Local Government Association Research and Development Scheme

Low Volume Road Asphalt Trial in SA

City of Salisbury

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Department of Planning, Transport and Infrastructure

a better approach

Document History and Status

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A	Draft for ARRB and DPTI review	RKE	HVL / ED		22 November 2013
B	Final Draft for ARRB and DPTI review	RKE	HVL / ED		13 December 2013
C	Updated Final Draft for AAPA Comment	RKE			19 December 2013
D	Update report with AAPA feedback	RKE	HVL / ED		19 February 2014
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F	Final	RKE	HVL / ED		27 March 2014

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1 Acknowledgements

This project is co-funded by the following organisations:

- Local Government Authority (Research and Development Fund) (LGA)
- City of Salisbury (CoS)
- West Torrens City Council
- City of Burnside
- City of Playford
- City of Port Adelaide Enfield
- Corporation of the City of Marion
- Corporation of the City of Adelaide
- Adelaide Hills Council
- City of Unley
- Light Regional Council
- Institute of Public Works Engineering Australasia (IPWEA).

This project was supported by Australian Asphalt Pavement Association (AAPA) and its members with in kind support for trials and input into the protocol.

Tonkin Consulting, ARRB and DPTI have provided in-kind support over and above available funding in order to complete this report.

2 Introduction

As part of the LGA Research and Development Scheme, the City of Salisbury on behalf of a collection of Councils secured funding to undertake trials in asphalt surfacing. The City of Salisbury engaged Tonkin Consulting to lead the project with support of the Australian Road Research Board (ARRB) and the Department of Planning, Transport and Infrastructure (DPTI).

This project is a trial of new asphalt mixes with the results to inform the development of a specification for long life asphalt for low trafficked roads. Most asphalt specifications to date are designed for heavy traffic loads and to withstand traffic damage. The majority of local government sealed roads have low traffic volumes and deteriorate more by environmental effects of oxidation and soil movements rather than by traffic damage.

This project is a collaboration between ten local governments and four asphalt contractors with the support of IPWEA to undertake trials of different asphalt mixes. This project is being closely followed by the Bitumen Product User Group (BPUG) which is a collection of interested parties that meet regularly to discuss matters related to bitumen surfacing issues.

A trial protocol was developed by Tonkin Consulting and ARRB (refer Appendix A), with close involvement from DPTI. The protocol provided a standardised approach across the trials for:

- The selection criteria for appropriate trial sites
- Mix design requirements (4 mix types)
- The recording requirements for construction sites
- The monitoring requirements
- Forms for reporting conditions and test results.

The trials were carried out at 11 sites across the metropolitan Adelaide Area. This report outlines the findings of the trials and provides recommendations for further work based on the learnings of this project.

3 Objectives

The aim of the low volume road trial project was to evaluate asphalt mixes that are specifically intended for use on residential streets carrying limited numbers of heavy vehicles. This is defined as an urban street carrying traffic that falls within the lowest category of Table A 2 of the Austroads 'Guide to Pavement Technology Part 4B: Asphalt', i.e.:

- A street that carries less than 100 commercial vehicles per lane per day
- The structural design level for the street should be less than 5×10^5 ESAs
- Light free flowing traffic.

These mixes are designed to yield a longer life, to be more environmentally sustainable and to minimise whole-of-life cost. The mixes would also be suitable for use in pedestrian areas and for maintenance patching.

The technical characteristics of the asphalt designs include: a fine, dense graded aggregate distribution in combination with a high binder content. The aim was to create mixes that are easy to compact, this is to remedy the rapid cooling that takes place when mixes are constructed in thin layers and the influence of other compaction challenges such as stiffness of underlying pavement, irregular shape of underlying pavement, access for full size paving and compaction equipment. Mixes were to be constructed to a low insitu air voids content. This reduces the permeability of the mixes, which helps to protect the underlying granular layers and limits oxidation aging of the binder. The high flexibility of the mixes accommodate the relatively high deflections in residential street pavements.

Some of the trial mix designs included Reclaimed Asphalt Pavement (RAP) to increase environmental sustainability and reduce cost.

Some of the trial mix designs included warm mix asphalt (WMA) additives to further improve compactability of the mixes and increase environmental sustainability.

Some of the trial mix designs included a softer grade bitumen (Class 170), to improve compactability durability and flexibility of the material.

Conducting this trial was expected to scientifically support increased scrutiny of asphalt supply and placement by local governments and to identify activities for particular focus and improvement

The outcomes of the trials will guide specification development in collaboration with DPTI.

4 Mix Descriptions

4.1 Mix Philosophy

The technical characteristics of the asphalt mix designs include: a fine, dense graded aggregate distribution in combination with high binder content.

The aim is to create mixes that are easy to compact, that is to remedy the rapid cooling that takes place when mixes are constructed in thin layers and the influence of other compaction challenges such as lack of stiffness of underlying pavement, irregular shape of underlying pavement, access for full size paving and compaction equipment. The aim is to construct mixes with low in-situ air voids. This will reduce the permeability of the mixes, which helps to protect the underlying granular layers and limits oxidation ageing of the binder.

This is consistent with the desirable aims outlined in APRG Technical Note 4 – Light Duty Non-Structural asphalt surfacing and overlays (July 1997), where residential mix aims were:

- Low air voids (density)
- High bitumen content (impermeability).

Oliver (1992) in a long term performance study of asphalt mixes on lightly trafficked Australian streets showed that aging of the binder is greatly reduced for mixes that are compacted to 6% air void content and below. The study showed these mixes to be more durable in terms of cracking resistance. As the air void content increases beyond 7% it becomes increasingly easy for water and oxygen to penetrate the asphalt, which leads to an increased rate of oxidation aging and a risk of stripping. Linden et al (1989) found that an asphalt pavement's life is reduced by 10 percent for each percent increase in voids above 7 percent. This finding may be expected to be exacerbated for thin surfacing layers. McLeod (1967) concluded that "compacting a well-designed paving mixture to low air voids retards the rate of hardening of the asphalt binder, and results in longer pavement life, lower pavement maintenance, and better all-around pavement performance."

4.2 Descriptions of Mixes

A total of 11 trials sites were selected on residential streets in the Adelaide area. Each site has four sub-sections where four different types of mixes were placed. The intention was that, for all four mixes placed on a site, the mix design is kept the same in terms of aggregate grading and binder content. The variations between the mixes are mainly in the binder type used, and whether any warm mix asphalt (WMA) additive or reclaimed asphalt pavement (RAP) was used, as follows:

- Mix A: class 320 bitumen
- Mix B: class 320 bitumen with WMA additive
- Mix C: class 170 bitumen with RAP
- Mix D: class 170 bitumen with RAP and WMA additive.

Table 4.1 presents more descriptions on the mixes and the trial sites. The DPTI classification of the mixes is 10 mm fine dense mix asphalt (Fine AC10) (draft DPTI specification: Part 227), refer Appendix B.

Table 4.1 Mix descriptions (Fine AC10)

Site name	Mix A	Mix B	Mix C	Mix D
Bridges Avenue	C320 binder RAP 0%	C320 binder RAP 0% WMA (Cecabase RTBO 10)	C170 binder RAP 20%	C170 binder RAP 20% WMA (Cecabase RTBO 10)
Castlebar Road	C320 binder RAP 0%	C320 binder RAP 0% WMA (foam)	C170 binder RAP 10%	C170 binder RAP 10% WMA (foam)
Clifford Street	C320 binder RAP 0%	C320 binder RAP 0% WMA (foam)	C170 binder RAP 10%	C170 binder RAP 10% WMA (foam)
Counter Road	C320 binder RAP 0%	C320 binder RAP 0% WMA (foam)	C170 binder RAP 10%	C170 binder RAP 10% WMA (foam)
Cypress Street	C320 binder RAP 0%	C320 binder RAP 0% WMA (type not reported)	C170 binder RAP 20%	C170 binder RAP 20% WMA (type not reported)
Ellerslie Street	C320 binder RAP 0%	C320 binder RAP 0% WMA (foam)	C170 binder RAP 10%	C170 binder RAP 10% WMA (foam)
Elmgrove Road	C320 binder RAP 0%	C320 binder RAP 0% WMA (Sasobit)	C170 binder RAP 20%	C170 binder RAP 20% WMA (Sasobit)
Marleycombe Road	C320 binder RAP 0%	C320 binder RAP 0% WMA (foam)	C170 binder RAP 10%	C170 binder RAP 10% WMA (foam)
Mortess Street	C320 binder RAP 0%	C320 binder RAP 0% WMA (Sasobit)	C170 binder RAP 20%	C170 binder RAP 20% WMA (Sasobit)
Old Adelaide Road	C320 binder RAP 0%	C320 binder RAP 0% WMA (foam)	C170 binder RAP 20%	C170 binder RAP 20% WMA (foam)
Woodcroft Drive	C320 binder RAP 0%	C320 binder RAP 0% WMA (Sasobit)	C170 binder RAP 10%	C170 binder RAP 10% WMA (foam)

4.3 Aggregate Grading

The grading envelope for the Fine AC10 class mix is defined in accordance with the draft DPTI specification Part 227 with some slight differences for the trial protocol. The grading envelopes are summarised in Table 4.2 below.

Table 4.2 Mix Grading Envelopes of Fine AC10 Mix Asphalt

Sieve	DPTI Specification Fine Dense Grade mix Part 227(May 2013) (% passing)		Trial protocol grading (% passing)	
(mm)	Max.	Min.	Max.	Min.
19	100	100	100	100
13.2	100	100	100	100
9.5	100	90	100	90
6.7	90	75	90	75
4.75	77	63	77	62
2.36	56	43	56	43
1.18	41	30	40	29
0.6	29	20	28	19
0.3	20	13	19	12
0.15	13	8	12	7
0.075	8	5	7	4

The design gradings for the trial mixes are generally conforming to trial protocol criteria with the exception of 6 mixes. However, in those mixes, the non-conformance was limited to at worst two sieve sizes with the % passing values falling below the lower limit by 4 percent at the extreme and usually only by 1 percent.

For the trial the gradings can be considered to generally comply with the specification grading limits.

For the purposes of future specification the DPTI specification above will be used.

4.4 Binder Content

A requirement of the trial was that the binder content is to be higher than 5.5%. The target and production binder contents of individual mixes are presented in

Table 4.3. All the target binder contents conformed to the minimum value of 5.5%.

Table 4.3 Design binder content of mixes

Site name	Target binder content (%)	Production binder content (%)			
		Mix A	Mix B	Mix C	Mix D
Bridges Avenue	5.8	5.8	5.8	**5.4**	5.6
Castlebar Road	6.0	5.8	6.0	5.8	5.9
Clifford Street	6.0	5.9	6.0	5.8	5.8
Counter Road	6.0	6.1	6.1	6.1	6.2

Site name	Target binder content (%)	Production binder content (%)			
		Mix A	Mix B	Mix C	Mix D
Cypress Street	5.5	5.6	5.6	5.6	5.6
Ellerslie Street	6.0	6.0	6.0	5.7	5.9
Elmgrove Road	5.5	**5.4**	5.5	**5.4**	5.6
Marleycombe Road	6.0	5.9	5.9	5.9	5.7
Mortess Street	5.5	**5.4**	**5.4**	**5.4**	5.5
Old Adelaide Road	5.5	5.5	5.5	5.5	5.5
Woodcroft Drive	6.0	5.8	5.9	5.9	6.0

Three of the sites, and a total of six trials showed production binder content that was 5.4%, marginally lower than the required minimum 5.5%.

5 Construction

5.1 Asphalt Mix Spreading Temperature

DPTI specification for asphalt pavement construction (Part 228) states that, during the construction, mixes shall be placed at temperatures recommended in the Australian standards (AS 2150: 2005). The recommended spreading temperatures of the standard document are presented in Table 5.1.

Table 5.1 Spreading temperatures for dense-graded asphalt

Road surface temperature (°C)	Thickness of layer (mm)		
	< 30	30 - 40	41 – 100
	Minimum (°C)		
5 - 10	-	-	145
10 – 15	150	145	140
15 – 25	150	145	135
> 25	150	145	130

Source: based on AS 2150: 2005 (Table 12).

The nominal layer thickness of the Fine AC10 surfacings used for this trial was not reported.

However, the heights of cores taken for the air voids measurements (refer to Section 3.2) were generally around the 30 - 40 mm range, with many cores having the values within the range. It was therefore assumed that the nominal layer thickness of the surfacings was in 30 – 40 mm range. A spreading temperature of 145 °C was consequently chosen from Table 3.1 to assess the conformity of the mix spreading temperatures. As a noted exception, and based on the DPTI specification part 228, the spreading temperature minimum 120°C was adopted for the WMA (Warm Mix Additive) mixes.

The temperatures of mixes at auger were recorded during the construction and these records were used as the spreading temperatures. The spreading temperature records of individual mixes show that most (38/44) mixes conformed to the spreading temperature requirements (120°C WMA or 145 °C normal asphalt).

Of the non conforming sites, 4 relate to normal asphalt sites with spreading temperatures were 139-140 degree C and 2 were for warm asphalt sites where temperatures were 114-115 degree C.

5.2 Compaction and Air Voids

The trial protocol document states that achieving satisfactory field compaction (i.e. having relatively low in-situ air voids) is the most important goal of this trial. The trial participants were permitted to use a higher binder content than the normal design values determined from the mix design procedure and the laboratory air voids at 50 cycles and binder film thickness were reporting requirements only to allow some flexibility in the trial.

For the field compaction assessment, a number of cores were taken from each test section on the trial sites one day after the construction. Air voids of the cores were then measured in the laboratory and compared to the target air voids range of 4% to 6%.

Table 5.2 and Table 5.3 present the air voids test results and calculated min/max characteristic air voids of mixes.

- It is noted from the tables that most mixes did not meet the required air voids range, the calculated maximum characteristic air voids were higher than the required maximum air voids of 6% (i.e. mixes were under-compacted)

- Two mixes on the other hand were ‘over-compacted’ with the results below the minimum air voids criteria
- There was only one mix for which the results indicate that the characteristic values are within the 4% to 6% target range.

Table 5.2 Air voids test results of cores taken from the trial sites (Mixes A and B)

Site Designation	Mix A					Mix B				
	Air voids (%)		K value*	Characteristic air voids (%)		Air voids (%)		K value*	Characteristic air voids (%)	
				Min	Max				Min	Max
Bridges Avenue	Mean	6.2	0.72	5.5	7.0	Mean	**5.8**	0.72	4.6	7.0
	Std.	1.1				Std.	1.7			
Castlebar Road	Mean	6.8	0.62	6.3	7.4	Mean	7.3	0.62	6.9	7.8
	Std.	0.88				Std.	0.74			
Clifford Street	Mean	6.4	0.62	6.1	6.7	Mean	**5.5**	0.62	4.9	6.1
	Std.	0.44				Std.	1.01			
Counter Road	Mean	**3.5**	0.62	2.8	4.2	Mean	**5.9**	0.62	5.2	6.6
	Std.	1.1				Std.	1.2			
Cypress Street	Mean	6.6	0.62	6.0	7.2	Mean	6.4	0.62	5.9	6.9
	Std.	**1.04**				Std.	**0.82**			
Ellerslie Street	Mean	8.95	0.62	8.0	9.9	Mean	8.96	0.62	8.3	9.6
	Std.	1.5				Std.	1.0			
Elmgrove Road	Mean	6.7	0.62	5.6	7.9	Mean	6.9	0.62	5.7	8.2
	Std.	1.83				Std.	2.0			
Marleycombe Road	Mean	8.1	0.62	6.3	9.9	Mean	9.2	0.62	7.9	10.6
	Std.	2.9				Std.	2.2			
Mortess Street	Mean	**5.1**	0.62	4.6	5.6	Mean	8.3	0.62	6.8	9.7
	Std.	0.8				Std.	2.3			
Old Adelaide Road	Mean	7.9	0.62	6.8	9.0	Mean	7.1	0.62	6.4	7.8
	Std.	1.83				Std.	1.18			
Woodcroft Drive	Mean	6.8	0.62	6.2	7.4	Mean	7.8	0.62	7.2	8.4
	Std.	1.0				Std.	1.0			

** Different K values are used according to the number of cores tested (draft DPTI specification Part 228). In most cases, four cores were taken for the testing (i.e. K = 0.62). If five or six cores were used for the lot, the K values are 0.68 and 0.72, respectively.*

Table 5.3 Air voids test results of cores taken from the trial sites (Mixes C and D)

Site name	Mix C					Mix D				
	Air voids (%)		K value*	Characteristic air voids (%)		Air voids (%)		K value*	Characteristic air voids (%)	
				Min	Max				Min	Max
Bridges Avenue	Mean	7.7	0.68	7.0	8.4	Mean	6.8	0.72	6.1	7.5
	Std.	1.0				Std.	1.0			
Castlebar Road	Mean	5.6	0.62	4.7	6.6	Mean	6.8	0.62	6.1	7.4
	Std.	1.52				Std.	1.08			
Clifford Street	Mean	7.0	0.62	6.8	7.3	Mean	6.5	0.62	6.2	6.8
	Std.	0.44				Std.	0.48			
Counter Road	Mean	4.1	0.62	3.3	5.1	Mean	6.1	0.62	5.5	6.7
	Std.	1.4				Std.	1.0			
Cypress Street	Mean	6.8	0.62	5.8	7.8	Mean	7.9	0.62	7.3	8.5
	Std.	1.65				Std.	1.03			
Ellerslie Street	Mean	8.3	0.62	7.7	8.8	Mean	10.2	0.62	8.5	11.9
	Std.	0.9				Std.	2.8			
Elmgrove Road	Mean	7.6	0.62	6.7	8.5	Mean	7.1	0.62	5.9	8.4
	Std.	1.4				Std.	2.0			
Marleycombe Road	Mean	9.4	0.62	8.3	10.5	Mean	9.2	0.62	8.5	9.9
	Std.	1.7				Std.	1.1			
Mortess Street	Mean	6.8	0.62	6.5	7.1	Mean	7.0	0.62	6.2	7.8
	Std.	0.5				Std.	1.3			
Old Adelaide Road	Mean	**6.0**	0.62	4.8	7.2	Mean	8.4	0.62	7.6	9.2
	Std.	2.0				Std.	1.3			
Woodcroft Drive	Mean	**5.6**	0.62	4.8	6.4	Mean	**5.7**	0.62	5.2	6.1
	Std.	1.3				Std.	0.7			

** Different K values are used according to the number of cores tested (draft DPTI specification Part 228). In most cases, four cores were taken for the testing (i.e. K = 0.62). If five or six cores were used for the lot, the K values are 0.68 and 0.72, respectively.*

The mean insitu air voids results were plotted in Figure 5.1 to graphically represent where the tabulated results from above fitted with respect to the target range of 4% to 6% insitu air voids. 9 of the 44 trials (20%) resulted in a mean insitu air voids result within the target range. It is worth noting that while some of the calculated mean results met the target band, not all samples that contributed to that mean value fell within the target band, nor did the characteristic values that were calculated.

It is also worth noting that 18 of the 44 trials (40%) resulted in a mean insitu air voids result above 7.0% (see dashed line in Figure 5.1).. Section 4.1 of this report discussed the reduced life of surfaces with air voids above 7% due to increased permeability for oxygen and water, and accelerated ageing of the binder.

