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Enhancing Society Together

Jointed Concrete Pavement Restoration using **Ultra Thin Continuously Reinforced Concrete** on Airport Aprons

OR Tambo International Airport (ORTIA)
Performance of UTCRCP Experimental Sections

34th Road Pavement Forum (CSIR)

14 November 2017

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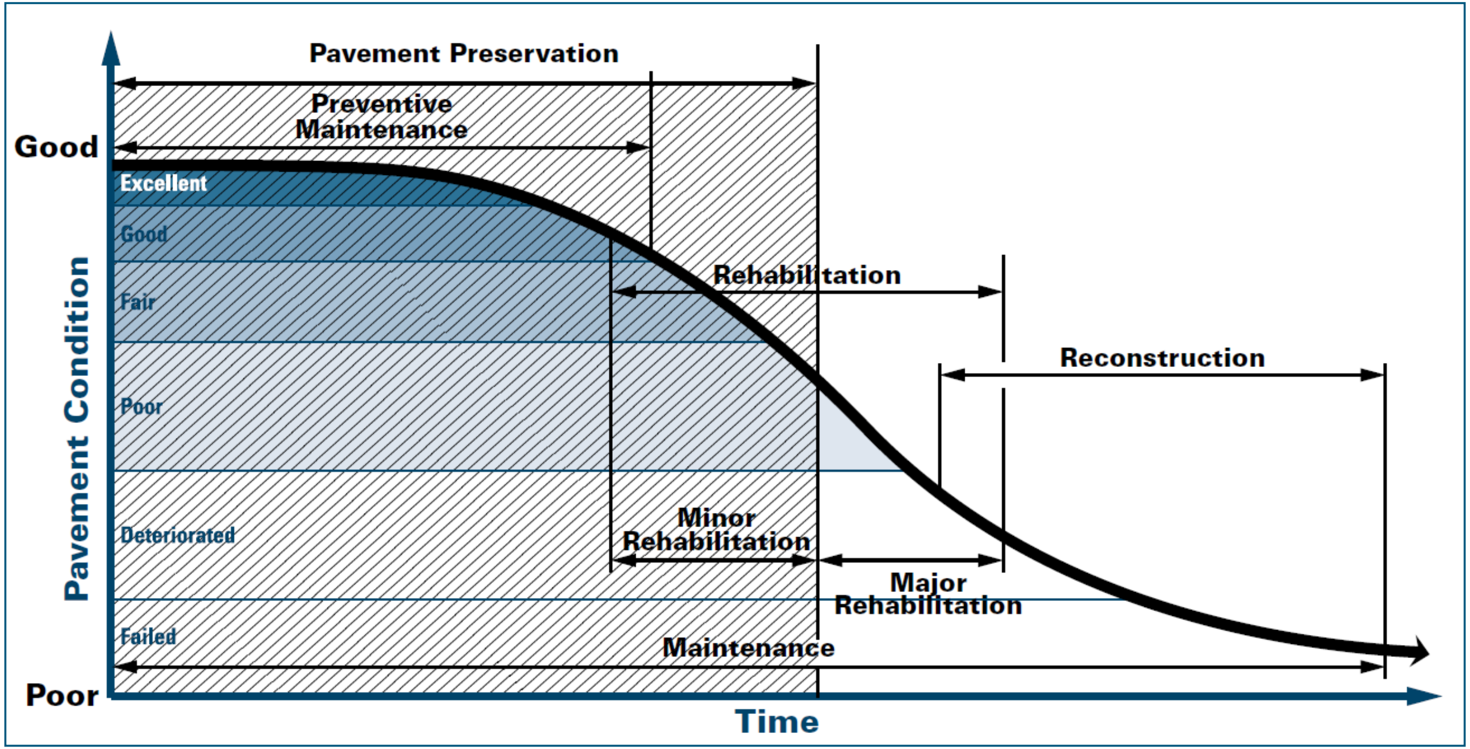
Piet Agema (former ACSA)

UTCRCP experimental inlays at OR Tambo Int Airport Contents

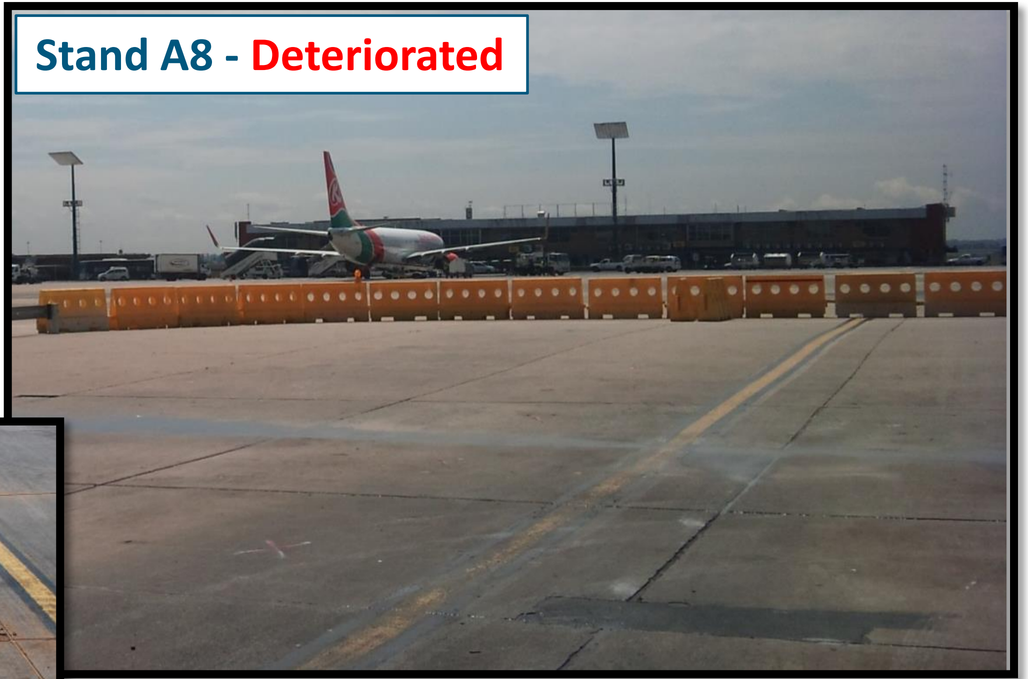
- Concrete pavement rehabilitation in Context
- Objectives of the UTCRCP overlay/inlay experimental sections
- Original pavement condition
  - Stand A6
  - Stand A8
- Construction details
- General Performance to date
- Lessons learned

Context: Phases of pavement maintenance

Guide to Concrete Overlays: Sustainable Solutions for Resurfacing and Rehabilitating Existing Pavements
ACPA Publication TB021.03P (3rd edition)



