Is the asphalt density that we are reporting the actual density?

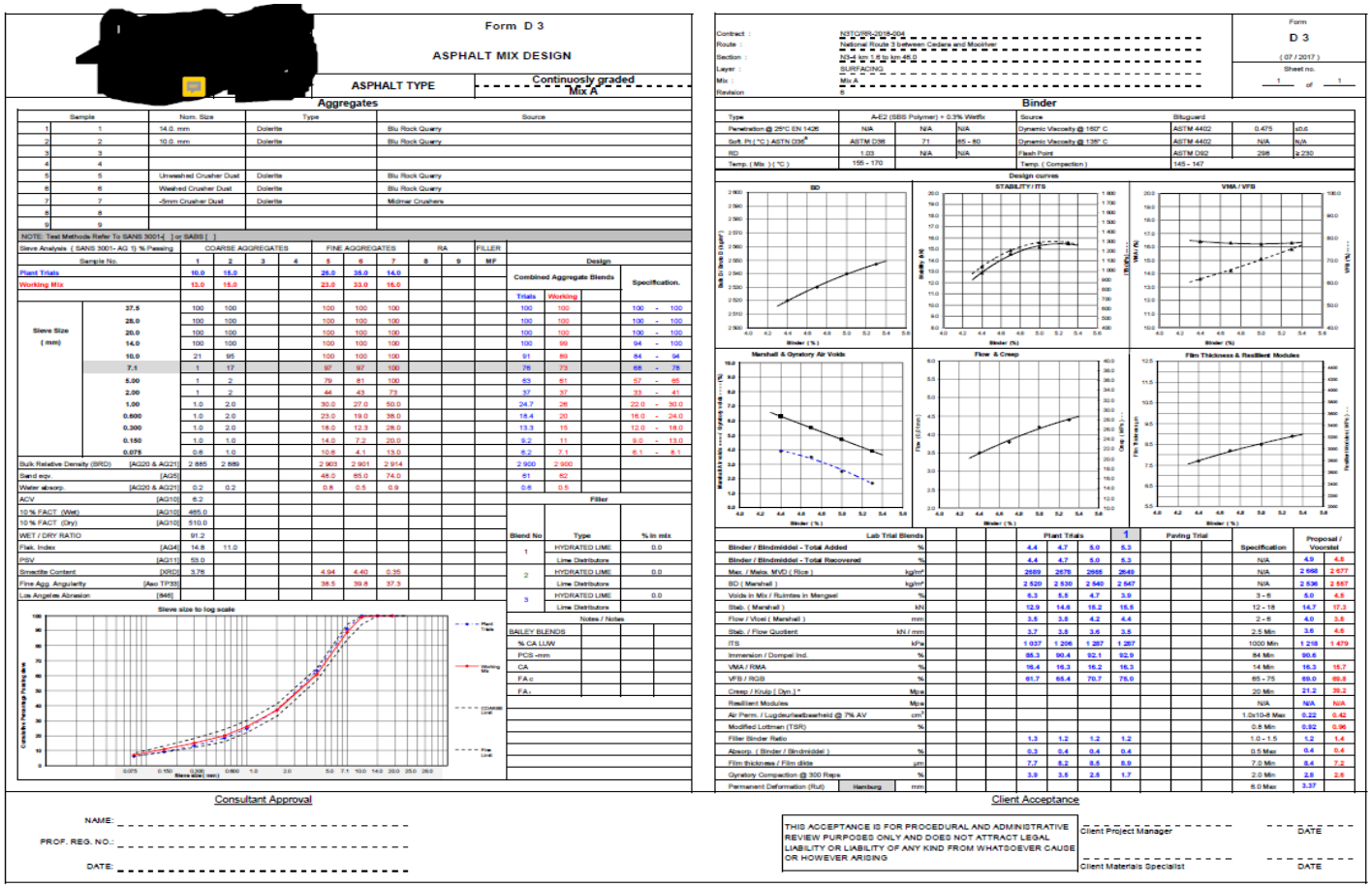
or alternatively

do we know the real voids in the road?

Douglas Judd
N3 Toll Concession (Pty) Ltd

Assisted by
Piet Louw
DMV Baeletsi Consulting Engineers

Mix design done and approved



Form D 3

ASPHALT MIX DESIGN

ASPHALT TYPE: Continuously graded Mix A

Aggregates

Sample		Nom. Size	Type	Source
1	1	14.0 mm	Dolerite	Blu Rock Quarry
2	2	10.0 mm	Dolerite	Blu Rock Quarry
3	3			
4	4			
5	5	Unwashed Crusher Dust	Dolerite	Blu Rock Quarry
6	6	Washed Crusher Dust	Dolerite	Blu Rock Quarry
7	7	-5mm Crusher Dust	Dolerite	Midmar Crushers
8	8			
9	9			

NOTE: Test Methods Refer To SANS 3001-[ ] or SABS [ ]

