eThekwini Municipality

Engineering Unit
Roads Provision Department
Pavement & Geotechnical Engineering Branch

Technical Note

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TN Authority	**Designation**	**Name**	**Service No.**	**Signed**
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P&GE TN001v1
ASPHALT MIX USE, DESIGN AND QUALITY MANAGEMENT

1. PURPOSE

The Roads Provision Department is the custodian of the eThekwini Municipality's surfaced road network. As such it seeks to guide layer-work design and the use of materials in road construction. This Technical Note seeks to guide the manufacture and use of asphalt mixtures within the eThekwini Municipality.

The Roads Provision Department has moved from the empirically/recipe based method of asphalt mix design to a performance based approach to asphalt mix design. There is a significant shift in responsibilities of role players in the design of asphalt mixes under this approach. This Technical Note outlines the requirements for implementation of this approach when specifying the use of asphalt.

2. SCOPE

This Technical Note covers the design and manufacture of hot/warm mix asphalt supplied to the eThekwini Municipality. Appendix A gives a brief outline on the selection and use of asphalt mixes from a project implementation perspective.

3. REFERENCES AND STANDARD SPECIFICATIONS

Reference to the standard specifications, guideline documents and codes of practice in Table 1, and references within these documents shall be deemed to be part of this Technical Note.

Table 1 Reference and Standard Specifications

Reference	Title	Date of Issue
SANS 9001	Quality management systems – Requirements	Edition 5 2015
SANS 4001-BT1	Penetration grade bitumen	Edition 1.3 2016
SANS 4001-BT3	Anionic bitumen road emulsions	Edition 1 2014
SANS 4001-BT4	Cationic bitumen road emulsions	Edition 1 2014
SANS 1083	Aggregates from natural sources	Edition 2.6 2018
SANS 824	Lime for soil stabilization	Edition 2.1 2006
SANS 50197-1	Cement – Part 1:Composition, specification and conformity criteria for common cements	Edition 2 2013
SATS 1028	South African PG Binder Classification System	Draft 2019
Act 85 of 1993	Occupational health and safety act	As amended
Act 39 of 2004	National environmental management : Air quality act	As amended
Sabita Manual 5	Guidelines for the manufacture and construction of hot mix asphalt	4th Edition January 2008

Reference	Title	Date of Issue
Sabita Manual 27	Guidelines for thin hot mix asphalt wearing courses on residential streets	May 2008
Sabita Manual 32	Best practice guideline for warm mix asphalt	September 2011
Sabita Manual 33	Interim design procedure for high modulus asphalt	July 2015
TRH 8 / Sabita Manual 35	Design and use of asphalt in road pavements	Revised 2nd Edition February 2019
Sabita TG1	The use of modified bituminous binder in road construction	4th Edition January 2019
TRH 21	Use of reclaimed asphalt in the production of asphalt	2016 (Draft)
SAPEM	South African Pavement Engineering Manual	Second Edition October 2014

4. DEFINITIONS

4.1. Definitions

The following definitions and abbreviations are used throughout the Technical Note.

Table 2 Definitions

NMPS	Nominal maximum particle size
Sa	Sand skeleton mix
St	Stone skeleton mix
SMA	Stone mastic asphalt
EME	Enrobé à module élevé
UTFC	Ultra thin friction course
WMA	Warm mix asphalt
BRASO	Bitumen rubber semi-open graded asphalt
S	Standard traffic and speed conditions
H	Heavy traffic and speed conditions
V	Very heavy traffic and speed conditions
E	Extreme traffic and speed conditions
R	Permanent deformation (Rutting) foremost consideration in mix
F	Fatigue foremost consideration in mix

4.2. Mix Nomenclature (or Mix Description)

A mix shall be defined from amongst the following mix types :-

- Sa
- St (currently not applicable for eThekwini roads unless as a special mix (e.g. SMA))
- Special Mixes
    - SMA
    - EME
    - UTFC
    - BRASO
    - Proprietary Mixes

The mix type shall be further defined by the following :-

- the typical conditions under which a mix is to be used (type Sa mixes only)
  - S Standard conditions
  - H Heavy conditions
  - V Very heavy conditions
  - E Extreme conditions

  The criteria for these conditions is based on the binder grade selection procedure outlined in Sabita Manual 35 (reproduced below).

Table 3 Traffic Loading Conditions

Design Traffic (10^6 E80's)	Traffic Speed (km/h)		
	< 20	20 – 80	> 80
< 0.3	S	S	S
0.3 – 3	H	S	S
> 3 - 10	V	H	H
> 10 – 30	E	V	H
> 30 – 100	E	E	V
> 100	E	E	E

- the NMPS of the mix
  - Permitted NMPS sizes are noted in Table 4.
- the critical failure consideration for the mix (optional for type Sa mixes only))
  - F fatigue
  - R permanent deformation (rutting)
- The class of the mix (EME mixes only)
  - Either class 1 or class 2.

