Meeting Difficult Hot Mix Asphalt Challenges with Warm Mix Asphalt Solutions

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Since about 1995, a number of products have been developed that facilitate the reduction of the working temperature of hot mix asphalt (HMA). These products or technologies essentially reduce the viscosity of the asphalt and lower production temperatures by as much as 50 ºC. Lower plant mixing temperatures mean fuel savings which in turn lowers emissions. This results in reduced odour, fumes and greenhouse gas emissions. In Europe, the development of these products was in direct response to reducing greenhouse gases as per the targets of the Kyoto treaty. The reduction in viscosity also offers several auxiliary paving benefits such as better workability, improved compaction, the ability to increase RAP usage or recycling and permits longer hauling distances.

The asphalt community has embraced this technology at an astonishing pace and from a sustainability perspective warm asphalt makes sense in every respect. This paper discusses the practical aspects of ongoing work across Canada with warm mix asphalt. The focus is on plant production and lay down and the ability to pave at lower ambient temperatures without compromising quality; emission reduction and fuel savings on various projects are also presented.

INTRODUCTION

Over the last few years there has been a significant interest in evaluating an emerging new technology that has a number of potential benefits in the asphalt paving sector. Warm-mix asphalt (WMA) is characteristic of a number of processes that permit substantially lower plant mixing (production) and placement temperatures of asphalt mixes. These products or technologies essentially reduce the viscosity of the asphalt and lower production temperatures by as much as 50 ºC. Initially, this reduction in temperature was seen purely as an environmental benefit in terms of lower emission and reduced energy costs. However, in the application of the technology, practitioners have identified a number of potential paving benefits that can help improve the overall performance of asphalt pavements.

The unsurpassed level of interest in this technology is best demonstrated by the attendance at the Warm-Mix Asphalt conference held in Nashville in November 2008. The conference "smashed" attendance records with nearly 700 attendees in person and an additional few hundred viewed a live internet feed.

The NAPA News Release properly stated:

"This was the largest single-subject conference ever for the asphalt industry…" [1]

By comparison the heightened interest shown for WMA seems to be greater than that for Superpave. This is not to say that Superpave was not important to the asphalt industry, but it would seem that WMA is being advanced and accepted at a much faster pace. This bodes well in meeting several of the challenges faced by the industry today.

MEETING TODAY'S CHALLENGES

The current economic outlook, the volatile price of oil and high energy cost – the associated high price of asphalt cement – have all contributed to some of the key challenges we face today. Couple this with the need to reduce greenhouse gases, the advent of carbon tax in some jurisdictions and the vision of green specifications; the reasons for the pace of implementation are simple to understand. On top of all this, owner agencies still have an enormous backlog of roadways, highways and bridges to repair; at the same time the roadway system becomes even more vital in our day-to-day life. In reference to a commonly used definition for sustainable development that states:

"…Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[2]

In this regard, we all have to focus or pay much more attention to the social, economic and environmental impact of our decisions. Therefore from a sustainability perspective, WMA makes a lot a sense. In a very simplistic way if we apply this notion to what we do everyday with respect to building roads, we could say building quality roads plays an essential role in sustainability in the asphalt industry in some respect: ***quality = sustainability***.

WARM-MIX ASPHALT TECHNOLOGIES

There are several methods of producing WMA. The technologies incorporate: 1) the introduction of moisture to create a foaming process to coat the binder; 2) a two stage process which uses hard and soft binder; 3) viscosity reduction and flow enhancer 4) emulsion based processes and/or chemical additives or agents and 5) HMA Plant modifications or add-ons. Essentially, all these processes lower the working temperature of the binder to derive the expected benefits both environmentally and from a mix or quality perspective. The relative production temperatures and comparative fuel use per Ton of HMA are shown in Figure 1.