Context: ORTIA Pavement Surface Condition



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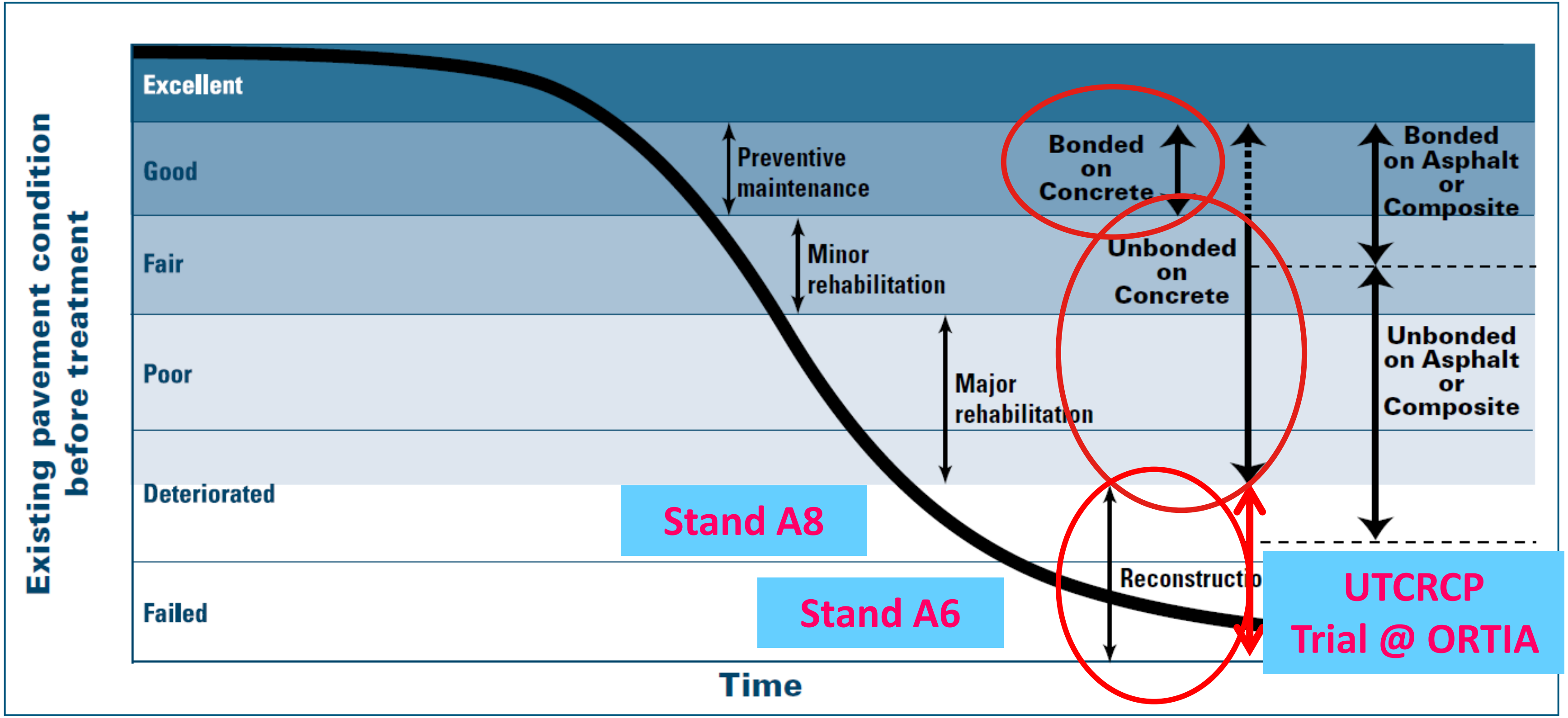
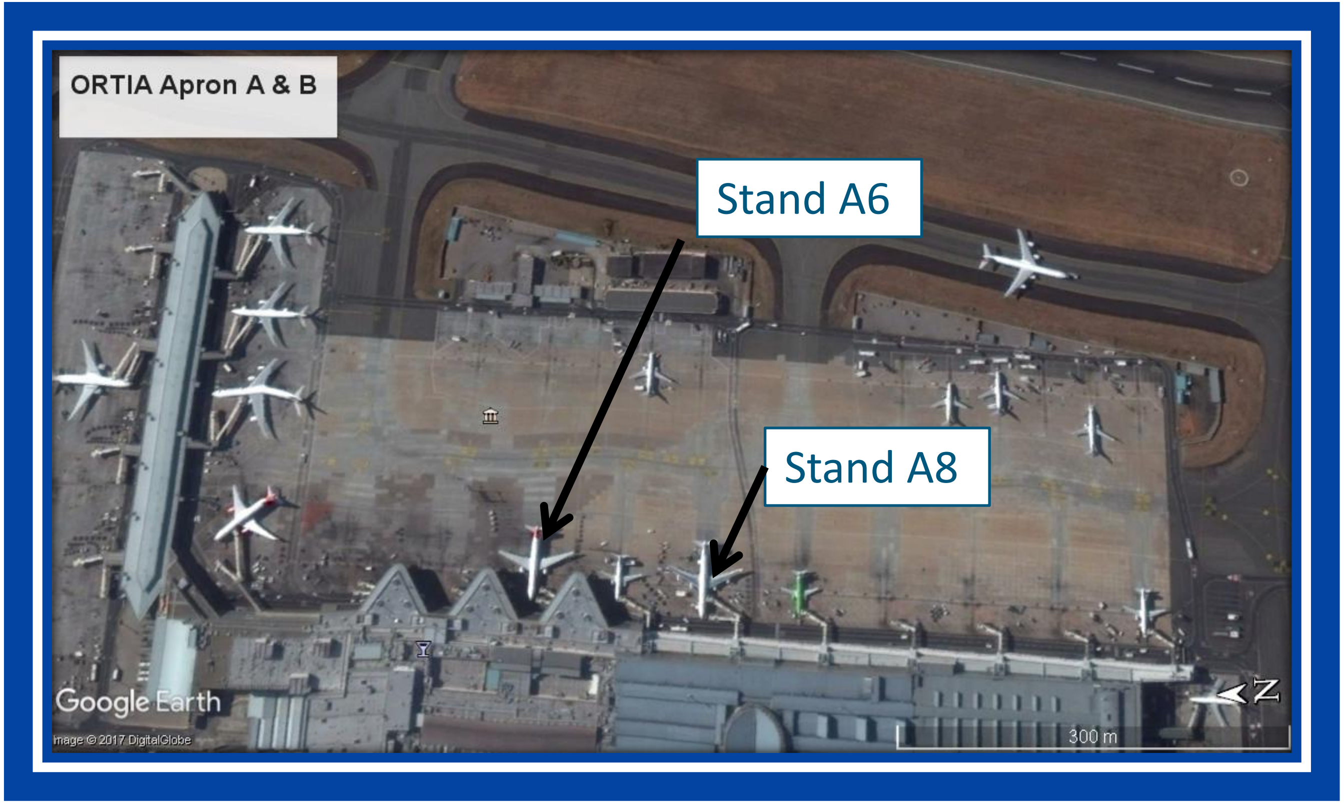
Context: ORTIA concrete apron rehabilitation options

