ROAD PAVEMENTS FORUM

CRCP, Concrete Interlayer & BRAGG over Concrete

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Project Scope

- Upgrading of National route 3, section 2 from km 30.6 to km 34.369 and section 3 from km 0 to 0.8.
- Widening of the mainline from 2 and 3 lanes Northbound (NBC) and Southbound (SBC) to 4 and 5 lanes

  - Construction of a 250mm CRC pavement on the mainline, (labour enhanced construction)
  - Construction of a 100mm Concrete Interlayer (10MPa), (labour enhanced construction), using recovered material from existing JCP
  - BRAGG functional layer over CRC

100mm Lean Mix Concrete Interlayer

Specification:

100mm, lean mix concrete, 10MPa using recycled aggregate

- Recycled aggregate – large aggregate recovered from existing JCP

Laid by hand:

Continuous pour, with cracks induced at 10m centres

Recovered material:

Two methods adopted :

- NBC - cut and haul to off site crusher
- SBC - break, in place and haul to on site crusher

Benefits of Lean Mix Concrete

- Resist erosion of the subbase and limit the likelihood of “pumping” at joints and slab ends
- Provide uniform support for the base slab
- Enhance load transfer across the joints
- Provide accurate levels for the base
- Maximise reuse of existing materials to provide a working platform

Concrete Mix Design

- Recovered aggregate/natural sand & crusher dust (limit shrinkage and reduce the water content)
- Achieved a +-50% ratio of recovered aggregate and natural sand in mix
- 1.5MPa flexural strength /14MPa compressive

