Fine Asphalt Trials for Low Traffic Volume Urban Roads in South Australia

Building exceptional outcomes together

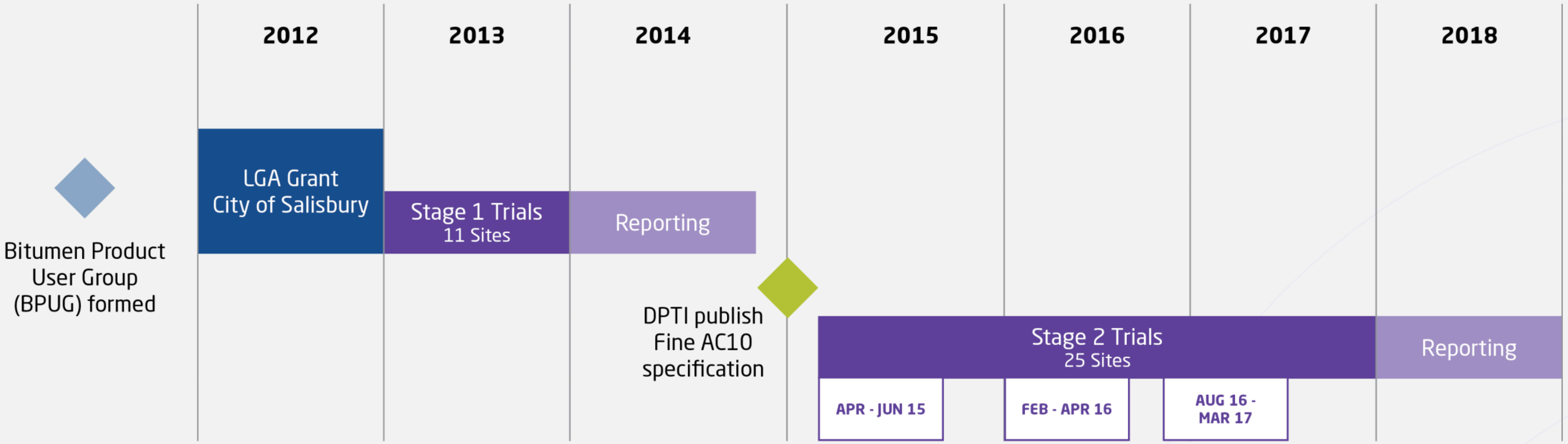
Outline of the 2012 - 2018 asphalt trials process

- Stage 1 2013 Trials of mixes used for Local Government by Industry
- Stage 2 2015 trials using the Fine AC10 specification developed as a result of Stage 1
- Where to from here?

Low Volume Road Characteristics

- Carries < 100 commercial vehicles per lane per day
- Design level < $5x10^5$ ESAs (equivalent standard axles)
- Light free flowing traffic

Project Timeline



Project Structure

	Stage 1 (2012 – 2014)	Stage 2 (2015 – 2018)
Reference Group	IPWEA SA AAPA ARRB Tonkin DPTI	IPWEA SA AAPA Tonkin DPTI
Project Funding	LGA 11 Councils	10 Councils
Project Sponsor	City of Salisbury	IPWEA SA
Project Leader	Tonkin	Tonkin
Contractors	Boral Top Coat Fulton Hogan Downer	Boral Top Coat Fulton Hogan Downer

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Project Process

Data | **Post-processing** | **Reference Group**

Protocols

- Site condition
- Mix design
- Construction records
- Field testing

→ Analysis → Report

Contractors | **Tonkin** | **Tonkin**

Combined grading

Sieve size [mm]	Percent passing
19	100
13.2	100
9.5	89-100
6.7	75-89
4.75	59-73
2.36	41-51

Properties of the mix design

Binder type (C170,C320)	C170
Warm mix additive (type)	—
Bulk density (50 gyrations) [t/m³] (AS2891.9.2)	50
Maximum density [t/m³] (AS2891.7.1)	2.450
Air void content after 50 gyrations [%] (AS2891.8) *	3.0-5.5
Temperature record for lab air voids (°C)	150
Binder film thickness [μm]	8.5

Combined grading after inclusion of RAP

Sieve size [mm]	Percent passing
19	100
13.2	100
9.5	89-100
6.7	75-89
4.75	59-73
2.36	41-51

RAP grading 7mm RAP. (15%.)

Sieve size [mm]	Percent passing
19	
13.2	
9.5	100
6.7	99
4.75	90
2.36	67

Street Name: **Counter Road (Forrestall Road to Crisp Road)**

Type of Seal: **Spray Seal**

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	4	3
Transverse cracks	3	1
Crocodile cracks	2	2
Potholes	1	2
Surface Defects (Ravelling/Stripping)	4	4
Surface Defects (Delamination)	0	0
Bleeding/Flushing	0	0
Pumping of fines	0	0
Rutting	0	0
Undulation (differential settlement)	3	3
Patching	4	3
Services trenching	2	2
Drainage problems	0	0

Location sketch of distresses, if relatively isolated:

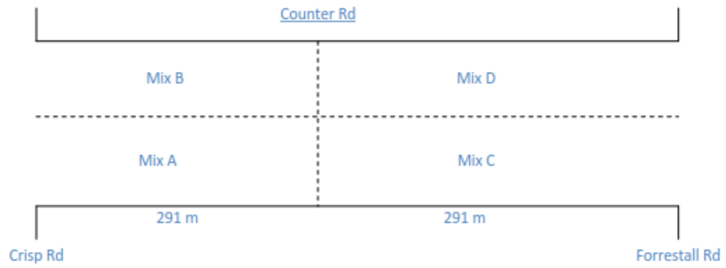
Presence of trees at site (please tick)

	exclusive	X	average		isolated		No trees

Site description

Name:	Counter Rd		**Date:**	25/07/2013	
Location of the site:	Elizabeth Downs, between Forrestall Rd and Crisp Rd.				
Traffic	Light vehicles per lane per day:	< 100 vpd	Percentage commercial vehicles:	18%	
Reason(s) for road being resurfaced:	During Council's annual condition rating, the seal on Counter Rd was found to be in poor condition and considered to be a medium to high priority for reseal compared to other streets within the City.				
Age of existing surfacing	32 years. Counter Rd was constructed in 1961 with nominal granular pavement and sprayed seal. It was resealed with spray seal in 1981.				
Extent of preparation works carried out (e.g. patches, crack sealing)	Minor maintenance patching in the years prior to reseal. No specific treatment ahead of reseal.				
Describe profiling treatment and potential for debonding	The road was profiled to a depth of 30 mm, fully removing the existing seal.				
FWD survey conducted?	yes	no			

Provide situation sketch of site and proposed location of different mixes (refer Figure 1 of protocol)



Site Condition

Mix Design

Properties of the variations to the mix design

Mix	A	B	C	D
Binder type	C320	C320	C170	C170
Warm mix additive (type)		Foam		Foam
Bulk density (50 gyrations) [t/m³] (AS2891.9.2)	2.358	2.390	2.399	2.387
Maximum density [t/m³] (AS2891.7.1)	2.461	2.458	2.458	2.446
Air void content after 50 gyrations [%] (AS2891.8) *	4.2	2.8	2.4	2.4
Temperature record for lab air voids (°C)	150.7/ 150.9	130.7/ 129.8	148.9/ 150.0	128/ 130.3
Binder film thickness [µm]	8.47	7.63	7.81	7.77
Indirect tensile strength [MPa] TP 460	161.4	133.8	165.2	141.3
RAP content [%]			10 %	10 %
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.