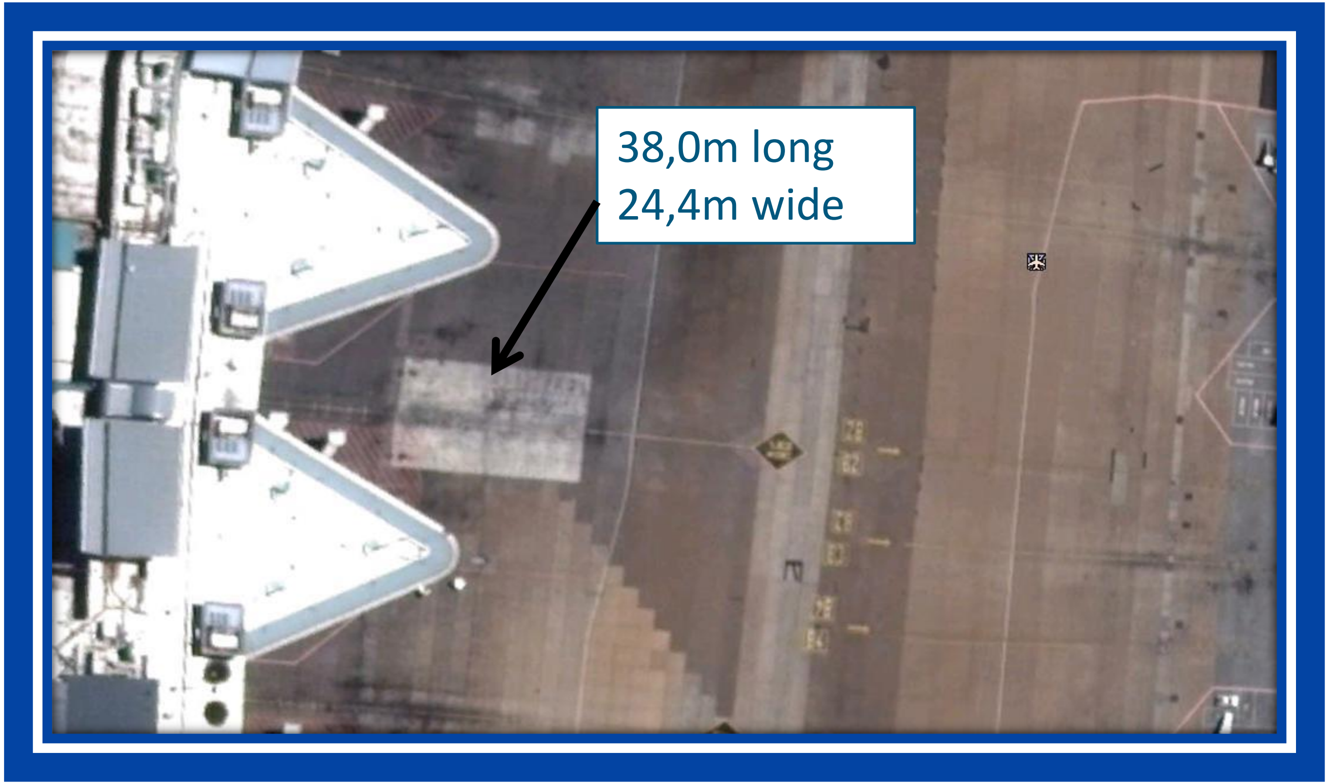
Guide to Concrete Overlays: Sustainable Solutions for Resurfacing and Rehabilitating Existing Pavements



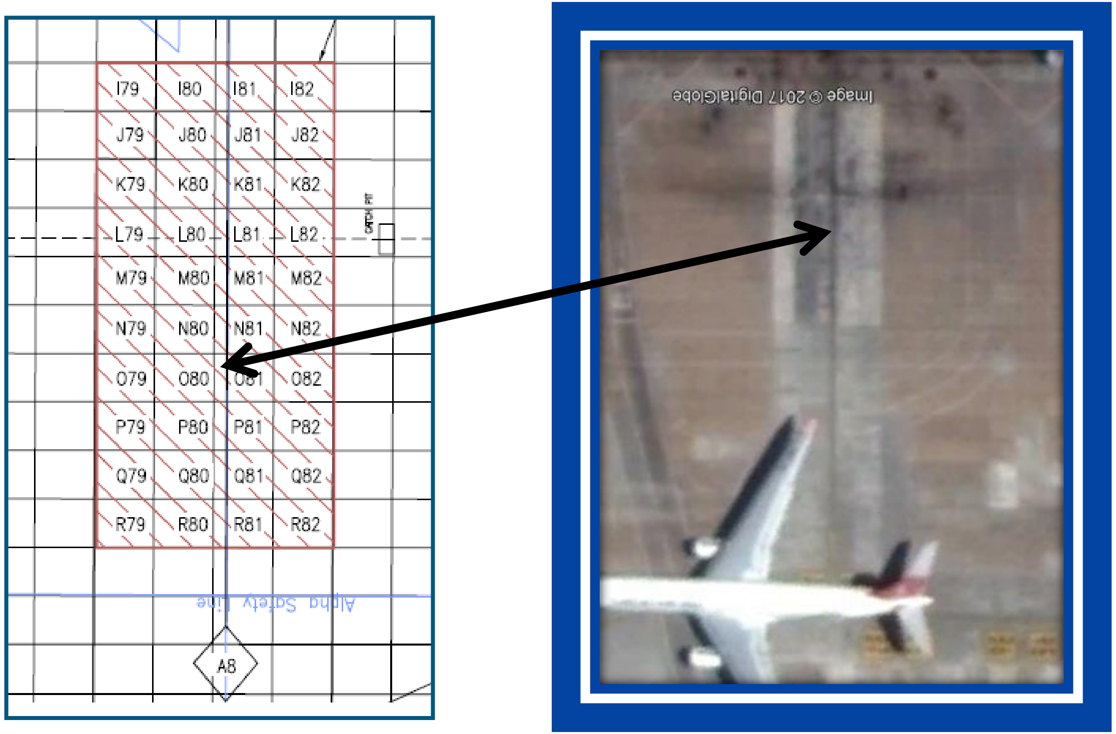
ORTIA – Apron layout: Stand A6 and Stand A8



UTCRCP Layout @ ORTIA – Stand A6. Constructed in May 2010



UTCRCP Layout @ ORTIA – Stand A8.
Constructed in May 2012 (38,0m long – 18,4m wide)



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Objectives of the Experimental work

