Use of RAP in Pavement Recycling South African Perspective

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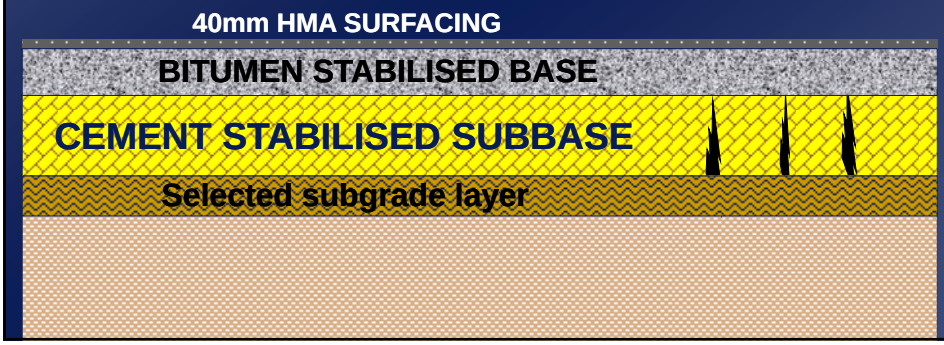
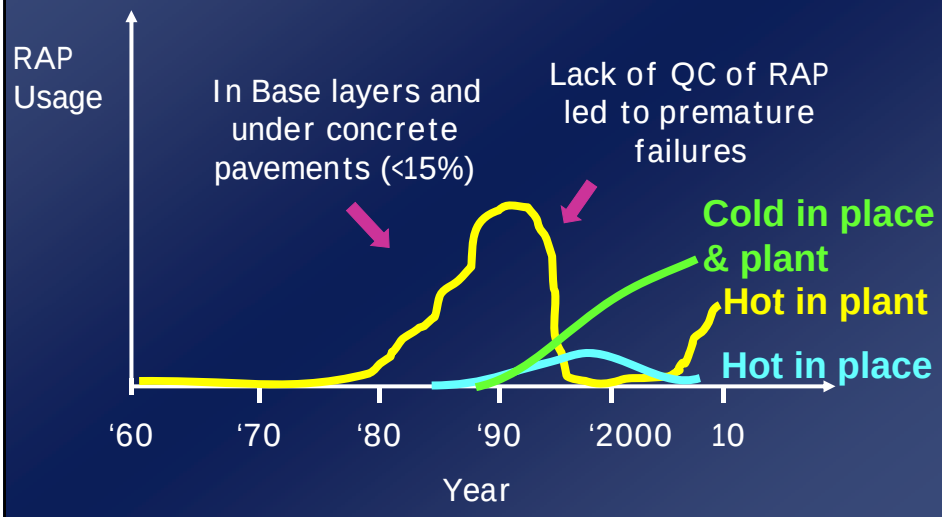
Stellenbosch

The South African "upside-down" pavement

The Recycled Layer

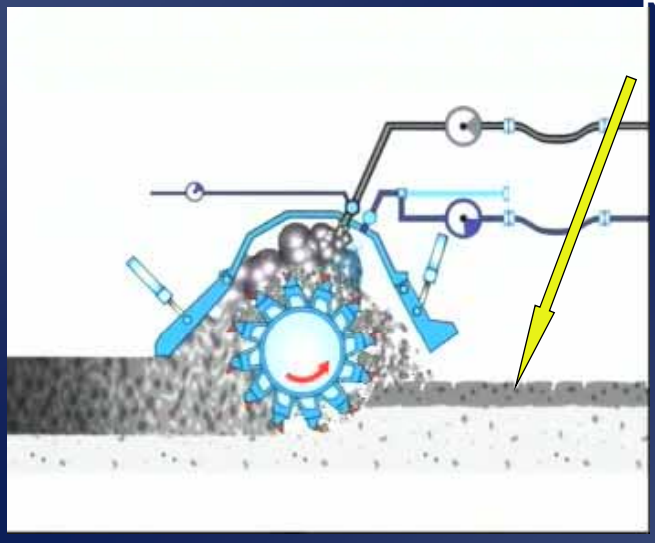


Evolution of RAP recycling in SA



How RAP is included in CIPR

Granular and RAP Materials



Barriers to recycling of RAP in South Africa (and many developing countries)

- Lack of understanding (perceived to be low quality materials)
- Lack of specs/legislation
- Variability of HMA's in situ
- 80% of surfacing in SA = seals
- Economic benefits not realized (need legislation to enforce recycling then contractors will use it for competitive edge)

