Plans", the Illinois Bituminous Paving Conference, Champaign, Illinois (2017).

FATIGUE BEHAVIOUR UNDER DIRECT TENSION CYCLIC FATIGUE TESTS





FUEL-IMMERSION TEST

- P-401 specifications required compacted mix samples to be immersed in jet fuel for 24 hours
- Standard Hot Mix Asphalt mixture loses 10% weight from 24-hour soak in jet fuel

Mix Name	Design Method	% Mass Loss After 24 hour Immersion	FAA P-404 Requirement
Trap Rock	Marshall 50 blows	0.27%	1.5% maximum weight loss after fuel immersion
Diabase		0.16%	
Gabbro		0.14%	
Trap Rock	Superpave	0.14%	
Diabase		0.11%	
Gabbro		0.12%	

LABORATORY STUDY FINDINGS

» Conclusion

- All the three mixes prepared with PGAC 82-28FR grade asphalt cement showed high fatigue quality, excellent rutting performance and resistant to jet fuel damage.

» Recommendation

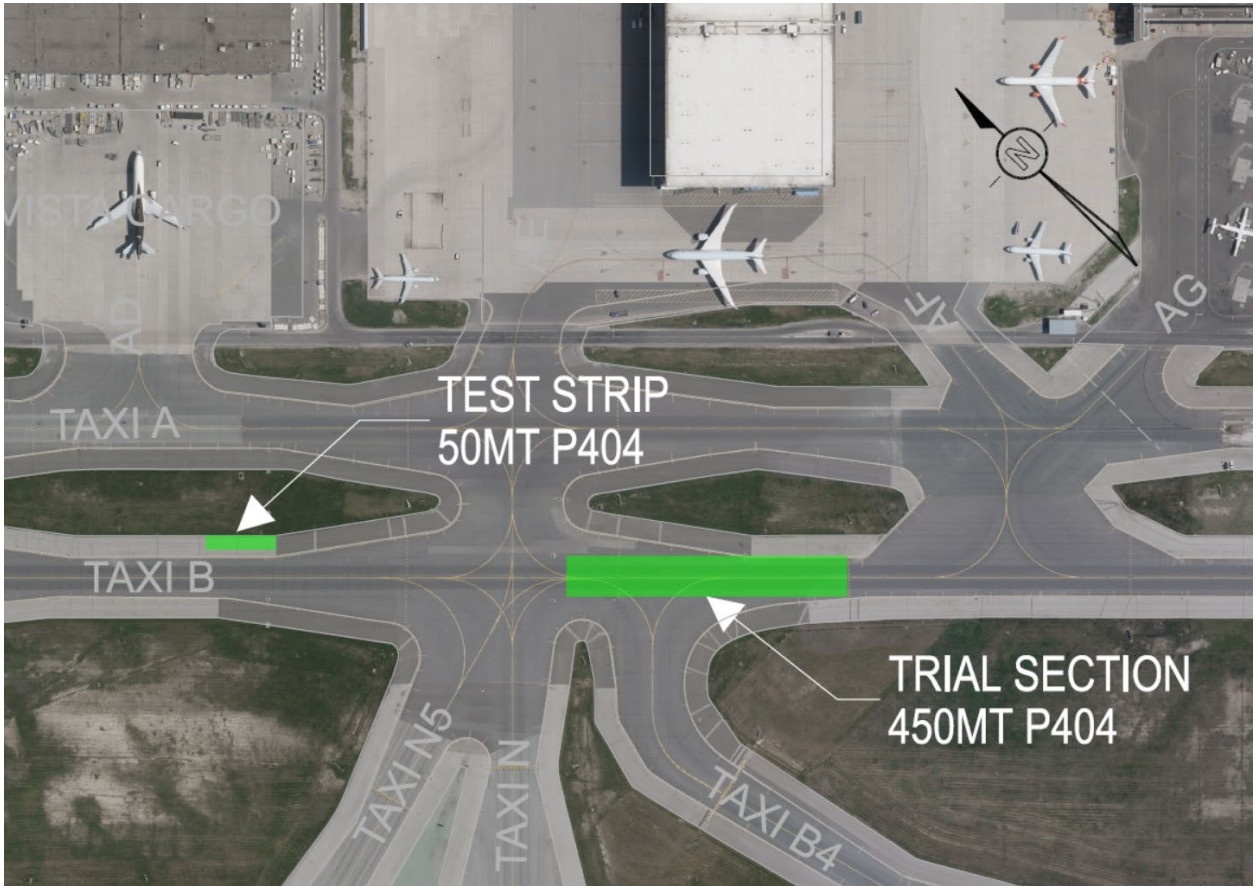
- GTAA to carry out a field study with fuel resistant mix by paving a trial section of the runways / taxiways using P-404 Fuel resistant mixes and compare the performance against a control section paved using GTAA conventional mixes
- Monitor the pavement for in-service pavement performance