Construction record for trial at:	Counter Rd, Elizabeth Downs	Date:	21/5/2013

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]	14	17.2	18	18.6
Surface temperature prior to AC placement [°C]	12.6	16.4	15.3	21
Temperature of mix at auger [°C]	145	120	150	125
Temperature of mat prior to compaction [°C]	135	116	140	112

Type of compaction equipment	222 Dynapac Steel/ Multi
Weight	7.6t Steel/ 11t Multi
Number of rollers	2
Vibration / static	Two vibrating passes and two static passes.
Rolling pattern (incl. number of passes and vibration setting)	Two drums on law amp. – Two static passes.
Was the mix easy to compact? (Easy, Average, Difficult)	-
Detail delays during paving	Paver break down at start of shift.

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

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Construction Records

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)	2.375	2.314	2.358	2.297

Bulk density

Mix A

	Core 1	Core 2	Core 3	Core 4
Bulk density [t/m^3] (AS2891.9.2)	2.373	2.340	2.402	2.385
Air void content (AS2891.8) [%]	3.6	4.9	2.4	3.1

Mix A

Mean air void content [%]	3.5
Standard deviation [%]	1.1
K (DPTI Part 228, Table 9.20	0.62
Low characteristic value of air voids content (Lvc) [%]	2.8
High characteristic value of air voids content (Hvc) [%]	4.2

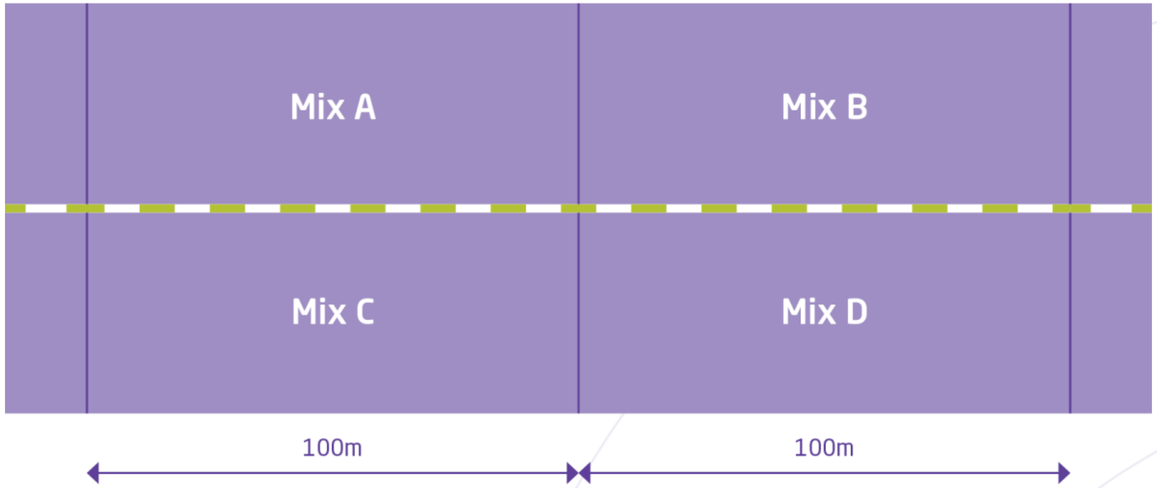
A. Class 320 bitumen
B. Class 320 bitumen in combination with a warm mix additive
C. Class 170 bitumen in combination with 20% RAP
D. Class 170 bitumen in combination with 20% RAP and a warm mix additive

Field Testing

2013 Trial Mix

- Four variations of a single mix design at each site.