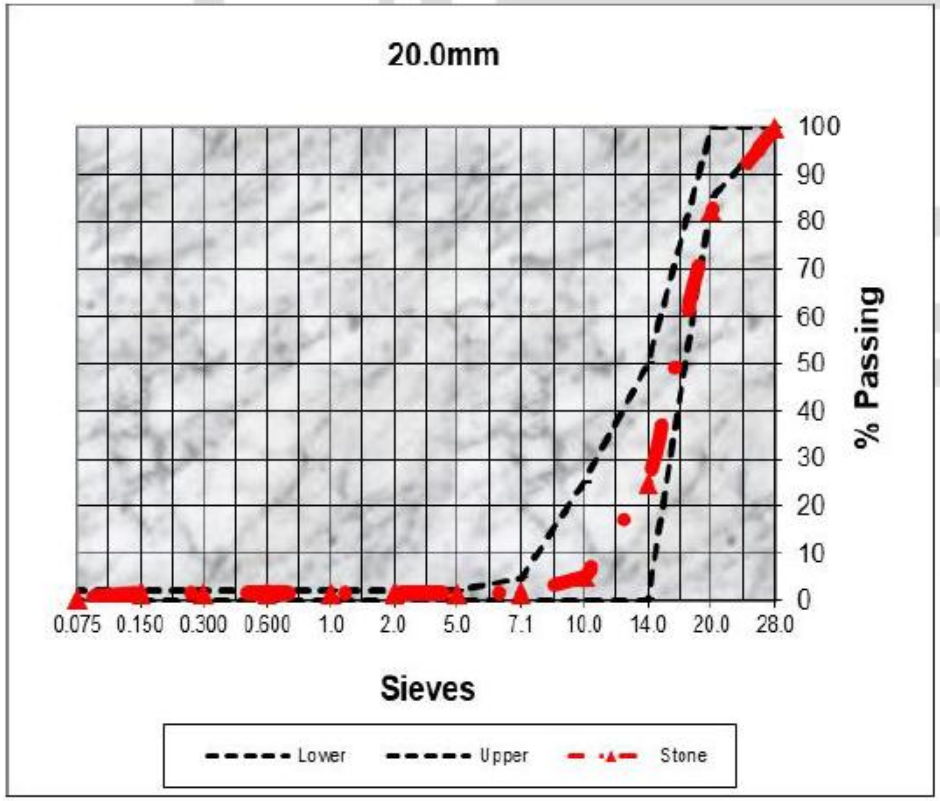
Tests on Recovered Aggregate

Test required	Test method	Aggregate	
		20mm Recycled Stone	Recycled Crusher Dust
Grading (incl. FM for sand)	SANS3001 AG1:2018	X	
Relative Density	SABS844:1994	X	
Loose Bulk Density	SANS845:1994	X	
Compacted Bulk Density		X	
Voids	-	X	
Flakiness Index	SABS847:1994	X	
Water Absorption	SABS843:1994	X	
Sugar Content (Outsourced)	Qualitative	X	
pH (Outsourced)	pH Meter	X	
Water-Soluble salts (Outsourced)	Gravimetric	X	
Water-Soluble Sulphates/Sulfates (Outsourced)	Gravimetric	X	
Chloride Content (Outsourced)	Titrimetric	X	
Shrinkage 5836	SANS5836:2007		X
Expansion on re-wetting			X
M.L.D / A.L.D (Average Least Dimension) (Outsourced)	SANS AG2	X	
Ethylene Glycol (Outsourced)	SANS AG14	X	
Magnesium Sulphate Soundness (Outsourced)	SANS 5839	X	
PSV (Polished Stone Value) (Outsourced)	SANS AG 11	X	
AAR	SANS6245		X
ACV – Wet	SABS841:1994	X	
ACV – Dry		X	
10% Fact – Wet	SABS842:1994	X	
10% Fact – Dry		X	
Electrical Conductivity	Conductivity Meter	X	

Grading

***20.0mm Recycled Stone* (692/6204)**

The 20.0mm Recycled stone sample tested met the grading requirements of SANS 1083:2006.



Sieve Size (mm)	Cumulative % passing	
	Limits	Sample
28.0	100	100
20.0	85-100	82
14.0	0-50	25
10.0	0-25	5
7.1	0-5	1
0.075	0-2	0.5

rd	2.64
lbd	1340
cbd	1510
voids	42.8

Material Re-Use

The Plan:

- Establish on site plant for crashing of existing JCP
  - Breakup method

To Consider:

- Non availability of site
- Cost impact
- Time impact
- Overall cost impact for re-use of material for this purpose or consider downscaling

Material Re-Use

Batching Site:

- A designated batching site at RCL 9 quarry was identified at RCL

Alternative Plan: (Limited to NBC)

- Commercial Crusher
- Method of JP removal changed - cut, lift and transport vs break-up method

Postulated Approach: (SBC)

- Alternative site made available

Sub Contracting/Labour Opportunities

- **CPG Goal:**
  - Opportunities: 6
- **CPG Spend:**
  - R33 million
- **Employment:**
  - Labour employed: 110
  - Total Man-days: 9 936

Continuously Reinforced Concrete

Specifications

Part A: Paver Laid Concrete Layers
Part B: Labour Enhanced
Part C: Measurement And Payment
Part D: Lean Mix Concrete Interlayer

Consider:

- Design Requirements
- Period required for mix design and approvals
- Plant mix, trial section requirements
- Target strengths
- Performance of mix
- Acceptance Control

A6.1.4.2 Design requirements

a) **Water-cement ratio**

The water-cement ratio shall not exceed 0,53.

b) **Minimum cement content**

The total cementitious content of the mix shall be not less than 320 kg/m^3.

c) **Specified strength**

The relationship between the 28-day compressive, 28-day indirect tensile strengths and the 28-day flexural of the concrete shall be established by laboratory tests. While compressive strength will remain the specified property against which the concrete pavement will be evaluated, the targeted 28-day flexural of the concrete as well as the 28-day Indirect Tensile Strength of the concrete cores are the ultimate properties that are important to ensure good performance of the concrete pavement.

The specified compressive strength shall be the highest of the following four values:

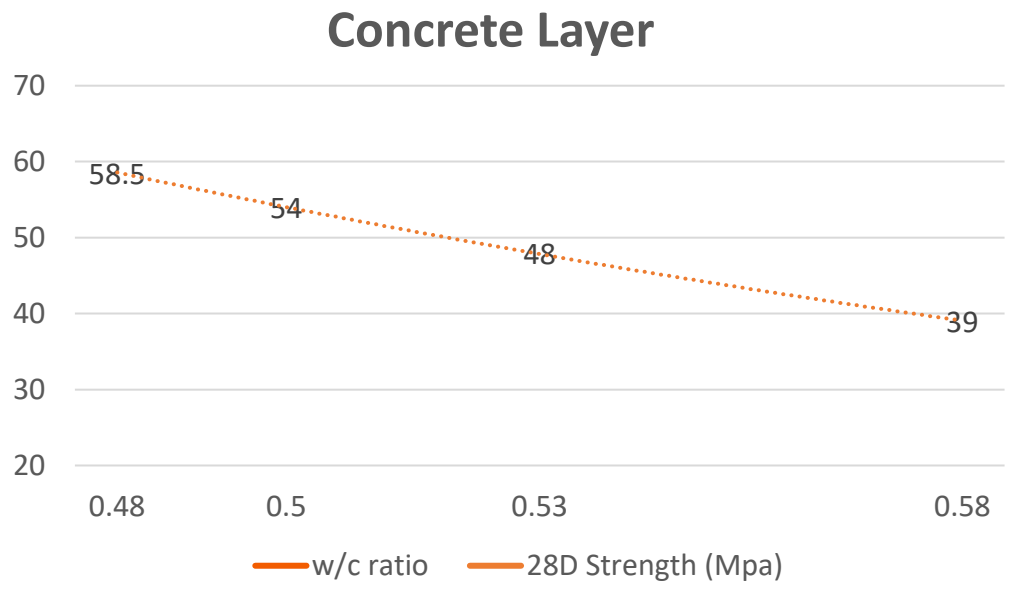
(i) 35 MPa at 28 days; or
(ii) 0,85 f_{c1} where f_{c1} is the 28-day compressive strength corresponding to a 28-day flexural strength of 4,2 MPa.
(iii) 0,85 f_{c2}, where f_{c2} is the 28-day compressive strength corresponding to a water: cement ratio of 0,53.
(iv) 0,85 f_{c3}, where f_{c3} is the 28-day compressive strength corresponding to a cement content of 320 kg/m^3.

Where f_{c1}, f_{c2} and f_{c3} shall be the 28-day compressive strengths determined from laboratory mixes as prescribed in Clause A6.1.4.3.

(iii) Compressive-strength control shall be exercised on the basis of the acceptance-control plan as described in clause 8206 for full acceptance and clause 8208 for conditional acceptance. Attention is drawn to the special requirements relating to concrete for concrete pavements. The resubmission of concrete lots on the basis of cores for full acceptance or conditional acceptance shall not be allowed. The Contractor's attention is drawn to clause 8209.

(iv) The relationship between the 28-day compressive and the 28-day flexural strengths of the concrete established by the preliminary tests shall be monitored during paving operations by regular tests at the discretion of the Engineer.

Mix Design



Requirements

- Max w/c ratio 0.53
- Min. Cementitious content - 320kg/m3
- *Specified strength -highest of:*
  (i) 35MPa @ 28 day
  (ii) 8 5% of comp str = 4.2MPa FS
  (iii) 85% of comp str @ 0.53
  (iv) 85% of comp str @ 320kg/m3