Sieve Analysis (SANS 3001- AG 1) % Passing		COARSE AGGREGATES				FINE AGGREGATES			RA		FILLER
Sample No.		1	2	3	4	5	6	7	8	9	MF
Plant Trials		10.0	15.0			26.0	35.0	14.0			
Working Mix		13.0	15.0			23.0	33.0	16.0			
Sieve Size (mm)	37.5	100	100			100	100	100			
	28.0	100	100			100	100	100			
	20.0	100	100			100	100	100			
	14.0	100	100			100	100	100			
	10.0	21	95			100	100	100			
	7.1	1	17			97	97	100			
	5.00	1	2			79	81	100			
	2.00	1	2			44	43	73			
	1.00	1.0	2.0			30.0	27.0	50.0			
	0.600	1.0	2.0			23.0	19.0	38.0			
	0.300	1.0	2.0			18.0	12.3	28.0			
	0.150	1.0	1.0			14.0	7.2	20.0			
	0.075	0.6	1.0			10.6	4.1	13.0			
Bulk Relative Density (BRD)	[AG20 & AG21]	2 885	2 889			2 903	2 901	2 914			
Sand equ.	[AG5]					48.0	65.0	74.0			
Water absorp.	[AG20 & AG21]	0.2	0.2			0.8	0.5	0.9			
ACV	[AG10]	6.2									
10 % FACT (Wet)	[AG10]	465.0									
10 % FACT (Dry)	[AG10]	510.0									
WET / DRY RATIO		91.2									
Flak. Index	[AG4]	14.8	11.0								
PSV	[AG11]	59.0									
Sinactite Content	[XRD]	3.76				4.04	4.40	0.35			
Fine Agg. Angularity	[Aso TP33]					38.5	39.8	37.3			
Los Angeles Abrasion	[M6]										

Design

Combined Aggregate Blends			Specification.	
Trials	Working			
100	100		100	- 100
100	100		100	- 100
100	100		100	- 100
100	99		94	- 100
91	89		84	- 94
78	73		68	- 78
63	61		57	- 65
37	37		33	- 41
24.7	26		22.0	- 30.0
18.4	20		16.0	- 24.0
13.3	15		12.0	- 18.0
9.2	11		9.0	- 13.0
6.2	7.1		6.1	- 8.1
2 900	2 900			
61	62			
0.6	0.5			

Filler

Blend No	Type	% in mix
1	HYDRATED LIME	0.0
	Lime Distributors	
2	HYDRATED LIME	0.0
	Lime Distributors	
3	HYDRATED LIME	0.0
	Lime Distributors	

Notes / Notes

BAILEY BLENDS			
% CA LUW			
PCS.-mm			
CA			
FA.c			
FA.f			

Sieve size to log scale

Cumulative Percentage Passing (%)

Sieve size (mm)

Plant Trials

Working Mix

COARSE Limit

Fine Limit

Consultant Approval

NAME:

PROF. REG. NO.:

DATE:

Contract :
Route :
Section :
Layer : SURFACING
Mix : Mix A
Revision : 0

Form D 3 (07 / 2017) Sheet no. 1 of 1

Binder

Type	A-E2 (SBS Polymer) + 0.3% Wetfix			Source		Sliguard	
Penetration @ 25°C EN 1426	N/A	N/A	N/A	Dynamic Viscosity @ 160° C	ASTM 4402	0.475	≤0.6
Soft. Pt (°C) ASTN D36	ASTM D36	71	65 - 80	Dynamic Viscosity @ 135° C	ASTM 4402	N/A	N/A
RD	1.03	N/A	N/A	Flash Point	ASTM D92	298	≥ 230
Temp. (Mix) (°C)	155 - 170			Temp. (Compaction)		145 - 147	

Design curves

BD

Bulk Dens D (kg/m³)

Binder (%)

STABILITY / ITS

Stability (kN)

ITS (kPa)

Binder (%)

VMA / VFB

VMA (%)

VFB (%)

Binder (%)

Marshall & Gyratory Air Voids

Relative Density - Gyratory (%)

Air Voids (%)

Binder (%)

Flow & Creep

Flow (0.01mm)

Creep (kPa/mm)

Binder (%)

Film Thickness & Resilient Modules

Film Thickness (µm)

Resilient Modulus (MPa)

Binder (%)

Lab Trial Blends						Plant Trials			1	Paving Trial			Specification	Proposal / Voorstel	
Binder / Bindmiddel - Total Added	%					4.4	4.7	5.0	5.3				N/A	4.9	4.5
Binder / Bindmiddel - Total Recovered	%					4.4	4.7	5.0	5.3				N/A	4.9	4.5
Max. / Maks. MVD (Rice)	kg/m³					2689	2678	2668	2649				N/A	2 668	2 677
BD (Marshall)	kg/m³					2 520	2 530	2 540	2 547				N/A	2 536	2 557
Voids in Mix / Ruimtes in Mengsel	%					6.3	5.5	4.7	3.9				3 - 6	5.0	4.5
Stab. (Marshall)	kN					12.9	14.0	15.2	16.5				12 - 18	14.7	17.3
Flow / Vloei (Marshall)	mm					3.5	3.8	4.2	4.4				2 - 6	4.0	3.8
Stab. / Flow Quotient	kN / mm					3.7	3.8	3.6	3.8				2.5 Min	3.6	4.6
ITS	kPa					1 037	1 206	1 287	1 287				1000 Min	1 210	1 479
Immersion / Dompel Ind.	%					88.3	90.4	92.1	92.9				84 Min	90.6	
VMA / RMA	%					16.4	16.3	16.2	16.3				14 Min	16.3	15.7
VFB / RGB	%					61.7	65.4	70.7	75.0				65 - 75	69.0	69.8
Creep / Kruip (Dyn) *	Mpa												20 Min	21.2	39.3
Resilient Modules	Mpa												N/A	N/A	N/A
Air Perm. / Lugdeurlaatbaarheid @ 7% AV	cm²												1.0x10-8 Max	0.22	0.42
Modified Lottman (TSR)	%												0.8 Min	0.92	0.96
Filler Binder Ratio						1.3	1.2	1.2	1.2				1.0 - 1.5	1.2	1.4
Absorp. (Binder / Bindmiddel)	%					0.3	0.4	0.4	0.4				0.5 Max	0.4	0.4
Film thickness / Film dikte	µm					7.7	8.2	8.5	8.9				7.5 Min	8.4	7.2
Gyratory Compaction @ 300 Reps	%					3.9	3.5	2.5	1.7				2.0 Min	2.5	2.6
Permanent Deformation (Rut)	Hamburg												6.0 Max	3.37	

