FULL-SCALE IMPLEMENTATION OF WARM MIX ASPHALT IN SOUTH AFRICA

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Abstract

This paper reports on the first projects on which Warm Mix Asphalt has been used in South Africa on a routine basis. Extensive trials using Warm Mix Asphalt were carried out in the Durban area over a period of two years, from November 2008 to December 2010. Following the successful completion of this work, eThekwini Municipality approved the full-scale use of Warm Mix Asphalt on their road rehabilitation projects. The paper covers the experience that is being gained in the routine manufacture and paving of Warm Mix Asphalt.

1. INTRODUCTION

Shortly after thorough trialling of Warm Mix Asphalt (WMA) over a two year period in the Durban area, from November 2008 to December 2010, the process was approved by the eThekwini Municipality for full-scale implementation on their road rehabilitation projects.

This paper traces the most important lessons learnt from the trials which were put into practice when WMA was first used on a routine basis on these projects.

The use of two different WMA Technologies, which enable the asphalt to be manufactured and paved at significantly lower temperatures, are reported in this paper.
The paper describes the various components that make up the two different mixes, with particular emphasis on the preparation of the reclaimed asphalt and introduction of the RA into the mixes. It also covers the binders used in the mixes and the configuration of the mixing plant used to produce the “warm” mixes.
The results of tests undertaken on the two projects covered in this paper are summarised, with particular mention of the lower manufacturing and paving temperatures that have been successfully achieved.

Based on the experienced gained from the first few projects where WMA was routinely produced and paved in South Africa, the paper concludes that this process, where the quality of the mixes is at least the same as that of conventional HMA, has distinct benefits that will accelerate its acceptance and use around the country.

2. OVERVIEW OF MIXES USED ON THE TWO PROJECTS

The first WMA technology consists of a locally developed *foamed bitumen technology*, which was used in the asphalt base mix on the Route M5 where it passes through the Durban suburb of Malvern. The other, a *rheology modifyer-polymer hybrid type WMA technology*, was used in an asphalt surfacing mix which was paved closer to the city cente, in the Greyville area. The mixes used in both projects contained 15% of reclaimed asphalt (RA). A 40/50 penetration grade bitumen was used in the Route M5 mix while a 60/70 penetration grade bitumen was use as the base binder in the mix used in the Greyville project. It should be noted that 1% of lime, as well as an anti-stripping agent was used to improve the moisture susceptibility of the mixes used on both of the projects.

3. LESSONS LEARNT FROM WMA TRIALS

The three Warm Mix Asphalt trials that gave the eThekwini Municipailty the confidence to proceed in the routine use of this process on their road rehabilitation projects were probably the largest and most complex of their kind to be undertaken in South Africa. The mixes used on the two projects reported in this paper were included in the third trial on Higginson Highway. With the full spectrum of testing undertaken on these mixes, and with their quality found to be similar to that of equivalent hot mix asphalt, the level of risk was minimised.

Inevitably the WMA trials provided a wealth of experience, probably the most valuable being how to manage the plant to obtain the required significantly lower manufacturing temperatures (at least 20°C below those of equivalent HMA mixes) and to keep it consistently at this reduced level. Careful control of the burner fuel flow is required to achieve this. The lower heating energy requirements of WMA has the obvious positive spin-off in reducing burner fuel consumption.

As mentioned previously, both mixes covered in this paper contain reclaimed asphalt (RA). Another lesson learnt from the trials is the importance of proper preparation and introduction of RA into mixes, in order to ensure that the quality of the final product remains consistent; this is obviously not peculiar to WMA, but is applicable to all recycled asphalt mixes and becomes more critical as the RA content is increased above 10%. Experience has shown that the RA should be crushed and typically screened into two fractions, -16 mm +8 mm and -8 mm to dust.

Another important lesson learnt from WMA trials, is that a high binder temperature is required prior to the manufacturing of the mix, using *foamed bitumen technologies*; the temperature of 60/70 pen grade bitumen should be raised to 160°C to 180°C before mixing is carried out while *polymer modified binder* temperatures should typically be raised to 170°C to 190°C. Coating of the aggregate with the binder may be adversely affected should mixing be attempted with lower binder temperatures.

4. MATERIALS USED IN THE WMA

4.1 Aggregates and filler

A summary of the average moisture contents and temperatures of the aggregates used in the two projects included in this paper is given in Table 4.1.