Availability of RAP in South Africa

- Thick layers seldom used in RSA (only heavily trafficked ones)
- Type of RAP
  - 1960's to 70's = Gap graded RAP
  - 1970's to 90's = Semi-gap graded RAP
  - 1990's + = Continuously graded & PMBs

Mix Design in South Africa

- Recovered Pen, Tr&b and η if >15% RAP in new HMA
- Remember BC in RAP is higher in fines than coarse fraction
- Limits of RAP based on mix type
  - <2% in SMA <12% in PMA
    <18% in unmodified <23% in binder layer
    <27% in base

Manufacture limitations

	Mixing Plant Type	Max RAP
HOT	• Batch plant	
	– Added in pugmill	<15%
	– Added before hot elevator	<30%
	• Drum plant	
	– Parallel heating	10 – 20%
	– Contra-flow heating	20 – 30%
	• Twin-dryer drum	<50%
	• Double drum	<70%
COLD	• In plant & in place	<85%

Some general values

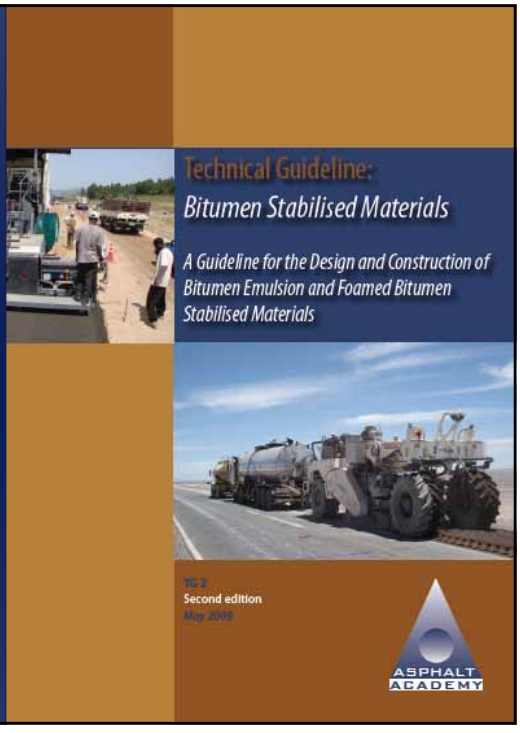
- In South Africa, less than 5% of total RAP used in HMA (see comparative figures in Introduction ppt)
- Only 4 million tons of new HMA every year

BITUMEN STABILISED MATERIALS

TG2 : 2nd EDITION

Published in South Africa by Asphalt Academy (CSIR / SABITA)

May 2009

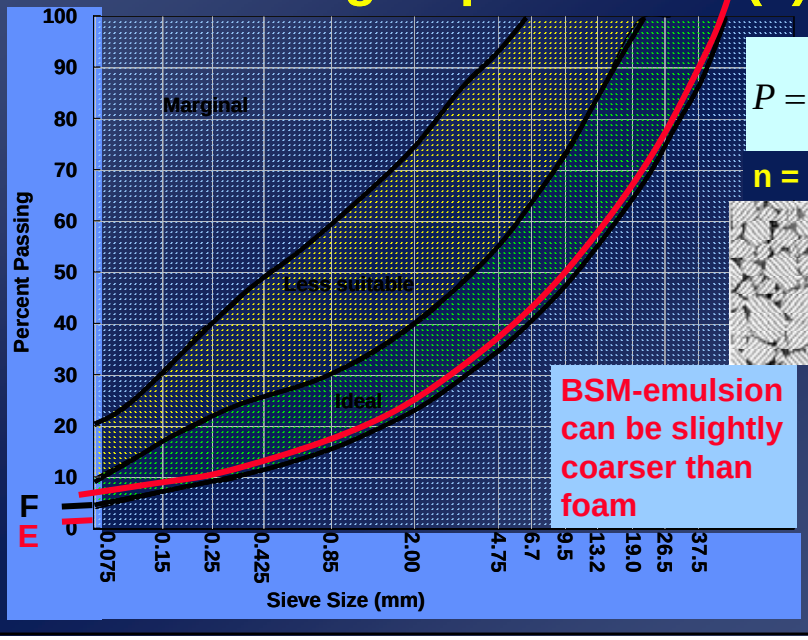


Mix Design

Some of the issues for developing countries

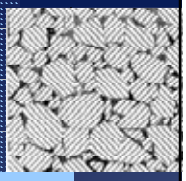
Classes of BSM

BSM Grading requirements (1)