The mix types shall thus be labelled as follows :-

- "Mix type"-"Condition""NMPS""Failure Mode""(Mix Class)"
  - Examples
    - Sa-H14F
      This is a Sand Skeleton mix for use under Heavy traffic loading and speed conditions with Nominal Maximum Particle Size of 14.0mm that should lend itself to maximizing fatigue resistance.
    - EME-14(2)
      This is an EME class 2 mix with Nominal Maximum Particle Size of 14.0mm.
    - SMA-14
      This is an SMA mix with Nominal Maximum Particle Size of 14.0mm.

Note that the mixes SMA, EME, UTFC and BRASO (etc.) will actually fall into either the type Sa or St mixes. However, these mixes (like the proprietary mixes) are special mixes with very specific characteristics and associated design approaches and are thus specifically and separately named.

5. MIX DESIGN

Asphalt mixes shall come from the list of permitted mixes noted in Table 4. Mix requirements will be detailed in the project specification in terms of :-

- Mix description (as outlined in clause 4.2 Mix Nomenclature)
- The required level of design.

Table 4 eThekwini Asphalt Mixes

Mix Nomenclature	NMPS (mm)			
	7	10	14	20
Sa-S	X	X	X	
Sa-H		X	X	X
Sa-V			X	X
SMA		X	X	
EME			X	X
Proprietary and Other Mixes	To hold Agrèment South Africa certification or subject to approval by Roads Provision. NMAS as per Manufacturer's specification.			

For costing purposes, a nominal binder content for the various mixes is noted in Table 5. The actual binder requirement shall be determined through the mix design process.

Table 5 Nominal Binder Content

Mix Type	NMPS (mm)	Nominal Binder Content (%)
Sa	7	6.5
	10	5.7
	14	5.0
	20	4.7
SMA	10	6.5
	14	6.5
EME Class 1	14	5.0
	20	5.0
EME Class 2	14	6.0
	20	6.0

Mix designs are to be conducted in accordance with the guidelines noted in Table 6.

Table 6 Asphalt Mix Design Guideline Documents

Sand Skeleton Mixes	TRH 8/Sabita Manual 35	Design and use of asphalt in road pavements
Stone Mastic Asphalt (SMA)	TRH 8/Sabita Manual 35	Design and use of asphalt in road pavements (Appendix B)
Enrobé à Module Élevé (EME)	Sabita Manual 33	Interim design procedure for high modulus asphalt

Special asphalt mixes (e.g. UTFC, proprietary mixes, etc.) shall hold Agrèment South Africa fit-for-purpose certification. Alternatively, the use of a particular mix shall be subject to the approval of the Roads Provision Department.

5.1. Materials

Materials shall conform to the requirements and recommendations outlined in Sabita Manual 35.

5.1.1. Binders and Aggregates

The specifications pertinent to specific raw materials should conform to accepted industry standards and shall be documented in the Asphalt Mix Design Report. These specifications shall be used for quality management purposes. Any deviations from standard industry practice as outlined in Sabita Manual 35 shall be documented in the Asphalt Mix Design Report and shall specifically be brought to the attention of the Roads Provision Department.

5.1.2. Reclaimed Asphalt

The use of reclaimed asphalt (RA) is permitted subject to the limitations noted under the specific mix types. The inclusion of RA in a mix design shall be documented in the Asphalt Mix Design Report.

5.1.3. Warm Mix Asphalt Technologies/Additives

The use of Warm Mix Asphalt (WMA) is permitted and shall be documented in the Asphalt Mix Design Report.

5.2. Mix Design

No mixes may be supplied without submission of an Asphalt Mix Design Report and acceptance thereof by the Roads Provision Department.

The mix design process shall consist of a laboratory design, a plant trial and (if required) a paved trial for every mix supplied.

5.2.1. Specific Mix Design Requirements

5.2.1.1. Sand Skeleton Mixes

A maximum of 10% natural sand (by mass of mix aggregates) may be used in sand skeleton mix types Sa-H, Sa-V and Sa-E.

The reclaimed asphalt (RA) content of sand skeleton mixes shall be limited to 50% maximum.

The following additional requirements and guidelines should be taken into consideration for any particular level of mix design :-

5.2.1.1.1. Level IA Design

The design should also take into consideration the recommendations of Sabita Manual 27 "Guidelines for thin hot mix asphalt wearing courses on residential streets".

Further to Sabita Manual 35 Table 21 (VMA), the VMA for the 7.1mm NMPS mix shall be 16% (target design voids 4%).

Mixes shall also comply with the requirements in Table 7.

Table 7 Empirical Performance Tests (Level 1A)

Test	Requirement	Test Method / Reference
VIM (%) (75 blows)	6.0 max.	SANS 3001-AS10 & AS11
Filler/Binder Ratio (Normalised)	1.3 max.	Sabita Manual 35 cl. 4.3.4 Note 4.3 & 4.4
Binder Film Thickness (µm)	7.5 min.	Sabita Manual 35 cl. 5.5.1(4)(a)
Modified Lottman (TSR)	0.8 min.	ASTM D 4867 M
Air Permeability (@ 7% Voids) (x 10-8cm^2)	1.0 max.	TRH 8 App C
Marshall Stability, Flow and Quotient	Report	SANS 3001-AS2

5.2.1.1.2. Level IB Design

The workability of the mix shall be verified against the method described in clause 5.5.2 step 2 of Sabita Manual 35. The voids in the specimen after 25 gyrations shall not exceed 7%.