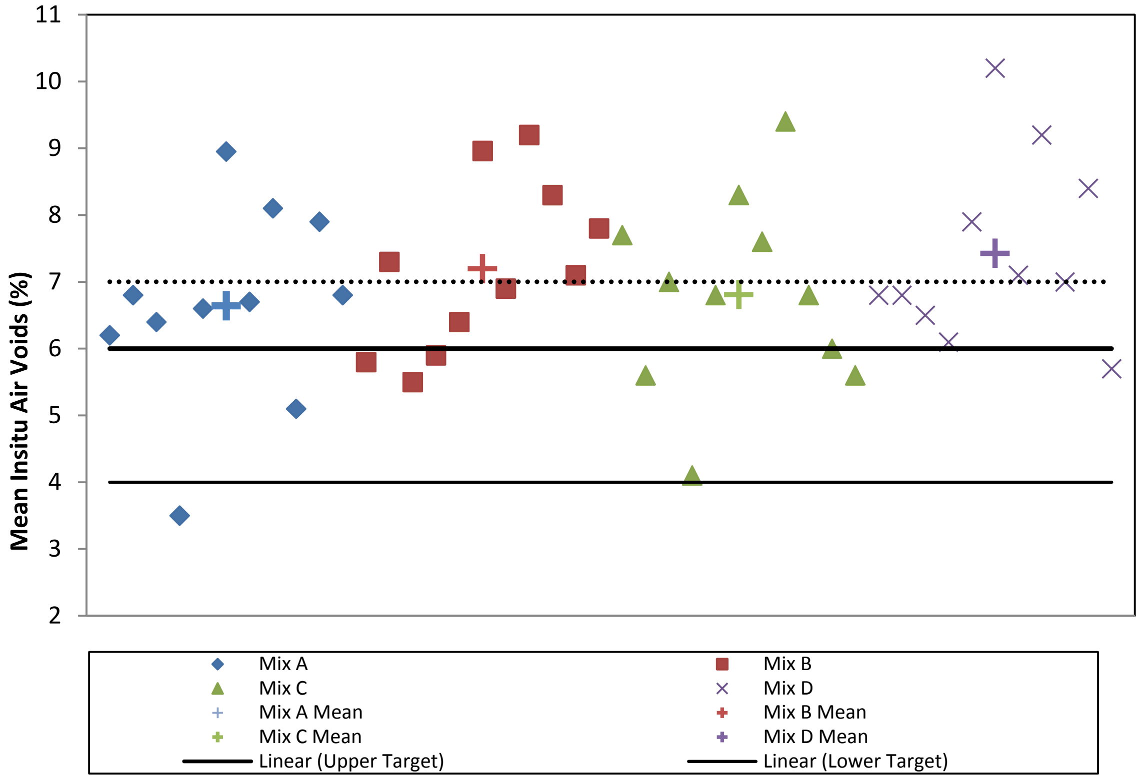

Figure 5.1 Insitu Air Voids with means and target limits

5.3 Compaction and Auger Temperature

The temperature in the auger was plotted against the insitu air voids and the results are presented below in Figure 5.2

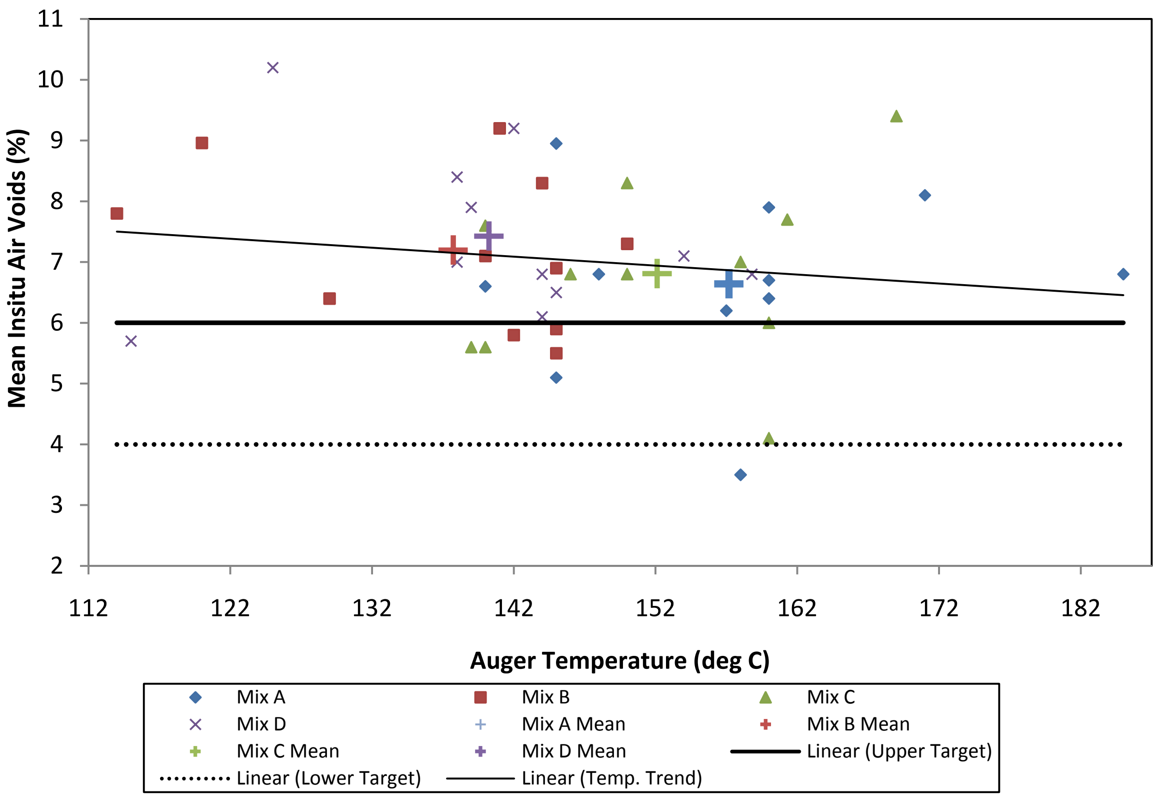

Figure 5.2 Insitu Air Voids with means and target limits vs Auger Temperature

From this there is a trend of improved field air void results with increased temperature. Warm Asphalt averaged around 140 deg C (well above the minimum of 120 deg C) and the hot asphalt was above 150 deg C to 155 deg C.

5.4 Asphalt Thickness

The thickness of individual cores for each mix is plotted against the insitu air voids.

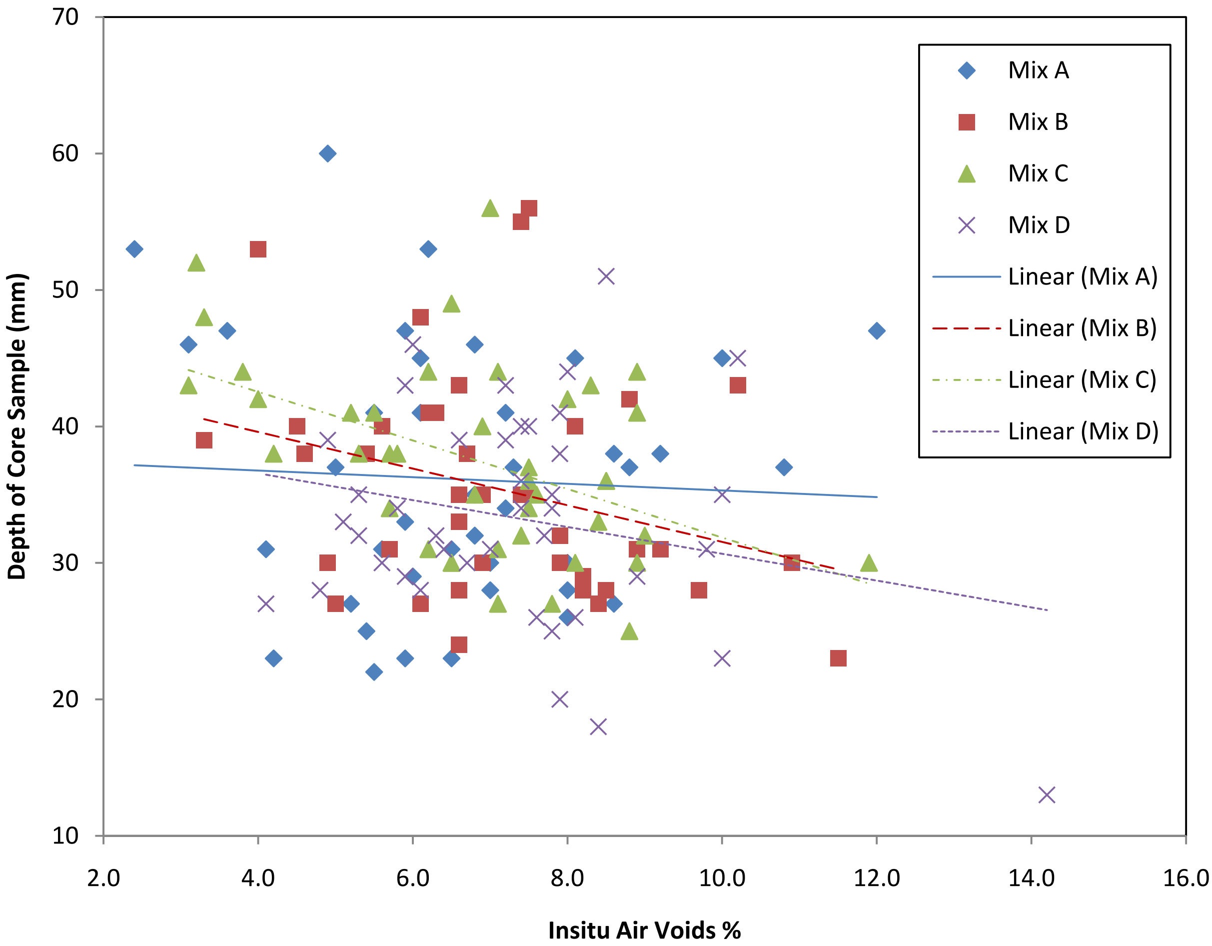

Figure 5.3 Individual Core Thickness and air voids

From the data it can be seen that the compaction of Class 320 hot bitumen is not as sensitive to thickness as other asphalt types.

As expected there is a trend that the thicker the surface the better the compaction, however it is a weak trend.

It highlights the importance of developing workable mixes.

5.5 Overview of Conformance of Mixes

Previous sections provide a review of design / test data of mixes used for the trial. The data was compared to the respective criteria given in the draft DPTI specifications (Part 227; Part 228). None of the mixes fully conform to the various assessment criteria. Nearly all of the mixes failed to meet the field air voids criteria. However, other than the field air voids criteria, mixes were generally conforming, e.g. mix spreading temperature. With the exception of field air voids criteria, a total of 30 out of 44 mixes were conforming.

6 Analysis and Discussion

The aim of the low volume road asphalt trials was to create more durable mixes with a higher bitumen content and a relatively low in-situ air voids content. However, the results from the trial sections indicate that the objective to compact the mixes to 4 - 6% air void was not achieved for most of the sections.

What follows is a discussion on some of the results from the trials.

6.1 Air voids vs Binder Content

One of the areas of interest in this study is to determine whether a higher binder content for these finely graded aggregates assists in achieving higher compaction (low air voids).

Figure 6.1 shows the binder content recorded during production plotted against the mean air void content determined for cores taken from the sections. The results indicate a very weak trend of decreasing air void content with increasing binder content.

The results seem to suggest that increasing the binder content alone did not have the desired effect on the compaction achieved in the field, and other factors need to be considered.

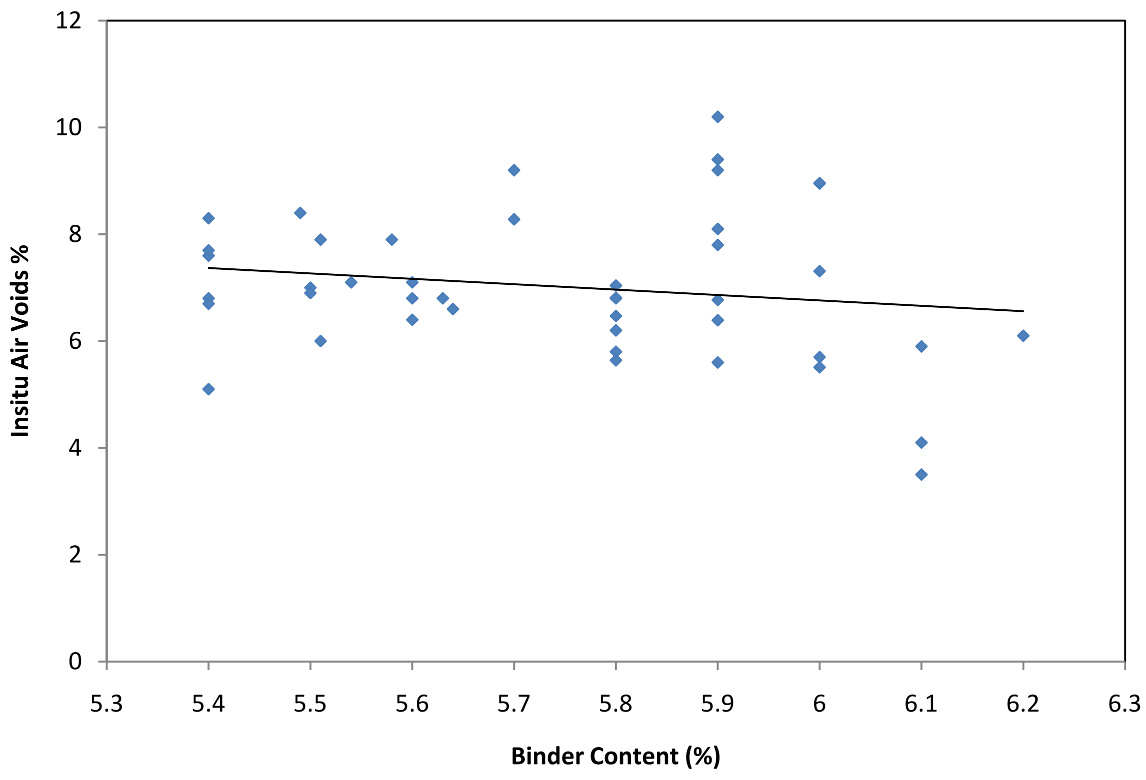

Figure 6.1 Insitu Air Voids % against Production Binder Content % for all trials

The mean air void results subdivided per mix type is shown below in Figure 6.2. The averaged mean air void content across the trials for each mix is shown in Table 6.1.

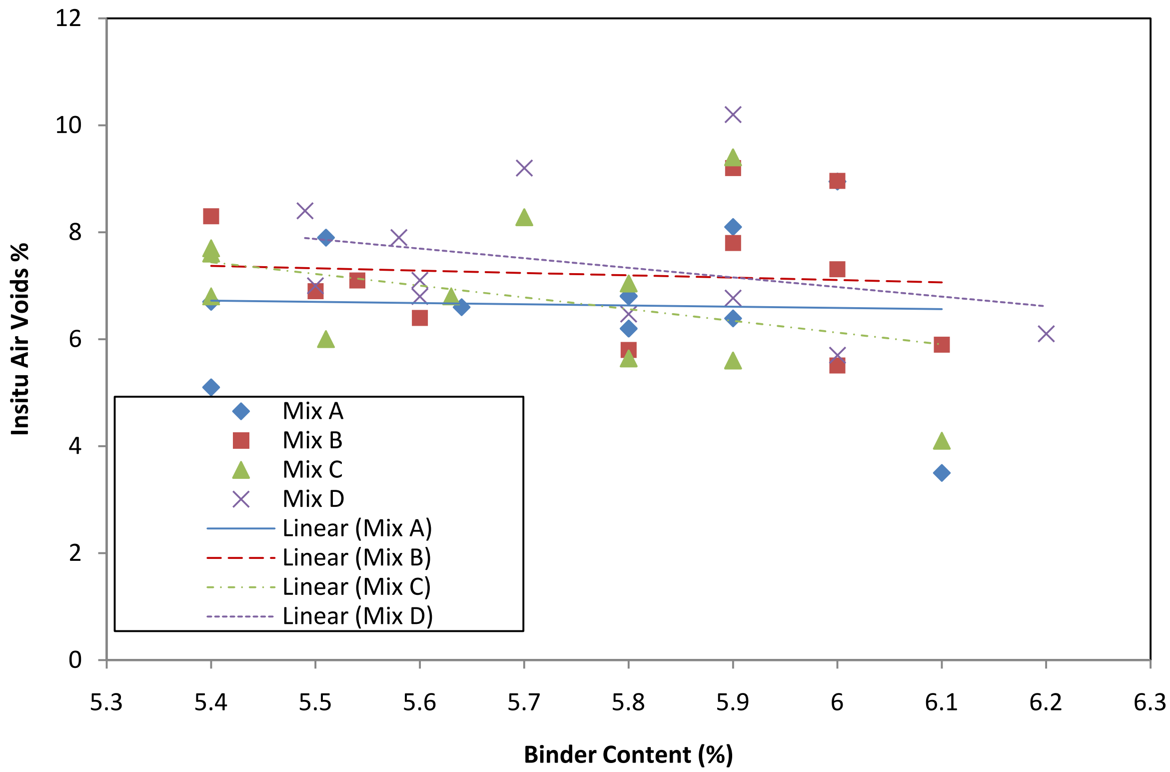

Figure 6.2 Binder content vs. construction air voids (for different mix types)

This graph shows for the trial mixes the following observations:

- warm asphalt had the higher air voids in the field
- C320 had lower air voids
- C170 binder showed a greater trend of better compaction with increased binder than C320 by the gradient of the trend line.

The minor differences in results between mixes can be affected by many variations in supply and placement, not withstanding these results present trends for further consideration.

Table 6.1 Summed air void statistics per mix type

Mix type	Summed mean air void content (all sections)	Summed standard deviation (all sections)
Mix A (C320)	6.6	1.5
Mix B (C320 WMA)	7.3	1.5
Mix C (C170 RAP)	6.8	1.3
Mix D (C170 RAPWMA)	7.4	1.4

The results in Table 6.1 indicate that the use of warm mix technology did not lead to improved compaction in the field. This is true for the combination of C320 and warm mix technology as well as for the combination of C170, RAP and warm mix technology. The results indicate that the mixing temperatures may have been dropped too low when using warm mix technology. It appears that rather than using the warm mix technology as an aid to achieve the required compaction, it was used primarily to reduce the required mixing temperature to achieve an equivalent density to hot mix.

6.1.1 Fine grading with High Binder Content

These trials all used finely graded aggregate. To know how successful the combination of a finer grading and higher binder content were in reducing the construction voids of these trial mixes compared to conventional mixes, the results need to be compared to typical void values for conventional mixes in SA, which is not available at this stage.

6.2 Air voids vs Stiffness of Underlying Pavement

As a means to investigate whether the compaction of the surfacing mix would have been affected by the stiffness of underlying base, a series of falling weight deflectometer (FWD) tests were conducted on each trial site after construction. This was an important investigation point of this study, since pavements in residential streets for which the new fine surfacing mix was developed would often be softer than those constructed for main roads (i.e. could cause difficulties in compaction of the mix).

The mean of maximum deflection values (at the centre of deflection bowl (D0)) were used as the parameter indicating stiffness of the base layer at each trial site (e.g. a softer base will deflect more under the same load). The relationship between the air voids and FWD deflection is illustrated in Figure 6.3, in which the mean FWD result per site is plotted against the average air void results for the different mixes at that site.

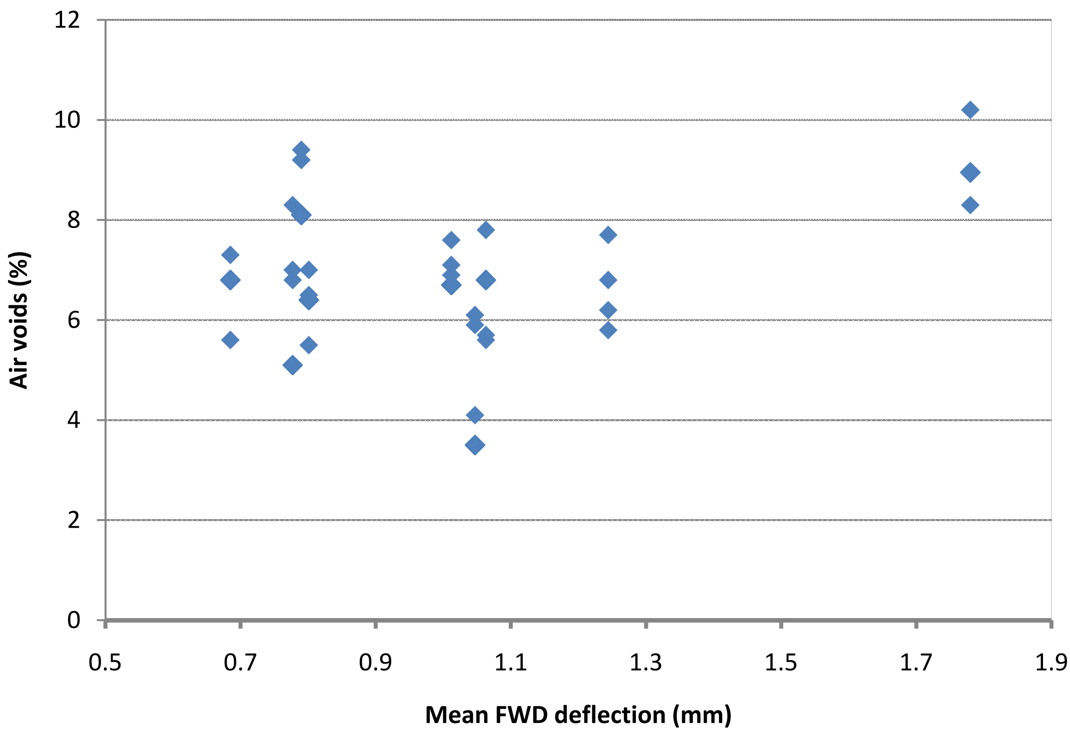

Figure 6.3 Insitu Air Voids vs Mean FWD deflection

The majority of the roads in this trial had deflections prior to resurfacing between 0.7 and 1.3 mm. Within this range due to the range of variables impacting insitu air voids, there is no clear trend in deflection impacting on compaction.

The trial did not have sufficient results for roads above 1.3 mm deflection to draw any conclusions.

The 2 sites show that air voids > 8% coincide with sites of high laboratory air voids discussed in the next section.

While deflection is not a dominant factor for the roads in this trial, it remains something for consideration, particularly if more roads above 1.3 mm deflection are included in future trials.

6.3 Air voids – differences between lab results and field results

The trial protocol did not mandate a lab air void target but encouraged contractors to develop a mix design and report on the air voids rather than be constrained by a specified value.

An analysis of the air voids (both laboratory (50 gyrations - AS2891.2.2) and insitu results) vs binder content for each of mixes was undertaken. A trend line was developed for the laboratory results and also for the insitu results.

For mix A and B there were 3 sites where lab air voids exceeded 6% (range 6.1 to 7.1). These were excluded from the analysis given they were outside the range. These sites also coincided with high air voids in the field.

The laboratory air voids results are plotted below in Figures 6.4 to 6.7(bold markers) and the trend line is also plotted.