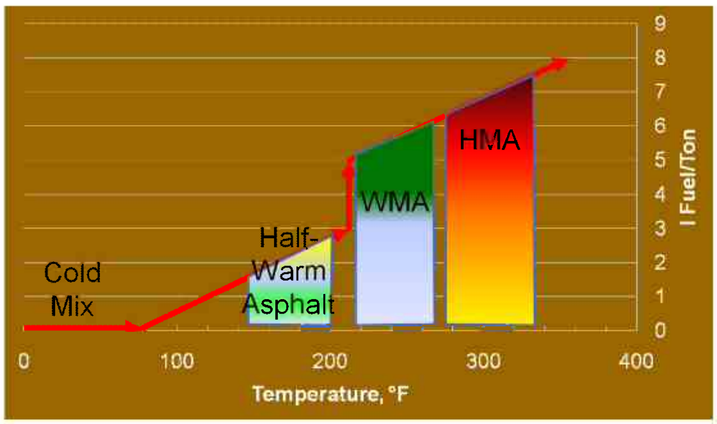


Figure 1 WMA Classification by Temperature Reduction

The list of available products is growing, at last count there were about 14 systems to choose from. The following is a list of several examples of the currently available technologies and a brief description of each method [3]:

WMA Foam

The WMA Foam process is a two stage blending process using a soft binder and a harder binder to produce the desired grade of asphalt. About 20 to 30 percent of the softer binder is first added to the coat the coarse aggregate, followed by a foaming of the harder binder with the addition of a controlled amount of water.

Zeolite

Synthetic zeolites are composed of alumina silicates and alkali-metals. The chemical 'package' incorporates about 20 percent water that increases the temperature of the product above the boiling point of water. This small amount of water creates a foaming effect which essentially reduces the viscosity of the binder.

Evotherm®

Developed in the United States, Evotherm is a chemical package designed to improve coating and workability at reduced temperatures. The initial use of this technology was as an emulsion. A new process is now available, known as Dispersed Asphalt Technology (DAT) that has essentially replaced the emulsion based process.

Low Energy Asphalt (LEA)

The LEA process involves mixing the binder at the normal temperature required for that particular grade and coating only the coarse aggregate. After the coarse aggregate has been coated, it is mixed cold with wet fine aggregate with 3 to 4 percent moisture, or a blend of fine aggregate and Reclaimed Asphalt Pavement (RAP). The moisture turns to steam and foams the mixture, which encapsulates the fine aggregate.

Double Barrel Green Technology

This system is basically a plant attachment or modification that uses a multi-nozzle device to foam the asphalt. The water added is approximately one pound per ton of mix and is regulated or metered by a positive displacement pump. A small amount of this water is incorporated into the binder, thereby increasing the volume or foaming the asphalt.

Sasobit

The Warm Mix Additive Sasobit is a long-chain aliphatic hydrocarbon that is produced by Sasol Wax in South Africa from coal/natural gas gasification using the Fischer-Tropsch process of polymerization. Initially manufactured from coal, but in 2003 Sasol invested $360 million into a pipe line, to pipe the gas from Mozambique to Sasolburg. Sasobit is a fine crystalline long chain aliphatic hydrocarbon commonly known as wax. However, this is not the wax that is naturally found in some liquid asphalt cements. The product has a melting point range of between 85 – 115 ºC (185 - 239 ºF) and is completely soluble in asphalt at temperatures above 115 ºC (239 ºF).

Sasobit is completely soluble in asphalt binder at temperatures in excess of 110 ºC (230 °F). It forms a homogeneous solution with base asphalt binder on stirring and produces a marked reduction in the binder's viscosity. This enables mixing and handling temperatures of the asphalt to be reduced by 10 – 38 ºC (50 – 100 °F), which in turn results in a significant reduction in the emissions of fumes and CO_2; during HMA production and paving operations. After crystallisation below 85 ºC (185 °F), Sasobit forms a lattice structure in the asphalt binder which is the basis for the structural stability of the HMA containing Sasobit.