- **Financial and economical** - Investigate possible cost saving with alternative rehabilitation methods
  - conventional rehabilitation method for concrete aprons at ORTIA – reconstruct slab and subbase.
  - 920 m^2 require approximately 14 days work.
  - UTCRCP can be constructed in 10 days or less.
  - saving on loss of operational income = R 2,0m.
  - 7% difference in construction cost between conventional and UTCRP.
- **Technical** - having to verify
  - constructability of UTCRCP on existing concrete pavement
  - structural and functional performance under aircraft loading

Challenges that needed to be addressed

- Single sollution to multiple signs of distress
- Absorb or contain the expected environmental related joint movement
- Prevent reflective cracking at joints and structural cracks
- Prevent the formation of FOD – i.e. Breaking up of the concrete
- Ensure long term durability and functional performance

Defining the Original Pavement Behaviour

- Visual condition
- Pavement Structure as confirmed with Coring and DCP testing
- Crack/Joint Activity under loading (Crack Activity Meter)
- Cyclic Temperature related Joint Movement (Joint Deflection Measuring Devise)
- Joint Load Transfer Efficiency (LTE) using FWD
- Deflection under FWD loading @ 120 kN (Before and after milling of existing slab
- Concrete properties - Indirect Tensile Strength of cores

Existing Pavement

Dynamic Cone Penetrometer (DCP) in concrete cores holes

Stand A6

	Stand A6
330 mm	Plain JCP ITS = 5,4 Mpa ELT = 50 - 70%
180 mm	Stabilsed Laterite E = 850 Mpa
240 mm	Stabilsed Laterite E = 1500 Mpa
	Subgrade CBR 10 - 12

Stand A8

	Stand A8
265 mm	Dowel JCP ITS = 4,6 Mpa ELT > 90%
200 mm	Waterbound Macadam E = 360 Mpa
100 mm	Waterbound Macadam E = 640 Mpa
	Subgrade CBR 8 - 10

Existing Pavement
Load associated Crack Activity using CAM on Stand A6

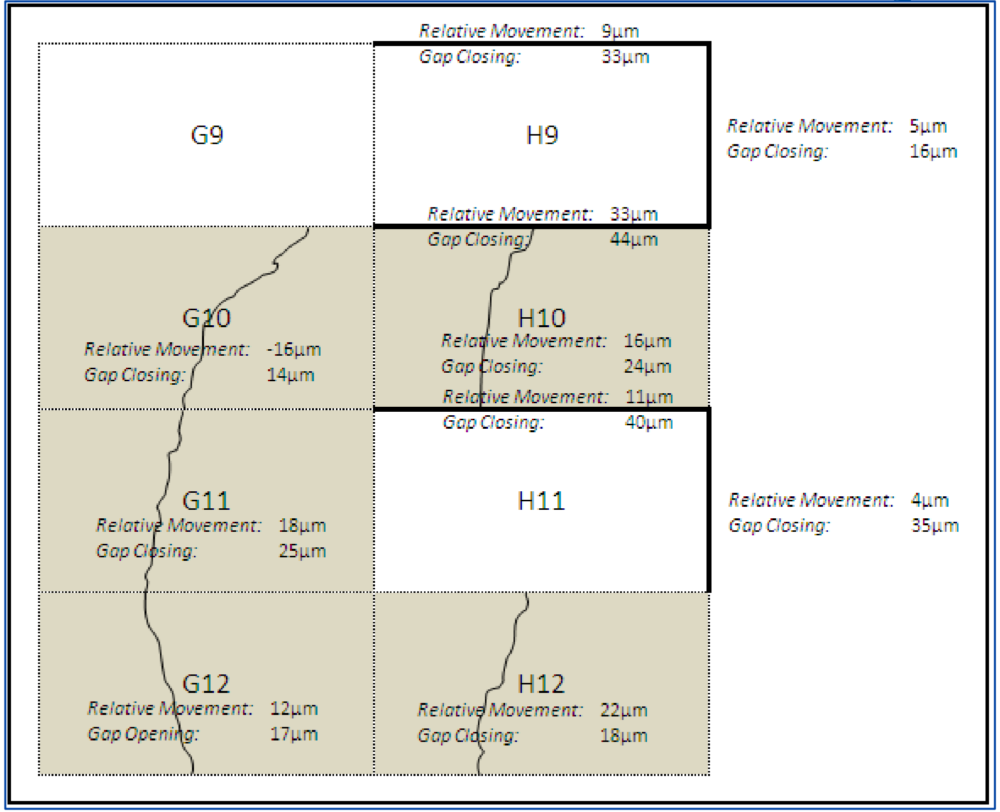
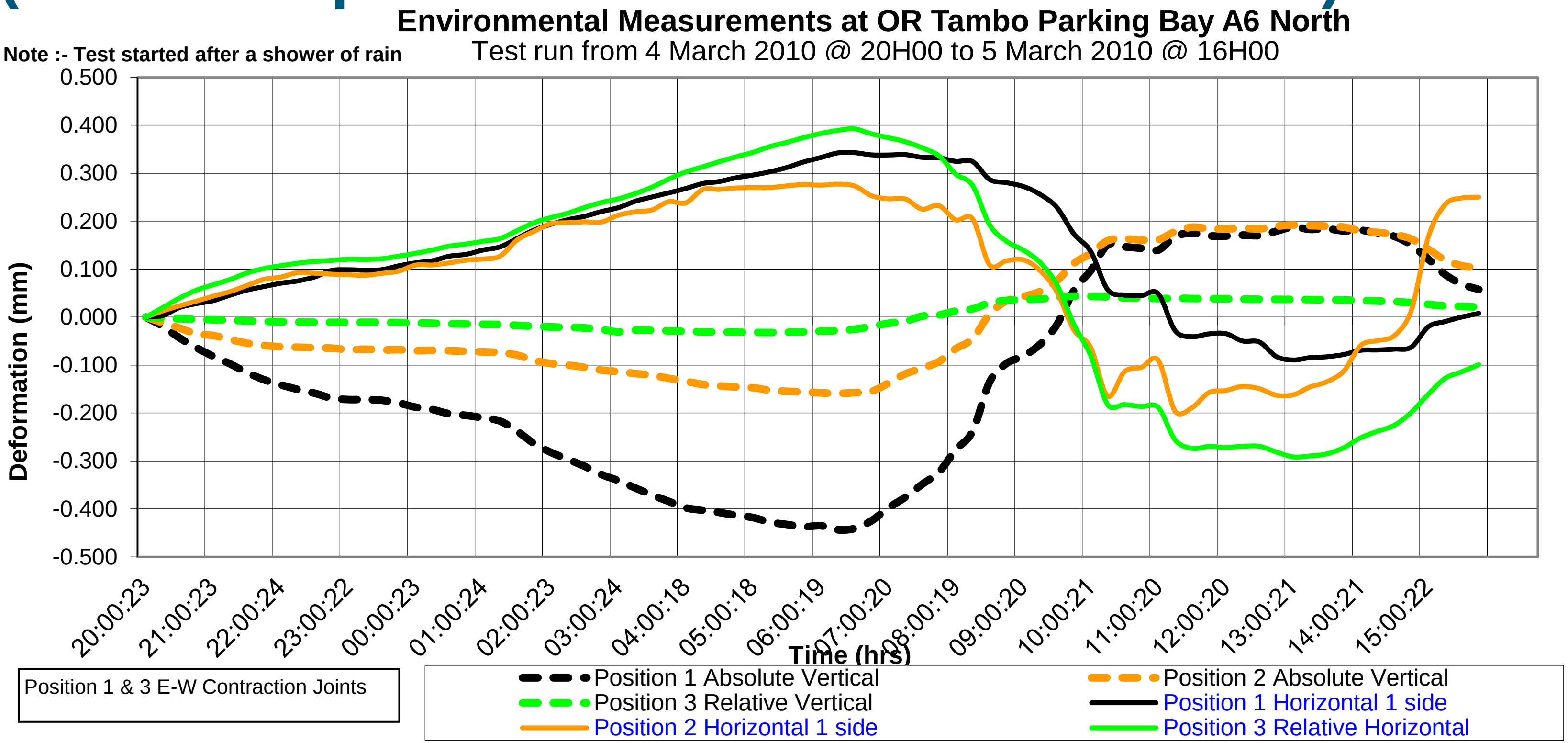