Consider Figure 6.4 as an example. The target lab air voids of 4.5% are marked as a horizontal line. The lab air voids trend line intersects the target line and the intersection occurs at a design binder content (5.68% binder). That binder content is then projected vertically up to the trendline for the insitu air voids result. The corresponding air voids value from the insitu air voids trend line shows a projected field air voids content based on the data (6.3% field air voids). Thus the difference (increase) of insitu air voids to design air void (4.5%) is able to be clearly seen.

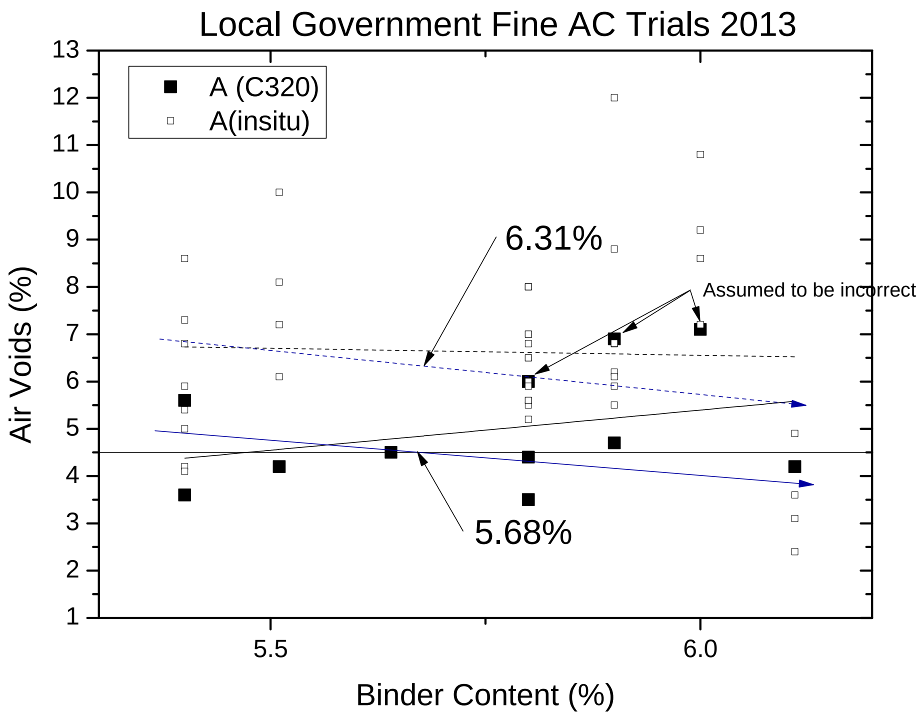

Figure 6.4 Plot of All asphalt company trials of AC10C320 – Mix A

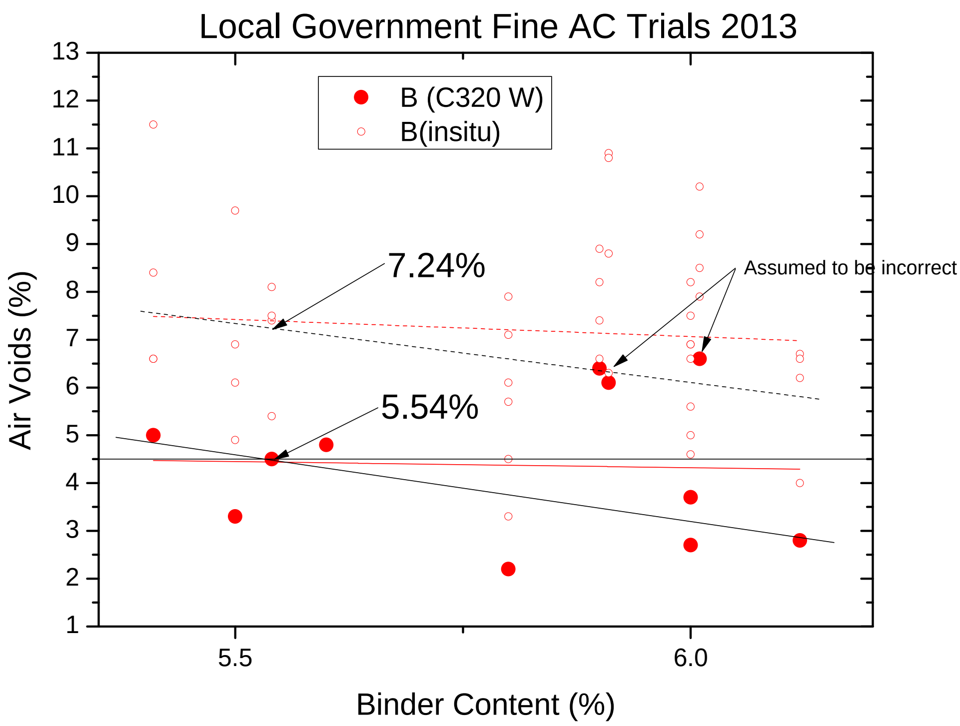

Figure 6.5 Plot of All asphalt company trials of AC10C320 Warm – Mix B

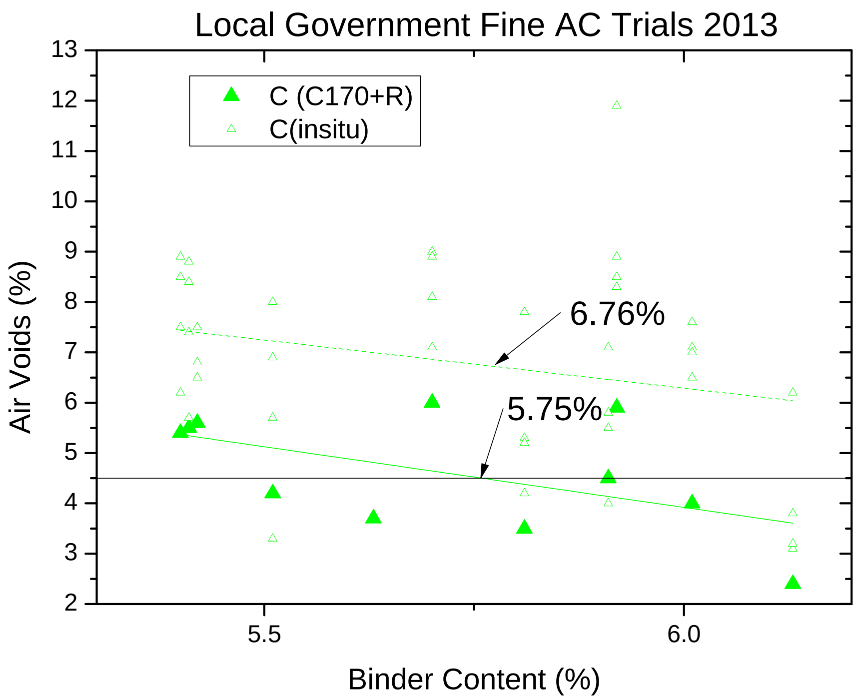

Figure 6.6 Plot of All asphalt company trials of AC10C170 with 20% RAP – Mix C

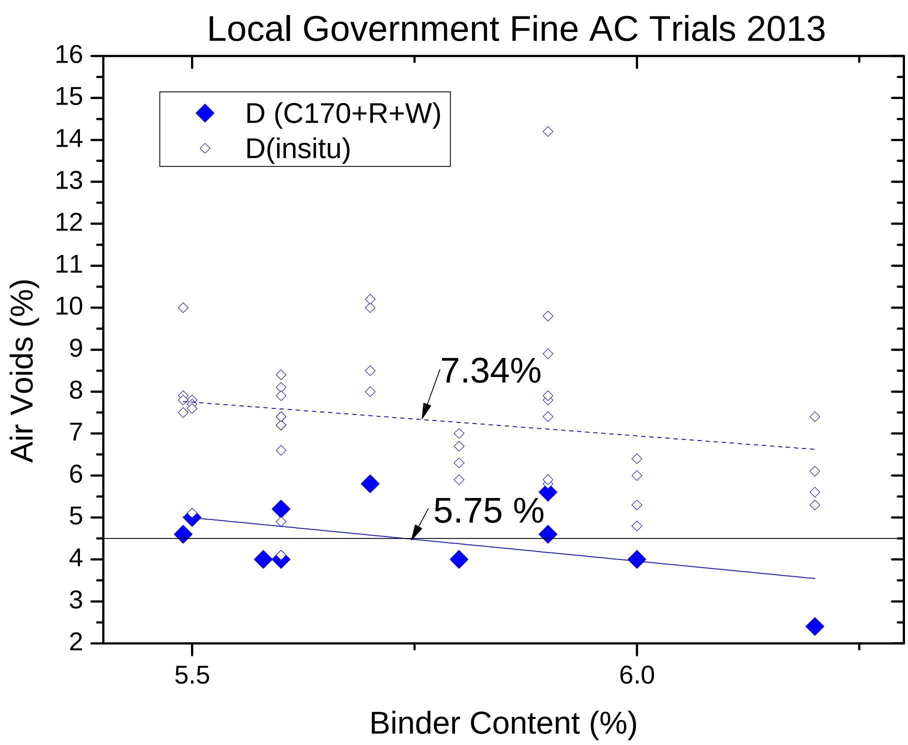

Figure 6.7 Plot of All asphalt company trials of AC10C170 with 20% RAP and Warm – Mix D

Table 6.2 summarises the results for each mix.

Table 6.2 Binder Content to achieve 4.5% air voids (50 gyrations - AS2891.2.2) and insitu average air voids at that binder content

Asphalt Mix	Mix Description	Binder Content from trend (at 4.5% air voids in laboratory)	Insitu Air Voids from trend (at target binder content)
A	AC10L320	5.68%	6.31%
B	AC10L320 Warm	5.54%	7.24%
C	AC10L170 20%RAP	5.75%	6.76%
D	AC10L170 20% RAP Warm	5.75%	7.34%

Using the same data points a lab air void target of 4% was used to estimate the binder content and corresponding ranges of insitu air voids.

Table 6.3 Binder content to achieve 4.0% air voids (50 gyrations - AS2891.2.2) and Insitu Average at that binder content

Asphalt Mix	Mix Description	Binder Content from trend (at 4.0% air voids in laboratory)	Insitu Air Voids from trend (at target binder content)
A	AC10L320	6.0% *	5.7%
B	AC10L320 Warm	5.7% *	6.87%
C	AC10L170 20% RAP	5.97%	6.34%
D	AC10L170 20% RAP Warm	5.98%	6.96%

**Corrected data, removing out of step data (see Figure 6.4 and Figure 6.5)*

A finding here from Table 6.2 is that warm mixes will result in at least 0.6% additional insitu air voids than hot mixes.

It can also be seen that based on Table 6.3 if target air voids was 4% then binder content would increase by 0.3% to approximately 6% and insitu air voids would decrease by approximately 0.6% to approximately 6.5%.

6.4 Indirect Tensile Strength

ITS was measured for each of the sites, with the results of ITS plotted against binder content in Figure 6.8 below. The data was grouped by Contractors that had higher binder content (C1, C2) and lower binder content (C3, C4).

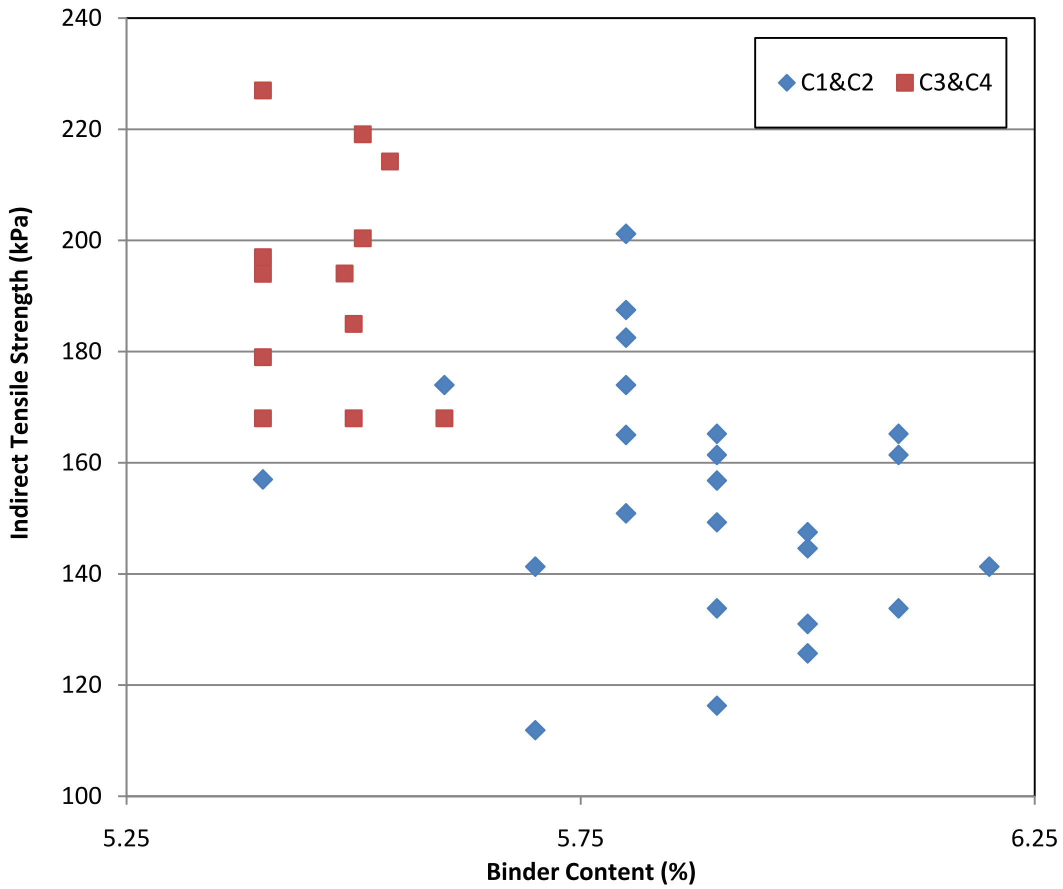

Figure 6.8 Indirect Tensile Strength vs Binder Content (separated by Contractor)

The findings here are that:

- The higher the binder content the lower the indirect tensile strength.

The results of the binder type on the ITS have also been plotted below.

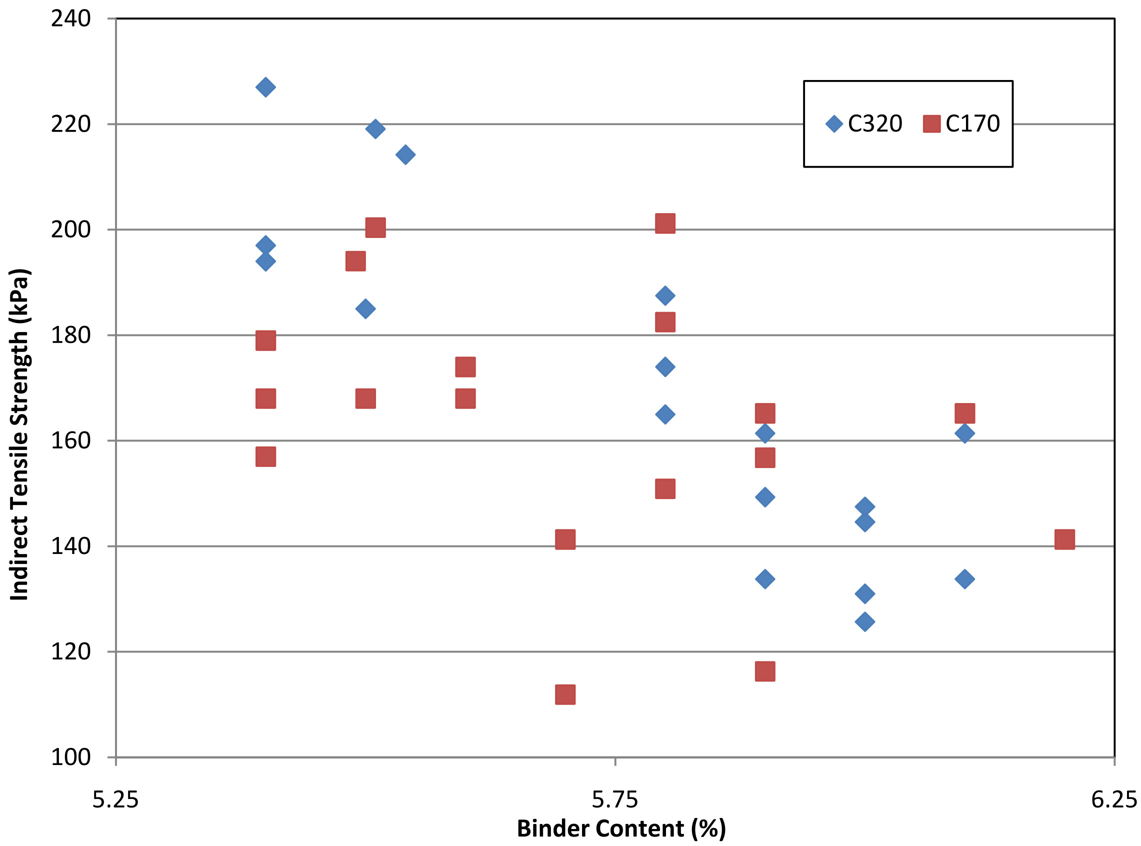

Figure 6.9 Indirect Tensile Strength vs Binder Content (separated by binder type)

The findings when comparing the two different binder types used throughout the trials is that there was no difference found between the different binder types AC10L320 and the AC10L170 20%RAP mixes with respect to indirect tensile strength. They both show a similar trend of decreasing ITS with increasing binder content, although the C320 has a tighter grouping.

A comparison of the warm mixes and the hot mix trials is shown below.

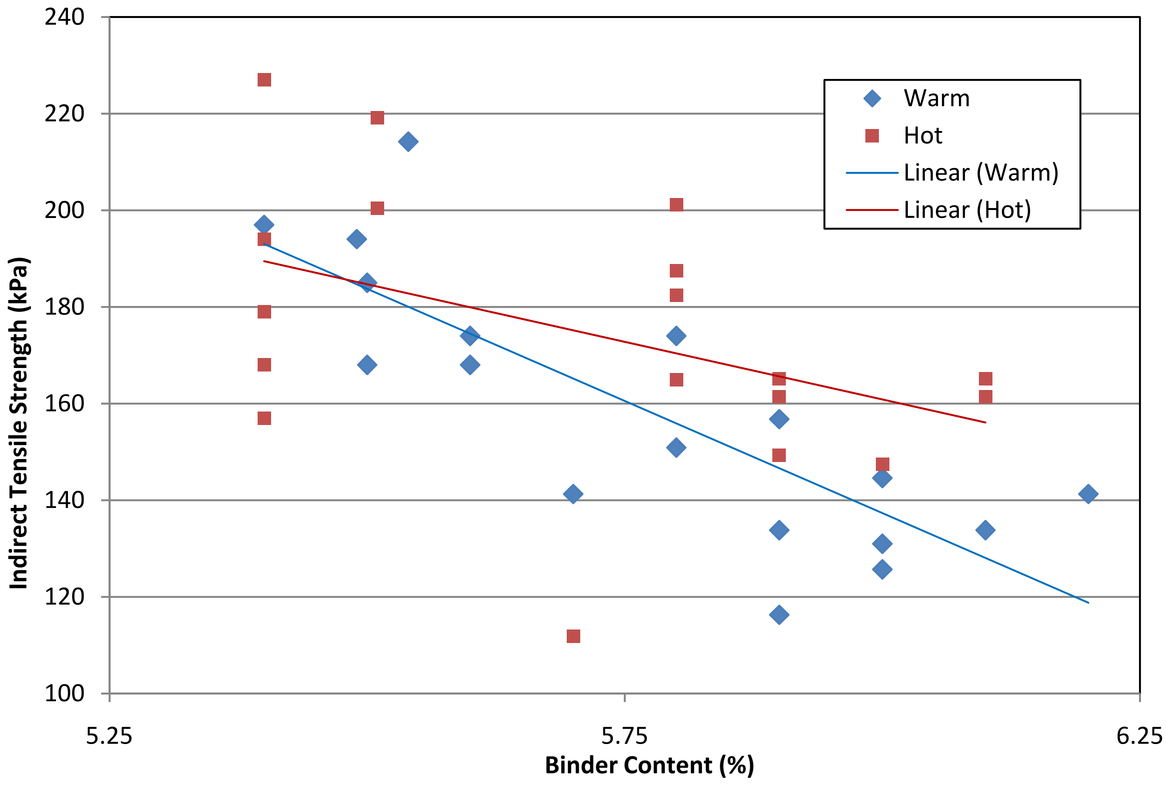

Figure 6.10 Plot of Indirect Tensile showing loss of strength for Warm

From Figure 6.10 it can be seen that there was a loss of strength for warm mixes compared to hot mixes. The warm mix loses its ITS with increasing binder content at a higher rate than the hot mixes, as evidenced by the steeper gradient of the trend line.

6.5 Binder Film Thickness

The 'raw' binder film thickness for each trial was measured in the laboratory and the results are plotted against binder content % below in Figure 6.11. The data was grouped by Contractors that had higher binder content (C1, C2) and lower binder content (C3, C4).

The water absorption of the aggregate is determined from the bulk density of the aggregate. Due to the difference in viscosity between bitumen and water, it is assumed in this report that the volume of binder absorbed by the aggregate is equal to 60% of the water absorption.