VICTORIA STREET TRIAL - OTTAWA

PROJECT DESCRIPTION

Victoria Street is located about 40 km southeast of the City of Ottawa. The test section is about one kilometre in length and runs east-west from Yorks Corners Road. The trial was completed as an addition to part of a rehabilitation project awarded to Tomlinson in 2007 (Boundry Road Overlay ISB07-5008). This section of roadway was in poor condition and manifested severe transverse cracking and rutting. The rehabilitation consisted of 50 mm of a 12.5 mm Superpave

WMA over 100 mm of in-place recycled foamed asphalt mix. The location of the trial is shown in Figure 2.

Figure 2 Project Location Map

WARM MIX ASPHALT DESIGN

Sasobit is added at a rate of 1.5% of total binder content. The addition rate is typically adjusted to compensate for the Recycled Asphalt Pavement (RAP) content in the mix. There are no modifications required to the standard HMA mix design. Sasobit can be added to the binder at the terminal or injected at the plant site. Due to the small amount of Sasobit added per ton of mix it's important to ensure that it's added and disbursed properly. Sasobit can be terminally blended to meet desired Performance Grade or can be add at the HMA plant using a standard fibre injection system.

Sasobit is available in a solid form (Figure 3).

- A prill (about 5 mm in diameter)
- Or a small prill (1 mm in diameter)
- Flaked form (3 mm chips)
- It is packaged in 20 kg bags and 600 kg super sacks

The product carries a food grade designation of FDA175.105 and has been used as hot melt adhesives for boxes with indirect food contact.

Figure 3 Sasobit – Prill Form Used for the Trial

The mixing and compaction temperatures are determined during the mix design process. Unmodified HMA samples are produced at the specified temperature and compacted to the required target density to determine the gradation and asphalt content. Once the gradation and asphalt content have been determined, a minimum of five HMA samples having the same gradation and asphalt content are modified with the WMA modifier. These samples are produced in the laboratory at various temperatures and compacted using the same compactive effort to reach the required density. The densities of the five samples are then plotted to determine the optimum compaction temperature of the WMA. The mixing temperature of the WMA is increased above the optimum compaction temperature by the same temperature increment as the standard or non-modified HMA. The mix design for this project is shown in Table 1.

CONSTRUCTION

The WMA was produced on the morning of October 23, 2007. The ambient temperature was around 3 °C in the early morning and reached 10 °C by the afternoon; it was sunny throughout the day with a cool breeze. The mix was produced at Tomlinson's Rideau Plant in Ottawa (Figure 4). Mixing started at 6:30 am; the production temperature for the first 450 tonnes of WMA was 128 °C. The plant operator also monitored fuel consumption for both the control and the WMA produced during the day. Based on the success of the placement of the WMA on the eastbound lane (EBL), it was decided to try a lower production temperature for the balance of the WMA to be placed on the westbound lane (WBL). This mix was produced around 10:30 at a temperature of 115 °C. The WMA was placed and compacted using conventional paving equipment shown in Table 2. Breakdown compaction was readily achieved with four passes of the vibratory; the rubber tire sealed the surface nicely and essentially completed the compaction process.

Table 2 Tomlinson's Paving Train

Paver:	Rubber Tire Cat Paver Model AP 100 D
Break Down Roller:	Cat Model CB 534C
Rubber Tire Roller:	Bomag Model BW 24R
Finishing Roller:	Cat Model CB 534C

Figure 4 Tomlinson's Rideau Plant – Ottawa

END RESULTS SPECIFICATION TESTING

Field samples of the 12.5 mm Superpave WMA were tested for quality control (QC) and for compliance to the City of Ottawa End Result Specification (ERS). The QC results for the project are presented in Tables 3 and 4; the ERS results are shown in Table 5. The samples tested indicate that the WMA was in control and representative of the original Job Mix Formula (JMF) for the project. The volumetrics also met the required specifications.

Performance Graded Asphalt Binder Testing

Additional samples of the loose mix were retained by Bitumar to conduct PGAB testing on the asphalt cement recovered from the standard HMA and the WMA. These results are presented in Table 5. Based on the testing conducted it would appear that the binder recovered from the HMA samples aged more than the Sasobit WMA. This is largely due to the affect of the harder asphalt in the RAP and has been noted by other researchers in Ontario [4]. The properties of the binder recovered from the WMA were very similar to the original PG 58-34 modified with 1.5 percent Sasobit. The penetration of the recovered binders was also similar.