Mix A	C320
Mix B	C320 WMA
Mix C	C170 RAP
Mix D	C170 RAP WMA



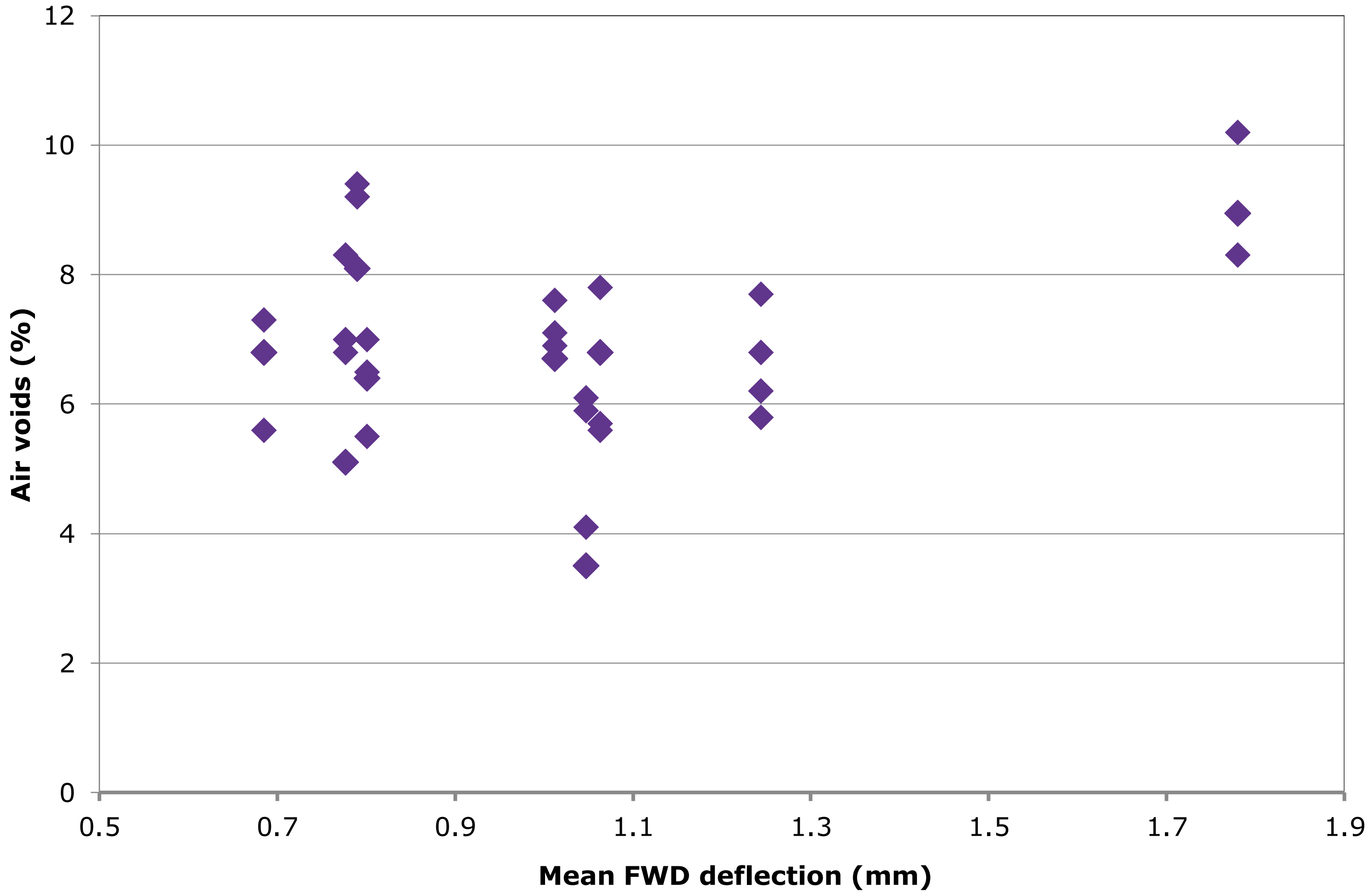
2013 Objective

- Select asphalt mixes which are easy to compact and have high flexibility and lower viscosity

- Develop a technical placement specification for asphalt used for low volume roads.

Deflection

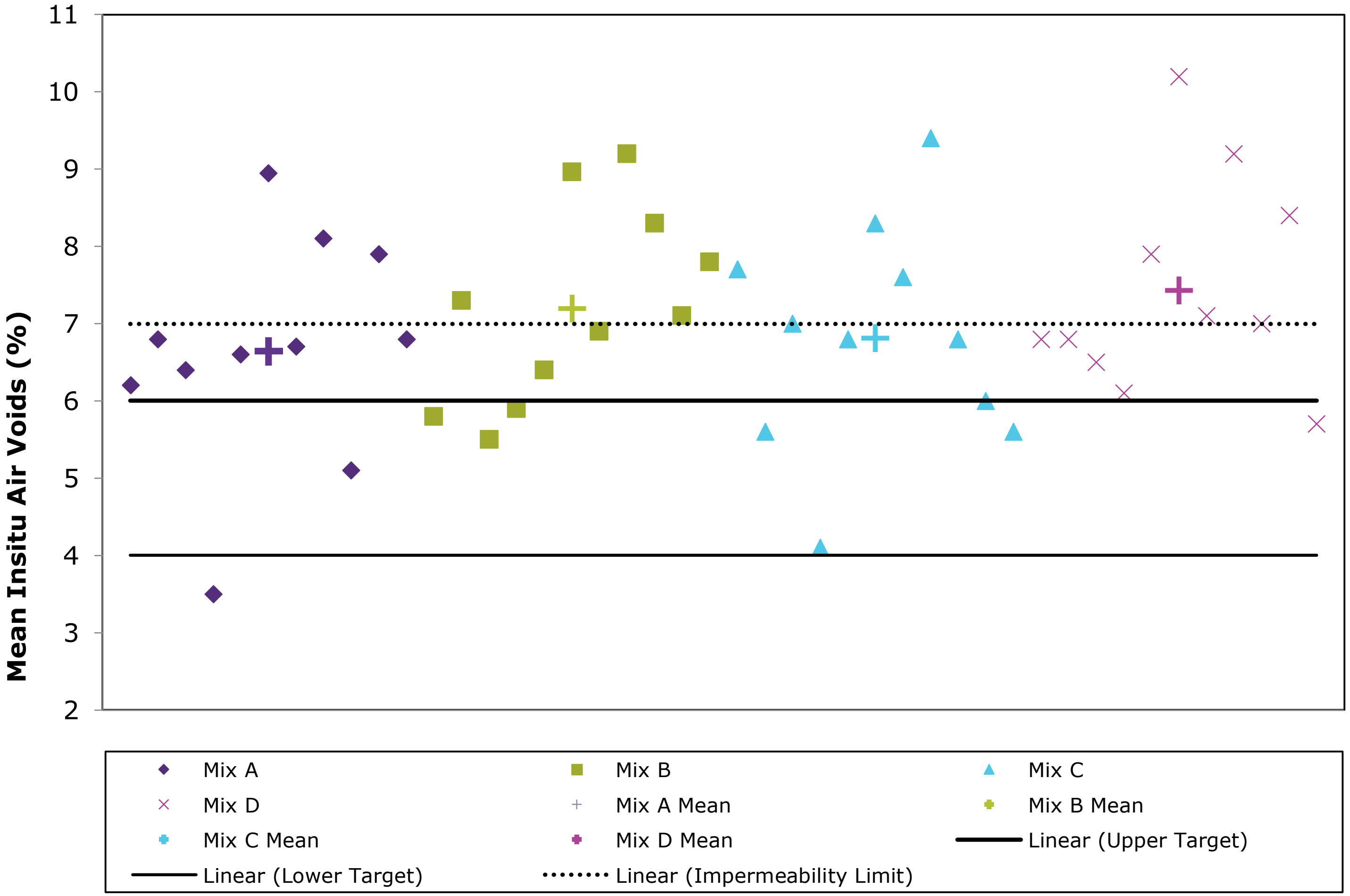
In situ Air Voids vs Mean FWD deflection



- No direct link found between deflection of existing pavement prior to resurfacing and compaction of the AC wearing coarse for deflections below 1.3 mm.