Table 4.1 Summary of average moisture contents and temperatures of the aggregates

	Route M5 - Base		Greyville Streets - Surfacing	
Aggregate descriptions	Moisture (%)	Temperature (°C)	Moisture (%)	Temperature (°C)
19mm Quartzitic sandstone	0.7	19	-	-
13.2mm Quartzitic sandstone	1.1	19	1.9	16
9.5mm Quartzitic sandstone	2.4	17	2.1	15
Tillite crusher dust	3.0	21	2.8	18
Washed quartzitic sandstone crusher dust	7.2	15	6.7	13
Quartizitic river sand	4.8	16	5.0	13

It can be seen that while the moisture contents of the coarse aggregates are low, those of the river sand, and particularly those of the washed crusher dust, exceed 4%.

4.2 Reclaimed asphalt (RA)

Milled asphalt, which is reclaimed from various rehabilitation projects across the metro, is prepared, firstly by crushing using a vertical impact type crusher, after which it is screened into separate fractions. The process is shown in the photograph in Figure 4.1.
Typically the RA is screened into two fractions, -16mm, +8 mm, and -8mm. In the case of the projects reported in this paper, both fractions were incorporated into the base mix on Route M5, but only the finer, -8mm fraction, was included in the surfacing mix used on the streets in Greyville.
Average moisture contents and temperature of the RA stockpiles are shown in Table 4.2.

Table 4.2 Moisture contents and temperatures of the RA used in the two projects

Aggregate descriptions	Route M5 - Base		Greyville Streets - Surfacing	
	Moisture (%)	Temperature (°C)	Moisture (%)	Temperature (°C)
-16mm, +8 mm	3.6	22	-	-
-8 mm	5.2	20	1.3	15

Figure 4.1 Photographs showing preparation of the RA by crushing and screening

4.3 Binders and WMA Technologies

Around 90% of the bitumen used in the mixes on these projects was resourced from the SAREF refinery, and about 10% from the ENGEN refinery. Modified binders are stored in four 20 ton to 45 ton tanks equipped with stirrers while the unmodified binders are kept in three other storage tanks which have a total capacity of approximately 120 tons.
In the case of the Route M5 Project, where the *foamed bitumen WMA Technology* was employed, the temperature of the 40/50 pen bitumen was raised to 170°C to 180°C before

use. It is essential to elevate the temperature of binders used in *foamed bitumen technologies* in order to produce foam with satisfactory properties that enable it to coat the aggregate properly; lower temperatues will inevitably result in poor coating and impact negatively upon the mix's quality.

On the Greyville Roads Projects, where the *rheological polymer-modified hydrid* was used, and blended into the 60/70 pen bitumen so as to create an A-E1 quality binder. Blending is carried out at a temperature of 175°C with the aid of the stirring and recirculating pumping systems to ensure that a consistent product is achieved. Once the blending is completed the temperature is allowed to fall to 150°C, and this is the temperature at which the binder is introduced into the mixing drum during the asphalt manufacturing process.

5. MIXING PLANT DETAILS

The asphalt mixing plant used to produce the mixes on both projects consists of a double drum continuous type plant with a maximum production rate of 180 tons per hour. As can be seen in Figure 5.1, aggregate is fed into the heating and drying drum. Once dried and heated, the aggregate passes into the second drum where it is mixed together with the binder. The RA is also added into this drum, which enables thorough mixing without any exposure of the RA to the burner flame. The *foam generator* is installed in this part of the plant. The plant has a fully automated integrated system that controls and monitors the binder temperatures and aggregate/RA proportions for each batch. The system records average skip discharge and exhaust temperatures as well as aggregate/RA and bitumen flow rates. The plant is equipped with a separate burner fuel flow gauge.

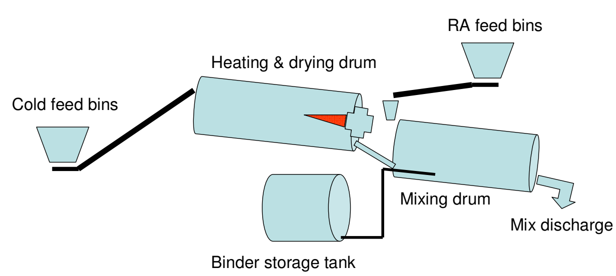

Figure 5.1 Schematic diagram showing plant layout

6. M5 – BASE MIX USING FOAMED BITUMEN TECHNOLOGY

The rehabilitation work on the portion of Route M5 where the WMA base was used consisted essentially of milling out the existing distressed, aged asphalt and replacing it with 80mm asphalt base and 40mm surfacing. Pertinent results of the WMA base, consisting of minus 26.5mm continuously graded mix, are summarised in Table 6.1.

