90-1075 WARM MIX ASPHALT – THE SOUTH AFRICAN EXPERIENCE

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Abstract

Following the road-building industry's commitment to sustainable practices the Warm Mix Asphalt Interest Group was formed. This group initiated trials over a two year period, from 2008 to 2010, the aim being to gather sufficient information to implement warm mix asphalt in South Africa. This aim has been achieved with experience being embodied in a Best Practice Guideline for WMA. And further more WMA is already being used on full-scale projects using a first iteration specification for WMA. This paper concentrates on the fast-tracking of the implementation process and discusses mile-stones, knowledge and practical experience gained. All indications are that WMA will become standard practice for asphalt in South Africa.

INTRODUCTION

The year 2008 proved to be a watershed for South Africa's asphalt industry. It began with the first national seminar, on Warm Mix Asphalt (WMA), arranged by SABITA. This landmark meeting brought together members from various sectors of the road building industry including clients, consultants, asphalt producers and warm mix asphalt technology owners and suppliers. Representatives from this group formed what became known as the Warm Mix Asphalt Interest Group (WMAIG).

At a subsequent Road Pavement Forum a resolution was made to pursue the introduction of WMA in South Africa.

From the end of 2008 to 2010, rapid progress was made to bring warm mix asphalt into implementation for routine use. Over a period of two years, through a series of national trials, South Africa's WMA knowledge and experience has been increasing exponentially. This knowledge and experience has been sufficient to produce the first iteration of a national WMA specification and a best practice WMA guideline document. The WMA

specification was already being implemented at the time of writing this paper whilst the best practice guideline document was well on course for its historic launch at CAPSA11.

The essence of this paper is to convey the way in which it was possible to fast-track the implementation of WMA in South Africa. This fast-tracking was possible due to the willingness of the WMAIG and the eThekwini Municipality, to support sustainable practices as well as asphalt producers that were willing to make a positive change to their industry.

FAST-TRACKING THE IMPLEMENTATION OF WMA

The WMAIG now became the champions of WMA in South Africa, its characteristics and strengths formed the basis of the fast-tracking. This was due to their:

1. Belief in WMA
2. Positive attitude
3. Non-sceptical mindset
4. Professional approach
5. Holistically responsible view

Another very important factor was a major client, eThekwini Municipality shared the enthusiasm and passion for environmentally sustainable road building solutions.

The WMAIG resolved that full scale trials were necessary as a professional and responsible means of gaining practical knowledge and experience to implement WMA in South Africa. It was expected that these trials would test the industry in terms of its capabilities, innovation, and would build up the necessary competence. Accepting this reasoning, the next step was necessary to find a suitable trial site.

The WMAIG was fortunate in having eThekwini Municipality take a pivotal role in the trials. This made it possible for the Municipality to assist in adding momentum to the trials and they achieved this by:

1. Dedicating senior staff and expertise to the trials
2. Providing sites to undertake the trials
3. Understanding and accepting the potential risks of new technologies
4. Giving public support to WMA
5. Encouraging the implementation and routine use of WMA in its projects

OVERVIEW OF THE TRIALS

Every two years eThekwini Municipality's Pavement Management System generates a list of candidate projects for rehabilitation whilst the Municipality's Road Rehabilitation Branch implements these projects. Given the Municipality's policy to actively seek and implement more sustainable road rehabilitation solutions, it volunteered one of these candidate projects as a site for the first national WMA trial. As this was now a rehabilitation project for the Municipality, it brought a definite focus and impetus to the implementation of WMA in South Africa. Targets and deadlines became fixed whilst risk-management became a guiding principle. This first trial was carried out on Brackenhill Road in the suburb of Waterfall in November 2008.

