Design and Construction of Enrobé à Module Élevé (EME) on the National Route 1 Section 1, North East of Paarl in the Western Cape.

(Contract N001-010-2014/1F)

Pavement Structure 3 (EME): Between km 57.43 and km 59.93

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Road Pavements Forum (RPF)

CONTENTS

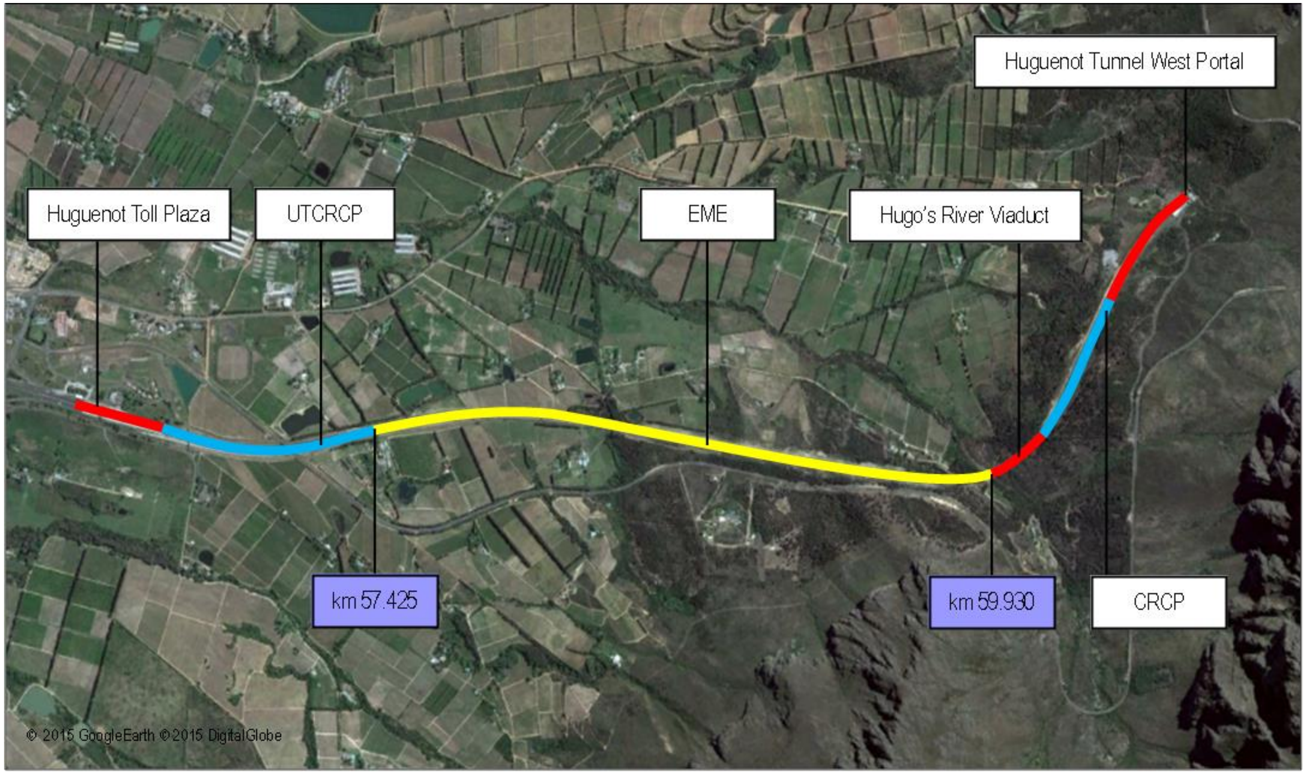
Design and Construction of Enrobé à Module Élevé (EME) on the National Route 1 Section 1, North East of Paarl in the Western Cape:

1. Project Background

- In 2009 the National Route 1 Section 1 between km 56.1 and km 61.5 was rehabilitated and widened.
- As part of the rehabilitation and widening contract, the downhill truck crawler lane was constructed as an experimental pavement section.
- This experimental pavement section was constructed with a 50 mm thick Ultra-Thin Continuously Reinforced Concrete Pavement (UTCRCP).
- Early in 2010 sections of the experimental UTCRCP started to fail and consequently necessitated repair.
- In October 2014, SANRAL appointed Royal HaskoningDHV (Pty) Ltd as the service provider for the special maintenance of the truck crawler lane on the National Route 1 Section 1.