The mix durability requirements noted in Table 26 of Sabita Manual 35 shall be altered to reflect a minimum Modified Lottman value of 0.8 for both Base and Wearing Course mixes.

5.2.1.1.3. Level II Design

In order to identify the requisite compaction parameters for a particular E80 design traffic loading, the Level II design will be labelled in the project specification as follows :-

- Level II(A)
  Level II(A) will cater for an E80 design traffic loading of less than or equal to 30 million E80's.
- Level II(B)
  Level II(B) will cater for an E80 design traffic loading of greater than 30 million E80's.

The mix durability requirements noted in Table 26 of Sabita Manual 35 shall be altered to reflect a minimum Modified Lottman value of 0.8 for both Base and Wearing Course mixes.

5.2.1.1.4. Level III Design

In order to identify the requisite compaction parameters for a particular E80 design traffic loading, the Level III design will be labelled in the project specification as follows :-

- Level III(A)
  Level III(A) will cater for an E80 design traffic loading of less than or equal to 30 million E80's.
- Level III(B)
  Level III(B) will cater for an E80 design traffic loading of greater than 30 million E80's.

The mix durability requirements noted in Table 26 of Sabita Manual 35 shall be altered to reflect a minimum Modified Lottman value of 0.8 for both Base and Wearing Course mixes.

5.2.1.2. Stone Mastic Asphalt Mixes

Stone Mastic Asphalt (SMA) mix designs are to be conducted in accordance with the guidelines set out in Sabita Manual 35 "Design and use of asphalt in road pavements – Appendix B".

SMA mixes are permitted for two NMPS:-

- 10mm
- 14mm

The mix design should ensure that the fine aggregate mortar should not induce dilation of the coarse aggregate stone skeleton after compaction on site thereby ensuring coarse aggregate interlock. Coarse aggregate for both NMPS shall be defined as all material retained on the 5mm sieve.

The use of "natural" sand and reclaimed asphalt (RA) shall not be permitted in SMA mixes.

The stability of the fine aggregate mortar will require enhancement with either cellulose fibre or through modification of the binder or both.

The SMA mix shall also conform to the requirements in Table 8.

Table 8 SMA Mix Specifications

Design Air Void Content (%)	4.0
Bitumen Content (Min.)	6.0
Voids in Mineral Aggregate (VMA) (Min.)	17
Modified Lottman (TSR) (Min.)	0.7
Schellenberg Drainage Test (%) (Max.)	0.3
Air Permeability (@ 7% Voids) (x 10^{-8}cm^2) (Max.)	1.0
VCA_{mix}[1] (%)	< VCA_{drc}[2]

Note 1. VCAmix is the voids in coarse aggregate (>5mm) of the compacted mix.

Note 2. VCAdrc is the voids in coarse aggregate (>5mm) of the dry rodded coarse aggregate.

SMA mixes shall also conform to the permanent deformation requirements noted in Table 31 of Sabita Manual 35.

The mix design document should clearly document the process followed to meet the desired SMA characteristics.

5.2.1.3. Enrobé à Module Élevé (EME) Asphalt Mixes

EME mix design are to be conducted in accordance with the guidelines set out in Sabita Manual 33 “Interim design procedure for high modulus asphalt”.

EME mixes are permitted for two NMPS:-

- 14mm
- 20mm

The use of “natural” sand shall not be permitted in EME mixes.

The reclaimed asphalt (RA) content of EME mixes shall be limited to 20%.

The mix design document should clearly document the process followed to meet the desired EME characteristics.

5.2.1.4. Warm Mix Asphalt

Should a Warm Mix Asphalt be used in the mix, the mix design shall incorporate the use of such a technology/additive in the mix design process. Any consequential deviations from the guidelines set out in Sabita Manual 35 “Design and use of asphalt in road pavements – Appendix B”, Sabita Manual 33 “Design procedure for high modulus asphalt (EME)” or standard industry practice shall be brought to the attention of the Roads Provision Department and shall be documented in the mix design report.

5.2.2. Asphalt Mix Design Report

Once satisfied that the laboratory design, the plant and (if required) paved trials meet the specified mix requirements, the Manufacturer shall submit an Asphalt Mix Design Report recording the essential information relating to the design. This shall be recorded on the relevant COTO “D3” form and shall be supplemented with a report documenting any further information required in terms of this Technical Note.

The final mix parameters (i.e. the Job Mix Formula (JMF)) will be used for production quality control and acceptance purposes.