Illustration of crack activity (µm) on the measured slabs for a 120kN FWD loading

	Cracks	
Relative movement	Max	Min
Vertical	22	12
Lateral	25	14
	Joints	
	Max	Min
Vertical	33	4
Lateral	44	16

Existing Pavement
(JDMD temp related movement on Stand A6)



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Existing Pavement (JDMD temperature associated)

- **Stand A6 – summary of temperature related joint movement - mm**

Max Contraction of Concrete	0.393	during night
Max Expansion of Concrete	0.292	during day
Total Horizontal Movement of Concrete	0.684	

Upward Movement of Concrete	0.192	during day
Downward Movement of Concrete	0.444	during night
Total Vertical Movement of Concrete	0.636	

Existing Pavement

- Falling Weight Deflectometer (FWD)

FWD Deflections(µm) under 120 kN load								
		Centre slab		Joint				
				Construction	ELT		Contraction	ELT
Stand A6								
Average		132		142	96%		138	68%
Range		89 - 200		83 - 226	78% - 100%		123 - 167	23% - 90%
Stand A8								
Average		198		216	95%		217	96%
Range		168 - 214		166 - 256	94% - 95%		164 - 256	95% - 98%

Existing Pavement

- **Stand A6 – Typical Concrete Joints**

Sawn contraction joint

Keyed construction joint

Construction Details - UTCRCP Specifications

Maximum Aggregate Size	6,7mm
Cement	CEM I (42,5MPa) with FA and CSF
Concrete Thickness	50 mm (depth of milling)
Concrete Strength (min/max)	100/120MPa (Characteristic strength a minimum of 90MPa)
Steel Reinforcement	Y5,6 @ 50mm - both directions c/c
Genuine Steel Fiber	80 kg/m³ - • Stand A6 – 12mm slit sheet fiber • Stand A8 – 30mm hooked fiber
Polypropylene (PPF)	2 kg/m³
Curing Period	6 Days

Stand A6 - Construction Details - 2010

Stand A6 Construction Details - 2010

200mm debonding

Double steel @ construction joint

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Stand A6 Construction Details - 2010

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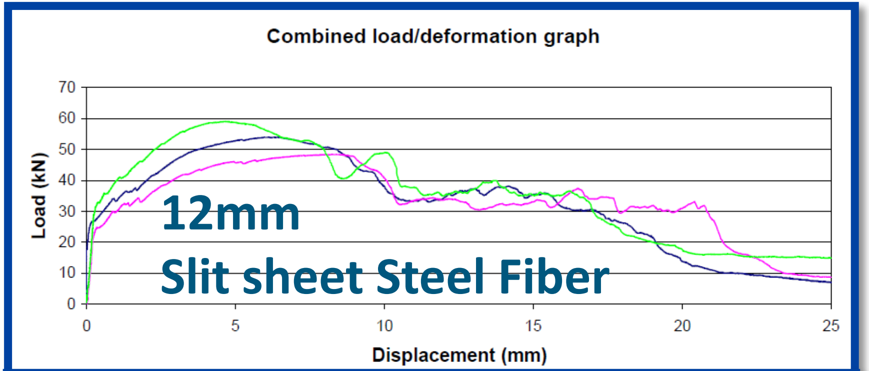
General Performance

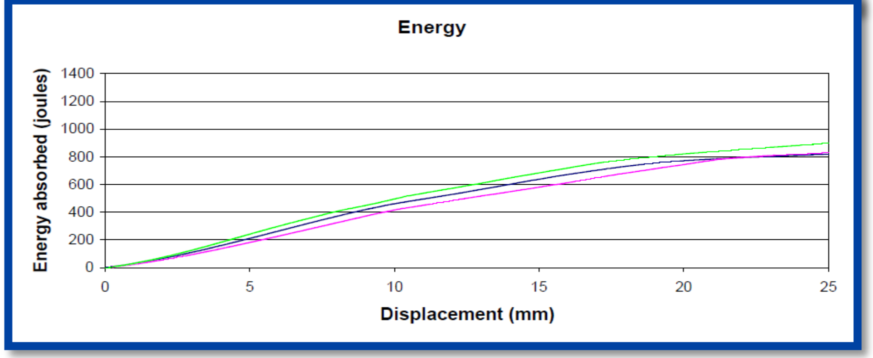
Energy Absorption Test (EAT) – Standard ASTM test (Round panel test) - **Adapted round disc test** (Kearsley and Mostert)

General Performance

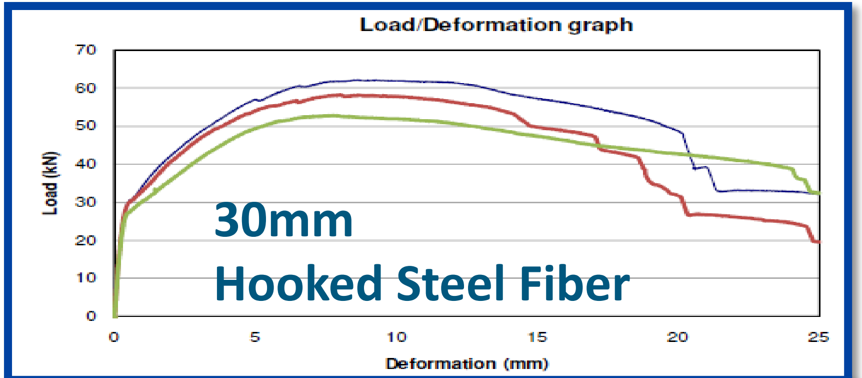
Energy Absorption Test (EAT) as adapted.