FIELD OBSERVATIONS

Based on the Victoria Street trial, the following observations were made during plant production, placement and compaction of Sasobit WMA [5].

Plant Production

There were no problems observed during the production of the Sasobit WMA at the asphalt plant. Conventional dry and wet mixing cycles were used and the finished mix was well-coated. The operating temperature of the aggregate dryer was 130 °C for the 12.5 mm Superpave warm mix as compared to 160 °C for the standard 12.5 mm Superpave hot mix.

Paving with WMA

Once again there were no issues with paving the WMA on this project. The paving crew noticed that there were no fumes and all commented that the Sasobit WMA was easy to work with in all respects. The paver operator noted that he had to adjust the angle of attack on the screed but the mix handled well, there was no evidence of texture irregularities. The crew also pointed out that this mix would make paving in the heat of the summer a lot easier. There were no concerns with handwork.

WMA Compaction

The WMA was very stable under the weight of the rollers. The breakdown roller was right behind the paver (Figure 5) and there were no signs of pushing or shoving of the mat. Compaction was achieved at temperatures as low as 90 °C (EBL); the compaction temperatures ranged from 90 to 110 °C. The longitudinal joint between lanes appeared to be very tight (Figures 6 and 7). Densities for the WMA ranged between 93 and 94 percent of maximum theoretical density based on the QC nuclear gauge testing conducted; the QA tests based on two cores was marginally lower and averaged 92.8 percent.

Figure 5 – Photograph of Paving and Breakdown Compaction

Figure 6 Photograph of WMA Joint Construction

Figure 7 Compacting the Longitudinal Joint

Figure 8 WMA Surface Texture Close-Up

Figure 9 WMA Finished Mat

SUMMARY AND CONCLUSIONS

Warm-mix asphalt makes sense:

- Reduces Greenhouse Gases
- Reduce/Eliminate Fumes
- Reduce Fuel Consumption
- Improve Density

The Victoria Street trial was extremely successful in every respect – Photographs of the final product on the road are shown in Figures 8 and 9. More importantly, the project demonstrated a significant reduction in fuel cost. Tomlinson reported fuel savings of about 30 % for WMA compared to the conventional HMA. A summary of the project details is shown in Table 6 below.

Table 6 Victoria Street Project Summary
City of Ottawa, Ontario

- Paved in late October 2007
- Approximately 950 tonnes of WMA
- 12.5 mm Superpave mix with 15 % RAP
- PG 58-34 Sasobit Modified
- EBL mixed at 128 °C (262 °F)
- WBL mixed at 115 °C (239 °F)
- Conventional HMA mixing temperature: 160 °C (320 °F)
- Compaction temperatures between 90-110 °C (194-230 °F)
- 93-94 % in-place density
- No mix problems
- Estimated 30% fuel savings

WARM-MIX ASPHALT COSTS

As with any new technology, the initial cost of the method is more difficult to ascertain. Reported cost for early trial projects range in the order of 15-30 % more per tonne of the WMA compared to the standard HMA. These costs are somewhat higher than expected, and are likely due to the experimental nature of the projects. The Sasobit cost in the noted trials was on the low end of the range. Nevertheless, based on the trials described in this paper, the additional cost of the Sasobit is in the order of $ 4-5/tonne.