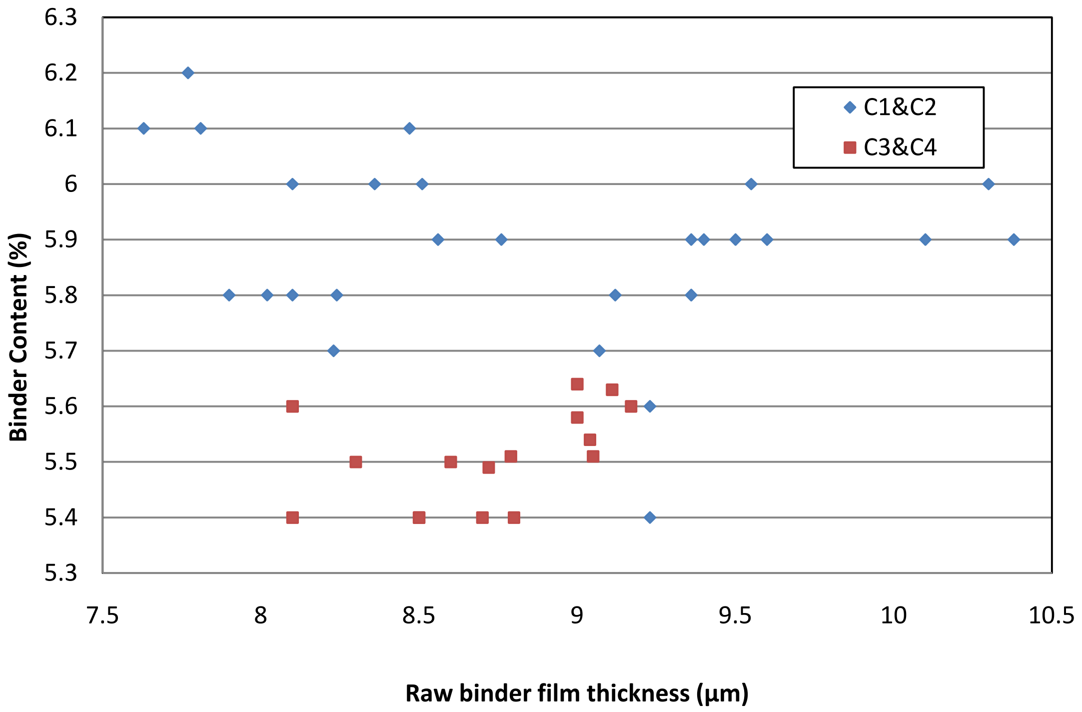

Figure 6.11 Plot of Raw Binder Film Thickness showing C3&C4 low binder content

Contractors 3 and 4 produced lower binder content and lower binder film thickness. This is shown even more clearly in Figure 6.12 below where the binder film thickness values have been adjusted for 60% absorption, represented in bands of field air voids.

Low field air void sites did not generally correspond with BFT < 8.2 and Binder < 5.8% or BFT > 9.5, but rather corresponded to binder > 5.8 or BFT (60%) above 8.5 but less than 9.5.

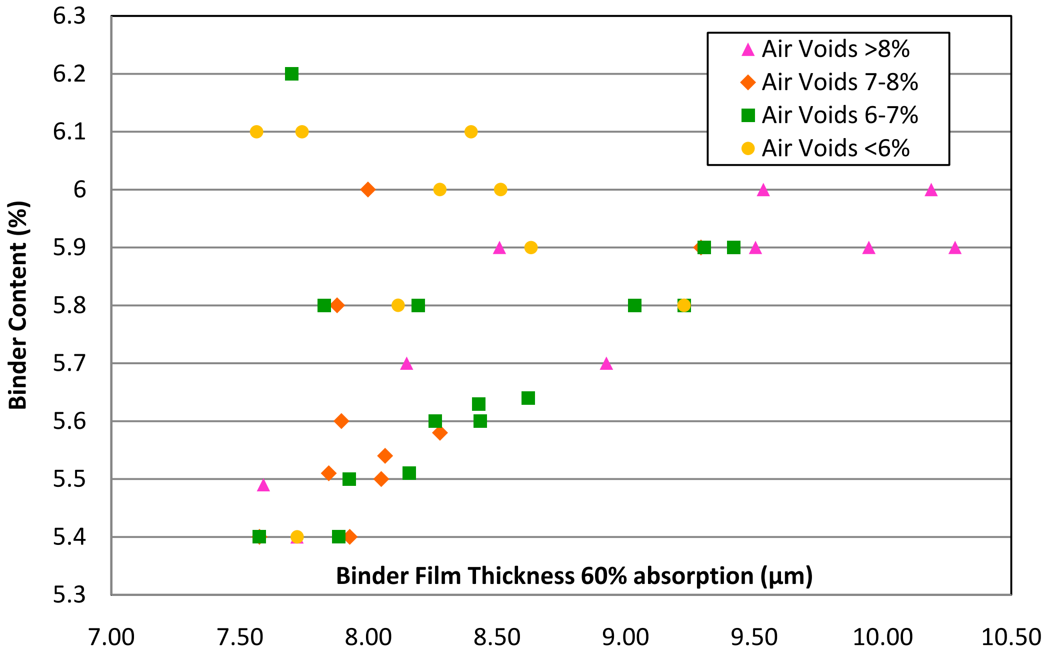

Figure 6.12 Plot of 60% absorption adjusted Binder Film Thickness against binder content grouped by field air voids

The relationship between binder film thickness and filler (0.075 mm sieve % passing) is also examined and presented in Figure 6.13 and Figure 6.14 below. The findings are that:

- For the raw BFT results there is a trend - the higher the percentage passing 0.075 mm sieve, the lower the BFT
- Once the data is adjusted for the 60% absorption the trend was preserved.

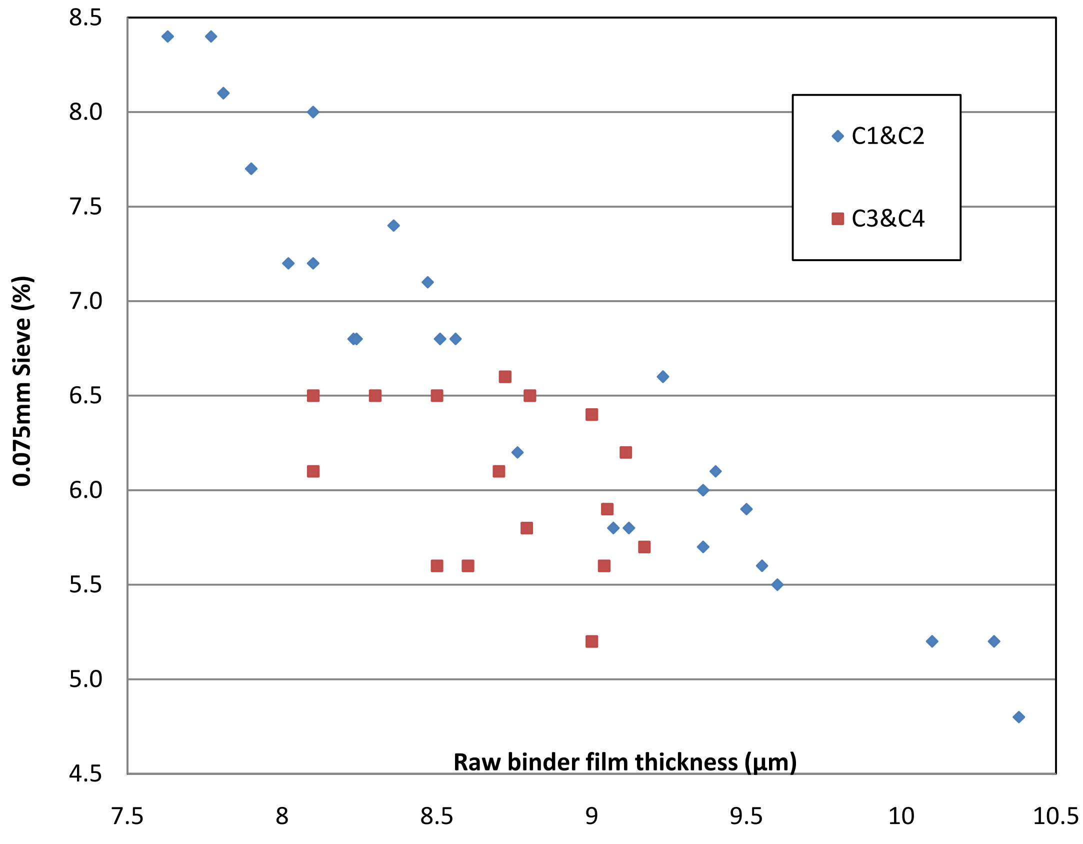

Figure 6.13 Plot of Binder Film Thickness and % passing 0.075 mm sieve grouped by Contractor

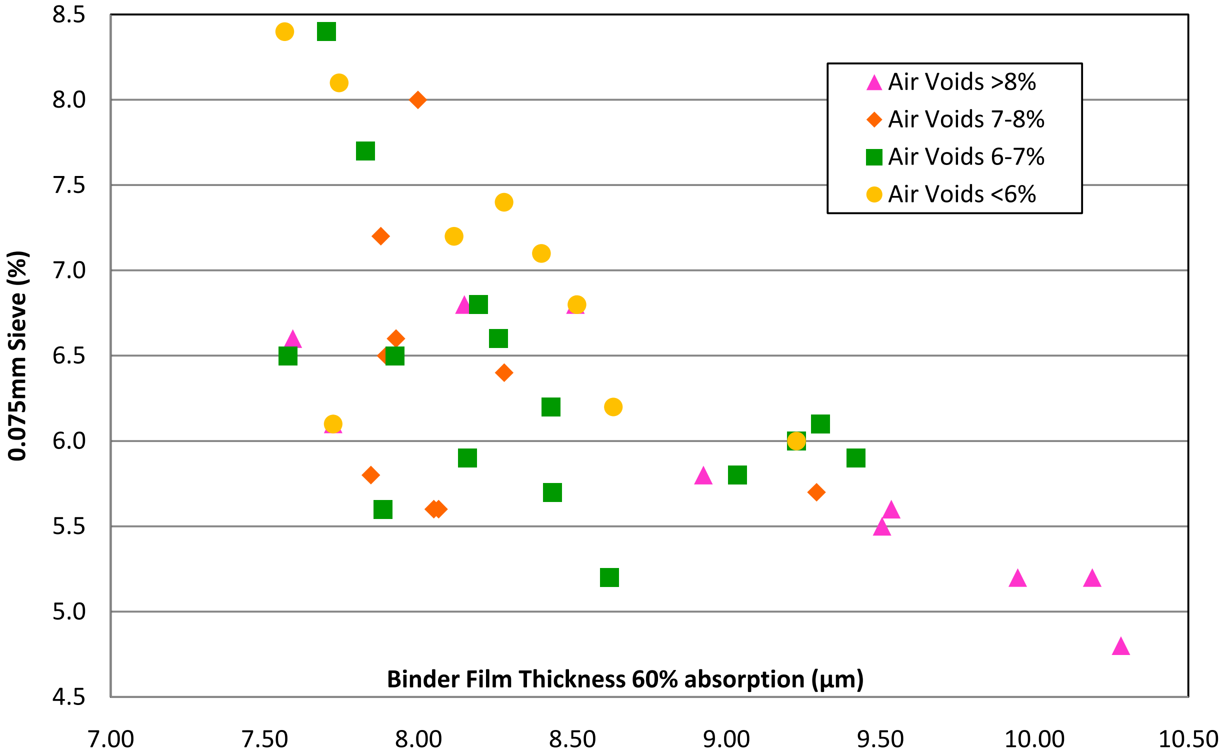

Figure 6.14 Plot of Binder Film Thickness (60% absorption) and % passing 0.075 mm sieve grouped by field air voids

When reviewing field air voids corresponding to the sites plotted, lower field voids occurred when 0.075 mm sieve (%) was greater than 6.8 and BFT (60%) < 8.5. The cluster of sites with 0.075 mm sieve less than 7 and BFT (60) < 8.5% were generally higher field air void sites. Some lower field air void sites occurred when 0.075 mm sieve (%) was less than 7 and BFT (60%) was greater than 8.5. However, above BFT (60%) 9.5 high air voids were dominant.

6.6 Filler Binder Ratio

The filler-binder ratio is measured as the percentage of aggregate passing the 0.075 mm sieve by mass of total aggregate, to the percentage of binder by mass of total mix. Figure 6.15 shows the plot of filler-binder ratio and binder film thickness (60% absorption).

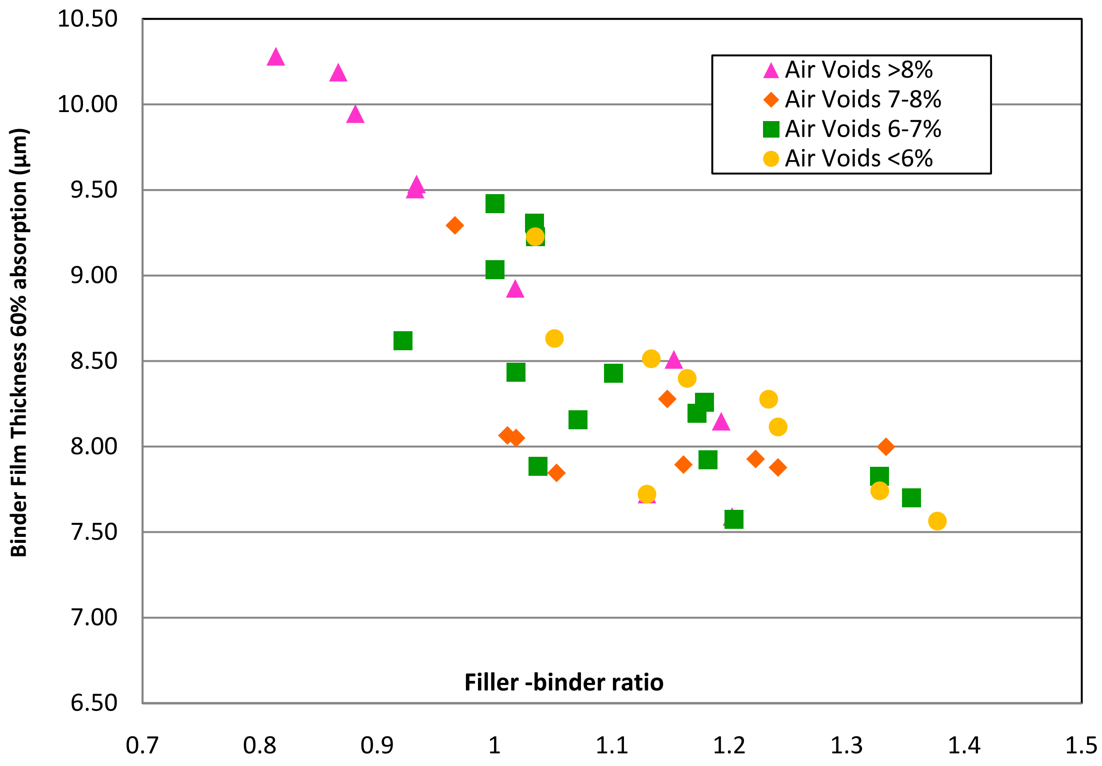

Figure 6.15 Plot of Binder Film Thickness vs Filler binder ratio grouped by field air voids

When reviewing field voids corresponding to the sites plotted, when BFT (60%) > 8.5% the sites with low voids had filler binder ratio 1 - 1.1. When BFT (60%) was less than 8.5, low voids were observed when filler binder ratio was 1.1 - 1.4. No low void sites were observed in the trial for filler binder ratio less than 1.

Figure 6.16 below shows the ITS and the filler binder results. It is worth noting that the ITS test was conducted at 45 deg C.

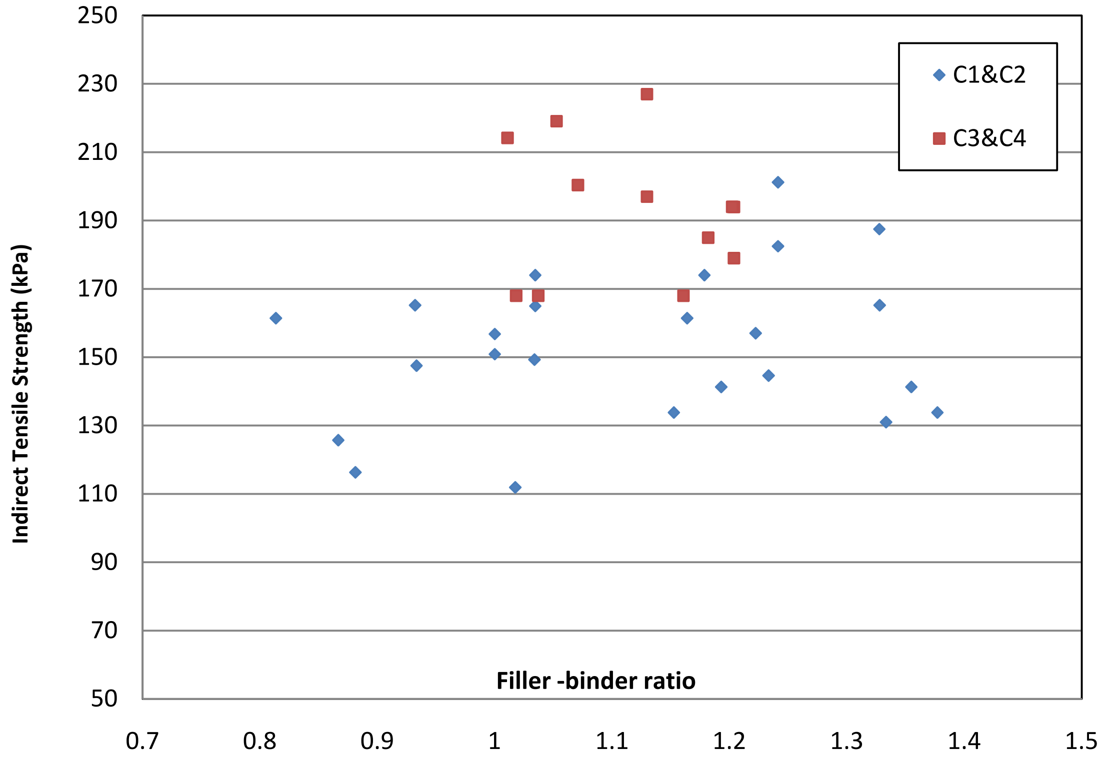

Figure 6.16 Plot of ITS vs Filler binder ratio

There is no significant trend for ITS or filler binder ratio. During the monitoring phase low ITS sites should be monitored for rutting/shoving to develop confidence in accepting lower ITS values for local streets.

6.7 Field results findings

Figure 6.8 shows clearly that Contractors 1 and 2 achieved a binder content greater than 5.75% for the majority of the trial. Figure 6.1 shows that for binder content greater than 5.8% a field air voids result was trending lower than that for binder content lower than 5.8%.

Furthermore the relationship between binder, filler and binder film thickness and field air voids suggests mix designs need to adapt to provide more workable mixes with careful consideration of binder and filler content.

7 Surface Site Inspection

Tonkin Consulting along with a DPTI representative conducted a site inspection to visually assess the surface quality of the different surfaces at each site. Each surface was given a rating between 1 and 4 as an arbitrary assessment of the surface texture and consistency of texture; 1 being the 'smoother' and more consistent surface, while 4 being coarse in appearance and inconsistent in texture.

Upon averaging the results the mix types are presented below in order of visual appearance from best to worst:

- Mix A: class 320 bitumen
- Mix C: class 170 bitumen with RAP
- Mix D: class 170 bitumen with RAP and WMA additive
- Mix B: class 320 bitumen with WMA additive.

While this is a subjective assessment it can be seen that normal asphalt (C320) provides the best appearance which is consistent with the lowest air voids in Figure 5.1 and normal asphalt (C170) with RAP provides the second best appearance which also coincides with the order of best compaction results in Figure 5.1. The third best mix was C170 with RAP and WMA which was the worst in terms of field air voids. The fourth best mix, visually, was C320 with WMA, which was the third best in terms of field air voids (Figure 5.1).

As an example, see below the photos of the surfaces that rated well at each site compared to other mix types at the same site. Not all are considered ideal but rather provide a visual indication of what the best mix looks like for A, B, C and D mixes.

Figure 7.1 Counter Road Mix A - C320

(Binder Content 6.1%, BFT_raw 8.47 micron, BFT_adj 8.4 micron, 7.1% 0.075 mm sieve, Insitu Air Voids min 2.8% max 4.2%), Lab voids 4.2%

This shows a consistent and smooth surface with low air voids.

Figure 7.2 Counter Road Mix B – C320WMA

(Binder Content 6.1%, BFT_raw 7.63micron, BFT_adj 7.57 micron, 8.4% 0.075 mm sieve, Insitu Air Voids min 5.1% max 6.6%), Lab voids 2.8%

This is a similar appearance to mix A at the same site, however the field voids were higher with warm asphalt.

Figure 7.3 Elmgrove Road Mix C – C170RAP

(Binder Content 5.4%, BFT_raw 8.5micron, BFT_adj 7.58 micron, 6.5% 0.075 mm sieve, Insitu Air Voids min 6.71% max 8.56%), Lab voids 5.5%

While this mix rated well in comparison to other mixes at the same site, the bony appearance is noticeable with inclusion of RAP and higher air voids.