Table 6.1 Summary of test results for mix used on Route M5

Sieve size (mm)	Average % / Standard deviation	Specification
26.5	100/0	100
19.0	98/0.9	80 – 100
13.2	81/3.0	60 – 80
9.5	64/3.7	51 – 71
6.7	52/3.5	44 – 64
4.75	46/2.9	36 – 56
2.36	34/1.7	28 – 44
1.18	26/1.1	20 – 34
0.600	20/1.4	15 – 27
0.300	15/0.9	10 – 20
0.150	9/0.6	6 - 12
0.075	6/0.4	2 – 6
Binder content (%)	4.2/0.2	3.9 – 4.5
Void content (%)	4.5/0.4	3.0 – 6.0
Marshall stability (kN)	13.5/0.8	10 - 18
Flow (mm)	3.3/0.3	2 – 6
Indirect Tensile Strength	1120/65.9	1000 min
Immersion Index	93.5/2.5	75 min
Moisture in mix (%)	0.05	0.5 max
Field compaction (%)	93	92 min

As can be seen in this table, the results of all the tests conform to the specified requirements. The normal manufacturing temperature for this type of mix, containing 40/50 pen bitumen, is between 165°C and 175°C, however, an average temperature of 144°C was measured at the mixing plant; a temperature reduction in the order to 25°C.

The average temperature of the mix at the paving site was 135°C; the fact that the specified compaction limit of minimum 92% voidless density could be achieved is evidence of the success of the *foamed bitumen WMA Technology*.

7. GREYVILLE – RHEOLOGY MODIFYER-POLYMER HYDRID

Pertinent test results from this project are summarised in Table 7.1.

Table 7.1 Summary of test results of mix used on Greyville streets

Sieve size (mm)	Average % / Standard deviation	Specification
19.0	100/0	100
13.2	99/0.7	92 – 100
9.5	85/3.6	74 – 90
6.7	68/4.4	63 – 79
4.75	56/4.4	52 – 68
2.36	39/3.9	36 – 52
1.18	30/3.3	24 – 40
0.600	24/2.3	18 – 28
0.300	17/1.5	10 – 20
0.150	10/0.8	6 – 12
0.075	6/0.4	4 – 8
Binder content (%)	5.1/0.1	4.6 – 5.2
Void content (%)	4.2/0.2	3.0 – 6.0
Marshall stability (kN)	12.6/0.6	10 – 18
Flow (mm)	3.3/0.1	2 – 6
Indirect Tensile Strength	1017/54	800 min
Immersion Index	92.8	75 min
Moisture in mix (%)	0.04/0.01	0.5 max
Field compaction (%)	93/0.3	92 min

The results in Table 7.1 show that the mix meets the specification in all respects, including field compaction.

With regard to mix temperatures, the usual manufacturing temperature limits for A-E1 modified mixes is between 165°C and 175°C. For the mix used on the Greyville streets project an average 144°C manufacturing temperature was recorded, with the average temperature at the paver slightly lower, at 140°C. A temperature reduction of between 25°C and 30°C was therefore achieved using this *rheology polymer-modified WMA Technology*.

8. CONCLUSIONS

The implementation of WMA (Warm Mix Asphalt) in routine production and paving is undoubtedly a major milestone for South Africa's Asphalt Industry, and closely follows practices in other countries where WMA is recognized for its environmental friendliness and cost saving benefits.

Extensive trials during the past two years contributed to a great extent in gaining sufficient knowledge and confidence in manufacturing and paving asphalt with temperatures at least 20°C below those of equivalent hot mix asphalt temperatures, as well as in incorporating significant proportions of reclaimed asphalt in the mixes.

The hot-off-the-press results of the first two projects reported in this paper prove that this process can indeed be successfully implemented locally, and that WMA with a quality at least as good as that of HMA can be achieved.

9. Acknowledgement

The authors wish to acknowledge eThekwini Municiaplity's role in being South Africa's first Road Authority to implement Warm Mix Asphalt routinely on its road rehabilitation projects. Acknowledgement is also due to the Warm Mix Asphalt Interest Group for its enthusiasm and hard work in gathering sufficient expertise and confidence to enable this to happen.