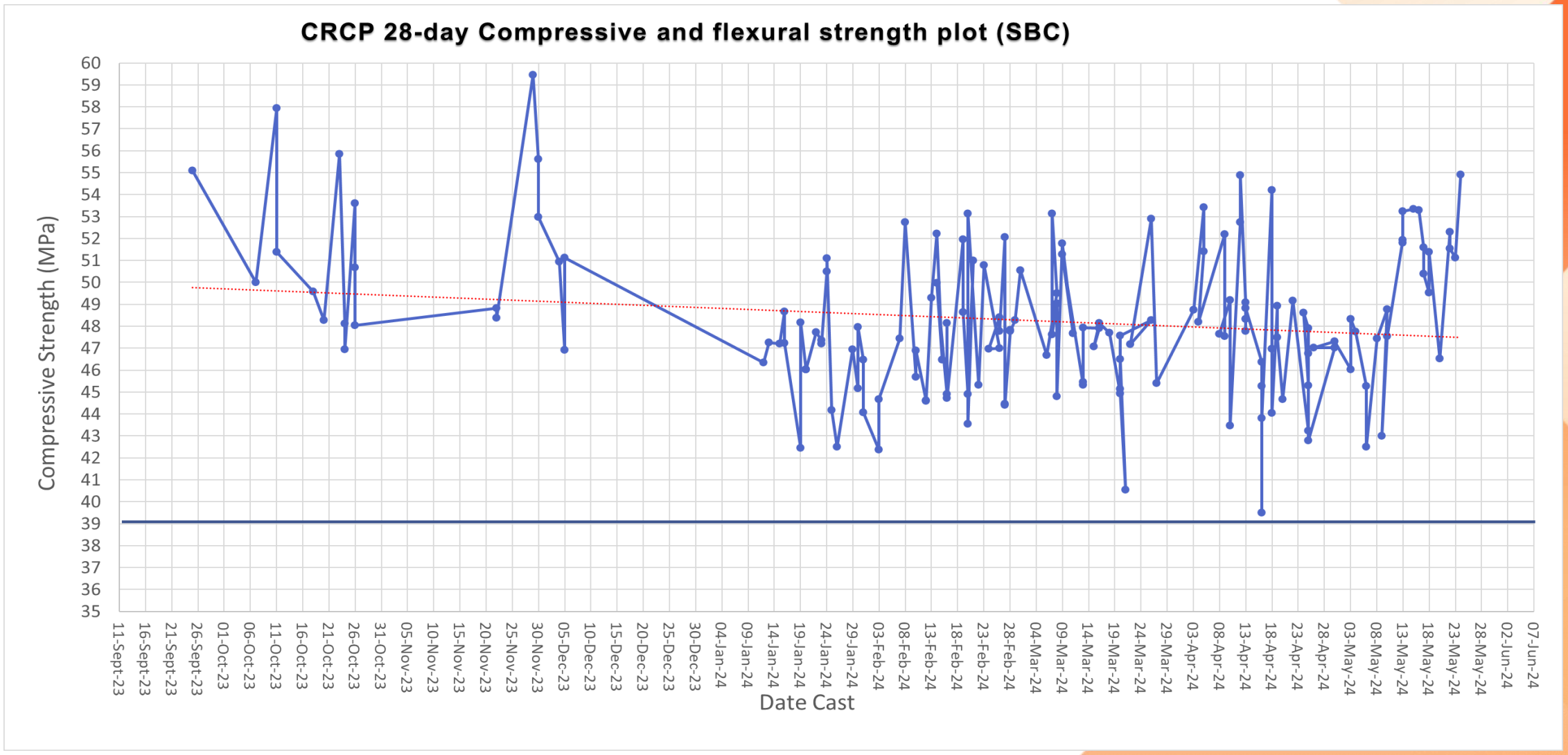
Mix Design

- The design specifications requires the use of binder with no more than 20% extender.
- KZN Tilite aggregates have the potential to cause alkali-silica reaction (ASR) due to reactivity.
- The reactivity is mitigated through the use of extenders (FA or GGBS) however due to the specifications, a different source of sand was used (AfriSam PMB dolerite)
- The design specifications does not allow for in-situ concrete strength verification through coring. If site cube strengths are low, the suspect in-situ cannot be verified.