Client Acceptance

THIS ACCEPTANCE IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OR LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING

Client Project Manager — DATE

Client Materials Specialist — DATE

Paving trials done and all set to go

Then- this mix met density requirements

Photo after first rains

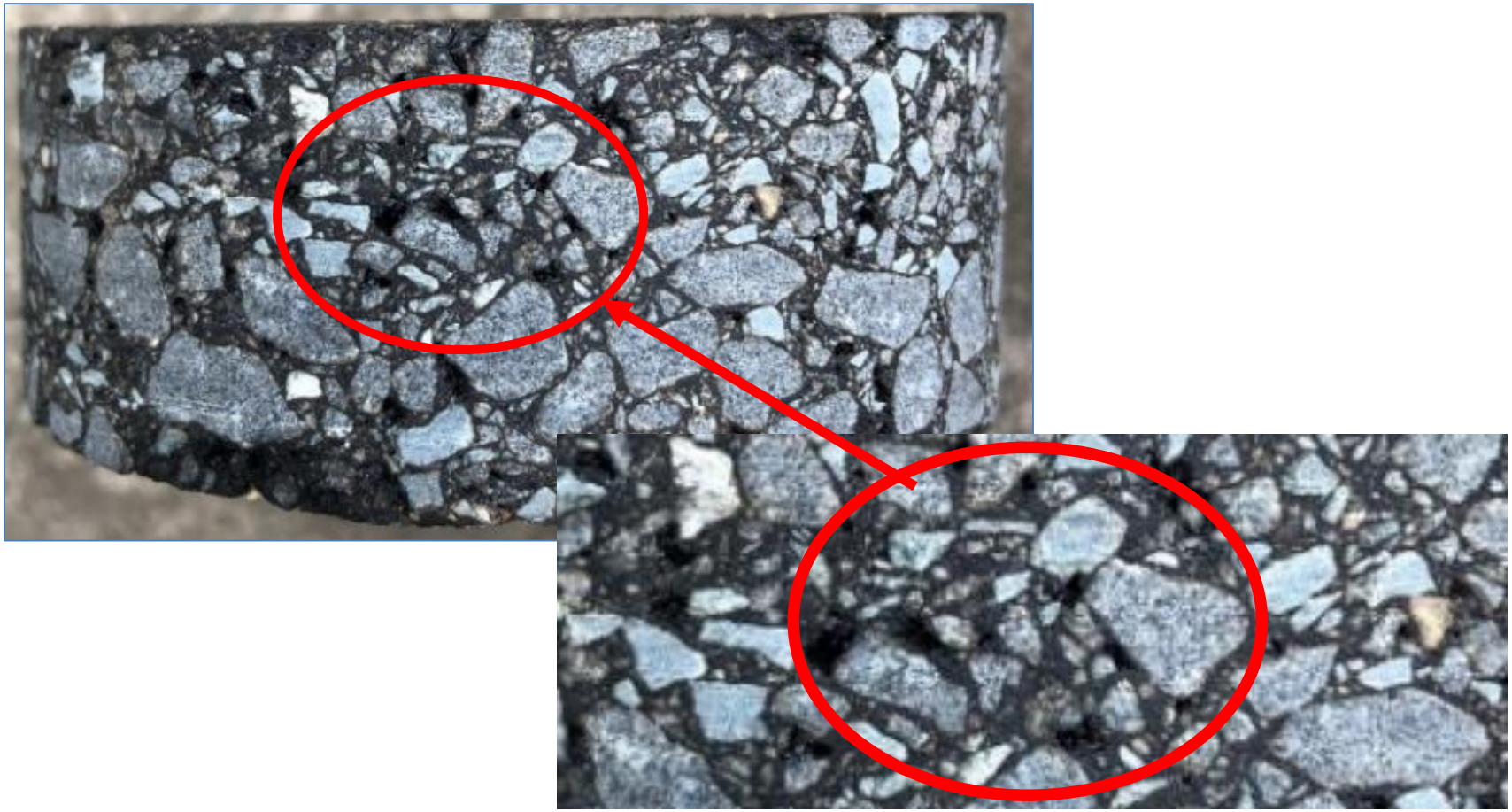
3 months after paving

Flat grade

- Setting the scene
- The test method
- Results based on two methods
- Where does the problem lie?
- Way forward / interim solution