FUTURE WORK

As a result of this trial, Bitumar also pursued construction of additional trials in southern Ontario, New York State and Quebec. A project was let late in 2007 by the City of Toronto, due to scheduling issues the project was not paved in 2007. This job was completed in May 2008 and will be reported on in later papers. The project included two 300 tonnes section of warm mix: the first section on Old Finch Road was paved with a Sasobit modified PG 64-28 terminally blended by Bitumar at their Hamilton plant and the other section on Plughat Road was paved an Evotherm (supplied by McAsphalt) warm mix. The binder was a modified with Sasobit to meet a PG 64-28. The next day an additional 300 tonnes section was placed in the City of Brampton. All the paving was carried out by Furfari Paving at their Scarborough plant. Similar energy savings to the Ottawa trial were observed by Furfari on the City of Toronto project. The plant operator indicated that about 6-7 m^3 of gas are typically used per tonne of HMA; about 5 m^3 was used during the production of the WMA trial.

The number of WMA projects constructed across Canada has increased fairly dramatically over the last two years and the interest continues to grow. In Ontario the Ministry of Transportation (MTO) has developed a Non-Standard Special Provision (NSSP), that is currently in the review process and a Task Group of the various stakeholders is being contemplated. The technology is being evaluated and research efforts continue in the US and Canada. It is envisioned by some that WMA will be specified more conventionally within five years. However, there are some unanswered questions or concerns that still need to be more fully addressed.

Industry Concerns:

- Baghouse Operations at Lower Temperatures
- Plant Modifications
- Available Binder Storage Tanks
- Changing Behaviours
- Changing Paving/Compaction Procedures
- Costs
- Department of Transportation (DOT)/Local Government Acceptance

DOT Concerns:

- Costs
- Testing
- Long-Term Performance
- Development of AASHTO Provisional Standard

REFERENCES

[1] National Asphalt Pavement Association (NAPA), NAPA News Release, Lanham Maryland, USA, November 2008.

[2] Kazmierowski T., “Pavement Recycling in Ontario - Moving Towards a Sustainable Future”, Ontario Ministry of Transportation, May 2007 Presentation.

[3] Prowell BD, Hurley GC., Warm-Mix Asphalt Best Practices, National Asphalt Pavement Association (NAPA) Quality Improvement Series 125 (QIS-125), Lanham, Maryland (2007).

[4] Davidson JK, Pedlow R. "Reducing Paving Emissions Using Warm Mix Technology", Proceedings, Canadian Technical Asphalt Association, 52, 40-59 (2007).

[5] R.W Tomlinson Limited. "Sasobit Warm Mix Asphalt Technology", Tomlinson Times (Internal Newsletter), Winter 2007 Issue, Ottawa, Ontario (2007).

Table 1 WMA Mix Design

R.W. TOMLINSON LIMITED
RIDEAU ROAD QUARRY
07R12CRWMA

5597 Power Road
Gloucester, Ontario
K1G 3N4

Tel: (613) 822-1867
Fax: (613) 822-1554
Lab: (613) 822-0543

SUPERPAVE VOLUMETRIC MIX DESIGN

CONTRACT:	City of Ottawa	MIX TYPE:	12.5mm RAP WMA	TRAFFIC LEVEL:	C
SPECIFICATION:	F-3106	ANTI-STRIPPING	0.6% PAVEBOND LITE	N_{INI}:	7
HIGHWAY:		DESIGN A/C %:	4.80(4.11% virgin a/c)	N_{DES}:	75
LOCATION:	Ottawa	A/C TYPE:	58-34(w/1.5%Sasobit)**	N_{MAX}:	115
ITEM No.		A/C SUPPLIER:	BITUMAR		

Note ** Actual PG Grade is 66.5-31.4

MIX PROPERTIES

		SPEC.
Air Voids (%)	4.0	4.0
Voids in theMineral Aggregate (%)	14.6	14.0
Voids Filled with Asphalt (%)	72.6	65-75
$\%G_{mm}$ @ $N_{initial}$	88.4	≤ 89.0
$\%G_{mm}$ @ $N_{maximum}$	97.4	≤ 98.0
Dust to Binder Ratio	0.88	0.6-1.2
Tensile Strength Ratio	0.84	≥ 0.83
Gmb	2.461	n/a
Gmm	2.563	n/a
Gsb_{blend}	2.742	n/a