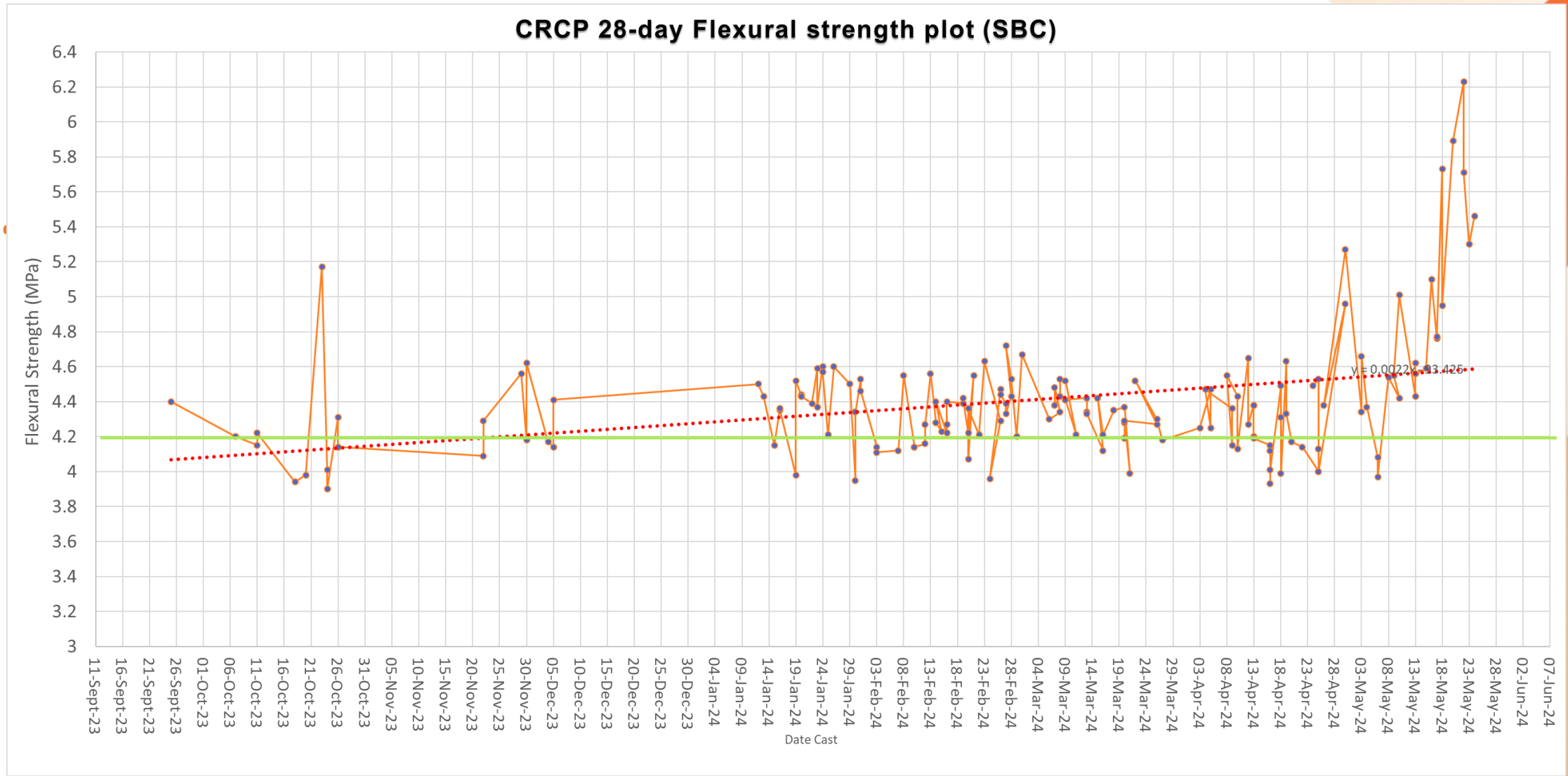
Performance of Mix

- Trial section mixes taken into permanent works, had challenges
- Rework required +/- 900m^3
- Revised mix performed well
- The notable change is the type of cement in mix.
  - Cem111/A-M (V-L), 42.5R vs Premium Cem111/A-s 42.5N

Performance of Mix



Performance of Mix



Placing

- Placement method – direct vs pump
- When placing, ensure concrete is not moved more than 1m per person to avoid segregation
- Pumping height fall not more than 1m
- Ensure enough trucks available for discharge to allow for emergency joint in case of plant breakdown
- Ensure enough team members to move concrete – do not move concrete with pokers

Striking and Finishing

- Ideal is to strike and use rolling screed, however vibrating beam effective enough.
- Always strike off towards camber to ensure concrete is pushed upwards
- Bullfloat transverse
- Broom finish gives a more even finish than burlap drag
- Tine as soon as possible

Risks in Finishing

- Vibrating beam camber
- Time between placing, striking and tining critical
- Weather conditions
- Improper vibrating – honeycombing
- Ladder edging (nosing tool)
- Curing compound application
- Plastic shrinkage cracking

Sub Contracting/Labour Opportunities

- **CPG Goal**
  - Opportunities: 12
- **CPG Spend**
  - R105 million
- **Employment**
  - Labour employed: 300
  - Man-days: 23 400

BRAGG over CRCP

Bitumen Rubber Asphalt Gap Graded (BRAGG)

- Functional layer over CRC
- 45mm, 14mm NMPs
  - Over prepared surface
  - Bond coat, subjected to Bond and Shear tests