PLANT PRODUCTION AND PAVING EXPERIENCE

» Production
- Located approximately 15 km from the Airport
- Mix produced at 165 ± 5°C using a drum plant
- No issues mixing the binder with aggregate blend to achieve proper coating

» Test Strip paved on October 13, 2020 (50MT) on Taxiway Bravo
- Establishing rolling patterns
- Allowing production & paving crew gain experience with the mix

TAXIWAY BRAVO – LOCATION MAP



PAVING 50MT TEST STRIP (OCTOBER 13, 2020)

- Intended to be paved in echelon
- Technical issues with one paver – switched to one-lane paving

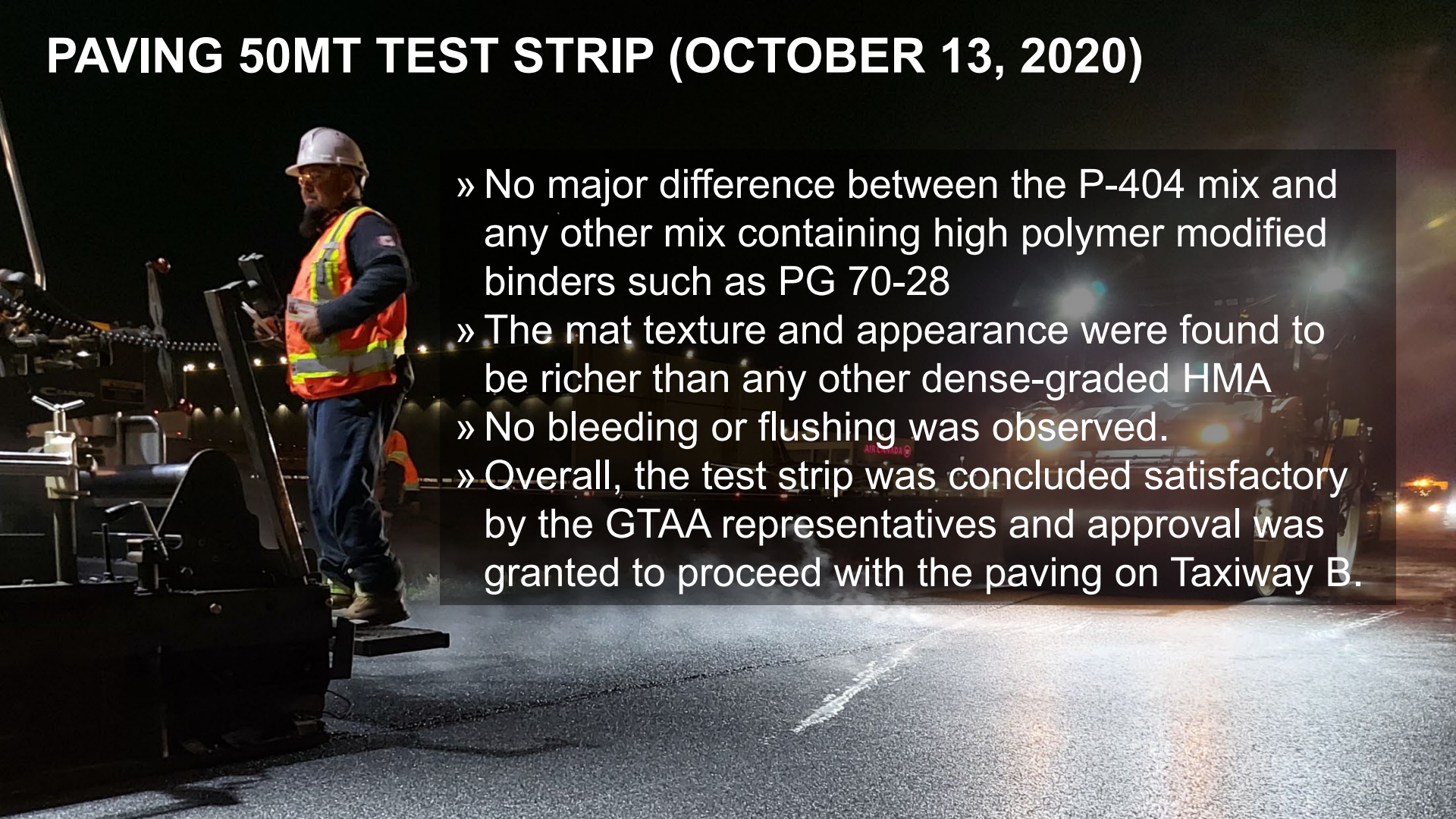
PAVING 50MT TEST STRIP (OCTOBER 13, 2020)