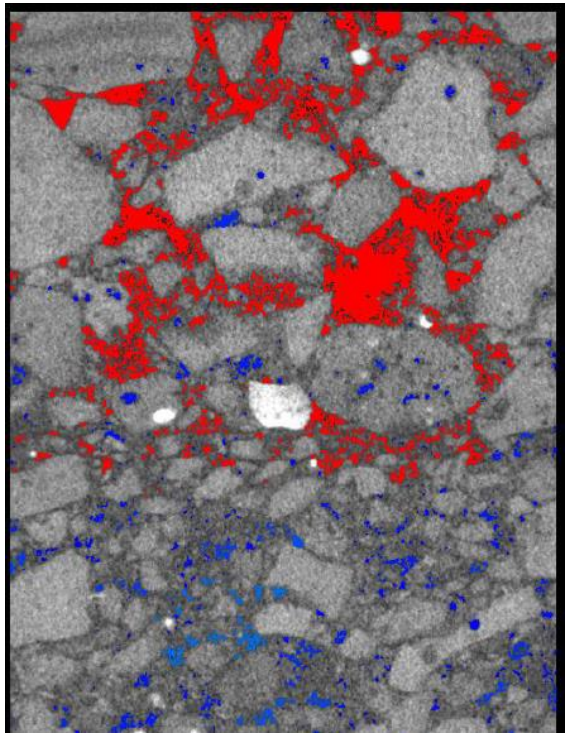
Setting the scene – Asphalt Core – Mix A

Setting the scene – Asphalt Core – Mix A

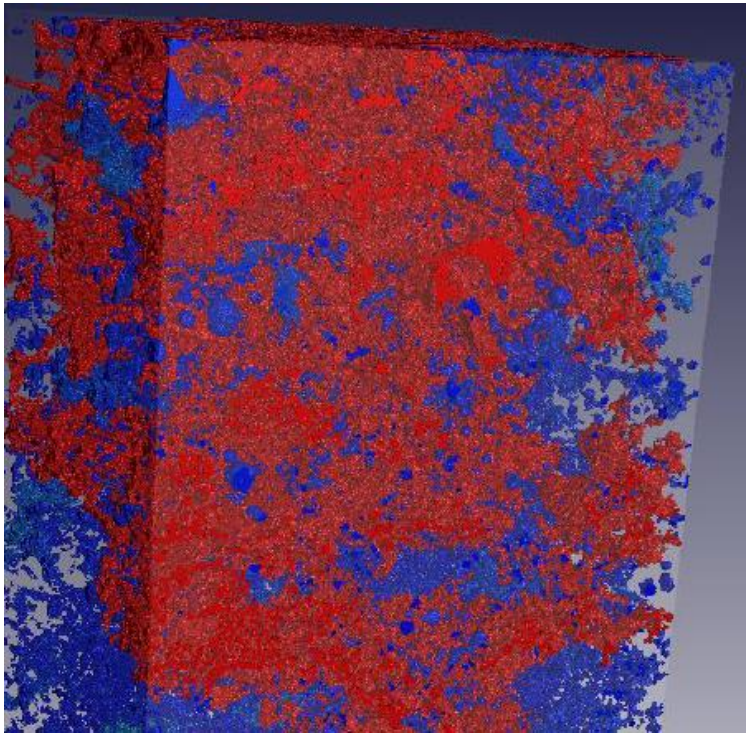


Setting the scene – CT Scan

2 D



3 D



Setting the scene

- Density is the relationship of Bulk Density / Maximum (void-less) Density.
- Voids in mix = f (density (design or in place))

- What has changed over time
  - Resistance to deformation more important
  - Aggregate shape is more cubicle
  - Sieve sizes have changed
  - Voids in mix are inter-connected

- Bulk density is determined according to test method SANS3001 AS10. Is the assessment of water absorption that determines which method to use is correct.

Determining Bulk Density SANS 3001 - AS10

6.2 Determining the volume of the specimen

Use the following three procedures to determine the volume of the specimen dependent on the
expected voids expressed in terms of the water absorbed by the specimen:

a) specimen water absorption < 0,85 % by mass of the total specimen (see 6.4);

b) specimen water absorption between 0,85 % and 15 % by mass of the total specimen (see 6.5);

and

c) specimen water absorption >15 % by mass of the total specimen (see 6.6).

Determining Bulk Density SANS 3001 - AS10

6.4 Volume determination using saturated surface-dry condition, expected specimen water absorption < 0,85 %

Immerse the specimen in a water bath at a temperature of 25 °C ± 1 °C for 3 min to 5 min. Weigh in water.
Surface dry and weigh surface dry specimen

6.5 Volume determination with elastomeric film covering, expected specimen water absorption 0,85 % to 15 %

Weigh elastomeric covered specimen in water and in air.