The Manufacturer shall include the following “mix characteristics” as a part of his Mix Design Report submission :-

- A unique identification number for every mix design
- Detail of the raw material specifications used (e.g. SANS 1083, SANS 4001-BT1).
- The grade of the base binder
- The type of modifier used and the modified binder characteristics to TG1 (if applicable)
- Binder classification in terms of the SA PG Binder Classification System

- The binder storage constraints (e.g. maximum storage times, etc.)
- The use of any Warm Mix Asphalt technology/additive. The Manufacturer shall document the name and type of technology/additive to be used together with any other technical information pertinent to its use in the asphalt mix. The Manufacturer shall further comment on any modifications to the "standard" mix design process consequential to the use of the Warm Mix Asphalt technology/additive.
- The maximum mix temperature in the truck at the exit from the plant (in line with industry norms)
- The minimum mix temperature in the truck on delivery (in line with industry norms)
- The minimum recommended mix temperature for compaction of the mix on site (in line with industry norms)
- Comment on any asphalt mix characteristics that should be brought to the attention of the asphalt paving/laying team on site (e.g. EME asphalt mix longitudinal joint construction)

Should substantial changes to material types and properties occur, the asphalt mix designs for affected mixes shall be reviewed and where necessary re-constituted and re-submitted for approval.

5.2.2.1. Mix Design Acceptance Process

It is not necessary for a new mix design to be compiled for every project. The Manufacturer may supply proof that an existing mix design is still current and has already been accepted by the Roads Provision Department. In the case of the submission of a new mix design, the Manufacturer shall submit his proposed mix design to the Roads Provision Department for acceptance of the mix design at least 2 weeks prior to initial supply of any particular mix.

Upon request by the Roads Provision Department, the Manufacturer shall supply samples of raw materials and any other relevant information as may be requested to facilitate acceptance of the mix design.

Once satisfied with the content of the mix design, the Senior Manager : Pavement & Geotechnical Engineering (or his nominee) will give signed acceptance for the mix.

5.2.3. Mix Design Review

Every mix design is to be reviewed at least annually. The review should include verification of the asphalt mix through testing of basic raw material properties and mix characteristics.

Should the binder, aggregate or mix characteristics of any particular mix differ significantly from the characteristics obtained in the initial mix design, then the mix shall be re-designed to meet the relevant volumetric and performance characteristics. In the event of a dispute over the significance of a particular characteristic, the Manufacturer shall undertake the appropriate performance test to prove compliance with the specification.

5.3. Asphalt Production

5.3.1. Mixing Plant

Asphalt shall be manufactured through a plant capable of meeting the full design requirements of any particular mix. The plant shall be operated and kept in a well maintained condition as directed by the Quality Management System. Records of such maintenance shall be made available on request. The plant shall be approved by the Roads Provision Department.

Sufficient reserves of raw materials shall be held at the plant for all mixes being supplied to the eThekwini Municipality to prevent delays in construction projects. It will be incumbent on the plant manager to ascertain demand and time frames from Contractors or Municipal Departments to whom they are supplying mix.

All cold aggregates shall be stockpiled and protected in a manner that precludes the possibility of aggregate contamination from adjacent stockpiles, from the underlying ground or from weather conditions.

Binder storage tanks shall be provided and managed to ensure that there is no risk of contamination of different binder types. Binder storage tanks shall be heated and the binder circulated in such a manner that the binder is not degraded during heating. The heating and circulation of binders should conform to the recommendations of the binder supplier.

The plant and its operation shall conform to the requirements of the following legislation:-

- Occupational Health and Safety Act
- National Environmental Management : Air Quality Act

5.3.2. Quality Control

The Manufacturer shall have an active Quality Management System in place compliant with the quality processes outlined in Sabita Manual 35. The quality of mix produced shall be monitored as directed in the Manufacturer's Quality Management System. The asphalt mix constituents (i.e. binder and aggregates), and the asphalt mix produced shall be checked for compliance and consistency on a regular bases through routine process control testing. The results of such testing shall be made available for review by the Roads Provision Department at all times.

5.3.2.1. Quality Management System

The Quality Management System (QMS) should include documentation outlining the asphalt mix design process, the annual mix review process and processes pertaining to delivery of the asphalt mix.

The QMS shall also include any agreed frequency of split sampling of either raw mix constituents or asphalt mixes (prepared as agreed) with the Roads Provision Department. Such samples are to be delivered to the Roads Provision's Bitumen and Asphalt Laboratory located at the Roads Provision Asphalt Plant in uMhlathuzana Road. All samples shall be adequately and uniquely labeled so that the location of any related mix is readily traceable.

The QMS shall also document the processes to be followed whenever a deviation from specifications is identified. The Manufacturer shall provide full rectification of any work undertaken with such asphalt mix or materials.

The plant laboratory should preferably be SANAS accredited for the tests undertaken. However, should the laboratory not be SANAS accredited, the laboratory will need to be approved by the Roads Provision Department.

In line with these processes, the QMS should include as a minimum the material characterisation tests included in Table 9 for every type of mix supplied.