2. Project Locality

- The project is located north east of Paarl in the Western Cape, between Huguenot Toll Plaza and the western portal of the Huguenot Tunnel.



- The project was limited to the southbound (downhill) truck crawler lane

3. Project Objective

- The project called for the reinstatement of the experimental UTCRCP with a re-engineered UTCRCP and a EME asphalt, at various locations along southbound (downhill) truck crawler lane.

- The project objective was specifically formulated to enable a long term performance comparison of both the re-engineered UTCRCP and the EME with UTFC under repeated traffic loading.

4. Pavement Design (Structural Analysis)

- After the experimental UTCRCP was removed, Falling Weight Deflectometer measurements were conducted on the residual pavement structure at 20 m intervals.
- The residual pavement structure comprised a 170 -185 mm Bitumen Stabilised Material (BSM) overlaying a 300 mm stabilised (C3) subbase layer, founded on good quality selected subgrade material.
- A mechanistic-empirical model was used as the primary pavement response model to calculate the critical response parameters for each material layer in the pavement structure under loading.
- A provisional fatigue prediction model developed by Professor Steyn (2014) was used to determine the bearing capacity of the EME asphalt base layer

4. Pavement Design (Structural Analysis)

- The mechanistic analysis supported the construction of a 120 mm EME base layer over the residual pavement structure to accommodate the future design traffic loading of 48 x10^6 E80's.

Pavement Structure 3: km 57.4 to km 59.9: Section Length 2.5 km

Existing Pavement Structure

Pavement Structure		Layer Thickness (mm)	Layer Description
PS 3	1.	50	UTCRCP
PS 3	2.	30	AC
PS 3	3.	185	BSM / (EG4)
PS 3	4.	300	C3 / (EG4)
PS 3	5.	350	G6/G7
PS 3			Subgrade

Rehabilitated Pavement Structure

Pavement Structure		Layer Thickness (mm)	Layer Description
PS 3	1.	20	UTFC
PS 3	2.	120	EME
PS 3	3.	125	BSM / (EG/4)
PS 3	4.	300	C3 / (EG4
PS 3	5.	350	G6/G7
PS 3			Subgrade

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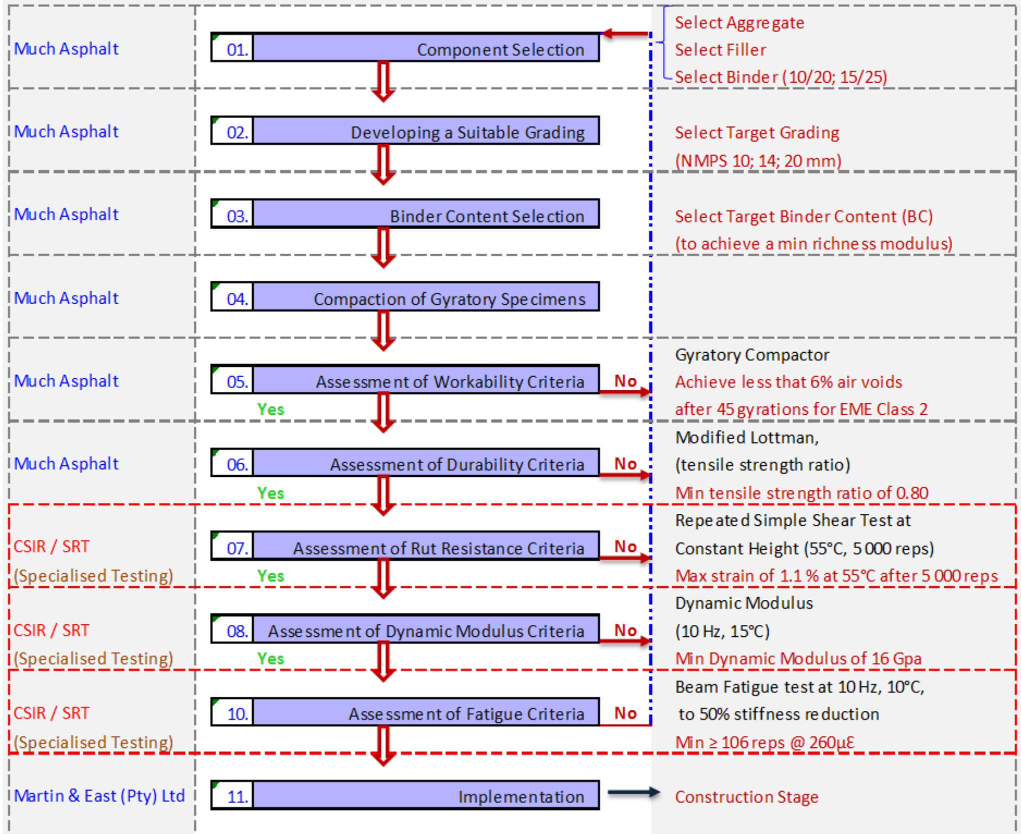
5. Material Design