Air Voids

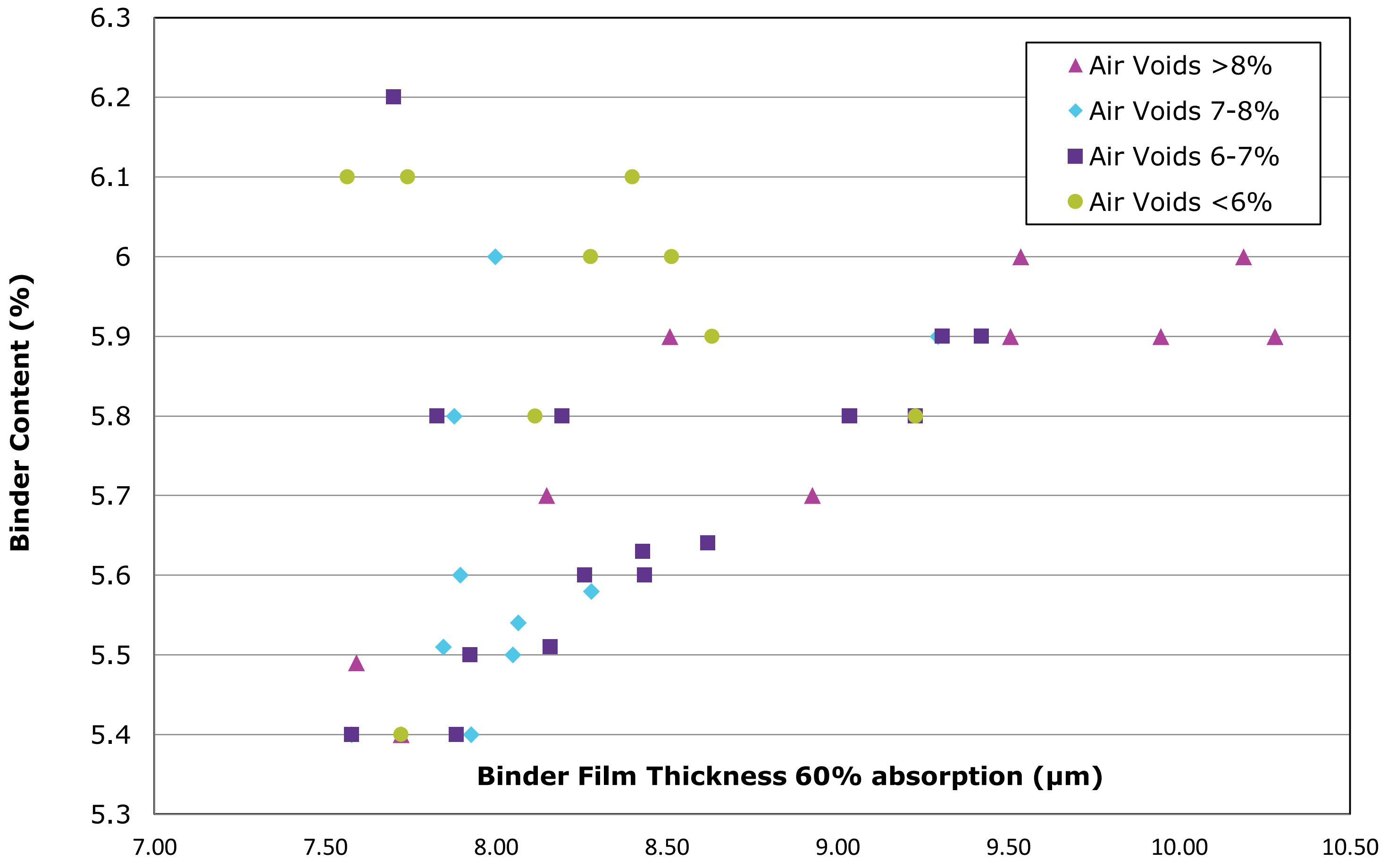
In situ Air Voids with means and target limits



- 20% of trial sites were within the target range 4-6%
- 40% of trial sites were above the 7%

Binder

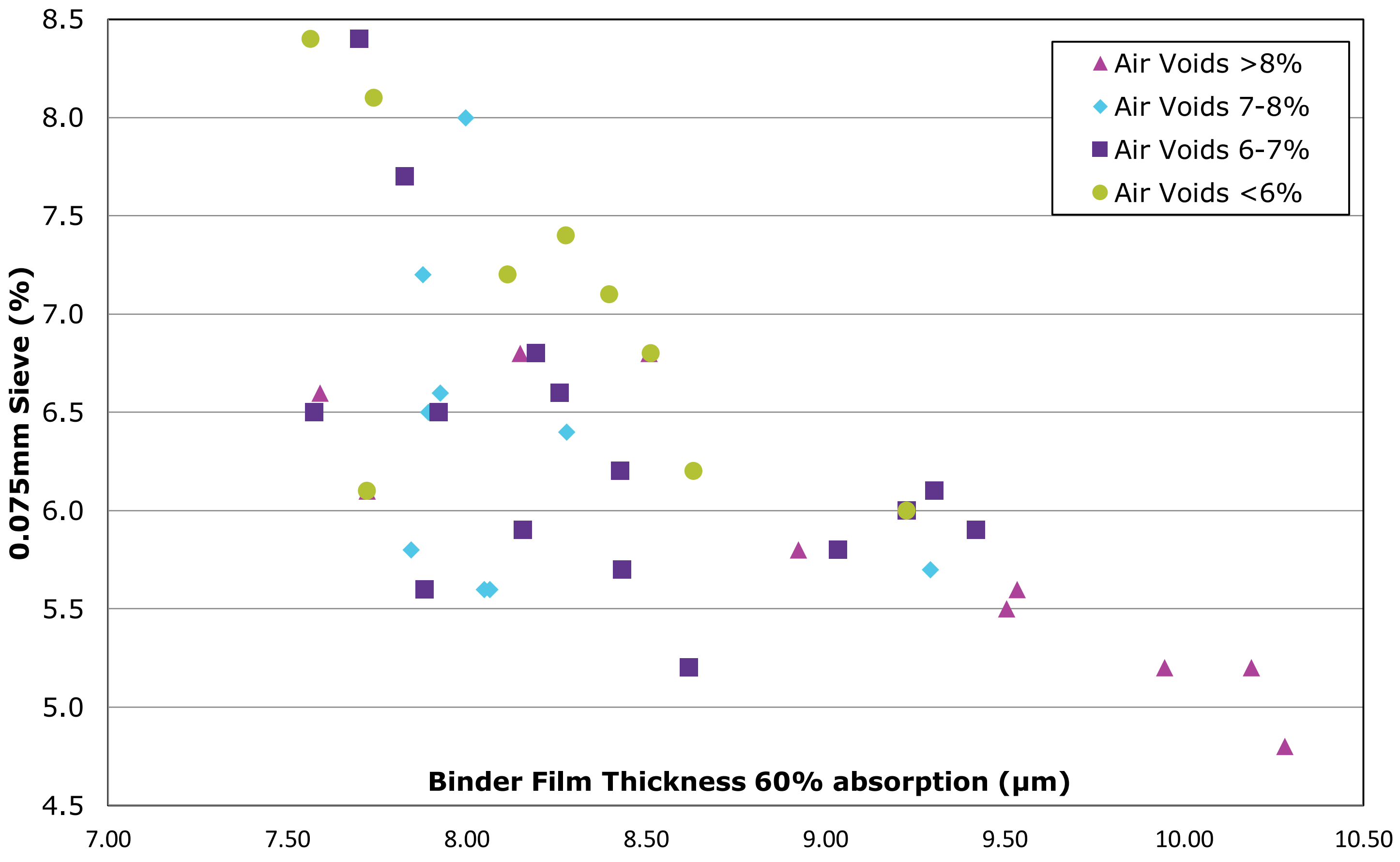
Plot of 60% absorption adjusted Binder Film Thickness against binder content grouped by field air voids