Table 9 Test Frequencies

Quality Control Tests			Minimum Test Frequency
Binder	Penetration		Every batch delivered
	Softening Point		Every batch delivered
	SA PG Binder Classification		1 per 6 months
Aggregate	Coarse Aggregate	Aggregate Grading	Every batch delivered
		Flakiness Index (Max.)	1 per month
		Aggregates BRD, ARD and Water Absorption	1 per month
		ACV, 10%FACT	1 per month
		Polished Stone Value (Coarse Aggregates)	1 every year per stone type and source
	Fine Aggregate	Aggregate Grading	Every batch delivered
		Aggregates BRD, ARD and Water Absorption	1 per month
		Sand Equivalent (Fine Aggregates)	Every batch delivered
		Methylene Blue Adsorption Value	1 per month
Asphalt Mix	Temperature of Mix	In the truck at the exit weighbridge	Every load
		In the truck at the point of delivery	Every load
	Binder Content		1 test per 200 tons of output or part thereof per day
	Extracted Mix Aggregate Grading Analysis		1 test per 200 tons of output or part thereof per day
	Voids Analysis (Bulk Relative Density and Maximum Theoretical Relative Density)		1 test per 200 tons of output or part thereof per day

5.3.2.2. Process Control

The temperature of the mix taken in the truck at the exit to the plant shall not exceed the value stated in the mix design. Furthermore, the temperature of the mix taken in the truck on delivery shall not be less than the value stated in the mix design.

Quality checks on mix production will be based on the Job Mix Formula (JMF) for the approved mix design. Tolerances on variation from the JMF are given in Table 10.

Table 10 Job Mix Formula Tolerances

			Permissible Deviation from JMF (%)	
			Individual Results	Average of 3 Consecutive Results
Aggregate Fraction - Grading	Sieve Size (mm)	28	± 5.0	± 3.0
		20	± 5.0	± 3.0
		14	± 5.0	± 3.0
		10	± 5.0	± 3.0
		7.1	± 5.0	± 3.0
		5	± 4.0	± 2.5
		2	± 4.0	± 2.5
		1	± 4.0	± 2.5
		0.6	± 4.0	± 2.5
		0.3	± 3.0	± 2.0
		0.15	± 2.0	± 1.5
		0.075	± 1.0	± 1.0
Voids in the Mix (@ design compaction)			± 1.5	± 1.0
Binder Content	General Mixes (Sa, SMA, EME, etc.)		± 0.3	± 0.2
	Gap Graded & Bitumen Rubber		± 0.4	± 0.3

All process control testing undertaken by the Manufacturer shall be signed off by the responsible person identified in the QMS and shall be made available to the Roads Provision Department.

- All process control test results shall be referenced back to the unique Mix Design reference number.
- Mix extraction gradings shall be made available within 48 hours of the asphalt being manufactured.
- Binder content and void content shall be made available by 08:00am on the day following manufacture of the asphalt.

The Manufacturer shall be responsible for rectification of any work completed (or partially completed) with asphalt mix that does not meet the specification to the satisfaction of the Roads Provision Department. The processes related to the rectification of such work shall be outlined in the QMS.

5.3.2.3. Acceptance Testing

After reviewing the results of the process control testing, the Roads Provision Department may elect to conduct their own testing of the binder, aggregates or asphalt mix produced. A copy of test results will be submitted to the Manufacturer as soon as they are available.

If the acceptance tests indicate that the mix (or any part thereof) is not to specification, the cost of any re-test by the Municipality shall be borne by the Manufacturer.

5.3.2.4. On Site Mix Problems

The Manufacturer shall also make himself available on site should the workability and compaction of the mix during the paving/laying operation be problematic in order to assist in trouble-shooting the cause of such problems. If the root cause of the problem is related to the asphalt mix design, the Manufacturer shall re-evaluate his mix design to correct such issues and re-submit his mix design for acceptance.

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TN 001v2 - Appendix A
Guidelines on the Use of Asphalt within the eThekwini Municipality

Asphalt is used for a wide variety of applications within the eThekwini Municipality; from sidewalks to major industrial arterials and freeways. This document seeks to guide the appropriate choice of asphalt for any given application, and to guide the quality management of the asphalt used.

Table A Definitions

P&GE	Pavement & Geotechnical Engineering Branch of the Roads Provision Department
NMPS	Nominal maximum particle size (mm)
Sa	Sand skeleton mix
St	Stone skeleton mix
SMA	Stone mastic asphalt
EME	Enrobé à module élevé
UTFC	Ultra thin friction course
WMA	Warm mix asphalt
BRASO	Bitumen rubber semi-open graded asphalt
S	Standard traffic and speed conditions
H	Heavy traffic and speed conditions
V	Very heavy traffic and speed conditions
E	Extreme traffic and speed conditions
R	Permanent deformation (Rutting) foremost consideration in mix
F	Fatigue foremost consideration in mix
MVD	Maximum voidless density
IRI	International roughness index (m/km)
BSM	Bituminous stabilised material

For a general technical overview of asphalt, reference should be made to the South African Pavement Engineering Manual (SAPEM).

- SAPEM Chapter 3 (s-ch.4.2) – Asphalt Tests
- SAPEM Chapter 4 (s-ch.4) – Material Standards
- SAPEM Chapter 9 (s-ch.10) – Asphalt Overview
- SAPEM Chapter 12 (s-ch.3.11 & Appendix) – Asphalt Paving & Appendix – Asphalt Paving Trial Section Checklist
- SAPEM Chapter 13 (s-ch.6) – Quality Management

The Roads Provision Department has opted to simplify the process of mix choice and definition through incorporation of the primary mix design requirements within the mix description. Reference should be made to clause 4.2 of Technical Note 001 for a detailed description of the method.

Mix requirements must be detailed in the project specification in terms of :-

- Mix description (or choice of asphalt mix)
- The required level of asphalt mix design.