- The design of the EME Class 2 asphalt base with a Nominal Maximum Particle Size (NMPS) of 14 mm was conducted by Much Asphalt in accordance with the performance related method, recommended by Sabita Manual 33 (2013).
- The performance related design process comprise 11 steps



5. Material Design

Component Selection:

- 13.2 (14) & 9.5 (10) mm crushed stone (Hornfels): Lafarge.
- Crusher Dust: Afrisam.
- Hydrated Lime Filler: Cape Lime
- 10/20 Penetration Grade Bitumen: Shell (Sapref).

Material Mix Design Process:

- Four key sieve sizes, provided a target grading as a point of departure in developing a suitable mix grading.

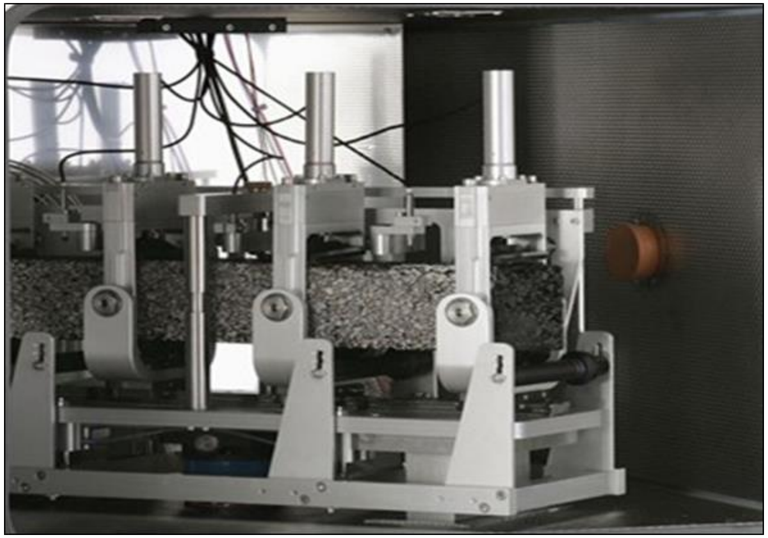
- The binder content was determined based on a min richness modulus K of 3.4

- The workability of the trail mix was assessed by monitoring the effort required to compact the material in the gyratory compactor.

- The laboratory mix with the 5.7% binder content and 4.8% Air Voids at 45 gyrations was selected to conclude the performance requirement testing.

5. Material Design

- The unavailability of specialised testing equipment, needed for performance requirement testing (with specific reference to the Four Point Beam Testing apparatus), delayed the laboratory material design process significantly.



Four Point Beam Testing Apparatus Needed for Performance Requirement Testing

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5. Material Design

- During the production and testing of the plant mix performance tests were repeated to ensure compliance of the plant mix.
  - dynamic modulus; fatigue; and permanent deformation:
- The dynamic modulus and fatigue test results compared reasonably well with the initial laboratory test results.
- The resistance to permanent deformation performed in accordance with test method AASHTO T320 (RSST-CH) did however, not compare with the initial laboratory test results.
- The variation between the laboratory and plant RSST-CH test results was attributed to the inconsistency in the preparation and conditioning of EME slabs prior to testing.
- No formal protocol existed at the time that clarified the required preparation and conditioning of asphalt slabs prior to testing.
- It was therefore decided to evaluate the permanent deformation in accordance with the Model Mobile Load Simulator (MMLS) and the Hamburg Wheel Tracking protocol.