AGGREGATE PROPERTIES

Designation:	C-1	F-1	F-2	F-3	F-4
Description:	HL3 Stone	W. Dust	Reg. Dust	SAND	1/2" RAP
Source:	Rideau	Rideau	Rideau	Redmond	RIDEAU
Source No.:	05-67	05-67	05-67	K03-070	05-67
Specific Gravity:	2.777	2.756	2.751	2.670	2.704
Absorption, (%):	0.505	0.615	0.730	0.920	0.844
Proportion by Wt., (%):	37.0	23.0	10.0	15.0	15.0

Sieve Size (mm)	Gradation (% passing)					JOB MIX FORMULA	CONTROL POINTS	PCS POINT
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100	
19.0	100.0	100.0	100.0	100.0	100.0	100.0	100	
12.5	90.6	100.0	100.0	100.0	99.3	96.4	90-100	
9.5	59.9	100.0	100.0	100.0	93.8	84.2	28-90	
4.75	6.9	90.2	92.3	99.5	60.3	56.5	-	
2.36	2.0	52.4	58.2	97.2	45.1	40.0	28-58	39
1.18	1.6	29.1	39.9	90.8	39.3	30.8	-	
0.600	1.4	15.9	27.7	71.4	33.6	22.7	-	
0.300	1.3	8.5	20.4	34.3	20.4	12.7	-	
0.150	1.2	4.7	15.8	6.2	15.2	6.3	-	
0.075	1.0	2.5	11.7	1.8	10.0	3.9	2-10	

Mixing Temperature:	130°C	Compaction Temperature:	110°C
Briquette Size:	4,920g	Re-compaction Temperature:	110°C
Date Issued:	September 28, 2007	Date Certified:	2 Oct 07
Issued By:	Paul Charbonneau	Certified By:	L.W. Hendriks, P.Eng.

Table 3 Quality Control Test Report

Superpave Hot Mix Asphalt Quality Control Test Summary

TOMLINSON
R. W. Tomlinson Limited
5597 Power Road
Ottawa, ON K1G 3N4

Sample No.: B07-00493 **Mix:** 12.5 RAP WMA C (07R12CRWMA **DATE:** October 23, 2007

Project Boundary Road Overlay ISB07-5008 SASOBIT WARM MIX

SAMPLE DATA

Plant:	Rideau Plant	**Date Sampled:**	22-Oct-07
Job No.:	07-029	**Time Sampled:**	3:25 PM
Client:	City of Ottawa	**Sample Type:**	
		Sampled By:	Brian Ingram
Lot: 2 **Sublot** 1 **Station:**	**Offset:** 0.5m	**Tested By:**	Paul Charbonneau
Location:	Victoria Street WBL@Roghorn Garden	**Date Tested:**	23-Oct-07