The choice of asphalt mix is however intricately related to the pavement layer-work design and should be as stipulated in the Pavement Design Report.

Nevertheless, the choice of asphalt mix will primarily be dependent on :-

- The usage under which the asphalt will be required to perform
- The thickness of asphalt layer lift (compacted thickness)

Mix Use

The typical use of various mix types and mix NMPS are portrayed in Table B.

Table B - Typical Mix Use

Asphalt Mix Use				Mix Type
Mix Nominal Maximum Particle Size (NMPS) (mm)				
7.1	10.0	14.0	20.0	
Patching/ Handwork				Sa
	Wearing Course (Paved)			Sa, SMA, UTFC, BRASO
		Base Course (Paved)		Sa, EME

The mix type is further defined by the typical conditions under which the asphalt mix is to be used (type Sa mixes only). Based on the typical vehicle usage and speed, the appropriate choice of Traffic Loading Condition can be made from Table C from amongst :-

- S Standard conditions
- H Heavy conditions
- V Very heavy conditions
- E Extreme conditions

Note that speeds on urban roads will typically fall between 20km/h to 80km/h. Speeds lower than 20km/h occur at intersections and are common in urban areas but are relatively short in extent. Unless a specific rutting problem is anticipated, the average speed between intersections should be used to determine the "Traffic Loading Condition". Only certain arterials and freeways carry heavy vehicle traffic with average speeds in excess of 80km/h.

Table C - Traffic Loading Conditions

Design Traffic		Traffic Speed (km/h)		
(10^6 E80's)	Description	< 20	20 – 80	> 80
< 0.3	Sidewalks, Patching, Light Access Roads (Cars & Taxis)	S	S	S
0.3 – 3	Collectors and Minor Bus Routes	H	S	S
> 3 – 10	Bus Routes, Light to Medium Industrial Roads	V	H	H
> 10 – 30	Major Bus Routes, Arterials/Freeways, Heavy Industrial Roads	E	V	H
> 30 – 100	Major Arterials/Freeways, Very Heavy Industrial Roads	E	E	V
> 100	Major Arterials/Freeways, Extremely Heavy Industrial Roads	E	E	E

The asphalt manufacturer will use this information to determine what binder and modifier (if necessary) should be used in the asphalt mix.

Layer Lift

The specified layer thickness will influence the choice of NMPS for the mix. The minimum compacted thickness that any particular mix can be laid at is a function of the NMPS of the mix (see Table D). Mixes paved at thicknesses lower than this are likely to cause problems with compaction resulting in premature failure of the layer.

Table D - Minimum Asphalt Thicknesses

NMPS (mm)	Design Layer Thickness (minimum) (mm)	
	Sa, SMA	EME
7.1	25	
10	35	
14	50	60
20	90	80

The maximum single lift thickness should not exceed 100mm. Any single layer thicknesses above 70mm will however require careful monitoring to ensure that compaction of the lower portion of the layer is not compromised and that there is not excessive movement of the mat during rolling which could have a ripple effect on level and grade tolerance controls.

Mixes Permitted by the eThekwini Municipality

Table E notes the mixes that are permitted for use on eThekwini Municipality projects.

Table E - eThekwini Asphalt Mixes

Mix Nomenclature	NMPS (mm)			
	7	10	14	20
Sa-S	X	X	X	
Sa-H		X	X	X
Sa-V			X	X
SMA		X	X	
EME			X	X
Proprietary and Other Mixes	To hold Agrèment South Africa certification or subject to approval by Roads Provision. NMAS as per Manufacturer's specification.			

Although the use of 20mm NMPS mixes is permitted, their use is not encouraged because of potential quality issues during paving. Coarser mixes are more prone to segregation during construction which can lead to unacceptable voids in the paved mat.

Special asphalt mixes (e.g. UTFC, proprietary mixes, etc.) must hold Agrèment South Africa fit-for-purpose certification. Alternatively, the use of a particular mix should be discussed with the P&GE Branch of the Roads Provision Department. These mixes are primarily chosen because of a particular feature of the mix :-

- UTFC Skid resistant surfacing for higher speed roads
- SMA Rut resistant surfacing on heavy bus routes and arterials
- BRASO Fatigue resistant surfacing for higher speed roads
- EME Rut resistant base course on heavily trafficked industrial route, arterials and freeways

Asphalt Mix Design Levels
In addition to the choice of type of mix, the level of asphalt mix design must also be chosen.

Table E – Asphalt Mix Design Levels

Level of Design	Design Traffic Loading (10^6 E80's)	Mix Design Philosophy	Typical Use
IA	< 0.3	Volumetric analysis (Marshall)	Sidewalks, Patching, Light Access Roads (Cars & Taxis)
IB	0.3 to 3	Volumetric Analysis (Gyratory)	Collectors and Minor Bus Routes
II(A)	3 to 30	Volumetric Analysis with Performance Assessments	Bus Routes, Arterials/Freeways, Industrial Roads
II(B)	> 30		Major Arterials/Freeways, Extremely Heavy Industrial Roads
III(A)	3 to 30	Volumetric Analysis with Extensive Performance Assessments	Bus Routes, Arterials/Freeways, Industrial Roads
III(B)	> 30		Major Arterials/Freeways, Extremely Heavy Industrial Roads

The Level III design should not be utilised unless fully motivated and discussed with the P&GE Branch. This level of design is associated with potential high risk usage where the consequences of early failure are extremely severe. The testing associated with this level is extremely expensive and time consuming.