After the first trial was successfully completed and a sustainable road rehabilitation solution was realised, the Municipality agreed that Warm Mix Asphalt needed to be more severely tested and under different conditions. It therefore volunteered another road rehabilitation

project for use as a site for the second national WMA trials. This trial came with the same constraints in terms of targets, deadlines and risk-management. The second trial was carried out on Leicester Road in the heavy industry area of Mobeni.
After evaluation of the second trial the Municipality felt comfortable with the trials process and WMA, it was therefore confident to hand over another rehabilitation project as a site for the third WMA trials. The third trial was carried out on Higginson Highway, a major urban arterial. This was a much larger trial than those done previously and as before the Municipality insisted on completion within a fixed period, bringing sharp focus on the timelines.

The relationship between the different parties is illustrated in Figure 1. As can be seen the main parties consist of road owners, with asphalt producers, WMA technology suppliers, consultants, road industry bodies, and academia all contributing to the trials.
Perhaps the most important contributor to quick decision making was the sustained and intense focus on WMA over the relatively short period of time. This ensured memory retention of lessons learnt, process, product understanding and other matters that went to build up knowledge and experience.
The other strength was the way the group was structured - everybody was pushing in the same direction rolling the trial forward. Also when one entity pushed, the entire trial moved forward.

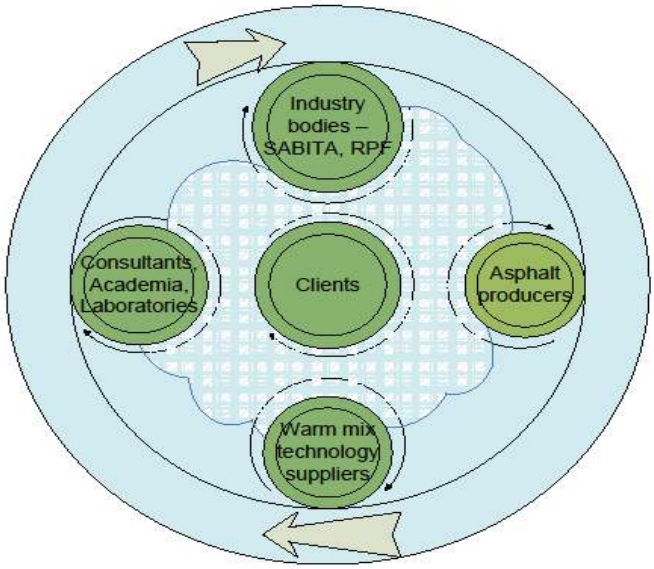

Figure 1 Relationship framework

Exponential gain in knowledge and practical experience

The three national trials were not planned nor structured as a series beforehand but evolved as experience was gained and further challenges were targeted. A key premise of all the trials was that the mix properties must be as good as HMA.

TRIAL ONE: BRACKENHILL ROAD – NOVEMBER 2008

This trial set out simply to prove that WMA could indeed be successfully manufactured and paved in South Africa. At this stage every step with WMA was a new experience for the group. Besides producing and paving the mixes the structure of the trial had to take into account that it was a normal rehabilitation project.

There was the basic understanding from WMA technology literature that the Warm Mix Asphalt Technology (WMA-T) was added after carrying out a conventional HMA mix design.

Also, that the reduction in mix temperature was achieved by reducing the fuel flow to the burner. Being a first trial these key factors were accepted.

A conservative but significant target temperature reduction of 20 ^{0}C was set. It was anticipated that the processes and products (one WMA-T of the organic wax category) would be trialled to establish whether it enabled the WMA manufactured at this reduced temperature to still meet or exceed the quality of HMA.

TRIAL TWO: LEICESTER ROAD – MAY/JUNE 2009

The success of the first trial and the rapid increase in knowledge allowed for momentum to be increased with the undertaking of the second trial. This included the process to design WMA, manufacture in a continuous feed drum mixing plant and pave WMA. Still keeping the target temperature reduction of 20 ^{0}C, the group sought to change other variables, one being the use of a batch mixing plant. The other significant variable changed was the inclusion of an additional WMA-T, this being from the chemical additive category.

Encouraged by the success with first trial it was decided that all mixes should include reclaimed asphalt (RA). A more rigorous test bed was selected for the second trial, with a dual carriageway carrying higher volumes of heavily loaded trucks and industrial traffic moving at maximum speeds of 50 kilometres per hour.