6.6 Volume determination by direct measurement, expected specimen water absorption > 15 %

Measure the specimen accurately and calculate volume

Determining Bulk Density SANS 3001 - AS10

7.1 Water absorbed by the specimen

Calculate the percentage water absorbed as using the following equation:

$$W_{ABS} = 100 \times \frac{(M_2 - M_4)}{M_4}$$

where

W_{ABS} is the percentage water absorbed by the specimen;

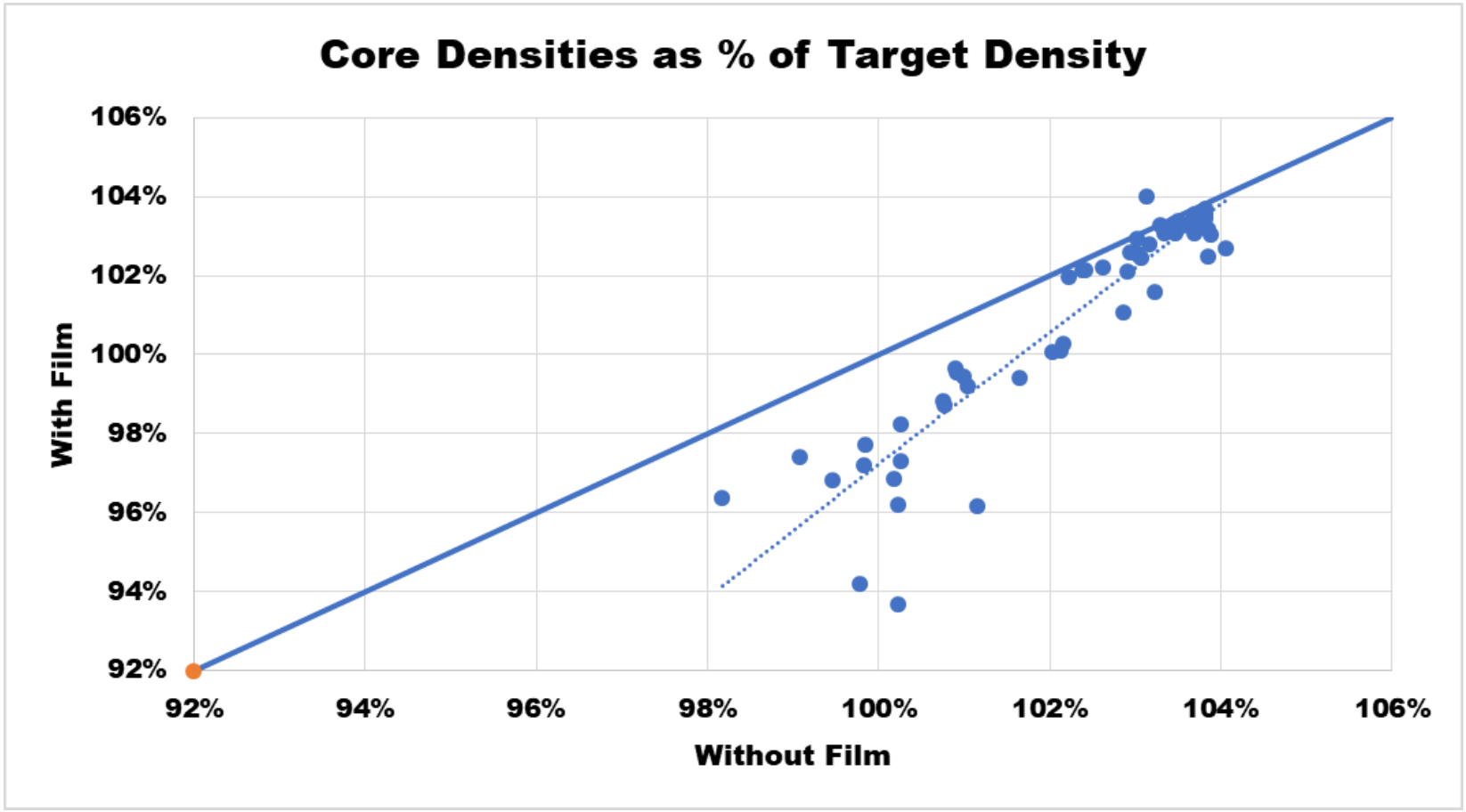
M_2 is the saturated surface-dry mass of the specimen, expressed in grams (g);

M_4 is the oven dry mass of the specimen, expressed in grams (g).