Examples
The following examples illustrate the approach to asphalt mix choice and specification.

A. An existing bus route is to be widened and associated sidewalks constructed. The pavement layer-work design is :-

Road-works	Sidewalk
40mm asphalt wearing course	25mm asphalt
70mm asphalt base course	

Asphalt mix choices:

Wearing Course	Sa-H10 Level II(A)
Base Course	Sa-H14 Level II(A)
Sidewalk	Sa-S7 Level IA

The project specification should stipulate the use of the above mixes with the asphalt mix design conducted in accordance with the requirements of Technical Note 001.

B. A gravel to surface road upgrade is to be constructed. The pavement layer-work design is :-

35mm asphalt wearing course

Asphalt mix choice:

Wearing Course	Sa-S10 Level IA

The project specification should stipulate the use of the above mixes with the asphalt mix design conducted in accordance with the requirements of Technical Note 001.

Particular Mixes and Mix Properties

The following is a general description of particular "special" mix types. It is however advisable to discuss their intended use with the P&GE Branch.

- **UTFC Mixes**

  UTFC mixes are thin wearing course mixes offering improved skid resistant properties through higher texture depths. They are typically used on higher speed roads (> 80km/h). These mixes are proprietary in nature and their intended use should be discussed with the P&GE Branch.

- **SMA Mixes**

  SMA mixes are wearing course mixes offering very good rut resistance. They are however relatively sensitive to manufacturing processes and good performance is dependent on the implementation of good quality management procedures during manufacture and construction.

- **Mixes containing Rubber Modified Binders (e.g. BRASO)**

  Mixes containing rubber modified bitumen have been used quite extensively in South Africa. They offer excellent fatigue characteristics and are ideal for pavement structures that are more flexible in nature and also in wearing course applications on higher speed roads requiring more open graded mix structures with higher texture depths ("Braso" mixes). These mixes are proprietary in nature and their intended use should be discussed with the P&GE Branch.

  It should be noted however that these mixes cannot be re-cycled through a hot-mix recycling type operation. There are environmental issues with re-heating the rubber in the mix. Nevertheless, there is no problem with a cold recycling approach (e.g. within a BSM material, etc.).

- **EME Mixes**

  EME mixes are base course mixes offering excellent rut resistance properties and have proven successful in heavy applications where standard modified mixes have performed poorly. An EME base mix will need to be surfaced with a suitable wearing course mix. There are two classes of EME mix.

  - Class 1

    Class 1 EME mixes offer excellent rut resistance but are limited in terms of fatigue life. They would be suitable for situations where the sub-base support is reasonable rigid (i.e. well cemented and thick sub-base layers). Conversely they should be avoided in pavement structures that are more flexible in nature. EME Class 1 mixes have not seen much use in South Africa.

  - Class 2

    Class 2 EME mixes offer excellent rut resistance and also have good fatigue properties (associated with the higher binder content of these mixes). EME Class 2 mixes have been the preferred choice of EME mixes in South Africa.

- **Warm Mix Asphalt**

  Warm mix asphalt is not a particular asphalt mix type. Rather it is a method of manufacturing asphalt that reduces emissions both at the manufacturing plant and on site. WMA also has enhanced compaction properties because of the lower manufacturing and compaction temperature requirements. The performance of any warm mix asphalt is required to be equal to or better than the performance of the particular asphalt mix without the use of the warm mix technology. The use of WMA

is encouraged both for environmental reasons and also for its enhanced compaction capabilities.

Functional Mix Properties

Functional properties of asphalt mixes are those properties that will affect the experience that the road user will have when driving on that surface.

- **Skid resistance**

  The required skid resistance of road surfaces is a very complex issue and dependent on numerous factors. Very simplistically though, skid resistance in general only really becomes an issue on higher speed roads (> 80km/h). Under these conditions normal Sand Skeleton mixes commonly used for wearing courses on low speed roads are inadequate. It is common practice to utilise a special mix (e.g. UTFC, SMA, BRASO) to provide the necessary texture and skid resistance under these circumstances.

  The use of "rolled in chips" which was common practice at one time has proven to be problematic with the medium to long term performance of certain asphalt mixes. For this reason the use of "rolled in chips" has been discontinued by the eThekwini Municipality.

Quality Management

There are several aspects to quality management of asphalt manufacture and paving/placing that are critical in ensuring that a quality layer is constructed. SAPEM Chapter 13 (sub-chapter 6) gives an excellent overview of quality management principles. The manufacture and paving/placing of asphalt are separate functions undertaken in most instances by separate sub-contractors. The roles and responsibilities of each are different but inter-connected.