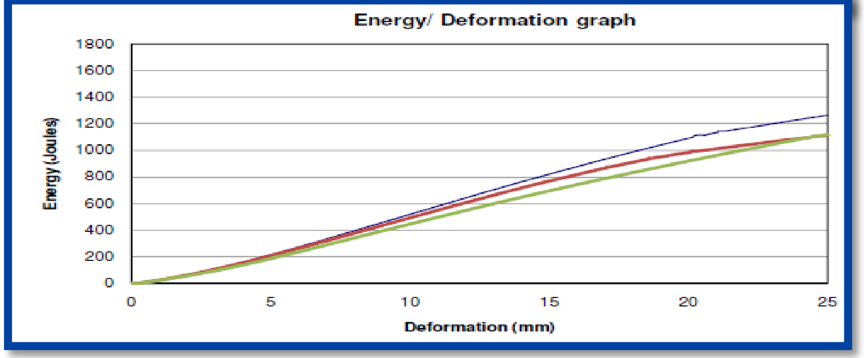
Stand A6





Stand A8



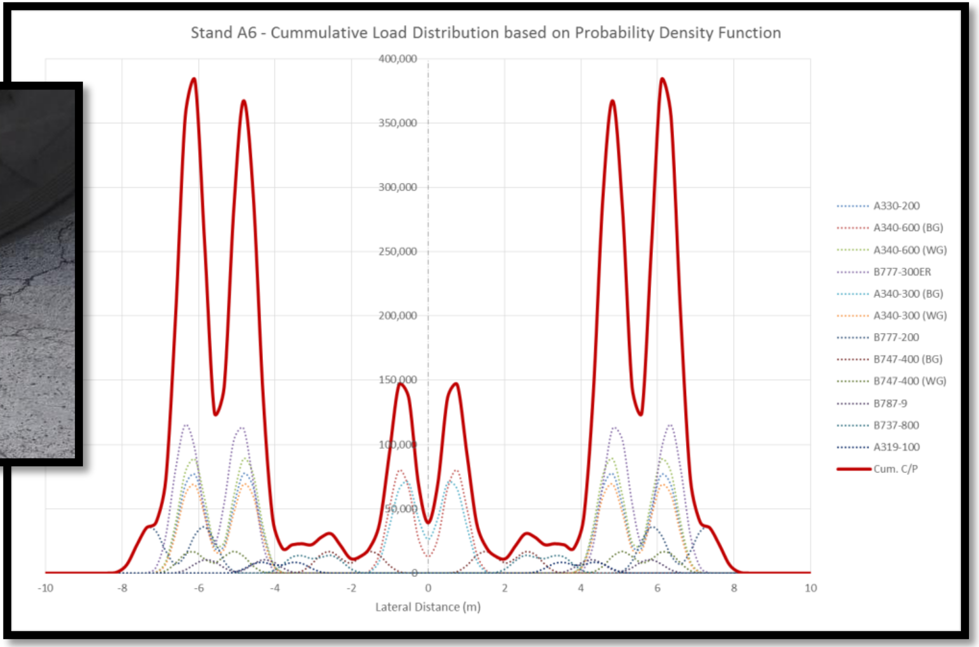


General Performance – Stand A6

- 2012 - Crack Pattern After 4000 Load Applications

General Performance – Stand A6

- 2017 - Crack Pattern After 10 500 Load Applications (7 years)



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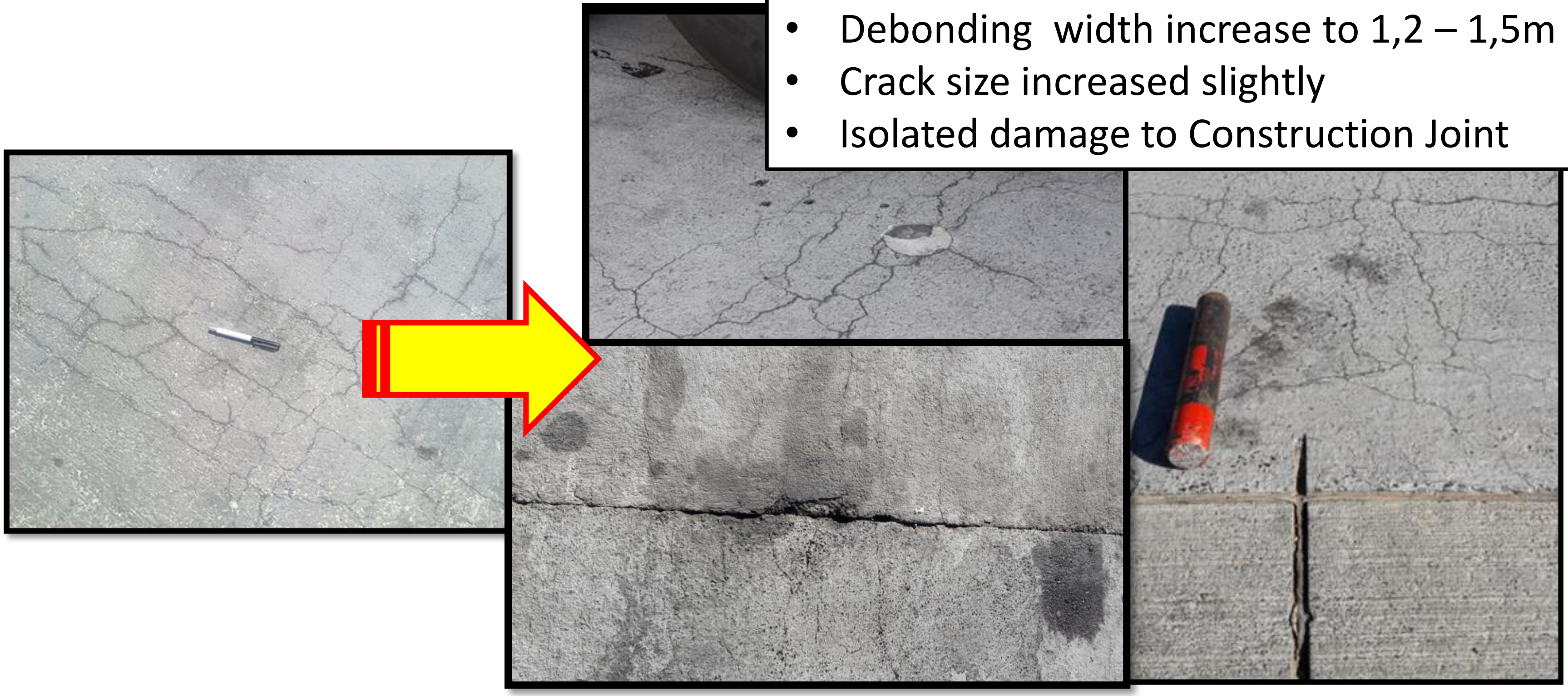
General Performance – Stand A6

