TECHNICAL NOTE

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THE USE OF PLASTIC WASTE IN ROAD CONSTRUCTION IN SOUTH AFRICA
Case study 3: Demonstration section of the wet modification process
Phase 1: Construction of earthworks and pavement layers

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KEY FINDINGS

This technical note summarizes the construction and quality assurance checks conducted by the Council for Scientific and Industrial Research (CSIR) during the construction of the supporting pavement layers for demonstrating the wet modification process on the use of plastic waste in South African road construction, i.e. Case Study 3. The test section was constructed for long-term performance testing with the CSIR's Heavy Vehicle Simulator at the University of Pretoria's Accelerated Pavement Testing track. This technical note covers the pavement design, construction and quality assurance tests conducted during the construction of pavement layers.

INTRODUCTION

In June 2022, Case Study 3 was the first research project constructed for Accelerated Pavement Testing (APT) at the University of Pretoria's Engineering 4.0 facility. The overall research project was initiated by the Department of Science and Innovation (DSI) through a research grant that aimed to demonstrate the use of waste plastic in road construction. The demonstration project consisted of Heavy Vehicle Simulator (HVS) performance testing on a 100 x 5 m APT track as shown in Figure 1 and Figure 2.

Figure 1: Location of APT track.

The main objective of the research grant was to combine the requirement for high-performance roads in South Africa with new and local end-use markets for plastic recycling through laboratory investigations and long-term performance simulations.

The project supported a Civil Engineering post-graduate student at the University of Johannesburg, who prepared the pavement design used in the construction project. WBHO was identified as the contractor to construct the 100 m test section and secured all construction materials in partnership with Afrimat's Lyttelton branch. Laboratory testing was conducted by Roadlab (Pty) Ltd and the CSIR's Advanced Materials Testing Laboratory (AMTL) to ensure compliance and quality of the constructed works.

SCOPE

CSIR Smart Mobility has investigated several methods for incorporating waste and alternative materials into road construction. The CSIR's investigation on incorporating waste plastics into asphalt road construction resulted in the demonstration of two methods of plastic modification, i.e. "dry modification" and "wet modification". The dry modification process was demonstrated in 2021 at a test section on road P159/1, also known as the R80 near Shoshanguve in the City of Tshwane. Case Study 3 focusses on the wet modification process where the waste plastic was used to modify the bitumen prior to manufacturing the asphalt mix.

Case Study 3 was carried out in three phases, namely:

- Phase 1: Earthworks and pavement layer construction
- Phase 2: Asphalt surfacing and quality assurance
- Phase 3: Heavy Vehicle Simulator (HVS) testing

The scope of this technical note (Phase 1) is to provide technical information from Phase 1 and highlights during the construction of layer works for Case Study 3. Phase 2 focusses on the manufacture, paving and quality assurance of the asphalt used, while Phase 3 highlights the comparative performance results from accelerated long-term testing using the HVS.

PAVEMENT DESIGN AND CONSTRUCTION

The greenfield project was designed based on the following assumptions:

- No traffic information was available given the research nature of the project.
- TRH 4 was used as the initial starting point and subsequently optimized.
- COTO (2020) was used for material specification.
- TRH 16 was used as a reference for traffic loading for pavement.

Table 1 shows the final ES30 pavement design used for constructing the test section and formed the basis for the project specific requirements.

Table 1: Pavement design

Layer no.	Layer name	Layer thickness (mm)	Layer description	TRH14 class
1	Surfacing	50	Continuously graded asphalt	A
2	Base	150	Graded crushed stone	G1
3	Sub-base	250	Cemented material	C3
4	Selected	150	Gravel soil	G5
5	In-situ	150	Gravel soil	G9

The underlying layers of the pavement structure were consistent throughout the section to provide a uniform foundation and allow comparative testing of the two asphalt mixes, for construction in Phase 2 and testing in Phase 3. The earthworks and pavement layers were constructed as per the programme shown in Figure 2.