Figure 7.4 Bridges Road Mix D – C170RAPWMA

(Binder Content 5.6%, BFT_raw 9.23micron, BFT_adj 8.26 micron, 6.8% 0.075 mm sieve, Insitu Air Voids min 6.1% max 7.5%), Lab voids 5.2%

While this mix was consistent the open texture was noticeably consistent with the higher filler and lower binder content. Air voids are on the higher side also and RAP is not noticeable.

The photos below provide an indication where the rating was poor.

Figure 7.5 Woodcroft Drive Mix A - C320

(Binder Content 5.8%, BFT_raw 8.24micron, BFT_adj 8.19 micron, 6.8% 0.075 mm sieve, Insitu Air Voids min 6.2% max 7.4%), Lab voids 6%

This is a more open texture and not typical of a binder rich, low air void appearance.

Figure 7.6 Castlebar Road Mix B – C320WMA

(Binder Content 6.0%, BFT_raw 8.1micron, BFT_adj 8.0 micron, 5.5% 0.075 mm sieve, Insitu Air Voids min 6.9% max 7.8%), Lab voids 3.7%

In comparison to Figure 7.5, this has slightly less bony appearance presumably due to higher binder, however air void remains similar and high.

Figure 7.7 Counter Road Mix C – C170RAP

(Binder Content 6.1%, BFT_raw 7.8micron, BFT_adj 7.74 micron, 8.1% 0.075 mm sieve, Insitu Air Voids min 3.3% max 5.0%), Lab voids 2.4%

While the voids were low, the binder was high and the inconsistency and bony appearance was noticeable.

Figure 7.8 Marleycombe Road Mix D - C170RAPWMA

(Binder Content 5.7%, BFT_raw 8.23micron, BFT_adj 8.15 micron, 6.8% 0.075 mm sieve, Insitu Air Voids min 8.5% max 9.9%), Lab voids 5.8%

The consistency is bony and air voids are very high.

Based on this visual assessment the consistency, tight binder rich appearance of a low air void surface was not observed generally. Rather a bony more open texture was more readily noticeable.

8 Cost Benefits

A cost benefit for any alternative mix is a clear objective for councils. The desired benefit is an extended life for the surface beyond that offered by current surface specification. The increase in useful life, if any, is yet to be determined for the mixes considered in this trial.

However, for the cost side of the equation there is already some data available.

8.1 Cost of production for each of the mixes

The asphalt suppliers involved in this study have each indicated a relative cost of production for the trial mixes compared to a baseline of their cost for standard Class 320 bitumen AC10 Council Hotmix. The results of the 4 Contractors were averaged and are shown in Table 8.1.

Table 8.1 Relative production costs for mix specifications

Mix Specification	Binder (%)	RAP (%)	Avg.
Class 320 bitumen AC10 Council Hotmix	5.5%	0	0.0%
Class 320/170 bitumen Hotmix	5.6%	0	1.0%
Class 320/170 bitumen Hotmix	5.7%	0	2.0%
Class 320/170 bitumen Hotmix	5.8%	0	2.9%
Class 320/170 bitumen Hotmix	5.9%	0	3.6%
Class 320/170 bitumen Hotmix	6.0%	0	4.6%
Class 320/170 bitumen Warmmix	5.5%	0	1.2%
Class 320/170 bitumen Hotmix	5.5%	10%	0.1%
Class 170 bitumen Hotmix	5.5%	20%	-1.5%
Class 170 bitumen Hotmix	5.5%	30%	-3.3%
Class 170 bitumen Hotmix	5.5%	40%	-2.7%*

** There were only 3 contractors that provided costs for a 40% RAP product. The relative production cost is therefore not as reliable as for other mixes where all 4 contractors provided a price.*

Based on these figures the following costs comparison is made for the trial mixes.

Table 8.2 Relative production costs by trial mix

			Production Costs	
	Description	RAP Content	5.5% Binder	6% Binder
Mix A	C320	0%	0.0%	4.6%
Mix B	C320 WMA	0%	1.2%	5.8%
Mix C	C170 RAP	10%	0.1%	4.7%
	C170 RAP	20%	-1.5%	3.1%
	C170 RAP	40%	-2.7%	1.9%
Mix D	C170RAPWMA	10%	1.3%	5.9%
	C170RAPWMA	20%	-0.3%	4.3%
	C170RAPWMA	40%	-1.5%	3.1%

There is a strong trend of increasing cost with increasing binder % and decreasing costs with increasing RAP%.

From this analysis the supply cost of asphalt from the plant when compared to a standard C320 5.5% binder mix can vary from -1.5% to +5.9%.

Binder is the most significant cost factor so increase of 5.5% to 6% for the trial increased the costs significantly.

Figure 8.1 shows results by mix type with groupings centred around binder quantities of 5.5% (left grouping – lower production cost) and 6% (right grouping higher production cost).

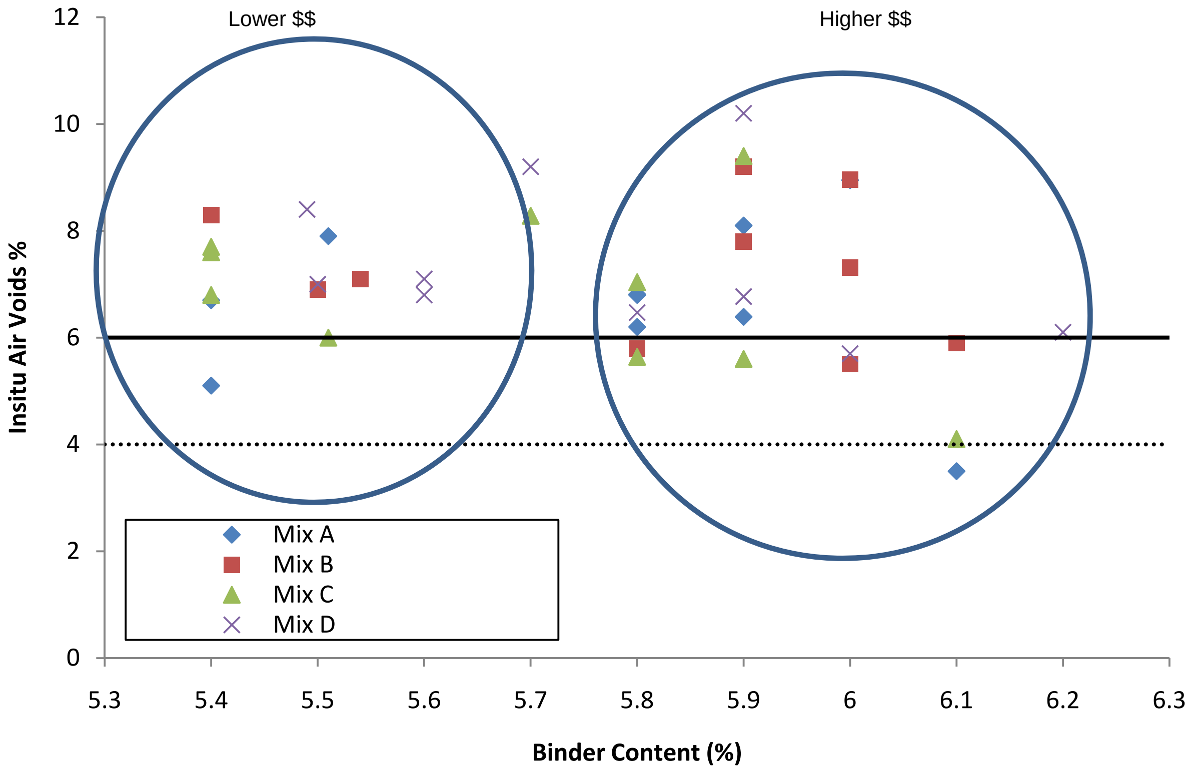

Figure 8.1 Insitu Air Voids against Binder Content by Mix

Mix A – For an increase in 4.6% cost of production the trial results indicated mixed results with reduction in air voids with higher binder.

Mix B – For an increase in 5.8% cost of production the trial results indicated that (3/11) 27% achieved the target (4-6%) voids in the field with higher binder, however 4 other sites showed higher air voids with higher binder .

Mix C – For an increase of between 3.1% and 4.7% in the cost of production (for 10% / 20% RAP) the trial results indicated a stronger trend with (4/11) 36% achieving the target (4-6%) voids in the field with higher binder, however 2 other sites shows high air voids with higher binder.

Mix D – For an increase of between 5.9% and 4.3% the cost of production (10% / 20% RAP) the trial results indicated there is a small reduction in field voids but only (1/11) 9% achieved within the range of 4-6% voids.

9 Discussion

The results from the trial sections provide a good indication of the asphalt products being delivered to Metropolitan Local Government in South Australia.

While the sample data is relatively small, it is sufficient to help provide direction to Local Government and industry to work together with DPTI to find ways to improve the manufacturing and placement of asphalt for low volume roads.

The application of the recommendations of this report apply to light free flowing traffic with streets carrying less than 100 commercial vehicles per day with less than 5 x 105 ESA.

The key findings can be summarised as follows.

Deflection

There was no direct link found between deflection of existing pavement prior to resurfacing and compaction for deflections below 1.3 mm. The sample size was too small to provide comment when deflections are above 1.3 mm, and should be further explored in future trials.

Air Voids

The trial was established with the intent to achieve 4-6% air voids in the field. The results of the trial indicate that the mixes used and work practices need to further adapt in order to reduce field air voids to this target range.

Binder

The trial provides some confidence that increasing binder content above 5.5% is a cost effective way to help reduce field air voids. Mixes with binder contents less than 5.8 that corresponded with binder film thickness 60% absorption less than 8.5 did not perform well with field compaction.

Filler

The trial indicates that filler binder ratio above 1 and mixes with 0.075 mm sieve (%) passing greater than 6 achieved lower field voids. A relationship with BFT 60% absorption revealed the higher the filler binder ratio (1 to 1.4) the lower the BFT 60% results (8.5-7.5) for low field air voids. Filler binder ratio less than 1 and BFT 60% greater than 9.5%, despite high binder did not perform in terms of field voids.

Binder Type

The trial provides some evidence that C170 binder responds better than C320 binder in reducing field air voids with higher binder content, however this needs to be tempered with risk of rutting.

Laboratory Air Voids

The trial used a range of laboratory air void to maximise compaction in the field. The report recommends lowering laboratory air voids to 4% (50 cycles Gyproc AS 2891.2).

Warm Asphalt

The trial indicated that warm asphalt compaction was less than traditional hot asphalt. Industry needs to further develop mix designs recognising the higher offset between laboratory and field compaction and the increased workability with higher binder contents.

General

From this trial a set of technical recommendations have been developed in order for DPTI to modify the standard asphalt specification for wide use by Local Government and Industry in South Australia.

The protocol established by this project has the potential to be used for future trials.

The trial has also left open the opportunity for Local Government and Industry to continue with a coordinated approach to improve the level of testing and reporting and potentially share information.

It is anticipated further funding will be needed for further specification developments and the analysis of results for further trials.

ITS

The trial provides evidence that increasing the binder reduces the Indirect Tensile Strength (ITS) of the asphalt. At this stage it is too early to observe any performance issues with lower ITS, however it is anticipated that ITS will not be a key criteria for testing for low volume roads. This will be further reviewed once the trial sites have been trafficked and re-inspected in 2 years.

10 Technical Recommendations

1. Adopt 4% Laboratory air voids (50 cycles Gyropac – AS 2891.2.2) for mix designs to improve workability for low volume road asphalt. The specification will provide a suitable range.
2. Incorporate a minimum binder film thickness (60% absorption) of 8.0 micron recognising the trial results and monitoring with road authority's trends across the country.
3. At this stage the use of filler/binder ratio as a specification reference is not supported, however figure 6.15 provides some reference for mix designers for referencing field void performance and relationships with BFT (60%) and filler/binder ratio when selecting filler content in mixes.
4. A minimum binder content of 5.7% should be specified.
5. Local Government should consider making density determination from the insitu asphalt part of the normal product acceptance process using characteristic values that are statistically analysed with a minimum of 4 samples per street.
6. Local Government and Industry should use the results of this trial to develop reasonable incentive/penalty clauses in contracts to reward Contractors for delivering low field air void mixes (4-6%) and penalise contractors for high air void mixes commensurate with the expected life reduction for every % above 7%.
7. Local Government should be aware of the potential for lower compaction with warm asphalt and industry should embrace more workable mixes to achieve compaction at lower field temperatures. This should occur with understanding of the offset between laboratory and field compaction and temperature.
8. Review density results for 'conventional' asphalt mixes used on low volume roads in SA and compare them to the results for the fine graded high binder content mix used in this study.
9. Review construction practices, and in particular, compaction practices.
10. As a result of this trial local government should use the specification update through DPTI (refer Appendix B) which includes the key recommendations from the trial.
11. LGA consider scope for continuation of a coordinated approach to funding research and to keeping abreast of national development.

11 References

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Appendix A

Trials Protocol Document

Local Government Research and Development Scheme

Low Volume Road Asphalt Trial in SA -

Protocol for the Establishment of Road Trial Sections

City of Salisbury

February 2013

Ref No. 20120799FR1C

Rod Ellis (Tonkin Consulting)

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Document History and Status

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C	Acknowledgement added	RKE	RKE	RKE	22 February 2013

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- City of Playford
- City of Port Adelaide Enfield
- Corporation of the City of Marion
- Corporation of the City of Adelaide
- Adelaide Hills Council
- City of Unley
- Light Regional Council
- IPWEA

Contents

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Appendices

1 Background

The aim of the low volume road trial project is to evaluate asphalt mixes that are specifically intended for use on residential streets carrying limited numbers of heavy vehicles. These mixes are designed to yield a longer life, to be more environmentally sustainable and to minimise whole-of-life cost. The mixes would also be suitable for use in pedestrian areas and for maintenance patching.

The technical characteristics of the asphalt designs include: a fine, dense graded aggregate distribution in combination with a high binder content. The aim is to create mixes that are easy to compact, this is to remedy the rapid cooling that takes place when mixes are constructed in thin layers and the influence of other compaction challenges such as stiffness of underlying pavement, irregular shape of underlying pavement, access for full size paving and compaction equipment. Mixes will be constructed to a low insitu air voids content. This will reduce the permeability of the mixes, which helps to protect the underlying granular layers and limits oxidation aging of the binder. The high flexibility of the mixes will accommodate the relatively high deflections in residential street pavements.

Some of the trial mix designs will include Reclaimed Asphalt Pavement (RAP) to increase environmental sustainability and reduce cost.

Some of the trial mix designs will include warm mix asphalt additives to further improve compactability of the mixes and increase environmental sustainability.

Some of the trial mix designs will include a softer grade bitumen (Class 170), to improve compactability durability and flexibility of the material.

This document is intended for use by local governments as guidance in selecting the mix designs for trials and for establishing trial sites.

The outcomes of the trials will guide specification development in collaboration with DPTI.

2 Selecting an Appropriate Trial Site

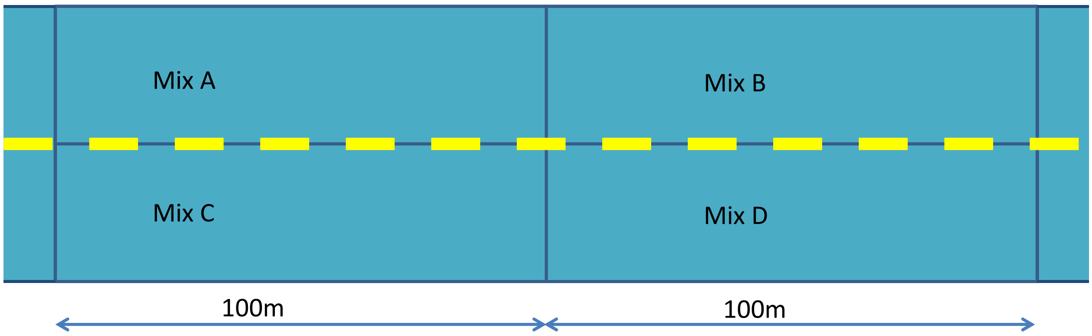
The trail site should be an urban street carrying traffic that falls within the lowest category of Table A 2 of the Austroads 'Guide to Pavement Technology Part 4B: Asphalt', i.e.:

- A street that carries less than 100 commercial vehicles per lane per day.
- The structural design level for the street should be less than 5 x 10^5 ESAs.
- Light free flowing traffic.

For the purpose of the trial a street should be selected that does not include steep inclines or busy intersections.

The intention is to trial four variations of a single mix design at each site. In order to achieve this, each site should be subdivided into four subsections. Each subsection should be at least 100m in length. Opposite lanes of a street could be used to construct the four subsections within 200m of total street length, as shown schematically in Figure 2.1. Ideally however, there would be a 50m change over zone between mixes to prevent the need for cold joints between the mixes.

Figure 2.1



The following information on the condition of the trial site and the nature of the proposed works should be gathered:

- The reason why the road or street is being resurfaced.
- A visual condition survey of the road, including photo register should be developed.
- A record of a visual inspection of the site describing any defects and the location (chainage) of the defects.
- The extend of the preparation works carried out before the trial is installed (e.g. patches and crack sealing).
- Describe the proposed profiling treatment and any potential for bond breakage between existing layers.
- A recent traffic count, differentiating commercial vehicles, should be available for the trial section.
- Ideally, a Falling Weight Deflectometer (FWD) survey of the section would be performed before the trial mix is installed. A testing pattern of one FWD measurement every 20m of trial section length is recommended.

The Council is required to complete Form 1 – Trial Site Condition form in Appendix A.

3 Mix Designs

The intention is that for all subsections of a trial the mix design is kept the same in terms of aggregate grading and binder content. The variables between the mixed on the subsections will consist of the binder type used, the use of warm mix additives, and the inclusion of RAP. The following variations between the mixed for each of the subsections are proposed:

A. Class 320 bitumen

B. Class 320 bitumen in combination with a warm mix additive

C. Class 170 bitumen in combination with 20% RAP

D. Class 170 bitumen in combination with 20% RAP and a warm mix additive

As part of the preparation for the low volume road asphalt trials, adjusted versions of DPTI specifications Part 227: Supply of Asphalt and Part 228: Construction of Asphalt Pavements will be prepared. The asphalt materials for the trial sections should comply with these specifications. A summary of the mix design method for fine dense graded mixes for low volume roads in the specifications is provided below. This summary is intended as a guideline only, the mix designs and material should comply with all relevant requirements in Part 227 and Part 228, with the following exceptions:

- For the purpose of the trial, the inclusion of hydrated lime as a filler is allowed, but is not a requirement.
- For the purpose of the trial, the inclusion of 20% RAP is allowed.

The fine graded mixes for the trial shall have a nominal maximum particle size of 10mm, the grading envelope is provided in Table 1 (which is based on AS2150).

Table 3.1

MIX GRADING ENVELOPES OF FINE DENSE MIX ASPHALT *		
SIEVE	FAC10	
19	100	100
13.2	100	100
9.5	100	90
6.7	90	75
4.75	77	62
2.36	56	43
1.18	40	29
0.6	28	19
0.3	19	12
0.15	12	7
0.075	7	4

The recommended mix design procedure consists of determining an optimum binder content based on a 50 gyratory cycles compactive effort, targeting 4.5% air voids in the laboratory. However for the trial, the designer is free to deviate from this procedure to produce a mix that can be more readily compacted to 4.0 to 6.0% air voids in the field, as field density is the key requirement for the design. The minimum binder content is 5.5% and the laboratory air voids and binder film thickness are reporting requirements rather than specified to allow the Contractor to showcase their mix designs to meet field requirements. This may include going higher with the binder content than the minimum for the trial to help inform the wider industry on what binder content provides the optimum results in the field.

For the mix design selected for the trial report:

- Combined aggregate grading.
- Binder content.
- Film thickness.
- Laboratory air voids at 150°C.
- Laboratory air void at proposed laying temperature for warm asphalt.

For each of four variations of the mix design report:

- Bulk density and air void content at 50 gyrations, and optionally at 10,20,30,40 gyrations if the equipment allows for this.
- Maximum density.
- Indirect tensile strength (on laboratory produced mix).
- Aggregate grading after inclusion of RAP (this should be as close as possible to the grading of the original mix design).
- RAP content.
- RAP binder content and grading.
- Origin of RAP, i.e.: plant waste, reclaimed from road, a combination of these two sources, or unknown.

The contractor is required to complete Form 2 – Mix Design Report form in Appendix B.

4 Construction

The target for compaction of the trial mixes in the field should be to achieve an air void content of 4.0% to 6.0%.

For each batch of mix produced for the trial retain 40kg of plant produced sample in tins for future performance testing.

The following should be recorded during the trial:

- Ambient air temperature.
- Temperature of existing surface prior to AC placement.
- Temperature of the mix at the auger for each truck load of material.
- Temperature of the asphalt mat prior to compaction.
- Type of compaction equipment, weight, number of rollers, whether vibratory or static rolling was used, rolling pattern (incl. number of passes).
- Perception whether the mix is easy to compact.
- Any delays during paving.
- Any signs of segregation, excess fines or excess binder.
- Any deficiencies, e.g. open construction joints.
- Visual condition, photos of the finished surface.

The Council and Contractor are required to complete Form 3 – Construction Record form in Appendix C.