TRIAL THREE: HIGGINSON HIGHWAY – OCTOBER / DECEMBER 2010

With aims of the second trial having been achieved, and with process and risk management addressed, the group decided that more variables should be included in the third trial. For instance it was decided that the WMA temperature should be reduced by 30 ^{0}C.
Other notable variables included RA contents up to 40%, polymer modified bitumen, a bitumen rejuvenator, four WMA-T, as well as different grades of bitumen. Armed with the knowledge of the previous trials and further plant mix trials, it was decided to reduce the dosage of one of the technologies. This was a world first for this particular technology supplier. This accepted change pointed to the confidence and understanding built up in the South African WMA trials. Most significantly it pointed to the need for mix designs to optimise the use of each particular technology based in its own specific characteristics.
The inclusion of the mechanical foaming technology at this stage, allowed a more focused understanding of different WMA-T approaches.
There was some debate that too many variables were being introduced in this trial. However, it is notable that there was no discussion around temperature reduction boundaries having been pushed too far. This illustrates the exponential gains in knowledge and practical experience that had being achieved over the relatively short period of two years.

The highlights and milestones of each successive trial that shows the successfully increase in understanding, knowledge and experience in WMA, are shown in the Figure 2.

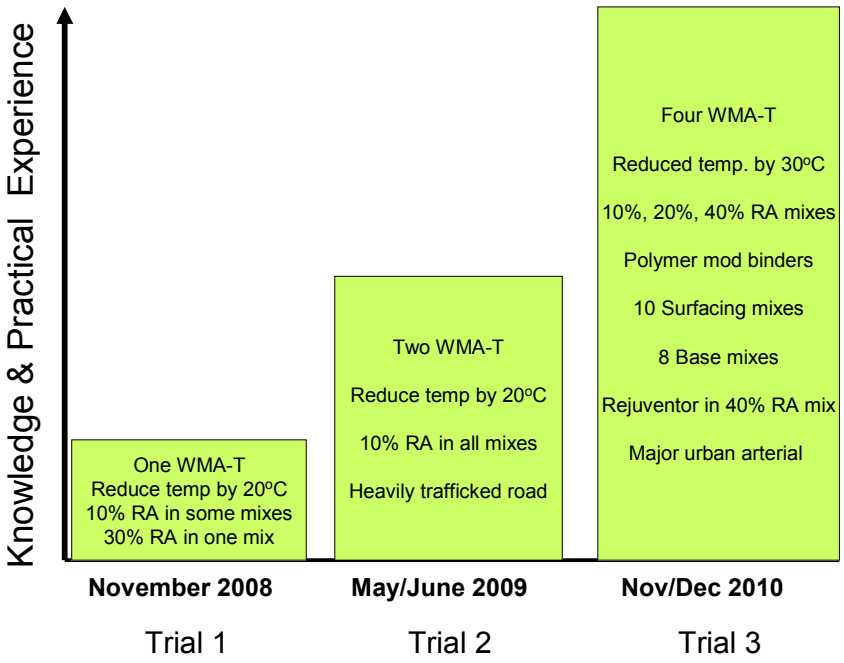

Figure 2 Exponential gains in experience

South Africa's WMA Trial milestones

WMA TRIALS TEMPLATE

Following the first trial, it became apparent that the trials needed to be structured to promote creativity, drive and to maintain smooth and continuous forward momentum. Also, the processes needed to be carried out in a logical way to ensure that there were no gaps. A template was prepared and used as a checklist for the each aspect of the trials. The template also ensured that the learning experience was progressive and complete for each step of the trial as it progressed. The complete template is shown in Figure 3.

THE WMA DIFFERENCE

The trials made it necessary to focus on best practice in mix design, manufacturing, paving and testing. In the case of WMA certain changes have to be implemented, the most significant being in the mix design and manufacturing processes.