- 2017 - Crack Pattern After 10 500 Load Applications



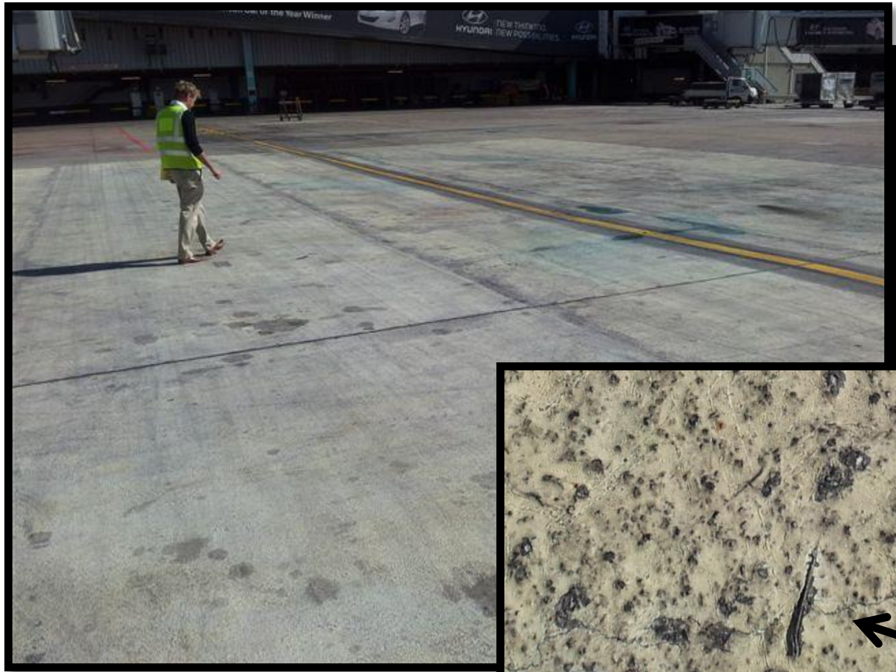
- Debonding width increase to 1,2 – 1,5m
- Crack size increased slightly
- Isolated damage to Construction Joint

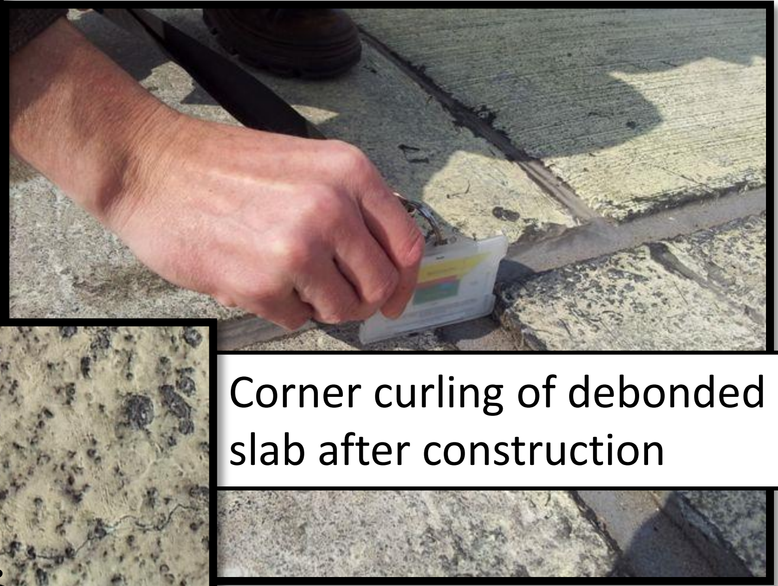
General Performance - Stand A8

Changes compared to Stand A6

- Steel fibre length increased from 12 mm to 30 mm result in improved energy absorbtion properties
- Eastern half - the UTCRCP slab was fully debonded from the surface
- Western half - all UTCRCP was debonded for 0,5 m across the joint

General Performance - Stand A8



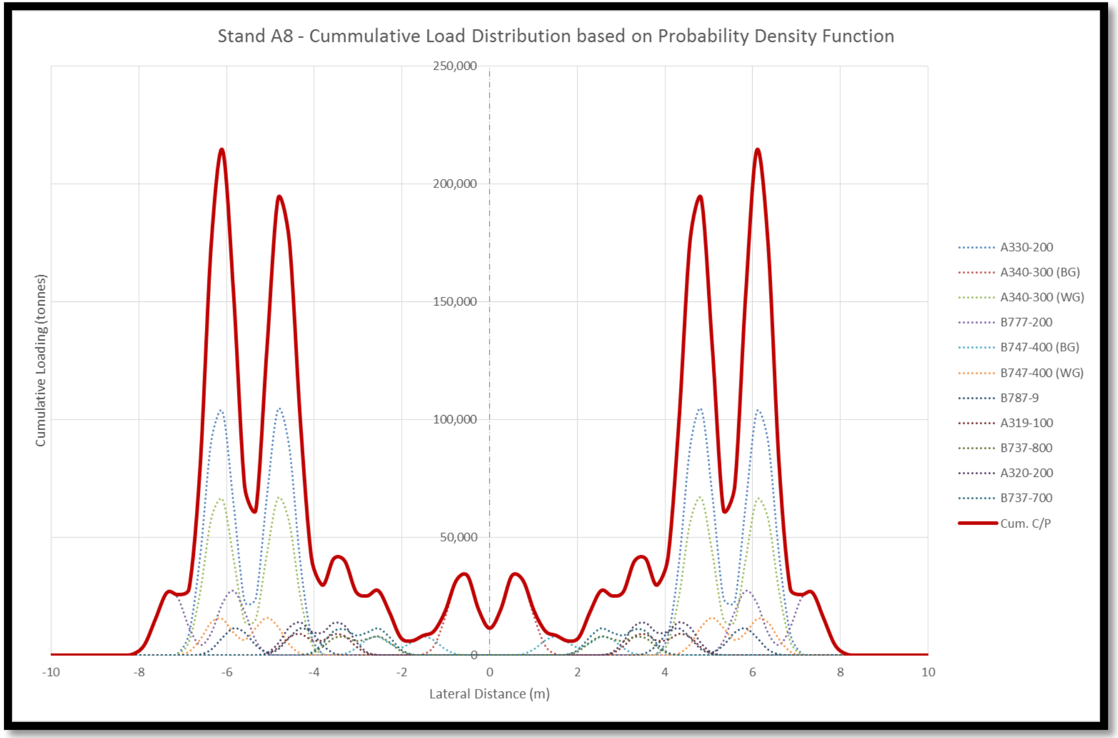


Corner curling of debonded slab after construction

Fine hairline crack after construction

General Performance - Stand A8

- 2017 - Crack Pattern After 7 500 Load Applications (5 years)