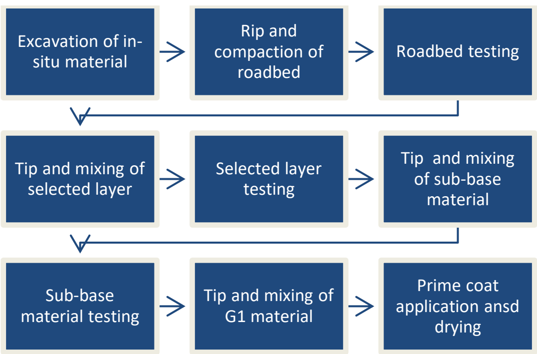

Figure 2: Earthworks and pavement layers construction

During construction of the pavement layers, compliance with the site Occupational Health and Safety Act (1993) was ensured as well as adherence to environmental regulations requirements as per the National Environmental Management Act (1998) especially given the site's location near protected plant species. Watering of the cement treated material (C3 layer) and slush compaction of the G1 base layer is shown in Figure 3a and 3b respectively.

QUALITY ASSURANCE TESTING

The following tests were conducted on each of the constructed pavement layers as seen in Figure 4:

- Determination of in situ density using a nuclear density gauge (SANS 3001-NG5: 2014).
- Determination of the moisture content by oven-drying (SANS 3001-GR20: 2010).

The following laboratory tests were conducted on the applicable pavement materials:

- Particle size analysis (SANS 3001-GR1: 2011).
- Determination of Atterberg Limits (SANS 3001 -GR10: 2013; -GR11: 2013; -GR12: 2013).
- Determination of the maximum dry density and optimum moisture content (SANS 3001- GR30: 2015; -GR31: 2015).
- Determination of the California Bearing Ratio (SANS 3001-GR40: 2013).

The following additional tests were conducted on the G1 base material:

- Determination of the flakiness index (SANS 3001-AG4: 2013).
- Apparent density of crushed stone base (SANS 3001-AG22: 2012).
- Determination of Aggregate Crushing Value (ACV) and 10% FACT (Fines Aggregate Crushing Test) as per SANS 3001-AG10: 2012.

(a) (b)

Figure 3: Earthworks and pavement layers construction

(i) Roadbed (ii) Selected layer

(iii) Sub-base (iv) Base

Figure 4: In-situ testing of constructed pavement layers

Key parameters were found to meet the pavement design requirements, where the compaction, Plasticity Index (PI), Grading Modulus (GM) and strength results for each layer are shown in Table 2.

Table 2: As-built pavement structure

Layer no.	Layer thickness (mm)	Compaction (MOD. AASHTO)	PI	GM	Strength CBR (%) /UCS (MPa)
1	*	*	*	*	*
2	150	91% AD+	NP	2.5	-
3	250	99%	NP	2.3	2.9 MPa
4	150	99 %	6	2.2	50 %
5	150	99 %	20	1.5	8 %

*Asphalt surfacing technical information is summarized in Rampersad (2024).
+AD – Apparent Density

The moisture levels in the G1 base were verified with a nuclear density gauge to ensure sufficient drying before applying the prime coat. Construction of all underlying layers for Case Study 3 were completed on 8 July 2022 with application of the prime coat (See Figure 5).

Figure 5: Final G1 base after priming

Phase 2 of the project included the asphalt paving and quality assurance for the asphalt mixes used in Case Study 3 and is summarized in Rampersad (2024), while the accelerated long-term performance testing with the HVS is summarized in Smit (2024).

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REFERENCES

1. Rampersad, A. 2024. The use of plastic waste in road construction in South Africa, Case study 3: Demonstration section of the wet modification process, Phase 2: Asphalt Quality Assurance. CSIR, Pretoria, South Africa.
2. Smit, M. 2024. The use of plastic waste in road construction in South Africa, Case study 3: Demonstration section of the wet modification process, Phase 3: Heavy Vehicle Simulator testing. CSIR, Pretoria, South Africa.

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