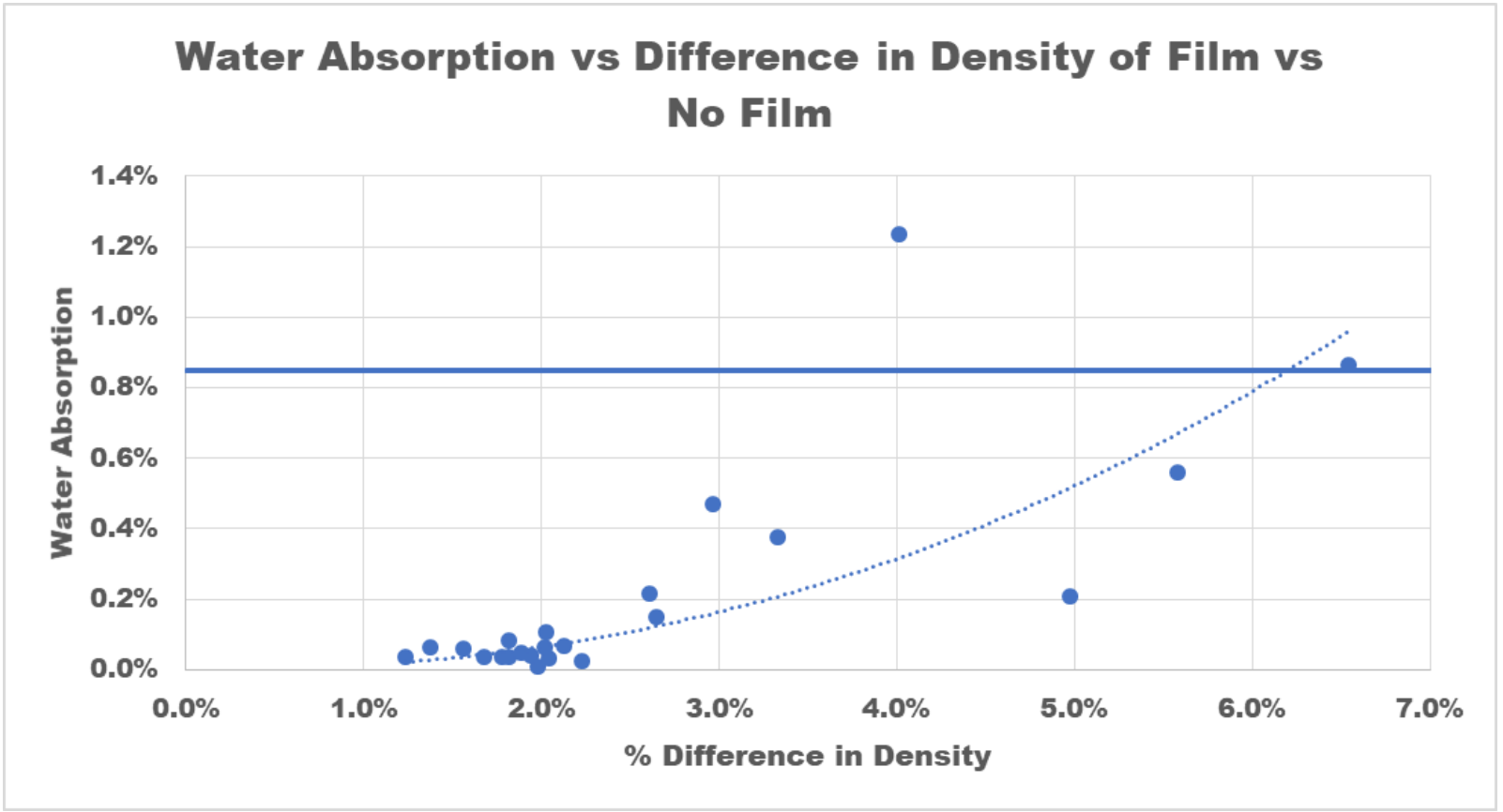
What is the reported density

- Density is the relationship of Bulk Density / Maximum void less density (Rice)
- Density can be expressed as a percentage of target density (97% - approved design voids)
- Voids in mix = 100 –density (design or in place)

Test Results using Method 6.4 & 6.5



Test Results using Method 6.4 & 6.5



WHERE DOES THE PROBLEM LIE?

- In the early days of testing procedures (green book), the volume of the briquette was determined after coating the core in wax to ensure no water penetrated.

- Due to a laborious process, this was changed to initially weighing the core in water as quickly as possible before water can penetrate and later soaking the core and accepting water filling the external voids is negated by a mass of the surface dry specimen.

- Then came TMH1 & SANS 3001 AS10

WHERE DOES THE PROBLEM LIE?

- Mixes designed to have a high resistance to deformation are prone to having interconnected voids as there is a certain amount of “lock-up” that can occur during compaction.

- Initial thought was that the marshal briquette manufacture process resulted in external voids being sealed off with binder. This seems to be incorrect. Parafilm or Corelock might be required here as well

Way Forward

- Suggestion that all laboratories start using SANS3001 AS10 Method 6.5. i.e. covering specimens with elastomeric film.
- If deemed necessary, make this prescriptive in all Project Specifications