- There is 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

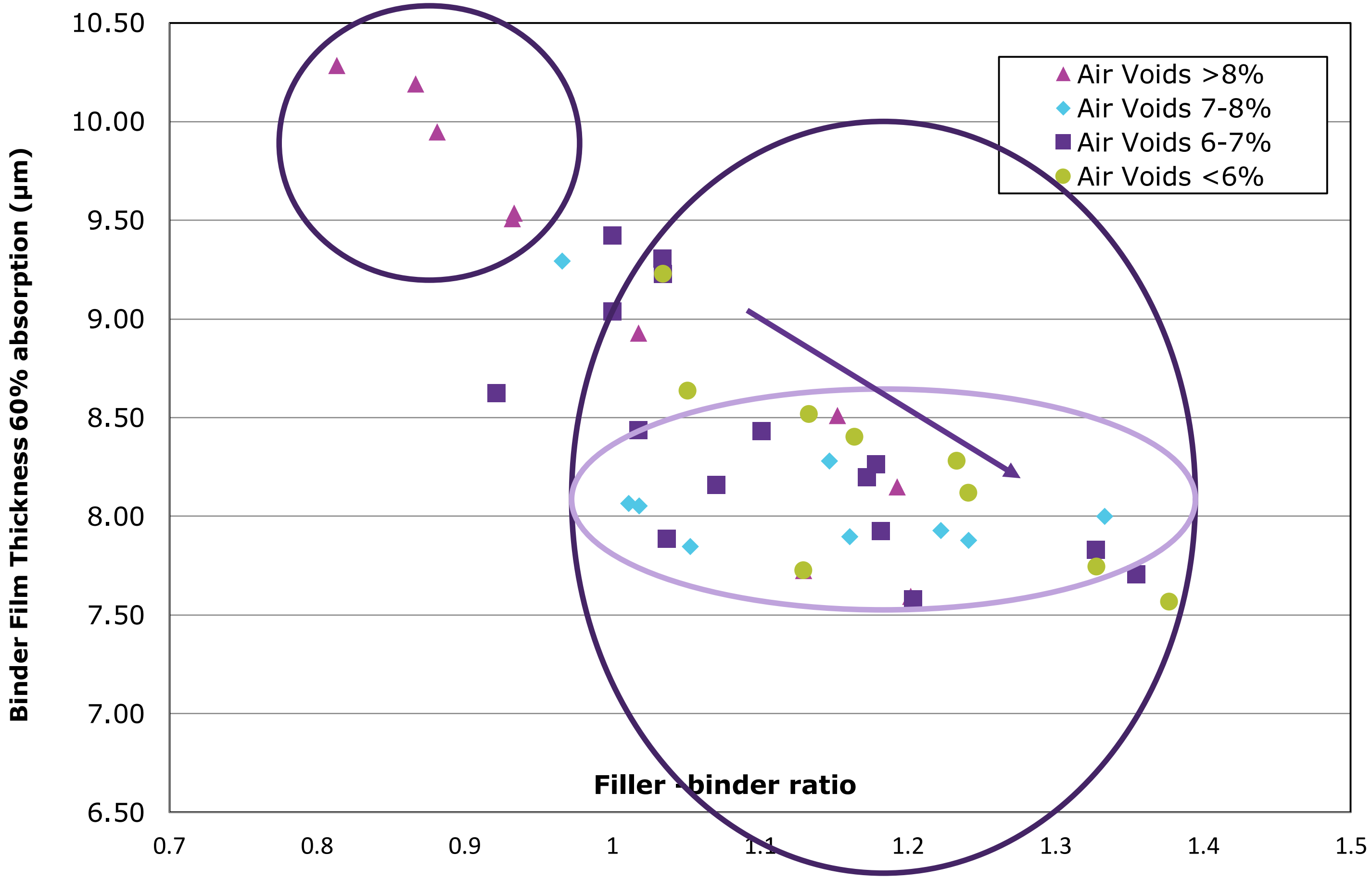
Plot of Binder Film Thickness (60% absorption) and % passing 0.075 mm sieve grouped by field air voids



- Mixes with 0.075 mm sieve (%) passing greater than 6 achieved lower field voids

Filler Binder Ratio

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



- Filler binder ratio less than 1 and BFT 60% greater than 9.5%, despite high binder did not perform.
- Filler binder ratio above 1 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.

Binder Type

- C170 binder responded better than C320 binder in reducing field air voids with higher binder content
- This needs to be tempered with risk of rutting; however higher density should mitigate this.

Laboratory Air Voids

- It was recommended to lower laboratory air voids to 4% (50 cycles Gyproc AS 2891.2) as a result of the trial.

Fine AC10 Ellerslie St, 340 sand patch, mean voids 8.8 to 12 upper characteristic

Warm Asphalt

- Warm asphalt compaction results was less than traditional hot asphalt
- Greater recognition is needed of the higher offset between laboratory and field compaction
- Increased workability with higher binder contents.

Indirect Tensile Strength (ITS)

- Increasing the binder reduces the 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 criterion for testing for low volume roads.