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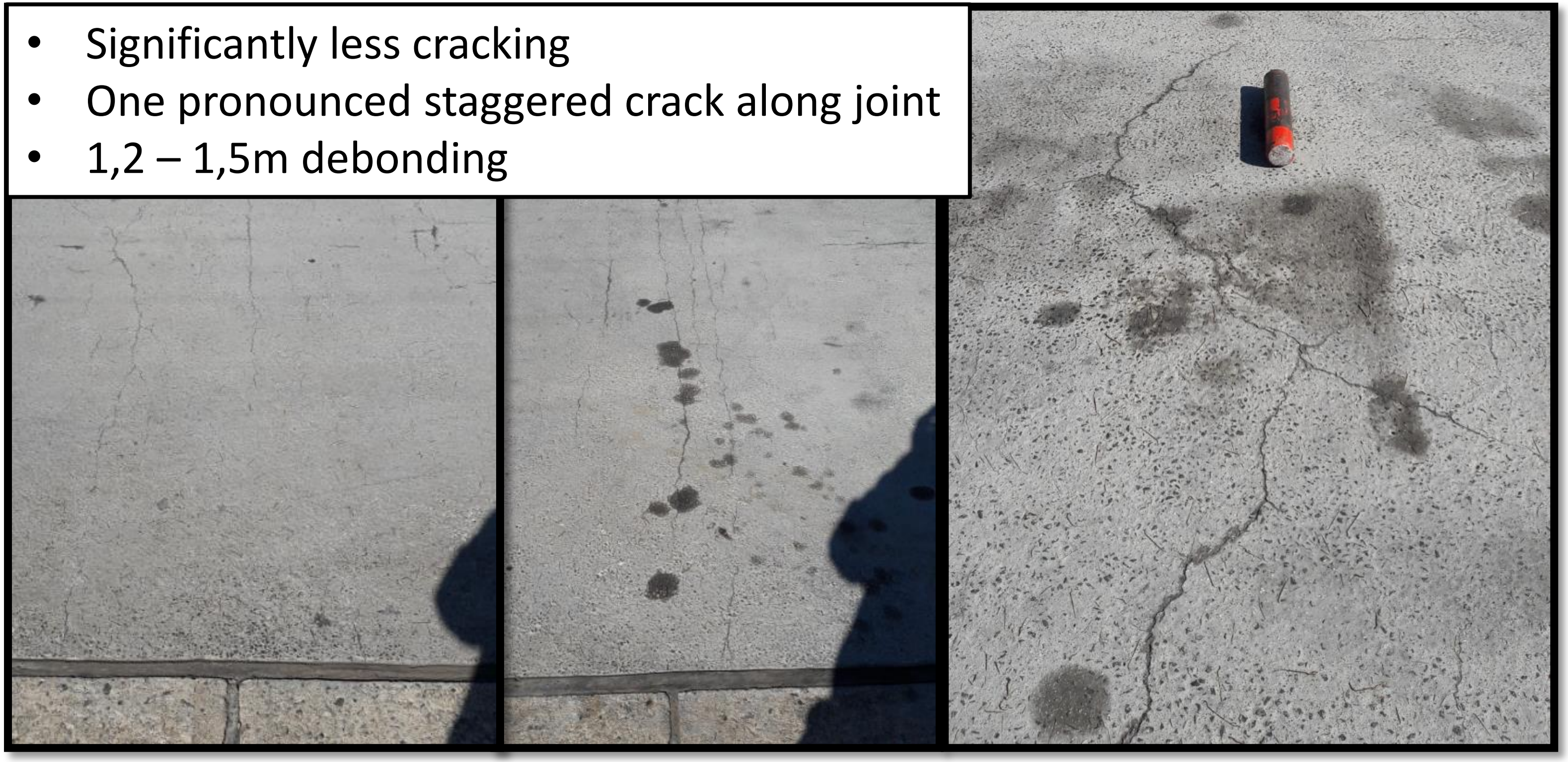
General Performance - Stand A8 – Bonded section

- Crack Pattern After 7 300 Load Applications

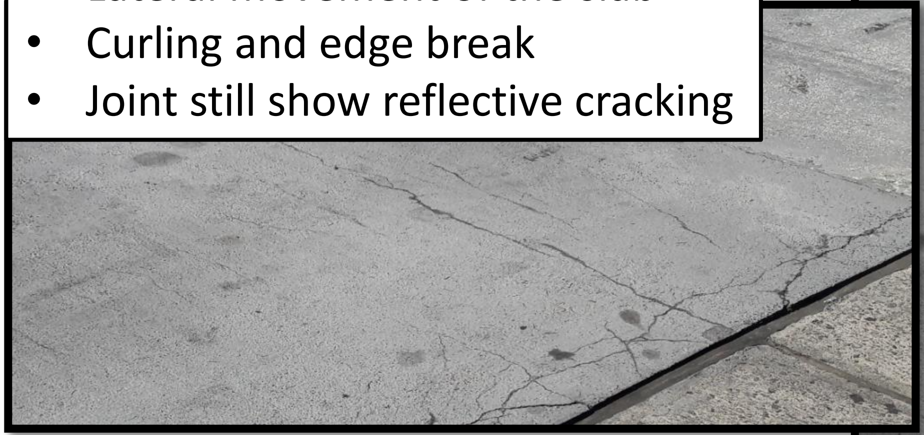
- Significantly less cracking
- One pronounced staggered crack along joint
- 1,2 – 1,5m debonding



General Performance - Stand A8 – debonded section

- Crack Pattern After 7 300 Load Applications

- Lateral movement of the slab
- Curling and edge break
- Joint still show reflective cracking



Lessons Learned

1. Bonded UTCRCP overlays on jointed concrete airport pavements show signs of being a feasible alternative to concrete pavement reconstruction.

2. Typical signs of concrete pavement distress such as structural cracks and pumping did not effect the performance of the bonded UTCRCP overlay

3. UTCRCP trials show that 1,2 – 1,5m debonding across the joints is required to absorb typical environmental joint movements and disperse reflective cracking into multiple hairline cracking

4. Consideration should be given to increase the overlay thickness to improve constructability and quality – signs of honeycombing were observed.

Lessons Learned

5. Improved concrete mix designs and especially improving the quality of steel fibers offer new opportunities to manage and improve the tensile performance of cracked concrete. The design of fiber reinforced concrete can include:
   - EN Notched Flexural Beam Tests and
   - Fatique test variations of the above Notched test.
6. It is believed that bonded UTCRCP overlays can be considered to rehabilitate
   - Industrial or other heavy duty concrete pavements
   - Minor roads (achieving high levels of riding quality with UTCRCP is still regarded a challenge)

Thank you for your attention

Questions ?