WMA mix design process

The mix design process used for the trials was to first use the Bailey Method to optimize the aggregate packing properties of the mix, with mixes with different aggregate/RA grading blends being manufactured and compacted at conventional (HMA) temperatures. The blend that produced the most satisfactory volumetric properties was selected for further testing to establish the optimum bitumen content, still at HMA temperatures. These designs were regarded as the "control" mix designs. The same blend of aggregates/ RA and bitumen content was used in the manufacture of the "warm" mix.

In the case of the "additive" WMA-T the mix was manufactured at 20°C to 30 °C below conventional mixing. This was done by heating the binder to 150 °C, after the WMA-T was blended into the bitumen. The dosage of the WMA technology was as prescribed by the WMA-T supplier. The aggregate was heated to between 125 °C and 130 °C. After 7 minutes of mixing, this resulted in the mix temperature of 155 °C -20 °C =135 °C. The briquettes were compacted at 115 °C. For the mechanical foaming technologies, the sample mix produced through full scale manufacture at the asphalt plant as there are no laboratory devices to produce the foamed bitumen (Figure 4).

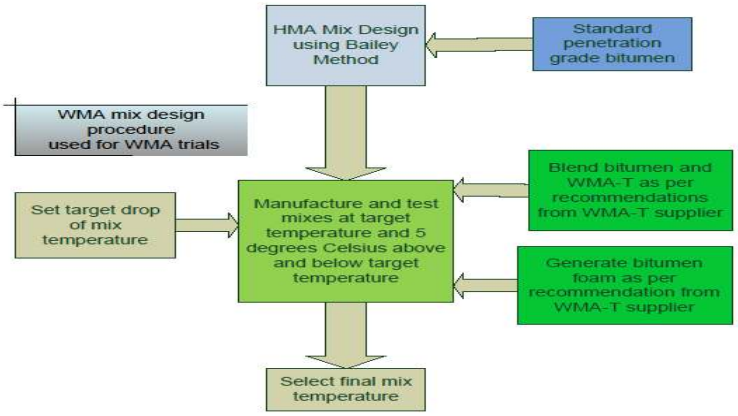

Figure 4 Flow diagram for WMA laboratory mix design

WMA Manufacturing

Importantly, the trials utilised both a continuous feed drum mixing plant as well as a batch mixing plant. The significant change to operating procedure was the reduction of the mix temperature and this was achieved in the following ways:

1. Trial one – continuous drum mixing plant - By increasing the volume of material going into the drum for the continuous feed drum mixing plant while keeping the burner fuel rate constant.
2. Trial two – batch plant – by reducing the amount of fuel being fed to the burner.
3. Trial 3 – continuous drum mixing plant, by reducing the amount of fuel being fed to the burner.

A further manufacturing procedure change was that the bitumen pumping system had to be adjusted to match the viscosity of the WMA-T blended bitumen.

WMA SPECIFICATION

For the first iteration of the WMA specification the WMAIG decided to use COLTO as a basis for a stand alone specification. From the trials, it became apparent that at the early stages

of implementation of WMA, a method specification would be more appropriate. The WMA specification takes this requirement into consideration and leans heavily on the WMA Best Practice Guideline as being an essential companion document to the specification. With WMA facilitating the use of higher RA contents, the specification includes the characterising, handling and processing of RA. Accepting that most WMA-Ts are proprietary products, the specification makes it a requirement for the contractor to supply detailed information on the particular technology that he proposes.

TRIAL OUTCOMES

The trials included an extensive amount of testing using the traditional hot mix asphalt specification as reference. Following the first trial, a test matrix was drawn up to bring structure around testing and it covered both routine and specialised testing. The matrix was used to:

1. Instruct testing
2. Monitor progress with testing
3. Compile test results in a structured manner
4. Identify gaps in the testing done
5. Control the cash-flow and budgeting for testing

Four critical parameters were identified in deciding that WMA could be implemented on a full scale and routine basis. These were:

Mix temperature

This a fundamental requirement of WMA which results in benefits such as less fuming, reduced emissions and better working conditions. The target temperature reductions were achieved on all of the mixes for all three trials.