Post Construction Examples

Target Asphalt Mix properties for Low Volume Roads

- Low air voids (mean 3.5%, upper characteristic 4.2%)

Construction Record - Form 3b				
Mix	A	B	C	D
Air Void Content [%] (AS2891.8)				
Core 1	3.6	6.7	3.1	6.1
Core 2	4.9	6.6	3.8	5.6
Core 3	2.4	4.0	3.2	5.3
Core 4	3.1	6.2	6.2	7.4

- High bitumen content (impermeability)

Mix	A	B	C	D
Binder Type	C320	C320	C170	C170
Warm Mix Additive (type)		Foam		Foam
Bulk Density (50 gyrations) [t/m^3] (AS2891.9.2)	2.358	2.390	2.399	2.387
Maximum Density [t/m^3] (AS2891.7.1)	2.461	2.458	2.458	2.446
Air Void Content after 50 gyrations [%] (AS2891.7.1)	4.2	2.8	2.4	2.4
Production Binder Content (%)	6.1	6.1	6.1	6.2
Temperature record for lab air voids (°C)	150.7/150.9	130.7/129.8	148.9/150.0	128/130.3
Binder film thickness (µm)	8.47	7.63	7.81	7.77
Indirect tensile strength (Kpa) TP 460	161.4	133.8	165.2	141.3
RAP content [%]			10%	10%

Example of poor Asphalt Mix properties for Low Volume Roads

- High air voids (mean 10.2%, upper characteristic 11.9%)

Construction Record - Form 3b				
Mix	**A**	**B**	**C**	**D**
Air Void Content [%] (AS2891.8)				
Core 1	10.8	9.2	9.0	8.9
Core 2	7.2	10.2	8.9	9.8
Core 3	9.2	7.9	8.1	14.2
Core 4	8.6	8.5	7.1	7.8

- High bitumen content (impermeability)

Mix	**A**	**B**	**C**	**D**
Binder Type	C320	C320	C170	C170
Warm Mix Additive (type)		FOAM		FOAM
Bulk Density (50 gyrations) [t/m^3] (AS2891.9.2)	2.291	2.297	2.311	2.32
Maximum Density [t/m^3] (AS2891.7.1)	2.465	2.46	2.157	2.457
Air Void Content after 50 gyrations [%] (AS2891.7.1)	7.1	6.6	6	5.6
Production Binder Content (%)	6.0	6.0	5.7	5.9
Temperature record for lab air voids (°C)	150.4/150.7	130.1/130.9	150.9/150.0	130.2/130.7
Binder film thickness (μm)	9.55	10.3	9.07	10.1
Indirect tensile strength (Kpa) TP 460	147.5	125.7	111.9	116.3
RAP content [%]	0	0	10	10

Example of poor Asphalt Mix properties for Low Volume Roads

- High air voids (mean 6.7%, upper characteristic 7.9%)

Construction Record - Form 3b				
Mix	A	B	C	D
Air Void Content [%] (AS2891.8)				
Core 1	7.3	6.9	5.7	8.1
Core 2	8.6	6.1	8.4	4.1
Core 3	6.8	4.9	8.8	8.4
Core 4	4.2	9.7	7.4	7.9

- Low bitumen content (less permeable)

Mix	A	B	C	D
Binder Type	C320	C320	C170	C170
Warm Mix Additive (type)		SASOBIT		SASOBIT
Bulk Density (50 gyrations) [t/m^3] (AS2891.9.2)	2.319	2.369	2.318	2.349
Maximum Density [t/m^3] (AS2891.7.1)	2.457	2.451	2.453	2.446
Air Void Content after 50 gyrations [%] (AS2891.7.1)	5.6	3.3	5.5	4.0
Production Binder Content (%)	5.4	5.5	5.4	5.6
Temperature record for lab air voids (°C)	150	125	150	125
Binder film thickness (µm)	8.8	8.3	8.5	8.1
Indirect tensile strength (Kpa) TP 460	194	185	179	168
RAP content [%]			20%	20%

Recommendations from 2013

1. Adopt 4% Laboratory air voids for mix designs
2. Incorporate a minimum binder film thickness (60% absorption) of 8.0 micron
3. At this stage the use of filler/binder ratio as a specification reference is not supported
4. A minimum binder content of 5.7% should be specified.
5. Local Government should consider making density determination from the *in situ* asphalt part of the normal product acceptance process
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 (7% and above)

Recommendations from 2013

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

8. Review density results for 'conventional' asphalt mixes used on low volume roads in SA and compare them to the results in this study

9. Review construction practices and compaction practices

10. Local Government should use the specification update through DPTI 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.

Outcome of 2013 Trials

- Department of Planning, Transport & Infrastructure (DPTI) included Fine AC10 and Fine AC7 supply and construction specification as a result of these trials
- IPWEA SA lobbied to continue trials with 10 councils with no further grants from LGA

2015 Objective

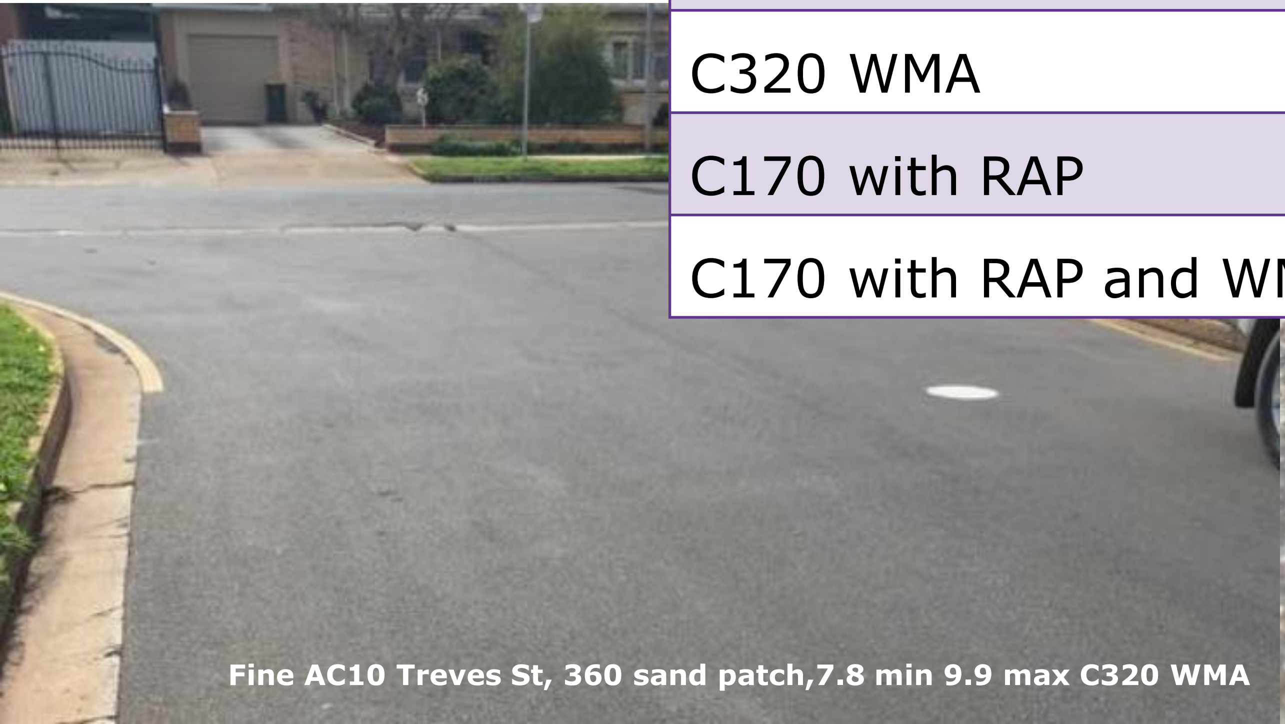
- To see if specification Fine AC10 could be placed between the following field air voids