5 Monitoring

One day after construction, a minimum of four cores should be taken from each subsection of the trial to verify whether compaction was achieved. The cores should also be tested for permeability. The testing for field compaction should occur in the centre third of the section to avoid transition zones from one mix to the other. It is intended to examine individual core results, mean and characteristic values to help inform future specification requisites for compaction.

Periodic visual inspection of the trial sites will be performed by the LGA asphalt trials project team. The inspections will include rut measurements using a 3 metre straight edge, and records of cracking, ravelling and surface texture.

Appendix A

Trial Site Condition Form

Low volume road asphalt trial
Form 1 - Trial site condition form

Site description

Name:				Date:	
Location of the site:					
Traffic	Light vehicles per lane per day:			Percentage commercial vehicles:	
Reason(s) for road being resurfaced:					
Age of existing surfacing					
Extent of preparation works carried out (e.g. patches, crack sealing)					
Describe profiling treatment and potential for debonding					
FWD survey conducted?	yes	no			
Provide situation sketch of site and proposed location of different mixes (refer Figure 1 of protocol)					

Low volume road asphalt trial
Form 1 - Trial site condition form

Visual assessment

Rate the condition of the existing surfacing at the trial site. Develop a photo register of the observed distresses and the overall condition of the section Rank the degree and extent of different distress types on a scale of 0 to 5, using the following guideline:

Degree = 1: slight distress, hardly visible   Degree = 5: severe distress

Extent = 1: isolated occurrence   Extent = 5: extensive occurrence over a most of the section

Use degree = 0 and extent = 0 in case the distress type does not occur at the section

Distress type	Degree	Extent
Longitudinal cracks		
Transverse cracks		
Crocodile cracks		
Surfacing defects (potholes)		
Bleeding/Flushing		
Pumping of fines		
Rutting		
Undulation (differential settlement)		
Patching		
Services trenching		
Drainage problems		
Location sketch of distresses, if relatively isolated:		

Presence of trees at site (please tick)

	exclusive		average		isolated		No trees

Appendix B

Mix Design Report Form

Low volume road asphalt trial
Form 2 - Mix design report form

Mix design for trial at:		Date:	

Combined grading

Sieve size [mm]	Percent passing
19	
13.2	
9.5	
6.7	
4.75	
2.36	
1.18	
0.6	
0.3	
0.15	
0.075	

Target Binder content	[%]

Hydrated lime content (not a requirement)	[%]

Low volume road asphalt trial
Form 2 - Mix design report form

Properties of the variations to the mix design

Mix	A	B	C	D
Binder type				
Warm mix additive (type)				
Bulk density (50 gyrations) [t/m³] (AS2891.9.2)				
Maximum density [t/m³] (AS2891.7.1)				
Air void content after 50 gyrations [%] (AS2891.8) *				
Temperature record for lab air voids (°C)				
Binder film thickness [µm]				
Indirect tensile strength [MPa] TP 460				
RAP content [%]				
Bulk density (40 gyrations) (optional) [t/m³] (AS2891.9.2)				
Bulk density (30 gyrations) (optional) [t/m³] (AS2891.9.2)				
Bulk density (20 gyrations) (optional) [t/m³] (AS2891.9.2)				
Bulk density (10 gyrations) (optional) [t/m³] (AS2891.9.2)				

* Note: Laboratory air voids at 150°C for a standard mix and at proposed laying temperature for warm asphalt.

A. Class 320 bitumen
B. Class 320 bitumen in combination with a warm mix additive
C. Class 170 bitumen in combination with 20% RAP
D. Class 170 bitumen in combination with 20% RAP and a warm mix additive

Low volume road asphalt trial
Form 2 - Mix design report form

Combined grading after inclusion of RAP

Sieve size [mm]	Percent passing
19	
13.2	
9.5	
6.7	
4.75	
2.36	
1.18	
0.6	
0.3	
0.15	
0.075	

Low volume road asphalt trial
Form 2 - Mix design report form

RAP grading

Sieve size [mm]	Percent passing
19	
13.2	
9.5	
6.7	
4.75	
2.36	
1.18	
0.6	
0.3	
0.15	
0.075	

RAP Binder content	[%]

Source of RAP (please tick)

	Plant waste (1)		Reclaimed from road (2)		Combined (1+2)		Unknown

Appendix C

Construction Record Form

Low volume road asphalt trial
Form 3a - Construction record

Construction record for trial at:		Date:	

Target level of compaction: 4.0 – 6.0 % air voids

Was 40 kg of plant produced sample retained in tins for every mix type?	Yes	No

Mix	A	B	C	D
Ambient air temperature [°C]				
Surface temperature prior to AC placement [°C]				
Temperature of mix at auger [°C]				
Temperature of mat prior to compaction [°C]				

Type of compaction equipment	
Weight	
Number of rollers	
Vibration / static	
Rolling pattern (incl. number of passes and vibration setting)	
Was the mix easy to compact? (Easy, Average, Difficult)	
Detail delays during paving	

A. Class 320 bitumen
B. Class 320 bitumen in combination with a warm mix additive
C. Class 170 bitumen in combination with 20% RAP
D. Class 170 bitumen in combination with 20% RAP and a warm mix additive

Low volume road asphalt trial
Form 3a - Construction record

Details and location of any segregation, excess fines, excess binder	
Describe any deficiencies (e.g. open joints)	
Describe visual condition of finished pavement, develop photo record	
Comments	

Low volume road asphalt trial
Form 3b - Construction record

Monitoring

A minimum of four cores per mix are to be taken for density determination. For each mix cores should be taken from the middle third of the paved section shall be the arithmetic mean of the five most recent test results for that mix as per DPTI specification Part 228. :

Maximum density

Mix	A	B	C	D
Mean maximum density [t/m^3] (AS2891.7.1)				

Bulk density

Mix A

	Core 1	Core 2	Core 3	Core 4
Bulk density [t/m^3] (AS2891.9.2)				
Air void content (AS2891.8) [%]				

Mix A

Mean air void content [%]	
Standard deviation [%]	
K (DPTI Part 228, Table 9.20	
Low characteristic value of air voids content (Lvc) [%]	
High characteristic value of air voids content (Hvc) [%]	

A. Class 320 bitumen
B. Class 320 bitumen in combination with a warm mix additive
C. Class 170 bitumen in combination with 20% RAP
D. Class 170 bitumen in combination with 20% RAP and a warm mix additive

Low volume road asphalt trial
Form 3b - Construction record

Mix B

	Core 1	Core 2	Core 3	Core 4
Bulk density [t/m^3] (AS2891.9.2)				
Air void content (AS2891.8) [%]				

Mix B

Mean air void content [%]	
Standard deviation [%]	
K (DPTI Part 228, Table 9.20	
Low characteristic value of air voids content (Lvc) [%]	
High characteristic value of air voids content (Hvc) [%]	

Mix C

	Core 1	Core 2	Core 3	Core 4
Bulk density [t/m^3] (AS2891.9.2)				
Air void content (AS2891.8) [%]				

Mix C

Mean air void content [%]	
Standard deviation [%]	
K (DPTI Part 228, Table 9.20	
Low characteristic value of air voids content (Lvc) [%]	
High characteristic value of air voids content (Hvc) [%]	

A. Class 320 bitumen
B. Class 320 bitumen in combination with a warm mix additive
C. Class 170 bitumen in combination with 20% RAP
D. Class 170 bitumen in combination with 20% RAP and a warm mix additive

Low volume road asphalt trial
Form 3b - Construction record

Mix D

	Core 1	Core 2	Core 3	Core 4
Bulk density [t/m³] (AS2891.9.2)				
Air void content (AS2891.8) [%]				

Mix D

Mean air void content [%]	
Standard deviation [%]	
K (DPTI Part 228, Table 9.20	
Low characteristic value of air voids content (Lvc) [%]	
High characteristic value of air voids content (Hvc) [%]	

A. Class 320 bitumen
B. Class 320 bitumen in combination with a warm mix additive
C. Class 170 bitumen in combination with 20% RAP
D. Class 170 bitumen in combination with 20% RAP and a warm mix additive

Appendix B

DPTI Specification Part 227 and 228

PART 227

SUPPLY OF ASPHALT

CONTENTS

1. GENERAL

This Part specifies the requirements for the supply of asphalt, including the design and manufacture of the following:

(a) Coarse Dense Mix Asphalt (AC10, AC14 & AC20);

(b) Fine Dense Mix Asphalt (FineAC7, FineAC10 & FineAC14);

(c) Open Graded Asphalt (OG10, OG14); and

(d) Stone Mastic Asphalt (SMA7, SMA10).

The meaning of terms used shall be as defined in:

(a) AS 2150 "Hot Mix Asphalt-A Guide to Good Practice"; and

(b) Austroads 4B “Guide to Pavement Technology Part 4B Asphalt”.

"Nominated Mix" means an asphalt mix design proposed by the Contractor.

"Asphalt Mix Register Number" is a mix approval number provided by DPTI to an accepted nominated mix. All mixes are placed on an Asphalt Mix Register and monitored by DPTI.

"AAPA" means Australian Asphalt Pavement Association.

"Process Control" means a controlled documented system of practices and procedures used to monitor and control the product inputs, equipment and manufacturing processes to ensure the product replicates the product design.

“Additive” means an organic wax or similar used to assist in the compaction of asphalt.

"Coarse Asphalt Mix" (AC) means asphalt of a coarse nature suitable for Medium, Heavy and Very Duty applications and is the standard mix for all DPTI applications unless used in Fine Asphalt Mix applications or expressly noted otherwise.

"Fine Asphalt Mix" (FineAC) means asphalt of a fine nature suitable for Light to Medium Duty applications and suitable for DPTI patch maintenance, bikeways, footpaths, car parks and Local Government residential streets.

2. QUALITY REQUIREMENTS

2.1 Process Control

The Contractor shall develop and implement a Process Control System.

Quality Plan, Procedures and Documentation

Further to the requirements of Part 140 "Quality System Requirements", the Contractor shall prepare and implement a Quality Plan that at a minimum includes detailed procedures and documentation for:

(a) Mix Design.

(b) Manufacture of Mixes.

- Process control requirements, which include a description of the flow of materials and the processes carried out on them from input materials to the plant through to delivery of asphalt to the customer. It shall incorporate a flow diagram and identification of the key elements of the manufacturing process requiring monitoring, measurement or verification
- Control of aggregates delivered to an asphalt plant
- Control of aggregates transferred from quarry stockpiles
- Requirements for labelling of storage bays and silos
- Requirements for heating, temperature control and insulation of tanks
- Requirements for labelling of tanks
- Control of binders
- Requirements for controlling delivery of binders into the correct tanks
- Control requirements for additives, admixtures, fillers and reclaimed asphalt
- Plant calibration and maintenance
- Control of batching instructions
- Weighing and delivery into trucks
- Description of the characteristics of any hot storage system and define its mode of operation
- Handling, storage and delivery of asphalt mixture to ensure the minimum of segregation or degradation and that the asphalt remains within the specified temperature range.

(c) Inspection and Test Requirements.

- An Inspection and Test Plan, vide Clause 140.7 "Inspection and Testing", which includes a schedule for monitoring and measuring the performance of the process (as identified in the key process element identification) and products. At a minimum, it shall meet the requirements of Clauses 227.6 and 227.7 and Appendix 227.1.
- Constant monitoring and statistical analysis of records to verify process capability and product characteristics.
- A Calibration Schedule, which includes daily visual inspection of all equipment and calibration of weighting equipment, admixture dispensers, flow meters, batching or proportioning systems and temperature monitoring equipment (vide Clause 140.7.4 "Inspection, Measuring and Test Equipment"). At a minimum, it shall meet the requirements of Appendix 227.1.

If not part of the Post Tender Submission, the procedures and documentation shall be submitted at least 10 days prior to the commencement of supply.

Provision of the procedures and documentation listed in this Clause shall constitute a **HOLD POINT**.

3. MATERIALS

3.1 Quality of Materials

Materials shall comply with the following:

Binder, Flux and Cutter	Part 225 "Supply of Bituminous Materials"
Aggregate and Mineral Filler	Part 215 "Supply of Pavement Materials"
Tack Coat	AS 1160 "Bitumen Emulsions for Construction and Maintenance of Pavements"
	AS 2157 "Cutback Bitumen"
Hydrated Lime Filler	AS 1672.1 "Limes for Building".

Plant waste (including asphalt and raw materials) shall not be incorporated in any mixes.

3.2 Reclaimed Asphalt Pavement Material

Reclaimed asphalt pavement material (RAP) shall be obtained from milling or excavation of existing asphalt pavements. RAP shall be crushed and screened as necessary to ensure a maximum size no greater than the maximum size of asphalt being produced and to achieve a reasonably well graded, free flowing, and consistent product.

RAP shall be free of foreign materials such as bound or unbound granular base, broken concrete or other contaminants.

Prior to use, RAP shall be placed in separate stockpiles not exceeding 500 tonne. Each stockpile shall represent a Lot, and test results shall be traceable between the Lot and asphalt mix containing the relevant RAP. RAP that has been stockpiled for some time and has bound together in some way shall be reprocessed, to ensure that it is in a free flowing state at the time of use.

4. MIX REQUIREMENTS

4.1 General

Mix properties for design shall comply with the requirements of the latest edition of AUSTROADS 4B, except as varied below.

All wearing course layers shall contain at least 1% added hydrated lime. Reclaimed Asphalt Pavement (RAP) shall not be included in any wearing courses. A levelling course that is trafficked between April and October inclusive shall be deemed to be a wearing course.

The determination of the design binder content of asphalt mixes to meet Table 4.2(a) requirements shall be based on the raw materials including C320 bitumen, aggregates, sands and fillers (and hydrated lime) excluding additives.

The Contractor shall obtain written approval for revised target air voids when additives are used.

4.2 Coarse Dense Mix Asphalt

Mix properties for the design and production control of coarse dense mix asphalt excluding RAP shall meet the requirements of Table 4.2(a) "Mix Properties of Coarse Dense Mix Asphalt" and mix target grading envelopes shall meet the requirements of Table 4.2(b) "Mix Grading Envelopes" and production tolerances on grading and binder content shall comply with Table 11 in AS 2150.

TABLE 4.2(a) MIX PROPERTIES OF COARSE DENSE MIX ASPHALT					
CHARACTERISTIC	**AC 10**	**AC 14**	**AC 20**	**AC14HB**	**AC 28***
Nominal Mix Sieve Size (mm)	9.5	13.2	19	13.2	26.5
Design Air Voids Target (%)	4.5	4.5	4.5	3.0	4.5
Production Air Voids Tolerance (%)	3.5 – 6	3.5 - 6	3.5 - 6	1.0 – 4.0	3.5 - 6
Tensile Strength Ratio (%)	75 min	75 min	75 min	-	75 min
Voids in Mineral Aggregate (VMA) (%)	15.5 min	14.5 min	13.5 min	-	13.0 min

* indicates 150 mm diameter specimens.

TABLE 4.2(b) COARSE DENSE MIX GRADING ENVELOPES *								
SIEVE	**AC10**		**AC14**		**AC20**		**AC28**	
50	100	100	100	100	100	100	100	100
37.5	100	100	100	100	100	100	100	100
26.5	100	100	100	100	100	100	92	80
19	100	100	100	100	92	80	81	67
13.2	100	100	92	80	82	66	-	-
9.5	92	80	83	67	70	53	61	43
6.7	82	66	70	54	60	43	-	-
4.75	70	52	60	43	51	34	45	26
2.36	48	34	42	28	36	23	32	18
1.18	34	21	30	19	27	14	24	11
0.6	24	14	21	12	19	10	17	7
0.3	17	8	16	7	14	6	13	4
0.15	11	5	10	6	9	5	9	4
0.075	7	4	6	3	6	3	6	3

* Aggregate gradings with percentage passing sieve size (mm), in accordance with AS 1152.

For very heavy duty mixes voids shall exceed 2.5% after 250 cycles. For AC 14 High Binder mix (AC 14HB), the grading properties shall be as for AC 14.

4.3 Fine Dense Mix Asphalt

Mix properties for design and control of fine dense mix asphalt excluding RAP shall meet the requirements of Table 4.3(a) "Mix Properties of Fine Dense Mix Asphalt", and the mix target grading envelopes shall meet the requirements of Table 4.3(b) "Mix Grading Envelopes of Fine Dense Mix Asphalt" and production tolerances on grading and binder content shall comply with Table 11 in AS 2150.

The requirements for fine dense mix asphalt shall be in the following order of precedence:

(a) This clause (Clause 4.3 "Fine Dense Mix Asphalt")

(b) AS2150 "Hot Mix Asphalt – A Guide to Good Practice"; and

(c) The rest of Part 227 "Supply of Asphalt".

TABLE 4.3(a) - MIX PROPERTIES OF FINE DENSE MIX ASPHALT			
CHARACTERISTIC	**FineAC7**	**FineAC10**	**FineAC14**
Nominal Mix Sieve Size (mm)	6.7	9.5	13.2
Minimum Binder Content (%)	6.0	5.7	5.2
Design Air Voids Target (%)(@ 50 cycles)	4.0	4.0	4.5
Production Air Voids Tolerance (%)	3.0 – 5.5	3.0 – 5.5	3.5 – 6.0
Binder Film Index (µm) Minimum	8.0	8.0	8.0

TABLE 4.3(b) - MIX GRADING ENVELOPES OF FINE DENSE MIX ASPHALT [(1)]						
SIEVE (mm)	**FineAC7**		**FineAC10**		**FineAC14**	
19						100
13.2				100	100	90
9.5		100	100	90	90	76
6.7	100	90	90	75	78	64
4.75	90	75	77	63	68	53
2.36	65	51	56	43	51	37
1.18	47	35	41	30	38	526
0.6	33	23	29	20	28	18
0.3	22	15	20	13	20	12
0.15	14	9	13	8	13	8
0.075	8	5	8	5	8	5

[(1)] Aggregate gradings with percentage passing sieve size (mm), in accordance with AS 1152.

4.4 Coarse / Fine Dense Mix Asphalt Including RAP

In addition to the requirements of this clause, Dense Mix Asphalt incorporating Reclaimed Asphalt Pavement shall meet the design requirements of Clause 4.2 "Coarse Dense Mix Asphalt" or Clause 4.3 "Fine Dense Mix Asphalt".

The viscosity reduction of combined asphalt with aged binder from RAP shall be deemed to be achieved by the following:

- For mixes with 5, 10% or 15% added RAP, no rejuvenation is required.
- For mixes with 20% added RAP, C170 binder shall be substituted for C320 asphalt binder.

RAP stockpile management shall include:

- Measurement and reporting of binder content and gradings at a minimum of two times per lot.
- Obtaining a one litre audit sample for DPTI for viscosity testing per lot.
- Meeting industry best practice requirements.

The proportion of RAP in the total mix shall not exceed 20%.

4.5 Open Graded Asphalt

Mix properties for design of Open Graded Asphalt shall meet the requirements of Table 4.5 "Mix Properties of Open Graded Asphalt", and shall be Austroads 4B Type II, to Medium Duty Design. The design is based on the Asphalt Particle Loss Test to provide a minimum binder content, voids at 20% providing maximum binder content, and the mean shall be adjusted up by the Asphalt Binder Drain-off Test to give the nominated design binder content.

The design gradings for open graded asphalt shall be within the envelope of AS 2150. The Contractor may add cellulose fibres to reduce binder drain down.

TABLE 4.5 MIX PROPERTIES OF OPEN GRADED ASPHALT		
CHARACTERISTIC	**OG10**	**OG14**
Nominal Mix Sieve Size (mm)	9.5	13.2
Design Air Voids Target (%)	AUSTROADS 4B	AUSTROADS 4B
Production Air Voids Tolerance (%)	18 - 23	18 – 23

4.6 Stone Mastic Asphalt

Mix properties for design of Stone Mastic Asphalt shall meet the requirements of Table 4.6 "Mix Properties of Stone Mastic Asphalt", and shall comply with the requirements of AAPA document "Stone Mastic Asphalt Design and Application Guide, 2000 Edition. The design shall be to Medium Duty category, and shall include a minimum of 1% of added hydrated lime filler, and 0.3% (by mass) cellulose fibre. Details for filler and fibre type and source shall be included in the nominated mix submission.

TABLE 4.6 MIX PROPERTIES OF STONE MASTIC ASPHALT			
CHARACTERISTIC	**SMA 7**	**SMA10**	**SMA14**
Nominal Mix Sieve Size (mm)	6.7	9.5	13.2
Design Air Voids Target (%)	3.5	3.5	3.5
Production Air Voids Tolerance (%)	3.0 – 5.0	3.0 – 5.0	3.0 – 5.0
Voids in Mineral Aggregate (VMA) (%)	19 min	18 min	17 min

4.7 Nominated Mixes

All nominated mixes shall be in accordance with MAT-PC044 “Approval and Registration of Asphalt Mix Designs”.

At least 10 working days before commencing production of asphalt, the Contractor shall submit to the DPTI Laboratory, Walkley Heights, details of each asphalt mix proposed, together with a Certificate from a laboratory with appropriate NATA registration, stating that each asphalt mix and its constituents meet the requirements of this Part.

Submission of the details of nominated mixes and Certificate(s) shall constitute a HOLD POINT.

For a nominated mix the aggregate grading and binder content and their sources shall be known as the "nominated combined aggregate grading" and "nominated binder content" respectively.