Moisture in the mix

Low moisture in the mix will go a long way to ensuring that bitumen adhesion and stripping will not be a concern. The requirement for 0.5% moisture was easily met. Besides the moisture contents of the mixes, moisture susceptibility of the mixes were checked using the Modified Lottman test method and a few of the trial mixes were found to produce results under the minimum 80% requirement for this test. This aspect is addressed later under conclusions.

Rutting

This is always a concern when designing asphalt mixes, particularly for heavy traffic conditions, and needs to be thoroughly explored. Rut testing was undertaken using both the MMLS and Hamburg Wheel Tracking devices and in almost all cases the maximum rut depth achieved was less than the 2.0 mm limit.

Field compaction

An adequate level of compaction influences properties such as durability; impermeability and reduced aging. The compactability of the warm mixes were found to be at least as good

if not better than those of HMA mixes and in all cases the requirement of minimum 92% of void-less density was achieved.

The extensive testing matrices generated a huge quantity of test results. The assessment of these results has been documented in separate reports for each of the trials. This paper is focused on way in which sufficient experience was gained to implement WMA in South Africa rather than providing technical analysis of the results.

VERIFICATION OF OUR EXPERIENCE – EUROPEAN STUDY TOUR

Midway through the third trials, the WMAIG organised a study to Europe. The intention was to find out the latest developments in WMA, verify our experience to date and to build relationships with European experts. The visit covered meeting contractors, public sector officials, researchers and technology owners in England, France, Germany, Holland and Italy. The findings were that we were on the right path with rolling out WMA in South Africa and in some instances were ahead of some countries in terms of development of a specification and WMA guideline document. It was found that the use of WMA had reached a very sophisticated level in certain countries with software optimising the variables to meet the various site and delivery conditions. There were distinctive preferences between some of the countries with regard to the type of WMA technologies with some strongly preferring foaming techniques and others chemical or organic wax type additives. The group came back encouraged by their findings.

CONCLUSIONS

This paper is focused on the successful full scale implementation of WMA in South Africa after an intensive trial period over two years. This fast-tracking was possible due to willingness on the part of a road owner, eThekwini Municipality, asphalt producers and WMA-T suppliers.

The three trials carried out on WMA enabled knowledge and practical experience to be gained at an exponential rate. Probably the most significant finding was that a variety of technologies can be successfully produced and used by South African asphalt producers at temperatures of 30 ^{o}C below HMA. An added benefit of the trials was the finding that polymer modified binders could also be used to produce WMA. Also, the synergy between recycling and WMA was confirmed and mixes with up to 40% of RA were successfully manufactured and paved.

While almost all the indications from the trials are that WMA has properties at least as good as those of HMA, the trials show that the mixes can be sensitive with regards to moisture susceptibility. During the design stage it is recommended attention be given to this and that active filler consisting of hydrated lime and possibly also the use of an anti-stripping agent should be explored.

Asphalt plants are currently designed to operate most effectively within the temperature range required for HMA and adjustments have to be made either in reducing burner fuel flow and/or production or mixing rates to lower the temperature. Although the WMA temperatures were achieved in each of the trials it should be noted that careful adjustment and close supervision is required to achieve this goal.

Useful experience was gained in the laboratory mix design of WMA, suggesting that the mix designs needed to optimise the use of each WMA-T based on that specific technology's characteristics. Extensive testing to investigate the rut resistance of the mixes, mostly carried out using the MMLS, showed that rutting does not exceed the usual maximum 2.0mm rut depth requirement.

Compaction was not an issue with any of the mixes, that were paved in these trials and all the trial sections were found to comply with the compaction requirements. The success of the trials as well as the vast amount of knowledge and experience gained is reflected the current WMA specification and the soon to be launched "Best Practice Guideline". However, both these documents are dynamic and will inevitably be updated to reflect further experience and development in WMA.

The European Study tour provided valuable insight into the state of the art and confirmed that the South Africa's WMA initiatives are in order. In order to assess long term performance in the field, a detailed Long Term Pavement Performance is in place.

The use of Warm Mix Asphalt is accelerating globally and experience gained thus strongly indicates that in terms of its environmental, health, cost and performance benefits will drive it to become a standard for asphalt in South Africa.