- Thickness varying between 45 to 60 mm
- 97 to 98% of MRD using nuclear density gauge after 4 passes of tandem vibratory steel roller

PAVING 50MT TEST STRIP (OCTOBER 13, 2020)

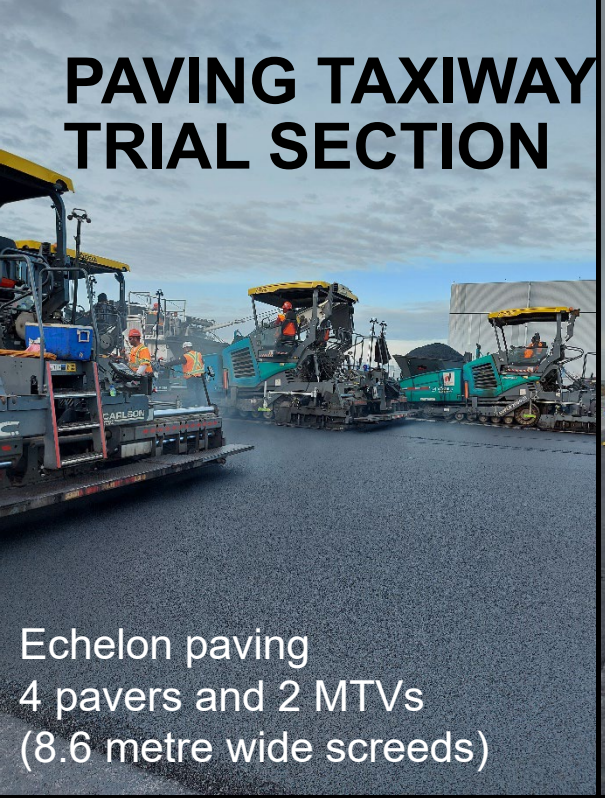
- In-situ density at the joint was recorded 94 to 96% of MRD.
- The joint was relatively colder than compaction temperature when second lane was placed

PAVING 50MT TEST STRIP (OCTOBER 13, 2020)