2.5%	7%
Lower characteristic air voids	High characteristic air voids

2015 Trials

DPTI Specification Compliance

Mix Type	No. of sites
C320 Hot mix	1
C320 WMA	5
C170 with RAP	11
C170 with RAP and WMA	8

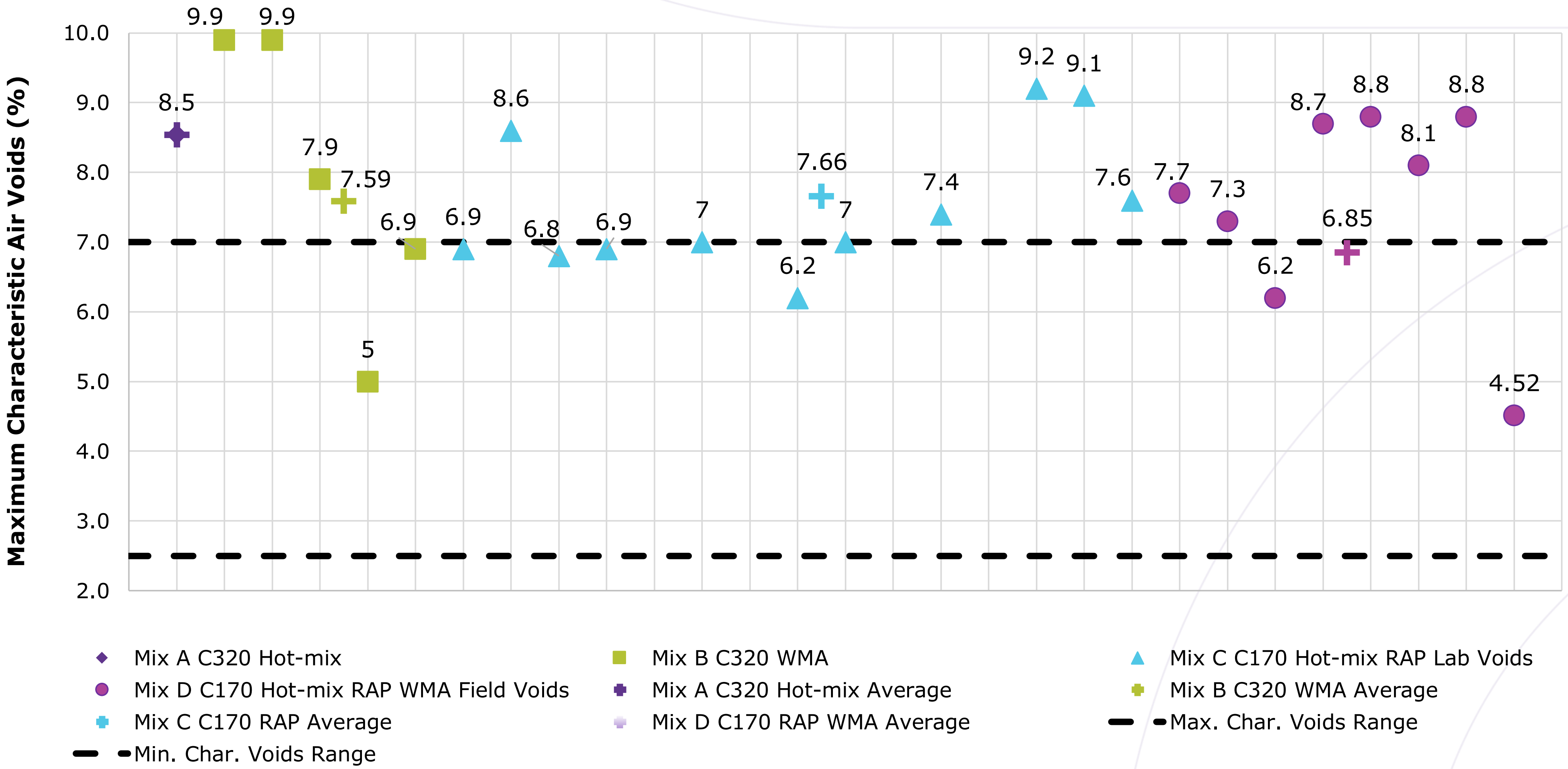


Fine AC10 Treves St, 360 sand patch,7.8 min 9.9 max C320 WMA

Deflection

- Deflection was not a dominant factor for the roads in this trial
- Should be considered if more roads above 1.3 mm deflection are included in future trials.

Maximum Characteristic Air Voids



Binder

- The trial provides some confidence that the specification requirement of a 5.7% minimum binder content is generally being met.