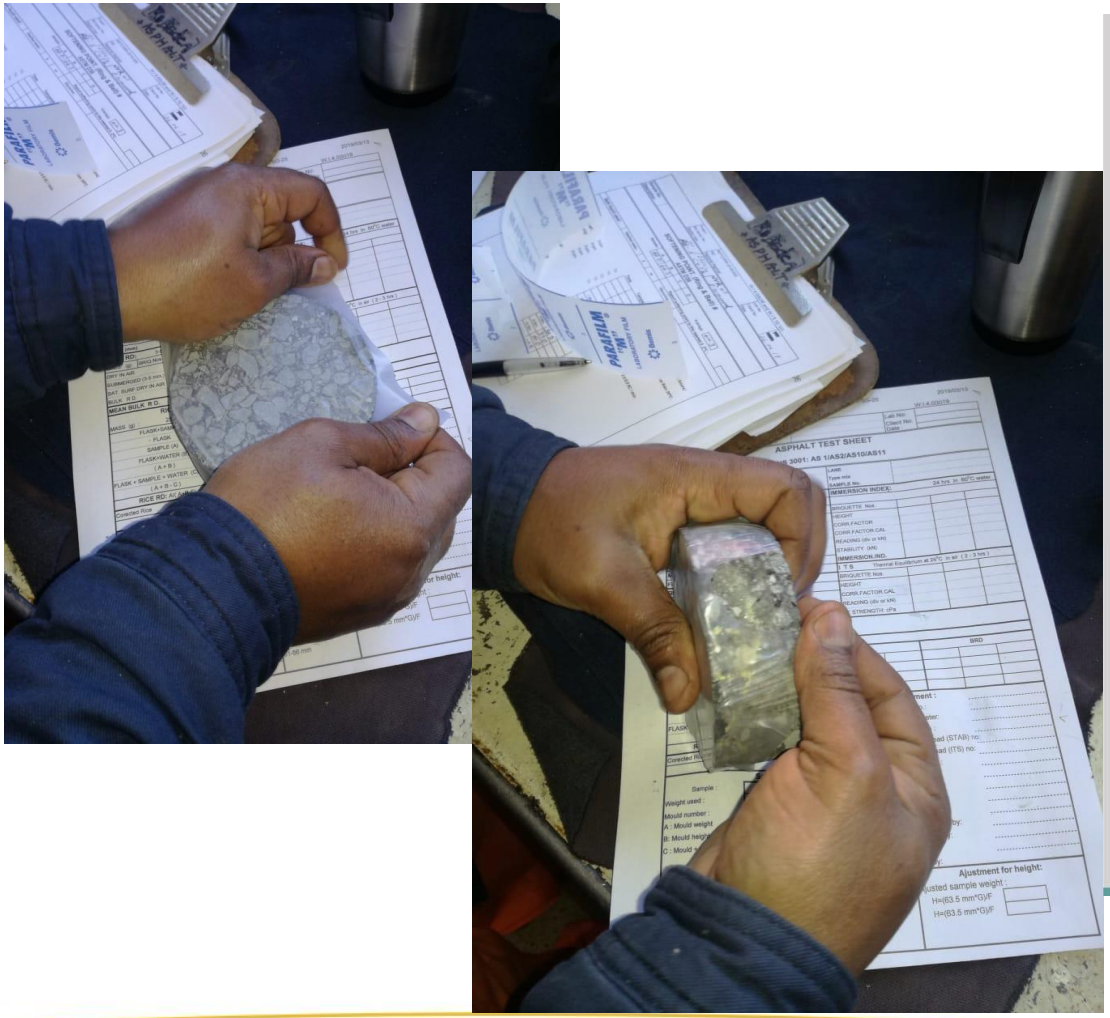
B8108 DETERMINING THE TOTAL APPROXIMATE DRY BULK RELATIVE DENSITY AND THE APPARENT DENSITY

Add the following sub-clause:

"**c) Determination of bulk density and void content of compacted asphalt**

The determination of the bulk density and voids content of asphalt cores will be executed using **SANS-3001-AS 10: 2011** - Procedure 6.5 (i.e.: Volume determination with elastomeric film covering, expected specimen water absorption 0,85 % to 15 %)."

Way Forward – elastomeric film or corelok



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specifications

CORELOK®

One Machine for All Your Gravity Measurements of Asphalt and Aggregates

The CoreLok is an extremely versatile system for measurement of bulk specific gravity and maximum specific gravity (Gmm) of asphalt. The Corelok also measures the apparent specific gravity, absorption and bulk specific gravity of fine and coarse aggregates. GravitySuite™ PC software can be used to calculate and manage the results. The Corelok does not require an empirical calibration and the results do not depend on material type or composition. Meets ASTM Standards D6752-02, AASHTO T-331 and D6857-03.

Bulk Specific Gravity of Compacted Samples:

Specific gravity (density) is the single most specified parameter in the construction industry. For open graded and absorptive mixtures of asphalt, the Saturated Surface Dry (SSD) method is inaccurate. Water infiltration in and out of the sample produces a lower than actual measurement for sample volume, higher calculated density and a lower estimate of air voids. The CoreLok system automatically seals these samples in specially designed polymer bags and allows for measurement of accurate water displacement tests. The present sealing methods, wax and films, are labor intensive and the results are extremely operator dependent. ASTM D6752-02 and AASHTO T-331.

Bulk Specific Gravity of Compacted Samples:

This method may be used as an alternative to the conventional "Rice Test" for the determination of maximum specific gravity of loose asphalt mixtures. The CoreLok test can be completed in 7 minutes with minimal exposure to water, eliminating the need for a lengthy "Dry Back" method. This procedure requires that a sample of dry asphalt mixture be placed inside the vacuum bag and sealed within the CoreLok vacuum chamber. The bag is then cut open under water and a submerged weight is determined. The weight in air and the submerged weight can be used to calculate the maximum specific gravity of the asphalt mixture. ASTM D6857-03.

Apparent Specific Gravity, Absorption and Bulk Specific Gravity of Aggregates:

Oven dry aggregates are used in this test to determine the specific gravity and absorption of fine or coarse aggregates in less than 20 minutes. This test is highly accurate and repeatable. In this test, a density measurement is obtained by vacuum sealing a sample using the CoreLok. Another density is measured under an unsaturated condition using a volumeter. These two densities can be used with already known standard equations to calculate apparent specific gravity, absorption and bulk specific gravity. The AggSpec™ PC software allows for simple entry and calculation of these parameters.