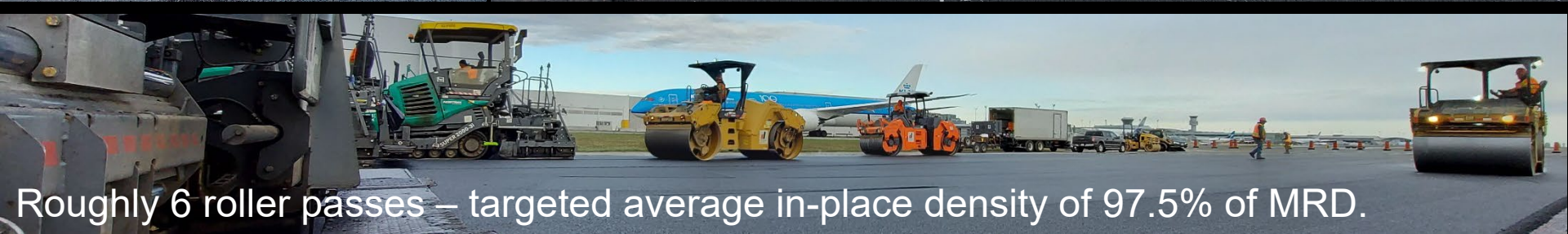
- No major difference between the P-404 mix and any other mix containing high polymer modified binders such as PG 70-28
- The mat texture and appearance were found to be richer than any other dense-graded HMA
- No bleeding or flushing was observed.
- Overall, the test strip was concluded satisfactory by the GTAA representatives and approval was granted to proceed with the paving on Taxiway B.

PAVING TAXIWAY BRAVO (OCTOBER 14, 2020) TRIAL SECTION



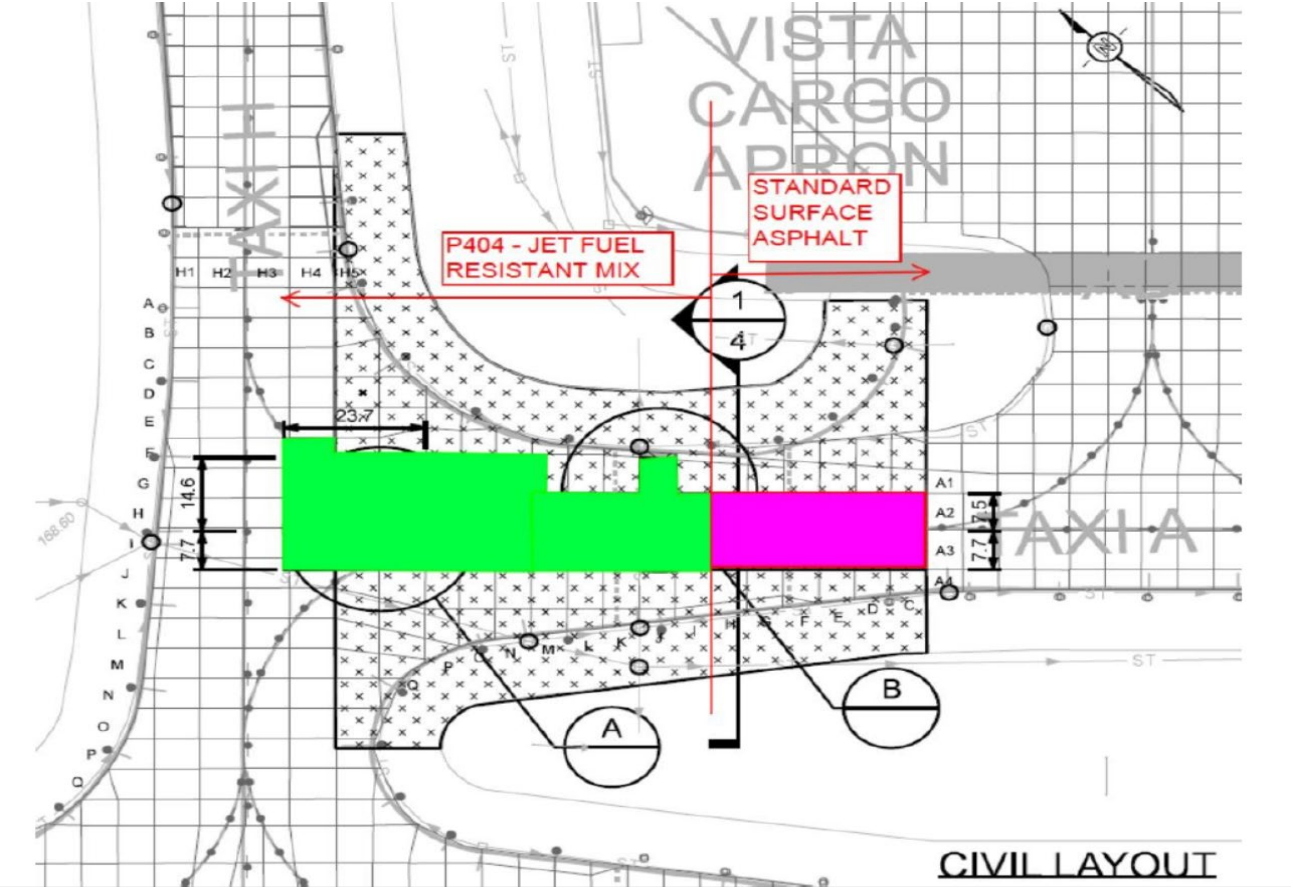
Echelon paving
4 pavers and 2 MTVs
(8.6 metre wide screeds)