Fine AC10 Hayward 4.5 max characteristic, 380 sand patch, C170 RAP & WMA

Binder Type

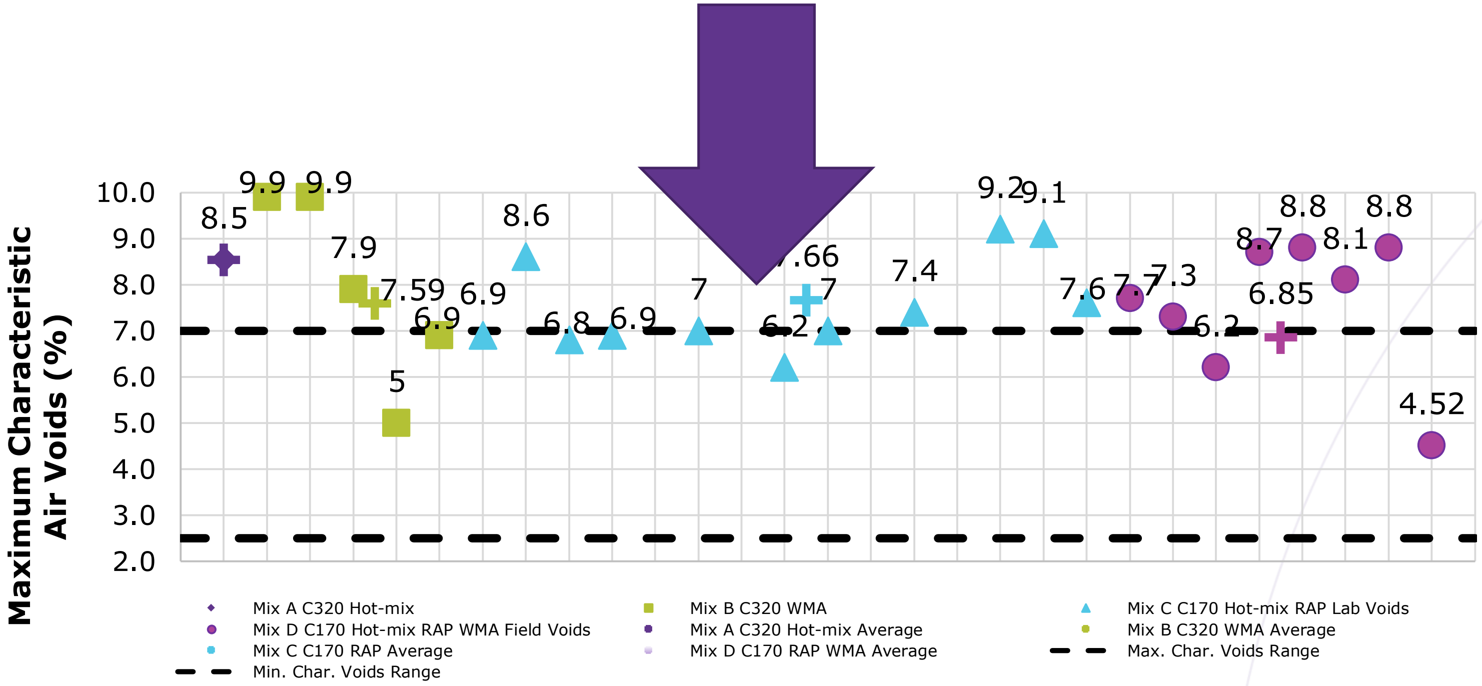
- C170 binder was predominantly used during these trials
- The potential benefits or limitations of C320 binder remains something for consideration

C170 RAP WMA

C320 WMA

Laboratory Air Voids

- There is potential for lowering laboratory air voids to 2-3% (50 cycles Gyproc AS 2891.2)



Grading

- Consider extending the bandwidth of grading for fine particles contained within fine asphalt mixes
- May contradict requirements of AS 2150

TABLE 4.4(b) - MIX GRADING ENVELOPES OF FINE DENSE MIX ASPHALT[1]				
SIEVE (mm)	FineAC7		FineAC10	
13.2				100
9.5		100	100	90
6.7	100	90	90	75
4.75	90	75	77	63
2.36	65	51	56	43
1.18	47	35	41	30
0.6	33	23	29	20
0.3	22	15	20	13
0.15	14	9	13	8
0.075	8	5	8	5

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

Wheel Tracking

- Results for Wheel Track Testing were limited
- Applied load of 700N and terminated at 10,000 passes

	Average Rut Depth (mm)	Central Rut Depth (mm)
C320 Hot Mix	-	-
C320 WMA	3.7	-
C170 RAP	3.86	3.62
C170 RAP & WMA	-	-

Acceptable range 3-6mm

Warm Asphalt

- Warm Mix results improved from the 2013 trials

Fine AC10 Dimbula, max characteristic 5, 400 texture, C320 WMA

Recommendations from 2015

1. For future trials the potential exists for 2-3% Laboratory air voids
2. Local Government should conduct in-situ field air void testing to better understand the achievement of improved asset life and reduce instances on high in-situ air voids above 8%
3. A minimum binder content of 5.7% should be maintained
4. Future trials should consider the benefit of incorporating wheel track testing within the protocol requirements to draw sound conclusions on the long term durability of the Fine AC10 mix

Recommendations from 2015

5. DPTI is encouraged to provide commentary on the acceptance criteria within the current specification for the maximum characteristic air voids of the Fine AC10 asphalt mix
6. Local Government needs to consider how to manage non-conformances associated with the maximum characteristic voids criteria of the current DPTI Specification
7. The implementation of future asphalt trials should investigate the incorporation of greater flexibility in the current specification/governing protocol and aim to achieve a sample set for varying mix types that is more uniform
8. Sponsors of future trials should consider scope for continuation of a coordinated approach to funding this research

Conclusions

- Established a protocol and trial process that engages asphalt companies and local Councils with close involvement from the State Road Authority
- Developed a preliminary technical specification for placement of AC10 on pavements used for low volume roads
- Verified that a large number of low volume roads are not being constructed to required standards
- Identified improvements to the preliminary technical specification are required
- Highlighted areas for future investigations.

The specified 7% upper characteristic air voids can be achieved.

There are a number of site conditions which need to be addressed to ensure that this specification can be met, including:

- Weak pavements
- Variable pavement conditions
- Variable thicknesses of mixes placed
- Ambient temperatures below 25 °C
- Hand work
- Binder type
- Lack of preparation work prior to surfacing which does not address or remove weak pavement sections
- Selection of warm mix additive and placing temperature may need to be higher when placed below ambient temperatures of 25 °C

Acknowledgements 2013

This project was co-funded by the following organisations:

- Local Government Authority (Research and Development Fund)
- City of Salisbury
- 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
- 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, ARRB and DPTI provided in-kind support over and above available funding in order to complete the report.

Acknowledgements 2015

The delivery and oversight of this project was managed by IPWEA SA on behalf of the following co-funding organisations:

- City of Salisbury
- West Torrens City Council
- 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
- City of Mitcham
- City of Prospect.

This project was supported by AAPA and its members with in kind support for trials, input into the protocol and providing feedback during reference group sessions.

DPTI provided valuable input to reviews and advising at reference group meetings at no cost.

Tonkin provided in-kind support over and above available funding to complete the report.

John Hutton provided oversight and reference group involvement for both trials initially representing the City of Salisbury and then IPWEA SA.

Observations Post Trials

- There is a greater push to put recycled material into roads e.g. plastic bags, glass, crumbed rubber
- Some councils are trialling Fine AC7 with a polymer
- General acknowledgement of the need to continue to develop the specification
- General need to gather more data and continue to learn
- Contractors and councils have become accustomed to trial environments
- The opportunity remains to take another step

Where to from here?

- No clear direction at present
- Report issued to contributing councils and is on IPWEA SA website
- IPWEA SA board has agreed to invite members, contractors and councils to a briefing late 2019
- Contributing councils and members will determine if there is enough momentum to continue the journey
- IPWEA SA will establish its role as a result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Thank you
Building exceptional outcomes together