ACKNOWLEDGEMENTS

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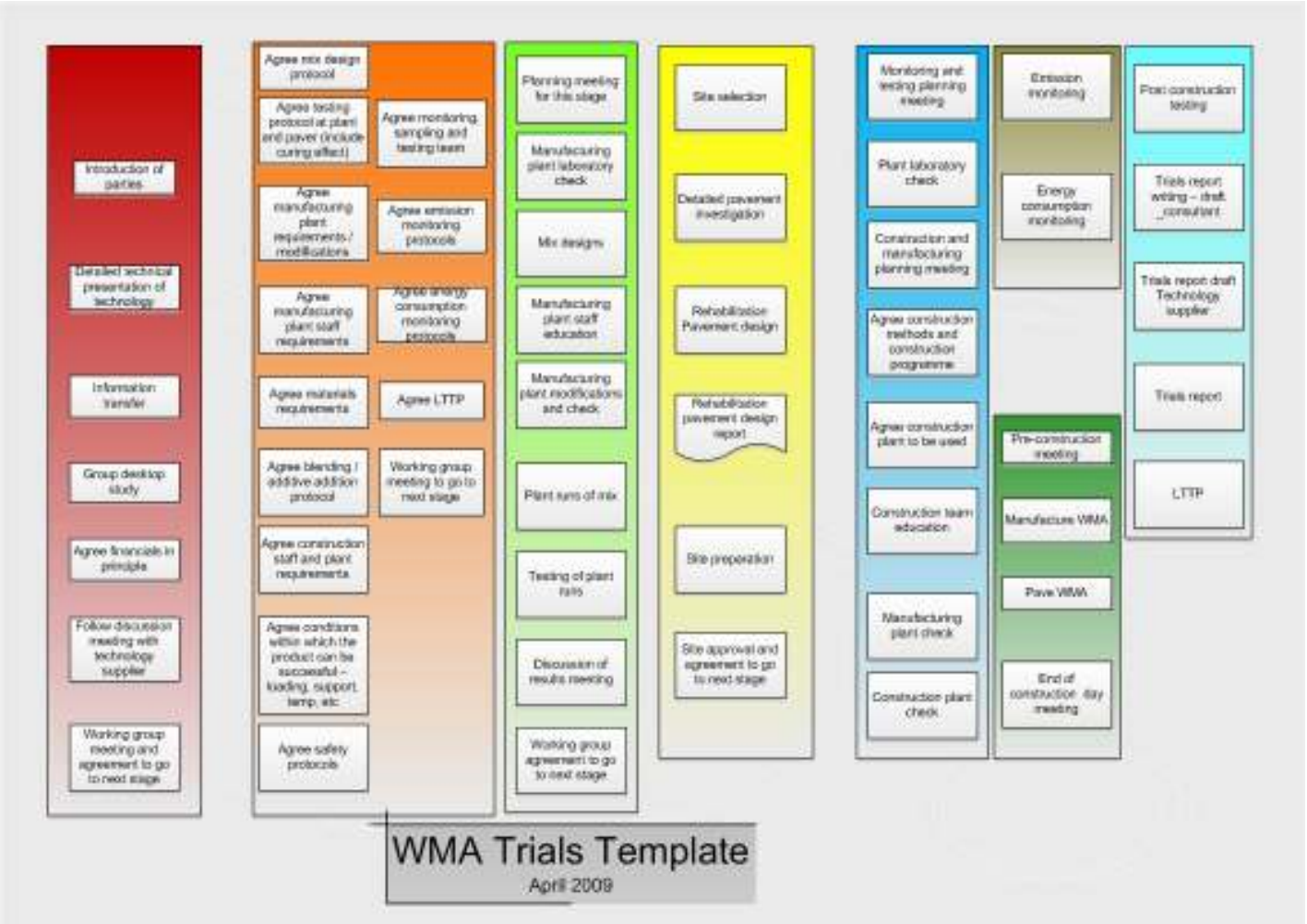

Figure 3 WMA Trials Template