Compaction train: Caterpillar steel rollers:
CB15, CB34 and CB64.

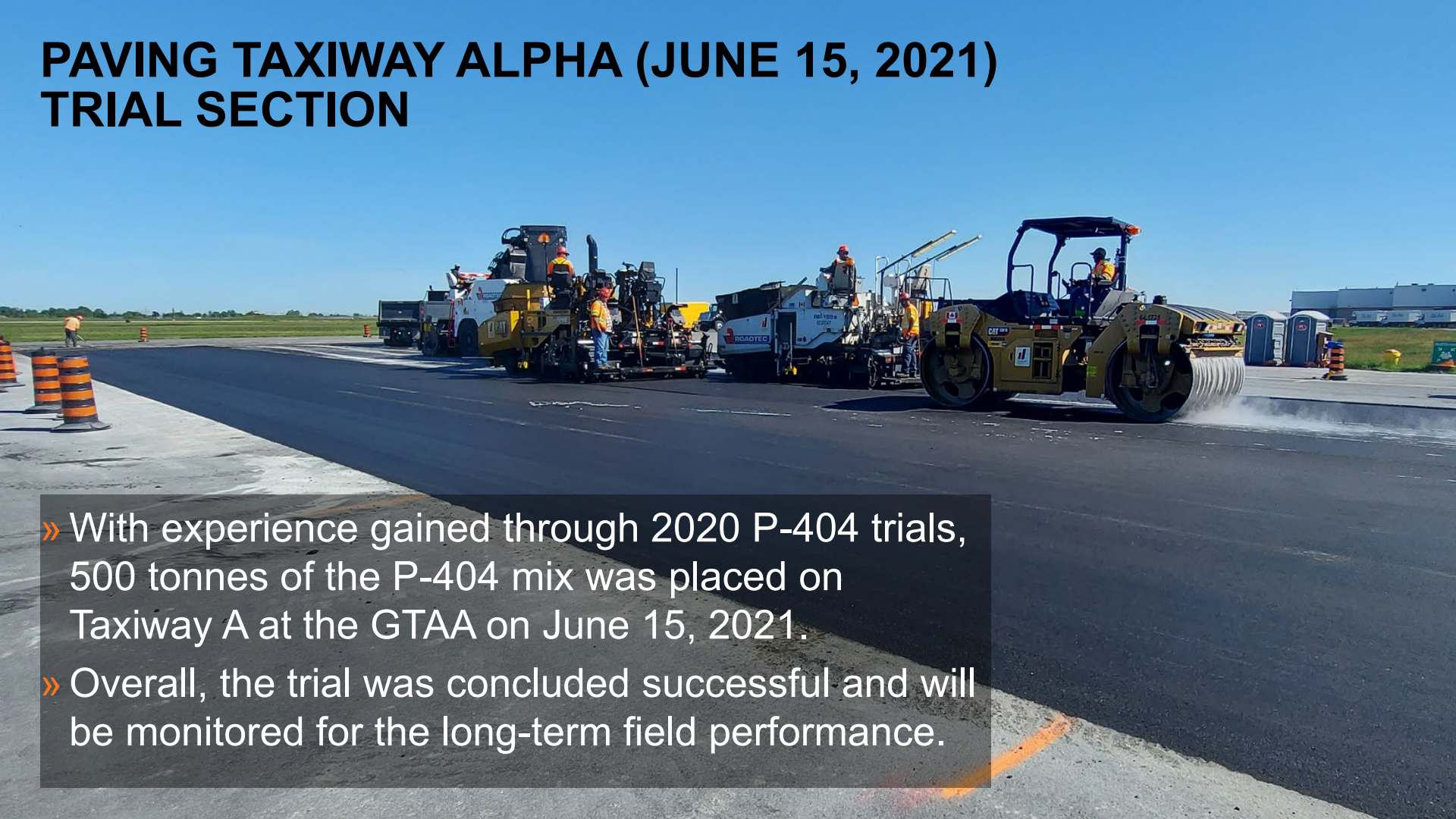


Roughly 6 roller passes – targeted average in-place density of 97.5% of MRD.

TAXIWAY ALPHA – LOCATION MAP

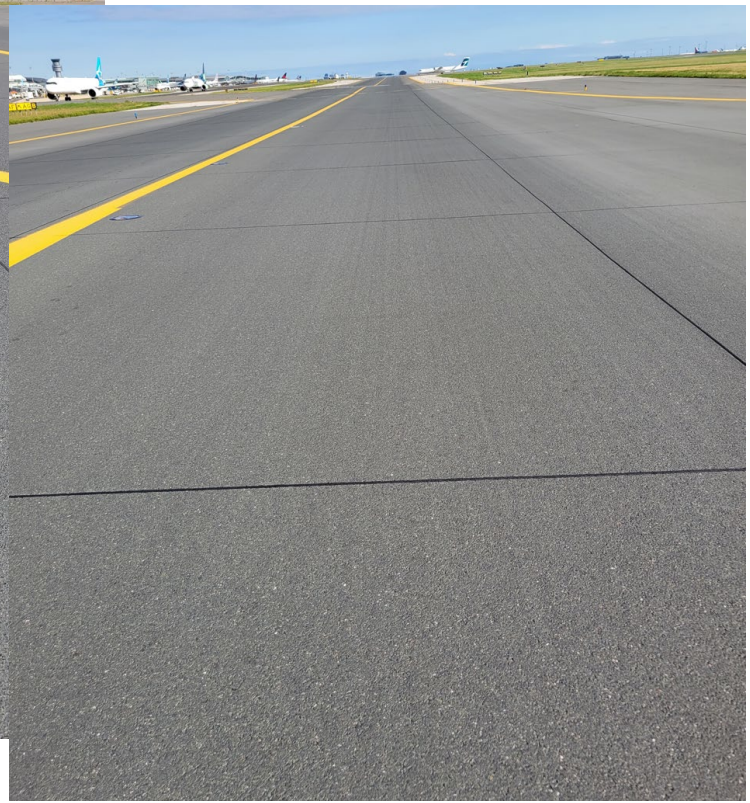


PAVING TAXIWAY ALPHA (JUNE 15, 2021) TRIAL SECTION



- With experience gained through 2020 P-404 trials, 500 tonnes of the P-404 mix was placed on Taxiway A at the GTAA on June 15, 2021.
- Overall, the trial was concluded successful and will be monitored for the long-term field performance.

FOLLOW-UP INSPECTION, SEPT 2022 – TAXIWAY BRAVO



FOLLOW-UP INSPECTION, SEPT 2022 – TAXIWAY ALPHA

SUMMARY

- FAA P-404 mix can be designed using locally-sourced aggregate and binder
- Finer mix with 2.5% design air voids - higher in-place density and durability
- Use of Performance testing were found significantly helpful in complementing the volumetric properties – moving toward ***performance-verified specification***
- Production and paving workability found satisfactory – breaking barriers and initial uneasiness toward fine, rich & highly modified binder (i.e. PG 82-28FR)
- Field follow-up has indicated good performance so far. A follow-up CTAA paper is intended to be prepared to report five-year field follow-up on these sections

QUESTIONS

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