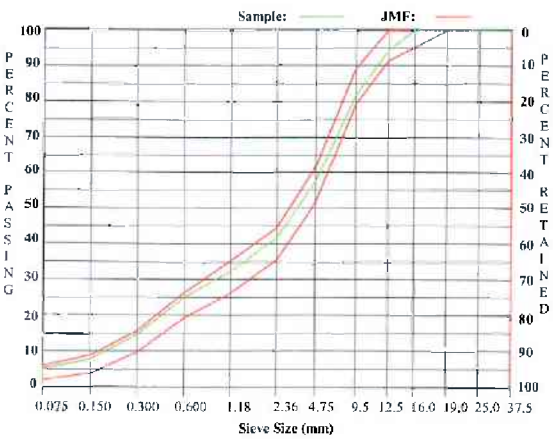
LAB DATA

EXTRACTION AND GRADATION

Sieve Sizes mm (In)	% PASSING SAMPLE	JMF		Out of Spec	Swing Back
37.5 (1 1/2):	100.0	100.0 - 100.0	*100.0*		100.0
25.0:	100.0	100.0 - 100.0	*100.0*		100.0
19.0 (3/4):	100.0	100.0 - 100.0	*100.0*		100.0
12.5 (1/2):	94.2	91.4 - 100.0	*96.4*		86.4
9.5 (3/8):	81.8	79.2 - 89.2	*84.2*		57.3
4.75 (3/16):	57.4	51.5 - 61.5	*56.5*		
2.36:	41.7	35.5 - 44.5	*40.0*		72.6
1.18:	32.4	26.3 - 35.3	*30.8*		56.4
0.600:	25.0	19.2 - 26.2	*22.7*		43.6
0.300:	14.7	9.7 - 15.7	*12.7*		25.6
0.150:	7.8	3.8 - 8.8	*6.3*		13.6
0.075:	5.0	1.9 - 5.9	*3.9*		8.7
AC (%):	5.04	4.30 - 5.30	*4.80*		

SGC - MIX PROPERITES

PROPERTIES	SAMPLE	JMF
Traffic Category:	C	C
Nini:	7	7
Ndes:	75	75
Nmax:	115	115
Properties @ Ndes		
Air Voids @ Ndes (%):	2.9	4.0
VMA:	14.5	14.0
VFA:	79.6	71.4
Dust Proportion:	1.1	0.6-1.2
Avg. Gmb:	2.470	2.461
Avg. Gmm:	2.544	2.563
% Gmm		
@ Nini:	89.7	89.0
@ Ndes:	97.1	96.0
@ Nmax:		98.0



Notes:
* Indicates Out of Specifications
The AC content reported is corrected for:
1. Mineral Fines, and
2. Moisture Content.

Comments:

Tested By:

Checked By:

Table 4 Quality Control Test Report

Superpave Hot Mix Asphalt
Quality Control Test Summary

TOMLINSON
R. W. Tomlinson Limited
5597 Power Road
Ottawa, ON K1G 3N4

Sample No.: B07-00492 **Mix:** 12.5 RAP WMA C (07R12CRWMA **DATE:** October 23, 2007

Project Boundary Road Overlay ISB07-5008 SASOBIT WARM MIX

SAMPLE DATA

Plant: Rideau Plant
Job No.: 07-029
Client: City of Ottawa
Lot: 1 **Sublot** 2 **Station:** 0+120 **Offset:** 0.5m
Location: Victoria Street EBL

Date Sampled: 22-Oct-07
Time Sampled: 11:45 AM
Sample Type:
Sampled By: Brian Ingram
Tested By: Paul Charbonneau
Date Tested: 23-Oct-07

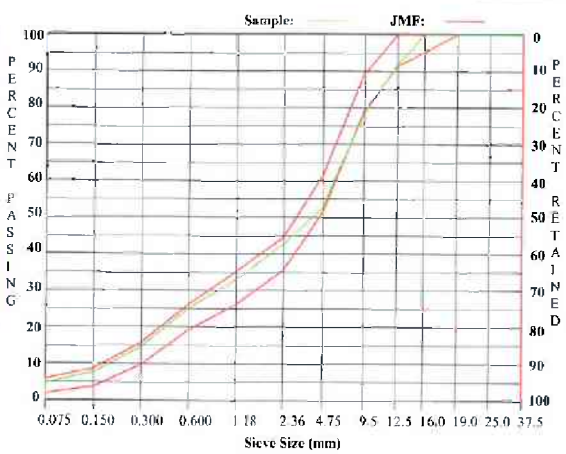
LAB DATA

EXTRACTION AND GRADATION

Sieve Sizes mm (In)	% PASSING SAMPLE	JMF		Out of Spec	Swing Back
37.5 (1 1/2):	100.0	100.0 - 100.0	*100.0*		100.0
25.0:	100.0	100.0 - 100.0	*100.0*		100.0
19.0 (3/4):	100.0	100.0 - 100.0	*100.0*		100.0
12.5 (1/2):	91.8	91.4 - 100.0	*96.4*		82.6
9.5 (3/8):	78.5	79.2 - 89.2	*84.2*	*	54.4
4.75 (3/16):	52.9	51.5 - 61.5	*56.5*		
2.36:	42.6	35.5 - 44.5	*40.0*		80.5
1.18:	33.1	26.3 - 35.3	*30.8*		62.6
0.600:	25.2	19.2 - 26.2	*22.7*		47.6
0.300:	14.7	9.7 - 15.7	*12.7*		27.8
0.150:	7.7	3.8 - 8.8	*6.3*		14.6
0.075:	4.8	1.9 - 5.9	*3.9*		9.1
AC (%):	4.61	4.30 - 5.30	*4.80*		