The use of an additive shall be deemed as a separate nominated mix.

The following details of nominated mixes shall be submitted:

(a) Constituent materials:

Aggregates - source, geological type,
Added Mineral Filler - type, source,
Binder - source, class or grade,
Bitumen Adhesion Agent - name, type, source,
Relevant test results verifying material properties for the above mentioned materials.

(b) Mix Design:

Design Mix maximum density,
Nominated combined aggregate grading,

Nominated binder content,
Mixing plant location, description and capacity.

(c) Test Results of the properties in Table 4.7 of representative material of each nominated mix produced by the mixing plant from which the asphalt is to be supplied.

(d) Manufacturer's instructions of any additive.

TABLE 4.7 NOMINATED MIXES - TESTING REQUIREMENTS

CHARACT-ERISTIC	AC 10#	OG 10#	SMA 7#	SMA 10#	AC 14#	FineAC 7/10/14#	SMA 14#	AC 20#	AC 14HB#	AC 28*
Gyropac Gyratory compaction										
Gradings	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Maximum Density	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Voids %	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
VMA	YES	NO	YES	YES	YES	YES	YES	YES	NO	YES
Tensile Strength Ratio	YES	NO	NO	NO	YES	YES	NO	YES	NO	YES
Binder Content	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Slab Compaction										
Resilient Modulus	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Dynamic Creep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Fatigue	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wheel Tracking	YES	NO	YES	YES	YES	NO	YES	NO	NO	NO

Gyropac Gyratory compaction to 250 cycles (very heavy duty mixes only)

CHARACT-ERISTIC	AC 10#	OG 10#	SMA 7#	SMA 10#	AC 14#	FineAC 7/10/14	SMA 14#	AC 20#	AC 14HB#	AC 28*
Voids %	YES	NO	NO	NO	YES	NO	NO	YES	NO	NO

100 mm diameter samples
* 150 mm diameter samples.

Testing shall be carried out on representative material of each "nominated mix" produced by the mixing plant from which the asphalt is to be supplied.

When requested, the Contractor shall submit a sample of 100 kg of loose asphalt of the nominated mix for verification of performance testing undertaken by the Principal.

4.8 Nominated Mix Performance Test Requirements

The Contractor shall conduct testing on plant produced mix as soon as practical after approval of the volumetric properties.

The nominated mix shall be tested as required by Table 4.7 and to meet the requirements of Table 4.8.

TABLE 4.8 MIX PERFORMANCE TEST PROPERTIES				
CHARACTERISTIC	**Wheel *Tracking AG:PT/T231**	**FATIGUE AG:PT/T233**	**Resilient Modulus AS2891.13.1**	**Creep AS2891.12.1**
AC10M35P AC10M10E	< 4 mm	-	-	-
SMA7M35P SMA10M35P	< 4 mm	-	-	-
AC10H35P AC10H10E	< 2 mm	-	-	-
AC14MC320 SMA14M35P	< 6 mm	-	-	-
AC14HC320	< 2 mm	-	-	-

* As repeatability testing for wheel tracking has not been carried out by DPTI, values shall be 'reported only' with values given being as a guide only, and are applicable for the Coopers Wheel Tracking Machine.

4.9 Job Mix Formula

The nominated mix will be assessed by DPTI for compliance with the requirements of this Specification. On compliance, an Asphalt Mix Register Number shall be allocated and shall be used as reference on all test data.

The Asphalt Mix Register Number shall have attributed to it a "Job Mix Formula" (JMF), described as the gradings, binder content and maximum density of the mix.

4.10 Compliant Mixes

If the Contractor has previously submitted the nominated mix to DPTI, and has a current Asphalt Mix Register Number from DPTI, and the mix has not been varied in accordance with Clause 4.9 "Variations to Nominated Mixes", the following shall be submitted:

(a) description of the Job Mix Formula; and

(b) copy of written compliance sheet from DPTI of the asphalt mix registration.

Submission of the above information shall constitute a **HOLD POINT**.

The Contractor shall monitor the production results of all their registered mixes, and shall submit a summary of previous mix production data for the submitted mix and to include:

(a) plot of voids verses binder content;

(b) summary sheet of JMF data; and

(c) summary of associated non-conformances and dispositions.

The Contractor shall demonstrate to DPTI that the average air voids determined from production tests are within ± 0.2% from target for 10 consecutive discrete samples.

In the event that the analysis of the production test results show that the average Air Voids is different from the Design Air Voids Target an alternative mix design shall be submitted.

4.11 Variations to Nominated Mixes

The Contractor shall submit a new nominated mix in compliance with Clause 4.6 "Nominated Mixes" if:

(a) the Contractor proposes to vary the proportions of the constituents in a nominated mix; or

(b) the Contractor proposes to change the source of supply of any constituent; or

(c) Asphalt Mix Register Number is withdrawn.

4.12 Mobile Plants

At commencement of a mobile plant each mix type with approved mix design shall be manufactured and placed in an approved trial location.

Plant settings and mix design parameters shall be met before proceeding with the permanent works and shall constitute a **HOLD POINT**. The cost of all verification work shall be borne by the Contractor

5. MANUFACTURE OF MIXES

5.1 General

Mixes shall be manufactured to replicate the Job Mix Formula in accordance with AS 2150, Clause 7 "Manufacturing and Storage of Mix".

Mixes shall not exhibit drainage of the binder and/or contain less than 95% of aggregate particles that are not fully coated with binder as determined by AS 2891.11.

Asphalt shall be manufactured so that its properties comply with the requirements specified in Clause 12 "Verification Requirements and Records".

5.2 Manufacturing Controls

Plant temperatures and mixing times shall be maintained in a range sufficient to ensure a homogenous mix without causing deleterious effects to the binder through overheating and within the manufacturer's specifications as detailed in AAPA Advisory Note 7. The binder temperature used for storage/transport shall not exceed the values shown against the binder class indicated in Table 5.2.

TABLE 5.2 MAXIMUM BINDER TEMPERATURE	
BINDER CLASS	**MAX. TEMPERATURE(^{o}C)**
170	180
320	185
600	195

The above maxima may be increased by up to 10^{o}C when additives such as polymers or scrap rubber are incorporated in the binder.

Spray temperature of the binder into a pugmill type environment shall be such as to minimise oxidation or drainage of the binder.

The temperature of the mix delivered into each truck shall be recorded on the weighnote.

5.3 Manufacture of Mixes Including RAP

In batch mixing plants, the RAP shall be either:

(a) metered into the asphalt plant after heating and drying of aggregates;

(b) added directly to the weigh hopper with other aggregate materials, for each batch; or

(c) weighed separately and added direct to the pugmill.

If necessary, batch mixing time shall be increased to ensure adequate heat transfer and dispersion of RAP. In drum mixing plants, RAP shall be protected from excessive temperatures by a combination of entry point to drum and shielding from direct flame contact.

5.4 Manufacture of Asphalt with Additive

Subject to prior approval, the Contractor may use an additive:

(a) to manufacture asphalt at a lower temperature; or

(b) to manufacture at standard temperature but time until placement is extended and placement temperature reduced,

Where placement temperature is reduced, compaction requirements shall still be in accordance with Part 228 "Construction of Asphalt Pavements"..

The propriety product of the additive used shall be fully disclosed in accordance with Clause 4.6 "Nominated Mixes".

6. SAMPLING AND TESTING

6.1 General

The Contractor shall conduct sampling and testing of asphalt and binder for control and verification purposes during manufacture. Minimum sampling and testing frequency for each mix type shall be as shown in Table 6.1.

For mixes meeting Clause 4.3 requirements, sample rate is one per day's production.

Sample	Fixed Asphalt Plant and approved * Process Control	Fixed Asphalt Plant without approved* Process Control	Mobile Asphalt Plant
1	30 - 150	30 - 75	0 - 30
2	151 - 350	76 - 175	31 - 105
3	351 - 600	176 - 300	106 - 205
4	Additional sample/test each 300 tonne > 601	301 - 450	206 - 330-
5		Additional sample/test each 200 tonne > 450	331 - 480
6			Additional sample/test each 200 tonne > 480

* As documented in Mix Assessment Forms

A day's production is defined as plant start up to shut down. The Superintendent shall be notified if this is greater than twenty four hours.

The following tests shall be performed on each sample:

(a) Binder Content and Aggregate Grading;

(b) Bulk Density on compacted specimens;

(c) Maximum density; and,

(d) Indirect Tensile Strength (minimum of one test per mix per day's production).

The following calculations shall be reported for each asphalt sample:

(e) Air voids;

(f) Absorption (for Presaturation Bulk Density Test);

(g) Effective binder content (using 55% water absorption);

(h) Binder film thickness; and

(i) VMA.

6.2 Audit Samples

The Contractor shall provide samples for product auditing purposes in accordance with the below requirements and provide notification when sampling has occurred. All samples shall be delivered to the DPTI Materials Laboratory at 19 Bridge Road, Walkley Heights at a minimum of weekly intervals. The samples will be stored at the Principal's expense. The Contractor shall provide documentation to confirm that the samples have been received at the DPTI Laboratory, and submit this as part of the Lot package. All samples shall be clearly marked and traceable to the relevant Lot in accordance with Part 140 "Quality System Requirements".

(a) Asphalt

(b) From each verification sample taken, the Contractor shall provide 2 duplicate samples of asphalt for retention by the Principal (i.e. Two sampling tins of mix taken from a truck at asphalt plant). These samples may be used for product auditing purposes. No samples are required for Local Government contracts unless notified otherwise.

(c) Residual Bitumen

The Contractor shall provide one sample per batch (minimum of 1 litre) for product auditing purposes (not required for mixes meeting Clause 4.3 requirements).

(d) Polymer Modified Binder

The Contractor shall provide one sample per batch (minimum of 1 litre) for product auditing purposes (not required for mixes meeting Clause 4.3 requirements).

6.3 Gyropac Compaction

Each Gyropac shall be calibrated against the Superintendent's Gyropac using side by side testing of sufficient samples as deemed by the Superintendent. The Superintendent reserves the right to apply a Gyropac Adjustment Number to the target mix design air voids.

7. PROPERTIES OF PRODUCTION ASPHALT

In replicating the Job Mix Formula properties, production mix variations shall not exceed the limits shown in Table 11 of AS 2150, except that no tolerances shall apply for all sieve sizes up from the nominal mix sieve size as defined in:

- Table 4.2(a) "Mix Properties of Coarse Dense Mix Asphalt";
- Table 4.3(a) "Mix Properties of Fine Dense Mix Asphalt".
- Table 4.4 "Mix Properties of Open Graded Asphalt; and
- Table 4.5 "Mix Properties of Stone Mastic Asphalt".

Variations of the production Air Voids from the Design Air Voids Targets shall not exceed the Limits of Production Air Voids Tolerance in:

- Table 4.2(a) "Mix Properties of Dense Mix Asphalt";
- Table 4.4 "Mix Properties of Open Graded Asphalt; and
- Table 4.5 "Mix Properties of Stone Mastic Asphalt".

8. STORAGE OF ASPHALT

Asphalt shall be stored in accordance with AS 2150, Section 7.5 "Storage of Mix".

9. DELIVERY OF MIX

Mix shall be transported to site in a manner which does not result in a deterioration of the properties of the mix or contamination of the mix. The Contractor shall ensure that transport operations are arranged in a manner which ensures continuous placing of asphalt. If haulage distance is measured for the purpose of payment, the haulage distance shall be calculated from the Nominated Asphalt Plant which is closest to the work site, regardless of whether it is sourced from any other plant for any reason (including breakdown). The haulage distance only includes the loaded trip only and excludes the return trip.

10. TEST PROCEDURES

The Contractor shall use the following test procedures (refer http://www.dpti.sa.gov.au/contractor_documents) to verify conformance with the Specification:

TEST	TEST PROCEDURE
Sampling of Raw Materials Aggregates Bitumen Mineral Filler	 TP 226 AS 2008 TP 226
Sampling of Asphalt	TP 425
Sample Preparation - Mixing, Splitting and Conditioning of Asphalt in the Laboratory	TP 426
Compaction of Asphalt Test Specimens using a Gyratory Compactor	TP 428
Determination of the Maximum Density of Asphalt - Water Displacement Method	TP 435
Bulk Density of Compacted Asphalt Specimens Presaturation Method for Dense Graded Mensuration Method for Open Graded	 AS 2891.9.2 and Note A below AS 2891.9.3
Measurement of Thickness or Height of Compacted Asphalt	ASTM D3549
Calculation of Voids	AS 2891.8
Calculation of Vma	AS 2891.8
Calculation of Binder Film Index	Austroads 4B
Binder Content - Pressure Filtration Method - Ignition Oven Method	TP 470 TP 473
Stripping Potential of Asphalt – Tensile Strength Ratio	AG:PT/T231
Static Indirect Tensile Test - Draft	TP 460
Asphalt Particle Loss	AG:PT/T236
Asphalt Binder Drain-Off	AG:PT/T235
Particle Size Distribution by Dry Sieving	AS 1141.11
Voids in Dry Compacted Fillers	AS 1141.17
Moisture Content	AS 1289.B1.3
Specific Surface	AS 2350.8
Loss on Ignition	AS 3583.3
Water Soluble Fraction of Filler	AS 1141.8
Deformation Resistance of Asphalt Mixtures by the wheel tracking test	AGPT/T231
Fatigue life of compacted bituminous mixes subject to repeated flexural bending	AGPT/T233
Determination of the permanent compressive strain characteristics of asphalt – dynamic creep test	AS2891.12.1
Determination of the resilient modulus of asphalt – indirect tensile method	AS2891.13.1

Note A: Alter the following Clauses within AS2891.9.2:

Remove Note in Clause 1 and replace with “This test method should be used only with dense graded asphalt.”

Add additional calculation to Clause 7:

Percentage of mass of water absorbed (b) in the following equation:

$$b = \frac{(m_3 - m_1)}{(m_3 - m_2)} * 100$$

Where

b = percent of water absorbed by mass

m1 = mass in air of the sample, in grams

pw density of water at the test temperature, in tonnes per cubic metre (from Table1)

m3 = mass in air of the saturated sample, in grams

m2 = mass in water of the saturated sample, in grams

Note 1: For dense graded asphalt, if the percent water absorbed by the specimen exceeds 2.0 percent, use an alternative method for determining bulk density.

Note 2: For stone mastic asphalt, if the percent water absorbed by the specimen exceeds 1.0 percent, use an alternative method for determining bulk density.

Add additional report to Clause 8:

Report the absorption to the nearest 0.01 percent.

11. HOLD POINTS

The following is a summary of Hold Points, vide Part 140 "Quality System Requirements", referenced in this Part:

CLAUSE REF.	HOLD POINT	RESPONSE TIME
2	Submission of Procedures and documentation (if not in Post Tender Submission)	7 working days
4.6	Submission of the details of nominated mixes and Certificate(s)	7 working days
4.9	Submission of Job Mix Formula and Mix registration.	7 working days
4.11	Submission of Trial mix data from a mobile plant	2 working days

12. VERIFICATION REQUIREMENTS AND RECORDS

12.1 Test Records

The Contractor shall undertake the testing specified in this Clause and shall supply written evidence of compliance with the lot package.

CLAUSE REF.	SUBJECT	PROPERTY	TEST PROCEDURE	TEST FREQUENCY	ACCEPTANCE LIMITS
5.1	Manufacture of Mixes	Binder Content & Aggregate Grading	TP 470 or TP 473	Refer Table 6.1 "Sampling and Testing Frequency"	Refer Clause 7 "Properties of Production Asphalt"
		Voids on compacted specimens	AS 2891.8	Refer Table 6.1 "Sampling and Testing Frequency"	Refer Clause 7 "Properties of Production Asphalt"
		Maximum density	TP 435	Refer Table 6.1 "Sampling and Testing Frequency"	Report Only
5.2	Manufacture of Mixes	Temperature at manufacture	Thermometer reading or infrared gun	Each truckload	Refer Clause 5.2 "Manufacturing Controls"
3.1	Materials for Asphalt	Properties of Binder, Flux, Cutter, Aggregate, Mineral Filler and Hydrated Lime	Refer Clause 3.1	Refer Clause 3.1	Refer Clause 3.1

12.2 Other Records

The Contractor shall supply the following records:

CLAUSE REF.	SUBJECT	RECORD TO BE PROVIDED
6.2	Sampling	Notification that audit sampling has occurred
6.2	Audit Samples	Documentation confirming delivery of audit samples

APPENDIX 227.1

ASPHALT INSPECTION TEST AND VERIFICATION

Table A1: Plant Inspection Schedule

Control Area	Inspection/test	Purpose	Frequency
Cold feed bins	As set out in quality plan	To ensure correct feeding of plant	a) On installation. b) As set out in quality plan.
Dryer Drum	As set out in quality plan	To ensure correct heating and drying of aggregates	As set out in quality plan
Hot feed bins	As set out in quality plan	To ensure correct batching	As set out in quality plan
Binder	Tank temperature Penetration or softening point	To check storage temperature To check for binder hardening[1]	a) Daily b) In case of doubt
Additive Silos	As set out in quality plan	To ensure correct feed rates for additives	As set out in quality plan
Mixed asphalt	Temperature	To ensure temperature conforms	a) Every batch or continuously

[1]Binder can harden during storage, particularly when circulated. The quality plan should state the 'safe' storage period for binder in its tank configuration and require testing if that period is exceeded without fresh deliveries. In the absence of other information, a period of two weeks should be adopted

Table A2: Inspection and Test Frequencies for Additives[1]

Inspection/test	Purpose	Frequency
Appropriate tests to determine intrinsic properties	To confirm characteristics of product or check compliance with specification	a) Source approval prior to initial use b) As stated in the quality plan
Inspection of delivery ticket	To check that consignment is as ordered and from the correct source	Each delivery
Organoleptic check of consignment	For comparison with normal appearance	Each delivery, if practicable; otherwise in accordance with quality plan

[1] This table may include the results of tests and inspections by the additive supplier as part of the Process Control System

Table A3: Inspection/test Frequencies for Asphalt to be Delivered

Product Inspection/test	Purpose	Frequency
Organoleptic check on mixed asphalt	For comparison with normal appearance with respect to grading, evenness of mixing and adequacy of coating	Every load
Temperature	To ensure material conforms with Clause 5 or other requirements	a) As required under Process Control b) Whenever samples are taken
Grading, Binder Content, Voids & Max. Density	To ensure material conforms to Clause 4	
Other design characteristics	To assess conformity	As detailed in quality plan
Suitability of delivery vehicles by visual assessment	To check adequacy of insulation	Prior to first use and in case of doubt
Cleanliness of delivery vehicles by visual assessment	To avoid contamination	Every load prior to loading[1]

Table A4: Plant Calibration Requirements

Item of plant	Inspection/test	Purpose	Minimum frequency
Weighing equipment	Visual inspection	To ascertain that weighing equipment is functioning correctly	Daily
	Testing of weighing accuracy	To ensure accuracy within quality plan requirements	a) On installation[1] b) Annually c) In case of doubt
Admixture dispensers	Organoleptic inspection	To ascertain that the dispenser is functioning correctly	First batch of the day containing admixture
	Test for accuracy	To ensure accuracy within quality plan requirements	a) On installation[1]) b) Annually c) In case of doubt
Flow meters	Comparison of the actual amount with the metered amount by reconciliation	To ensure accuracy within quality plan requirements	a) On installation[1] b) Annually c) In case of doubt
Batching system (on batch plants)	Comparison of actual mass of constituents in the batch with the intended mass using the method prescribed in the quality plan	To ascertain the batching accuracy in accordance with the quality plan	a) On installation[1] b) Annually c) In case of doubt
Proportioning system (on continuous plants)	Comparison of actual mass in a measured period of time with the intended mass using the method prescribed in the quality plan	To ascertain the accuracy in accordance with the quality plan	a) On installation[1] b) Annually c) In case of doubt
Temperature Monitoring equipment	Visual	To ascertain the equipment is functioning correctly	Daily
	Test of accuracy	To ensure correct temperatures are recorded	a) On installation[1] b) Annually c) In case of doubt

[1] or after comprehensive repair.

PART 228

CONSTRUCTION OF ASPHALT PAVEMENTS

CONTENTS

1. GENERAL

This Part specifies the requirements for the construction of asphalt pavements.

The meaning of terms used shall be as defined in:

(a) AS 2150 "Hot Mix Asphalt-A Guide to Good Practice"; and

(b) Austroads AGPT04/07 Guide to Pavement Technology – Part 4B: Asphalt (Austroads 4B)

"Additive" means an organic wax or similar used to assist in the compaction of asphalt.

"Coarse Asphalt Mix" (AC) means asphalt of a coarse nature suitable for Medium, Heavy and Very Duty applications and is the standard mix for all DPTI applications unless used in Fine Asphalt Mix applications or expressly noted otherwise.

"Fine Asphalt Mix" (FineAC) means asphalt of a fine nature suitable for Light to Medium Duty applications and suitable for DPTI patch maintenance, bikeways, footpaths, car parks and Local Government residential streets.

The asphalt shall be placed in the configuration specified in **Contract Specific Requirements** "Pavement Work" or on the Drawings.