Performance

- Precision Bulk Specific Gravity: Repeated testing of 6" and 4" samples, ±0.002 g/cm3 Maximum Specific Gravity: Ten samples of 25 mm asphalt mixture, ±0.007 g/cm3 Aggregate: Apparent Gravity ±0.005 g/cm3; Bulk Gravity (Dry) ±0.008 g/cm3; Absorption ±0.1% (Ten samples of fine granite aggregate).
- ASTM D6752-02 and ASTM D6857-03.

Mechanical/Electrical

- 1.25 hp rotary vacuum pump.
- 120V, 60Hz, 13 amps (single phase) or optional 220V 50Hz, 6.5 amps.
- Vacuum level 29.95 in. Hg, 1 TORR, 1.33 MBARS.
- 16. in. (406 mm.) automatic wire sealing strip.
- Weight 140 lb. (64 Kg.).
- Shipping weight 200 lb. (91 Kg.).
- AggPlus Shipping weight with CoreLok: 225 lb (102.1 kg).
- Internal Chamber size: 16.75x7.25x19.6in. (425x184x497mm) (WxHxDepth).
- Footprint width 19.25" by depth 25" (489x636mm) (3.25 Sq. Ft.).
- Conforms to national & international standards and requirements.

Polymer Bags

- Impermeable to water.
- Flexible to conform to core surface irregularities.
- Puncture-resistant.
- Multiple sizes to accommodate large and small samples.

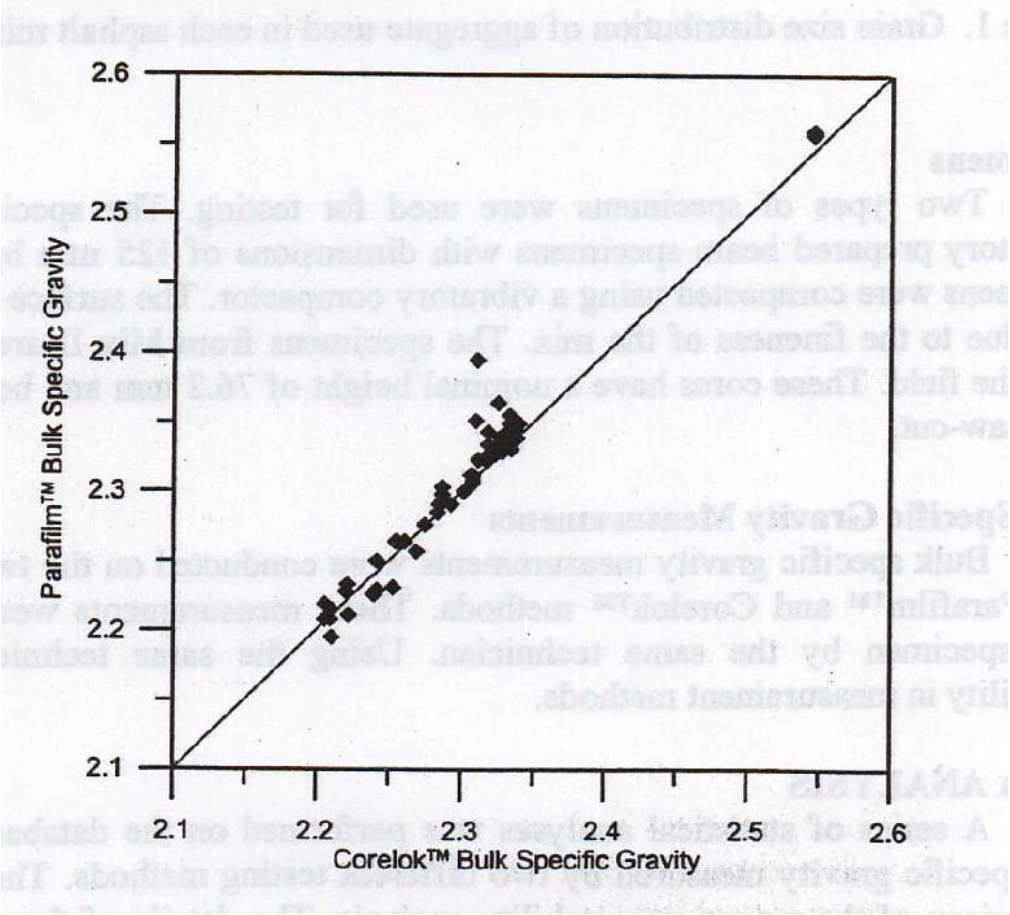
Software

- GravitySuite™ user-friendly PC software with built-in features for calculation of gravity and absorption of asphalt and aggregates.
- Computer Requirements: PC with a Pentium processor. Windows 98 or higher version.
- Export functions to Microsoft® Excel Spreadsheet.

Way Forward – elastomeric film or corelok

Comparative Study of Corelok™ and Parafilm™ Bulk Specific Gravity Measurements on Coarse-Graded HMA Specimens
Reno Nevada 2003

Corelok method more repeatable



Please provide feedback

Thank you