SGC - MIX PROPERITES

PROPERTIES	SAMPLE	JMF
Traffic Category:	C	C
Nini:	7	7
Ndes:	75	75
Nmax:	115	115
Properties @ Ndes		
Air Voids @ Ndes (%):	4.0	4.0
VMA:	14.3	14.0
VFA:	72.0	71.4
Dust Proportion:	1.1	0.6-1.2
Avg. Gmb:	2.463	2.461
Avg. Gmm:	2.566	2.563
% Gmm		
@ Nini:	89.2	89.0
@ Ndes:	96.0	96.0
@ Nmax:	96.8	98.0



Notes:
* Indicates Out of Specifications
The AC content reported is corrected for:
1. Mineral Fines, and
2. Moisture Content.

Comments:

Tested By:

Checked By:

Table 5 Quality Assurance (ERS) Report

*** Asphalt ERS LOT Pay Factor ***

Ottawa

SP F-3130 / F-3131 (Jan 07)

Infrastructure Management Division
Construction Quality Assurance Laboratory

Lot Pay Factor Calculation
Tel: (613) 851-9810 Fax: (613) 739-2982

Project	Victoria Rd	Contract Number:	ISB07-5008
Sample Type	12.5mm Level C PG5834-Warm Mix	Spve Level/lift	C Surface
Tender Qty	~~2750~~ 929.71 tones	Date Paved:	Oct 22,2007
Lot Number:	1 of 2	Number of Sublots:	2
Supplier:	Tomlinson	Mix Design Number:	07R12CR53

	Designated Large Sieve	4.75 mm Sieve	600 um Sieve	75 um Sieve	AC Content	% Air Voids	Compaction
JMF	**84.2**	**56.5**	**22.7**	**3.9**	**4.80**		
Oct 22,2007(QA453)	82.6	56.7	26.6	4.6	5.08		92.9
Oct 22,2007(QA455)	83.8	56.9	25.9	4.5	5.06		92.6
Sublot 3							
Sublot 4							
Sublot 5							
Sublot 6							
Sublot 7							
Sublot 8							
Sublot 9							
Sublot 10							
Mean	**83.20**	**56.80**	**26.25**	**4.55**	**5.07**	**Not Tested**	**92.75**
Std Dev.							
Count	2	2	2	2	2	0	2
LL	78.20	50.50	16.70	0.90	4.50	2.70	91.00
UL	90.20	62.50	28.70	6.90	5.10	5.30	98.00
LQI	n/a	n/a	n/a	n/a	n/a	n/a	n/a
UQI	n/a	n/a	n/a	n/a	n/a	n/a	n/a
PL	n/a	n/a	n/a	n/a	n/a	n/a	n/a
PU	n/a	n/a	n/a	n/a	n/a	n/a	n/a
PWL	2 samples	2 samples	2 samples	2 samples	2 samples	n/a	2 samples
PF	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Voids not tested

Gradation payment factor (sub)	4.00	Combined Gradation - AC - Voids (sub)	2.000
Gradation payment factor	1.00	Combined Gradation - AC - Voids	1.00
Combined gradation and AC (sub)	2.00	Combined Gradation, AC, Voids and Compaction (sub)	2.00
Combined gradation and AC	1.00	Combined Gradation, AC, Voids and Compaction	1.000

Applicable Spec

F-3131

Total Payment Factor **1.000**

Notes:

Reviewed by Lou Quigley
City of Ottawa QA Section

Date: Dec 18,2007

Asp.pay 07-5008 12.5C L1 Oct 22 07 Warm Mix ... Version Dec07A ... xls