Specifications

- **Torque:** 650 kPa
- **Shear:** 450 kPa

Surface Preparation

- Prior to asphalt paving, significant preparatory work was required on the CRCP surface.
- Since the CRCP was tined, surface refinement was essential to ensure optimal adhesion between the concrete and BRAGG.
- This was achieved through fine drum milling (micro-milling), which served to:
  - Remove tining from the surface;
  - Eliminate any residual resin-based curing compound
  - Expose uncontaminated, fresh concrete for enhanced bonding

Bond Coat

- Material : Suprabond-T
- Rate of Application : 0.3 L/m²
- Bond coat was sprayed using calibrated bitumen distributors.
- Application was done under strict weather-controlled conditions to prevent early breakage and ensure uniform adhesion.

Bond Coat – Torque/Shear

- Torque and shear results exceeds the minimum requirements.
- The area with prolonged weathering reactivated sufficiently during paving. This was experienced over the December shutdown.

Bond Coat – Torque/Shear

Torque Strength Summary

Bond coat application date	BRAGG paving date	Test Date	Surface prep	Bitumen content (%)	Max load (NM)	Torque (kPa)
2024/10/09 (Lane 6)	2024/10/25	2024/11/20	Tined	7.1	270	1031.3
			Tined	7.1	310	1184.1
			Tined	7.1	290	1107.7
			Milled	7.1	300	1145.9
			Milled	7.1	250	954.9
			Milled	7.1	260	993.1
			Milled	7.1	250	954.1
		2024/11/28	Milled	7.4	350	1336.9
			Milled	7.4	370	1413.3
			Milled	7.4	360	1375.1
	2024/10/24		Milled	7.7	350	1336.9
			Milled	7.7	360	1375.1
			Milled	7.7	350	1336.9
2024/12/05 (Lane 6, KM33+416 – KM32+421)	2025/01/22	2025/01/24	Milled	7.4*	190*	725.7
			Milled	7.4*	210*	802.1
			Milled	7.4*	280*	1069.5
	2024/12/09	2025/01/28	Milled	7.4	400	1527.9
			Milled	7.4	350	1336.9
			Milled	7.4	400	1527.9
2025/01/16 (Lane 5 + 6, KM31+250 – KM 32+980	2025/01/22		Milled	7.4	380	1451.5
			Milled	7.4	390	1489.7
			Milled	7.4	330	1260.5

*Bond coat applied Dec 2024, trial section to determine if bond coat still viable

Bond Coat – Torque/Shear

Shear Strength Summary

Bond coat application date	BRAGG paving date	Test Date	Surface prep	Bitumen content (%)	Max load (KN)	Shear (kPa)
2024/10/09 (Lane 6)	2024/10/25	2024/11/20	Tined	7.1	7.500	996.34
			Tined	7.1	5.125	685.02
			Tined	7.1	6.750	896.70
			Milled	7.1	5.875	778.87
			Milled	7.1	5.625	739.68
			Milled	7.1	Sample damaged, not tested	
			Milled	7.1		
		2024/11/28	Milled	7.4	9.500	1226.69
			Milled	7.4	5.375	701.09
			Milled	7.4	9.500	1231.65
	2024/10/24 (Lane 6)		Milled	7.7	8.875	1145.99
			Milled	7.7	7.500	968.44
			Milled	7.7	10.086	1304.99
2024/12/05 (Lane 6, KM33+416 – KM32+421)	2025/01/22	2025/01/24	Milled	7.4*	11.750	1359.56
			Milled	7.4*	9.875	1144.79
			Milled	7.4*	10.500	1212.61
	2024/12/09	2025/01/28	Milled	7.4	8.625	999.88
			Milled	7.4	6.875	795.48
			Milled	7.4	7.257	836.49
2025/01/16 (Lane 5 + 6, KM31+250 – KM 32+980	2025/01/22		Milled	7.4	6.027	697.37
			Milled	7.4	7.995	923.32
			Milled	7.4	6.519	754.29

*Bond coat applied Dec 2024, trial section to determine if bond coat still viable

Acknowledgements

- NME Team
- Site Construction Team (Rumdel)
- Concrete Supplier (Afrisam)