2. QUALITY REQUIREMENTS

The Contractor shall prepare and implement a Quality Plan that includes detailed procedures for:

(a) Provision for traffic (if not covered in the Traffic Management Plan)

(b) Preparation of the surface

(c) Setting out

(d) Tack Coating

(e) Placing the mix

(f) Placement of any mix less than 30 mm thick (vide Clause 4.1)

(g) Placement of any mix between 10 – 15^{o}C (vide Clause 4.2)

(h) Protection of Wearing Course not open to traffic (vide Clause 4.3)

(i) Placement of crack sealing (including details of nominated product)

(j) Placement of Open Graded mixes (vide Clause 9.5)

(k) Level control and Compaction

(l) Finished Asphalt pavement properties

(m) Sampling and Testing.

If not part of the Post Tender Submission, the procedures shall be submitted at least 28 days prior to the commencement of site work.

Provision of the procedures listed in this Clause shall constitute a **HOLD POINT**.

3. MATERIALS

Asphalt shall comply with Part 227 "Supply of Asphalt".

Sprayed bituminous surfacing shall comply with Part 226 "Application of Sprayed Bituminous Surfacing".

4. CONSTRAINTS TO THE PLACEMENT OF ASPHALT

4.1 General

Where a layer of asphalt is laid less than 30 mm in thickness for any reason, it shall be deemed to be a "special process".

Open graded asphalt and stone mastic asphalt shall not be placed between April and October inclusive. Where the staging of asphalt construction involves exposing lower asphalt layers between April and October Inclusive, an impermeable layer such as AC10 or SAMI shall be incorporated to protect these potentially permeable layers.

Modified binder mixes shall not be used when the time between batching and delivery into the paver hopper exceeds 3 hours, unless the Contractor can demonstrate that such a mix can be adequately compacted.

4.2 Temperature Restrictions

Mix shall only be placed at temperatures which conform with AS 2150, Clause 12.4 "Asphalt Temperatures". The minimum mix temperature referred to in AS 2150, Table 12 shall be the temperature of the mix at the time that it is first placed on the surface.

Minimum temperatures for mixes containing C320 and C600 binder shall be 10°C higher than in AS 2150, Table 12, whereas for mixes incorporating modified binders the temperatures shall be 20°C higher. The range of mix temperatures shall be highlighted accordingly.

Temperatures for open graded mixes, including those with modified binders shall be as indicated in AS 2150.

Asphalt less than 100 mm thick shall not be placed when the pavement temperature (measured in the shade) falls below 10^{o}C. Where the pavement temperature is between 10 - 15^{o}C asphalt placed to a thickness of less than 40 mm shall be deemed to be a "special process".

Asphalt conforming to the requirements of Clause 227.5.4 “Manufacture of Asphalt with Additive” may be compacted at lower temperatures to those required in this clause. The minimum compaction temperature at time of placement shall not be below 120 C.

4.3 Wearing Course Restrictions

The wearing course shall not be placed on a bituminous seal earlier than one day and no later than seven days of the seal being commenced.

The wearing course shall not be laid earlier than 2 weeks prior to the opening to traffic, unless the Contractor prepares and implements a procedure to protect the wearing course from any deleterious environmental effects.

Traffic shall not be permitted on any wearing course until it has cooled to a temperature below 65^{o}C except for stone mastic asphalt, which shall be not be trafficked until it has cooled to a temperature of 40^{o}C. Water sprays shall not be used to cool the road surface until the surface temperature is below 70^{o}C.

Refer to Part 120 "Provision for Traffic" for other constraints relating to traffic control.

5. CRACK SEALING

5.1 General

Prior to the placement of asphalt for all pavement types, spray seals or wearing course any remaining cracks greater than 3 mm in width shall be sealed with an approved crack sealant.

5.2 Material

The crack sealing compound shall be Class 170 bitumen to AS 2008 "Residual Bitumen for Pavements", modified with an appropriate polymer, designed to penetrate the crack, adhere to the crack surface and resist further crack activity. At least 14 days prior to the use of the product, the Contractor shall submit the manufacturer's instructions and product performance data. Submission of the information shall constitute a **HOLD POINT**.

The material shall remain stable on the pavement surface during periods of extreme temperature.

Gritting off of sealant or plugging excessively deep cracks prior to sealing shall be undertaken with SA 5-2, 5-2 mm Sealing Aggregate.

5.3 Crack Sealing Treatment

Prior to placement of sealant, all cracks shall be thoroughly cleaned of foreign material, without damage to the adjoining sound pavement, to provide a clean, dry surrounding. If the pavement is damp, warm/hot compressed air may be used in the drying of the surface of the crack.

Crack sealing shall not be undertaken unless the surfaces of the cracks are dry. Cracks shall be cleaned to a depth of between 10 - 15 mm. In excessively deep cracks, the crack may be plugged with SA 5-2, 5-2 mm Sealing Aggregate to within 10 - 15 mm of the pavement surface. All cracks shall be filled with sealant material to a level of not less than 10 mm below the pavement surface.

The level of sealant after gritting shall be flush with the adjoining road pavement. The width of the visible bond on the pavement surface shall be as narrow as is practical. Run out of the sealant over the asphalt surface beyond the crack length will not be permitted.

5.4 Gritting

The Contractor shall place 5-2 mm Grit on the surface of all sealed material while it is hot and prior to vehicular traffic. Grit shall be placed at the minimum application necessary to prevent pick-up of the sealant by traffic.

6. SURFACE PREPARATION

6.1 Overlay Placed to Specified Design Levels

This Sub-clause only applies where an asphalt overlay is to be placed to specified design levels on an existing pavement.

The existing pavement shall be surveyed. For each layer, the required thickness of asphalt shall be written on the existing surface at each point where there is a specified level.

Where multiple layers are to be placed, the Contractor shall prepare a plan and cross sections showing the layer configurations and areas to be planed. Submission of the survey data and overlay plan constitutes a **HOLD POINT**.

6.2 Planing

Where the minimum layer thickness cannot be achieved within the specified tolerances, the existing surface shall be planed to achieve the required layer thickness. Where an overlay has multiple layers, edge planing shall be undertaken for each layer so as to ensure that the minimum layer thickness is achieved and is keyed into the existing pavement. All planing shall be carried out in accordance with Part 230 "Cold Planing".

6.3 Cleaning

The surface on which each layer of asphalt is to be placed shall be cleaned free of loose stones, dirt or foreign materials.

Where the pavement has kerb and gutter, the loose material shall be picked up and removed from the site.

The cleaning shall be undertaken so as to keep damage or disturbance to the surface to the minimum practicable.

Following completion of the preparation of the surface and prior to the application of the tack coat a **HOLD POINT** shall apply.

This is to enable an assessment of the condition of the cleaned surface and assessment of whether a tack coat shall be applied or the application rate of the tack coat altered, if deemed necessary.

6.4 Tack Coating

A tack coat shall consist of CRS grade emulsion to AS 1160 "Bitumen Emulsions for Construction and Maintenance of Pavements", uniformly sprayed at ambient temperature (for 60% emulsions or in accordance with the manufacturer's specification for higher percentages of bitumen).

Tack coat shall be applied at the following locations:

(a) at vertical edges between old and new asphalt pavements;

(b) on top of existing asphalt layers; and

(c) on top of new asphalt not placed on the same day.

The tack coat for (a) above shall be applied at a rate sufficient to ensure bond at the joint between the old and new asphalt pavements.

The tack coat for (b) and (c) above shall be uniformly applied to the surface with a calibrated sprayer prior to placement of asphalt.

Asphalt shall not be placed until the tack coat is broken.

The Contractor shall coordinate work so that no tack coated surface is opened to traffic.

Tack coat shall be applied with a tolerance of ± 0.05 litre/square metre of the specified application rate. The Contractor shall supply the actual spread rates, including litres used and area covered for each lot.

7. PLACEMENT OF ASPHALT

7.1 General

The Contractor shall spread asphalt so as to:

(a) minimise segregation and loss of materials;

(b) produce a homogeneous product;

(c) achieve the specified relative compaction for dense graded asphalt or the specified air voids content for open graded asphalt before the asphalt has cooled; and

(d) provide the specified thickness of asphalt.

Spreading methods shall follow the guide to good practice set out in AS 2150, Section 12 "Spreading". The paver shall be a self-propelled paving machine with automatic level control.

Hand placement of asphalt shall be used only for minor correction of the existing surface and in areas where placement with a paver is impracticable. Laying of mix shall be in the direction of traffic.

If the Contractor proposes to source asphalt from more than one plant during a day's production, at least 48 hours notice shall be provided and a procedure prepared to ensure traceability of the product during placement.

Provision of the notice shall constitute a **HOLD POINT**.

If it becomes necessary to use more than one plant because of a plant breakdown, the Contractor shall provide immediate notification and details of the alternative mix.

Each course shall be compacted uniformly to the full depth and over the full width. Compaction methods shall be in accordance with AS 2150, Section 13 "Compaction". The Contractor shall ensure that compaction does not commence before any deficiencies in the spreading of the mix are corrected.

At the time of placing asphalt, the existing surface shall be dry.

A **HOLD POINT** shall apply between individual layers of asphalt.

7.2 Protection of Road Fixtures

The Contractor shall prevent tack coat, binder, aggregate, asphalt or other material used on the work from entering, adhering or obstructing gratings, hydrants, valve boxes, inspection pit covers, kerbs and other road fixtures.

7.3 Joints

Joints shall be constructed in accordance with AS 2150, Clause 12.6 "Joints" and the following additional requirements.

The Contractor shall spread the mix in a manner which ensures continuity of placing and the number and extent of joints is kept to a minimum.

The Contractor shall ensure that the density and surface finish at joints satisfies the requirements of this Specification, and the joints are well sealed.

Joints between old and new pavements, and between sections of work which have not been placed on the same day shall have tack coat applied in accordance with Clause 6.4 "Tack Coating".

Joints in successive layers shall be staggered at least 300 mm. Permanent transverse joints at the starts and ends of runs shall be ramped at the maximum rate of 1 in 20 down to a final edge which shall not exceed 10 mm in height.

All temporary joints which are to be opened to traffic shall be ramped at the maximum rate of 1 in 10 down to a final edge which shall not exceed 10 mm in height.

Prior to subsequent laying of mix adjacent to a temporary joint, the temporary ramp shall be cut back and removed to expose a near vertical face of fresh dense asphalt prior to the subsequent laying of the adjacent run.

In making the joint along any adjoining edge such as kerb, gutter or an adjoining pavement, and after the mix is placed by the finishing machine, sufficient hot material shall be carried back to fill any space left open. This joint shall be properly "set-up" with the back of a rake or lute at proper height and level to receive the maximum compression under rolling.

The wearing course for all pavement types and pavement overlay shall be laid in such a manner that the longitudinal joints correspond as far as practicable with the lane lines and, in particular, avoid the wheel paths.

8. SAMPLING AND TESTING

Sampling locations for density compliance assessment shall be undertaken on a stratified random basis in accordance with AS 1289.1.4.2.

The sampling frequency shall be in accordance with Table 8(a) "Sampling and Testing Frequency for Coarse Dense mixes, Opengrade and Stone Mastic Mixes" or Table 8(b) "Sampling and Testing Frequency for fine dense mixes".

TABLE 8(a) SAMPLING AND TESTING FREQUENCY	
LOT PRODUCTION QUANTITY (tonnes)	**MINIMUM NUMBER OF CORE COMPACTION SAMPLES AND TESTS**
30 - 150	4
151 - 300	6
> 300	6 plus 1 for each additional 100 tonne of delivered mix or part thereof.

TABLE 8(b) SAMPLING AND TESTING FREQUENCY FOR FINE DENSE MIXES	
LOT PRODUCTION QUANTITY (m^2)	**MINIMUM NUMBER OF CORE COMPACTION SAMPLES AND TESTS**
0 - 250	2*
251 - 700	4
> 700	4 plus 1 for each additional 700 m^2 of mix placed or part thereof.

* to be tested for depth as a minimum.

No core shall be taken within 150 mm of a free edge, and no more than one core per lot shall be taken within 150 mm of a joint.

The Contractor shall provide results of all cores taken from the pavement, notwithstanding whether these cores are for the Contractor's own internal processes or otherwise. Tests for density, air voids and layer thickness shall be carried out on each core.

9. PROPERTIES OF FINISHED ASPHALT PAVEMENT

9.1 General

Finished asphalt shall comply with the requirements specified in Clause 13 "Verification Requirements".

9.2 Compaction Acceptance Criteria

(a) Quality Standards

Statistical analysis using an unknown variability scheme shall be used to determine acceptance of the compaction of asphalt layers.

Compliance will be based on the analysis of a random set of tests taken from each lot of the works. Compliance shall be determined indirectly in terms of percentage defective compared to the desired quality of the lot (10% defective) at either the low or high limit value.

A 90% probability assurance is required that accepted lots comply with the desired quality at either the low or high limit value. The acceptability characteristic k, quantified in Table 9.2 "k Value" is used to provide this statistical assurance. A lot shall not exceed a days work. Compliance will apply to the whole of the lot of the works from which the set of tests is taken.

(b) Relative Compaction

The relative compaction of a core shall be the bulk density expressed as a percentage of mean maximum density and reported in air voids terms using AS 2891.8. The mean maximum density value used for a lot of cores shall be the arithmetic mean of the five most recent test results for that mix, provided that they meet all of the following criteria:

(a) They are from tests done within the past 4 weeks;

(b) The binder content of the samples tested are within ± 0.3% of the job mix binder content; and

(c) There has been no change in mix components or proportions.

Where 5 test results are not available the Contractor shall carry out a minimum of 5 tests in order to ascertain the mean maximum density value. Where more than 5 tests are carried out in a day, the average of all the test results for that mix for that day shall be used.

A low and high characteristic value of air voids content (Lvc and Hvc) of a lot shall be calculated from the formula, x - ks in the case of the low value and x + ks in the case of the high value. x and s are the mean and standard deviations respectively of the individual air voids test values of the lot and k is a constant depending on the number of test values in the lot as shown in Table 9.2.

TABLE 9.2 k VALUE			
Number of Tests	**K**	**Number of Tests**	**K**
4	0.62	13	0.877
5	0.68	14	0.890
6	0.72	15	0.901
7	0.76	16	0.910
8	0.78	17	0.919
9	0.81	18	0.928
10	0.83	19	0.937
11	0.85	20	0.946
12	0.86	21	0.952

Compaction criteria shall be:

(a) For AC10 and AC14 dense mix wearing and binder courses the minimum characteristic air voids value shall be 4% and maximum characteristic air voids value shall be 8.5.

(b) For AC20 dense mix binder courses the minimum characteristic air voids value shall be 2.5% and maximum characteristic air voids value shall be 7%.

(c) For stone mastic wearing and binder courses the minimum characteristic air voids value shall be 2.5% and maximum characteristic air voids value shall be 7%.

(d) for AC 20 and AC 28 base mixes the criteria in (b) shall apply, but such mixes shall not be laid in thicknesses of less than 60 mm.

(e) For AC 14 High Binder Mix the minimum characteristic air voids value shall be 1% and maximum characteristic air voids value shall be 5%.

(f) For FineAC7 dense mixes the characteristic air voids value shall be 2.0% and maximum characteristic air voids value shall be 5.0%.

(g) For FineAC10 dense mixes the characteristic air voids value shall be 3.0% and maximum characteristic air voids value shall be 6.0%.

(h) For FineAC14 dense mixes the characteristic air voids value shall be 4.0% and maximum characteristic air voids value shall be 7.0%.

Compaction air voids data shall be calculated and reported to two decimal places and rounded to one for the first decimal point as described in AS 2706, Clause 3.2.

9.3 Tolerances on Asphalt Layers

If the asphalt is to be placed to specified design levels, the finished level of asphalt layers shall be as specified in **Contract Specific Requirements** "Pavement Work" or on the Drawings.

Where asphalt is to be placed adjacent to kerb and gutter, the wearing course shall be constructed within a tolerance of + 5 mm, - 0 mm. At joints between the surface of new and existing pavements, the levels shall be flush. If tolerances of base courses and intermediate courses are not specified in **Contract Specific Requirements** "Pavement Work" or on the Drawings, the tolerance shall be ± 10 mm.

Tolerances on the specified lateral position of asphalt treatments shall be ± 50 mm.

The thickness of dense mix, SMA and open graded asphalt wearing course laid on asphalt base shall be determined from the specified spread rate using an assumed density of 2 400 kg/cubic metre, 2 400 kg/cubic metre and 1 900 kg/cubic metre respectively.

9.4 Open Graded Mixes

The spreading and compaction of open graded mixes shall be treated as a special process.

9.5 Surface Irregularity and Finish

The surface irregularities of asphalt courses, as measured by deviation from a 3 m straight edge, shall not exceed:

Wearing Course	5 mm
Correction and Intermediate Courses	10 mm
Base Courses	15 mm
Base Courses (where no Correction and Intermediate Courses)	10 mm.

The surface irregularities of asphalt courses at longitudinal and transverse joints, as measured by deviation from a 1.2 m straight edge placed centrally and at right angles over the joint, shall not exceed:

Wearing Course	3 mm
Correction and Intermediate Courses	5 mm.

The surface of finished asphalt courses shall be free of segregated or "bony" areas, soft and "fatty" areas, ravelling and loose material, surface cracking, shoving and ruts.

9.6 Ride Quality

The finished wearing course and any lower layers constructed shall have a smooth transverse and longitudinal profile. If Part 235 "Surface Characteristics" is included in this Specification, the measured roughness values in NAASRA roughness counts per kilometre shall not exceed those specified in Clause 235.4 "Acceptance Limits".

10. DISCARDED ASPHALT

All excess or discarded asphalt shall remain the property of the Contractor and shall be disposed of by the Contractor.

11. TEST PROCEDURES

The Contractor shall use the following test procedures (refer http://www.dpti.sa.gov.au/contractor_documents) to verify conformance with the Specification:

TEST	TEST PROCEDURE
Site Selection by Stratified Random Technique	AS 1289.1.4.2
Sampling of Asphalt	TP 425
Determination of the Maximum Density of Asphalt - Water Displacement Method	TP 435
Bulk Density of Compacted Asphalt Specimens Presaturation Method for Dense Graded Mensuration Method for Open Graded	AS 2891.9.2 and Note A below

	AS 2891.9.3
Measurement of Thickness or Height of Compacted Asphalt	ASTM D3549
Calculation of Voids	AS 2891.8

Note A: Alter the following Clauses within AS2891.9.2:

Remove Note in Clause 1 and replace with "This test method should be used only with dense graded asphalt."

Add additional calculation to Clause 7:

Percentage of mass of water absorbed (b) in the following equation:

$$b = \frac{(m_3 - m_1)}{(m_3 - m_2)} * 100$$

Where

b = percent of water absorbed by mass

m1 = mass in air of the sample, in grams

pw density of water at the test temperature, in tonnes per cubic metre (from Table1)

m3 = mass in air of the saturated sample, in grams

m2 = mass in water of the saturated sample, in grams

Note 1: For dense graded asphalt, if the percent water absorbed by the specimen exceeds 2.0 percent, use an alternative method for determining bulk density.

Note 2: For stone mastic asphalt, if the percent water absorbed by the specimen exceeds 1.0 percent, use an alternative method for determining bulk density.

Add additional report to Clause 8:

Report the absorption to the nearest 0.01 percent.

12. HOLD POINTS

The following is a summary of Hold Points, vide Part 140 "Quality System Requirements", referenced in this Part:

CLAUSE REF.	HOLD POINT	RESPONSE TIME
2	Submission of Procedures (if not in Post Tender Submission)	7 days
5.2	Submission of crack sealing product	7 days
6.1	On submission of survey data and overlay plan prior to overlay work	2 days
6.3	Following completion of the preparation of the surface and prior to the application of the tack coat	1 hour
7.1	Asphalt sourced from more than one plant	6 hours
7.1	Between individual layers of asphalt	1 hour

13. VERIFICATION REQUIREMENTS AND RECORDS

The Contractor shall supply written verification that the following requirements have been complied with and supply the verification with the lot package.

CLAUSE REF.	SUBJECT	PROPERTY	TEST PROCEDURE	TEST FREQUENCY	ACCEPTANCE LIMITS
6.4	Tack Coat	Application Rate	Calculated by dividing volume by area covered (calculations to be submitted)	Calculated for each application of tack coat	± 0.05 l/m^2 of the specified application rate
9.2 & 9.3	Asphalt Properties	Relative Compaction	Refer Clause 9.2(c)	Refer Clause 8	Refer Clause 9.2(c)
		Air Voids	AS 2891.8	Refer Clause 8	Dense Mix: Report only Open Graded Mix: All tests between 18% and 25%
9.4*	Asphalt laid to design levels	Level of course	As specified in Part 130	As specified in Part 130	As specified in Part 220 or the **Contract Specific Requirements**
	Asphalt laid to nominal thickness	Average Layer Thickness	ASTM D3549	Refer Clause 8	Wearing Course: + 5, - 10 mm of nominal thickness Other layers: ± 10% nominal thickness
		Minimum Layer Thickness	ASTM D3549	Refer Clause 8	Nominal thickness minus 5 mm
	Asphalt laid to Spread Rate	Average Spread Rate	Calculated by dividing volume by area covered (calculations to be submitted)	Calculated for lot	± 10% of the specified application rate
9.7**	Ride Quality	NAASRA Roughness Counts	Refer Part 235	Refer Part 235	Refer **Contract Specific Requirements**

* Verification to be provided in accordance with the method specified for determining layer thickness.
** If Part 235 "Surface Characteristics" is included in this Specification.