5. Material Design

- After the construction of a trial section and a holistic evaluation approach, taking into account relevant test results, the contractor commenced with the construction of the EME asphalt base layer with a 5.7 percent binder content.

6. Construction of the EME Asphalt Base

- Current best practice (Sabita Manual 33) calls for a mixing temperature of between 160ºC and 180ºC with a compaction temperature of above 140ºC;

Construction of Trial Section 1: (02 October 2015)

- The industry was however, warned about the typical stiffening up behaviour of EME during compaction, whereby the mat locks and any further rolling has very little impact on the required density.

- The mixing temperature was therefore adjusted (increased to beyond 180ºC) to compensate for project specific conditions, that included:

  - Haul distance; and
  - Uncertainty pertaining to the potential stiffening up behaviour.

- This unfortunately resulted in a slow setting / tender asphalt mix that proved difficult to compact even at relatively low temperatures.

6. Construction of the EME Asphalt Base

Construction of Trial Section 1: (02 October 2015)

- At the time it was suspected that the slow setting / tender asphalt was a direct result of mixt segregation (binder drainage) during transportation.

Construction of Trial Section 2: (19 October 2015)

- Consequently the mixing temperature was reduced to 170ºC and compaction commenced at 145ºC.
- The required density specification was thereafter achieved with ease.
- No stiffening up behaviour of EME was experienced during compaction process.

6. Construction of the EME Asphalt Base

- During construction of the first 60 mm lift of the 120 mm EME base layer, it was observed that stationary compaction equipment parked on the previous day's construction resulted in a slight indentation.

- The project team engaged with SANRAL, to discuss the problem. SANRAL indicated that they were observing similar occurrences with the EME base layer construction on the National Route 3 near Pietermaritzburg in Kwa-Zulu Natal.

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6. Construction of the EME Asphalt Base

- Sabita wished to become involved and called for a meeting with the view of setting up a working group to investigate the phenomena.
- Both the N1 and N3 projects under construction acquired their 10/20 unmodified penetration grade bitumen from Shell (Sapref) in Kwa-Zulu Natal.
- It was confirmed that the 10/20 penetration grade bitumen complied with the relevant penetration grade specifications.
- Although, the 10/20 penetration grade bitumen complied with the relevant penetration grade specifications, additional rheological and chemical testing was initiated to fully characterise and ultimately confirm the quality of the bitumen.
- Taking into consideration the time constraints (both N1 and N3 under construction)
- The working group recommended, reducing the binder content of the EME mix design for both the National Route 1 and 3 projects to enhance the materials resistance to permanent deformation properties.

6. Construction of the EME Asphalt Base

- Taking into consideration the working group's recommendation, the binder content was reduced to 5.4% and the mix design re-engineered accordingly.

- The resistance to permanent deformation properties of the material was improved and confirmed by both:

  - Model Mobile Load Simulator (MMLS) (Gyratory); and
    - 3,600 load repetitions per hour for Rolling Gradients and Trucks

  - Hamburg Wheel Tracking (Gyratory).
    - 20 000 passes at maximum impression

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6. Construction of the EME Asphalt Base

- The EME base was finally constructed in two 60 mm lifts:
  - The lower 60 mm lift was constructed with a 5.7 percent binder content (10/20 penetration); followed by
  - The upper 60 mm lift that was constructed with a reduced 5.4 per cent binder content (10/20 penetration), to improve the materials resistance to permanent deformation.

6. Construction of the EME Asphalt Base

- The reinstatement of the UTCRCP along the southbound (downhill) truck crawler lane on the National Route 1 Section 1 with the EME asphalt base and UTFC was successful executed.

6. Construction of the EME Asphalt Base

- The long term performance comparison of both the re-engineered UTCRCP and EME with UTFC under repeated traffic loading will ultimately provide valuable input data towards the evaluation of the Life Cycle Cost Analysis of the two alternative remedial actions.

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