1. **Asphalt mix design & manufacturing**

   The manufacturer is required to undertake an asphalt mix design for every mix supplied to the eThekwini Municipality. This process is covered in Technical Note 001. Once complete, the design will be summarised in an Asphalt Mix Design Report compiled on the standard COTO "D3" form. This may be supplemented by additional information not contained on the D3 form. Acceptance of the Asphalt Mix Design Report will be in writing from the P&GE Branch of the Roads Provision Department.

   In the Asphalt Mix Design Report, apart from the core technical content contained on the COTO D3 form, the manufacturer should also note pertinent aspects of the mix that should be adhered to both during manufacture and thereafter during paving/placing :-

   - Asphalt Manufacturer's Responsibility
     - The maximum mix temperature in the truck at the exit from the plant
     - The minimum mix temperature in the truck on delivery
   - Paving/Placing Sub-Contractor's Responsibility
     - The minimum recommended mix temperature for compaction of the mix on site (as recommended by the asphalt manufacturer)
     - Adherence to comment by the asphalt manufacturer on any asphalt mix characteristics that the paving/placing sub-contractor should conform to on site (e.g. EME asphalt mix longitudinal joint construction)

   Note that a <u>new</u> mix design is <u>NOT</u> required for every new project. The Project Manager should check with the P&GE Branch whether any particular mix type from a particular

manufacturer has a current Asphalt Mix Design Report accepted by the Roads Provision Department.

Quality management of manufactured asphalt mix centres on checking the following aspects against the requirements noted in Technical Note 001 :-

- Binder content
- Voids (at design compaction)
- Aggregate grading of the mix

Because of the specialist nature of asphalt mixes, the P&GE Branch of the Roads Provision Department offers a service to Project Managers to assist with quality management of asphalt mixes used on any particular project. The following process should be followed :-

1. Contact the P&GE Branch and request assistance with asphalt quality management. This should be done a few days in advance of asphalting commencing.
    - Thokozani Dlamini (Materials Tester)
        - 031 311 5777
        - thokozani.dlamini@durban.gov.za
    - Claydwin Kobeli (Senior Civil Engineering Technologist)
        - 031 311 7858
        - 078 419 9945
        - claydwin.kobeli@durban.gov.za

    The following information will be required :-
    - Project description
    - Contract number
    - Works order number (JDE)
    - Project number (JDE)
    - Technical information
        - Name of the asphalt manufacturer
        - Mix type
        - Mix design reference number
        - Date of manufacture
        - Layer description
            - Wearing course
            - Base course (1st lift)
            - Base course (2nd lift)
            - Base course (3rd lift)
            - Levelling course
            - Sidewalk
            - Patching
    - Contact information to send test results to
        - Email address
        - Contact phone number

2. Inform the Contractor to notify the asphalt manufacturer that they are to supply split samples for the eThekwini Laboratory together with the manufacturer's test results when they become available.

The P&GE Branch will assess the test results against the accepted mix design criteria and will provide comment on the suitability of the mix. Note that the P&GE Branch keeps a database of all asphalt mixes tested and can note trends in test results that can be used for quality management purposes.

2. Asphalt paving/placing

The paving/placing sub-contractor is responsible for constructing the asphalt layer such that it will perform in accordance with the design criteria once constructed. Typically these issues are dealt with through the Standard Specifications (e.g. COTO, SANS 1200, etc.). The Appendix to SAPEM Manual Chapter 12 has a checklist ("Asphalt Paving Trial Section Checklist") that gives guidance to site staff. The following aspects are however generally monitored :-

- Mix temperature

  Mix temperature will directly affect compaction of the mix on site and should be monitored throughout the paving/laying process.
  - Mix temperature (max. / min.) leaving the plant and on arrival at site
    - As directed in the Asphalt Mix Design Report
  - Mix temperature (min.) during compaction on site
    - As recommended in the Asphalt Mix Design Report
- Compaction

  Compaction of the asphalt layers is very significant for the long term performance of the layer. Poor compaction can result in a potential loss of up to 50% of the functional life of the layer. Typical compaction requirements are noted in Table F.

Table F Asphalt Compaction Requirements

Mix Type	Compaction Requirement
Sa, SMA	93% MVD to 96% MVD
EME	96% MVD minimum

  Note that the COTO specification for type Sa and SMA mixes refers to a minimum compaction requirement of "**97% - Design Voids (%)"** of MVD. The Roads Provision Department has adopted a standard simplified approach for all mixes with the assumption that the **target** Design Voids of 4% is equivalent to the **mix** Design Voids; hence the minimum compaction requirement of "**93%**" of MVD.
- Thickness

  It is essential that the design thickness of asphalt layers is achieved during construction both for constructability purposes and for future pavement structural life. Any asphalt layer in excess of approximately 40mm contributes to the structural strength of the pavement. For structural asphalt layer-works, small changes in asphalt thickness have a very pronounced effect on the overall pavement structural life.
- Level & grade

  Compliance with levels and grades are important to ensure that surface water rub-off drains from the road adequately.
- Surface regularity

  Surface regularity determines the quality of ride that the road user will feel. On high speed roads this is typically measured against set IRI limits. However, for most urban applications this approach is not feasible and a simplistic evaluation is conducted through the measurement of surface "bumps" using a 3m Rolling Straight Edge.

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