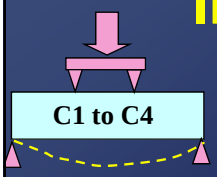
$$P = \left(\frac{d}{D}\right)^n$$

n = 0.45

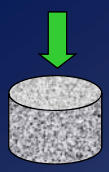


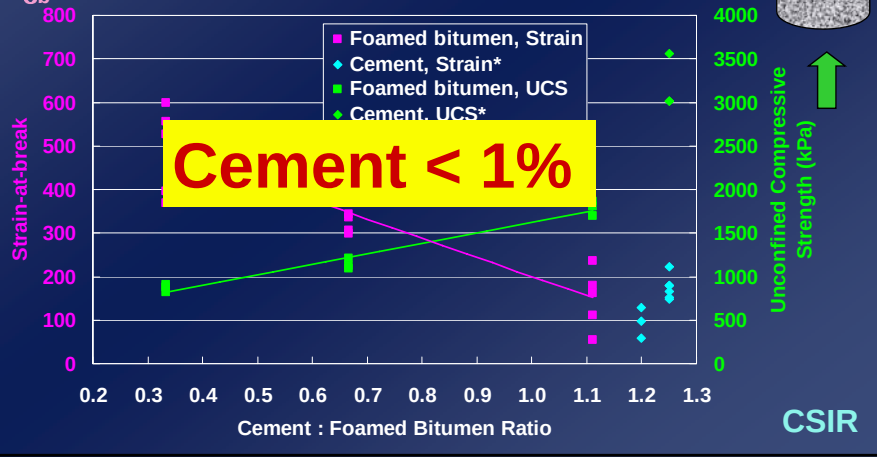
BSM-emulsion can be slightly coarser than foam

Influence of Active Filler



Strength and flexibility



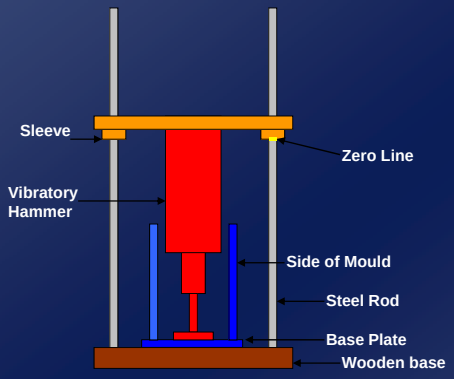


Cement < 1%

CSIR

Vibratory Compaction Hammer

To prepare specimens



Rear View of Frame

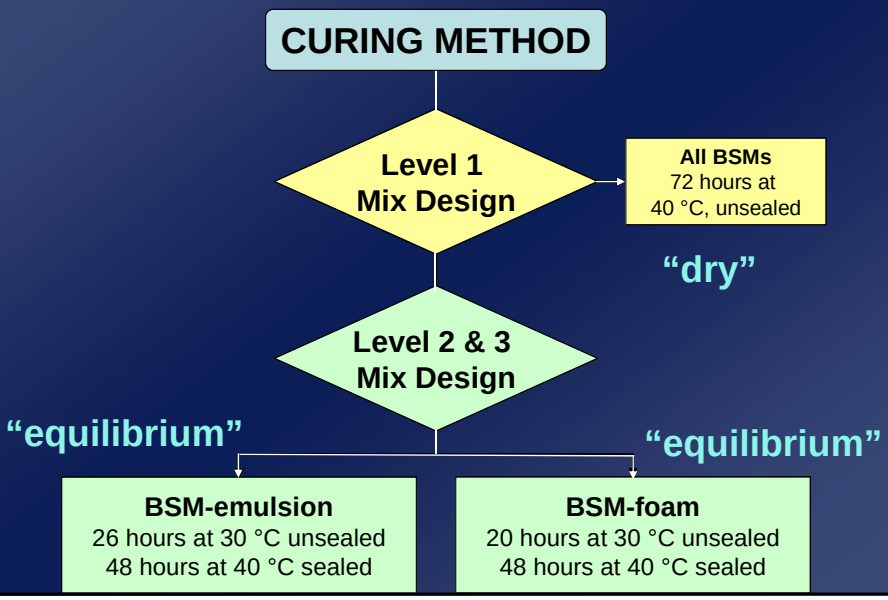
Kelfkens

Compaction time (vibratory)

Phase	Level 1	Level 2		Level 3
Test	ITS	ITS	UCS	Triaxial
Foot ϕ	100mm	150mm	150mm	150mm
Height	65mm	95mm	125mm	300mm
Layers	1	2	2	5
Surchg	5 kg	10 kg	10 kg	10 kg
Foam	10 sec	25 sec	25 sec	25 sec
Emuls	10 sec	15 sec	15 sec	15 sec

Comp Time

Final Curing Protocol



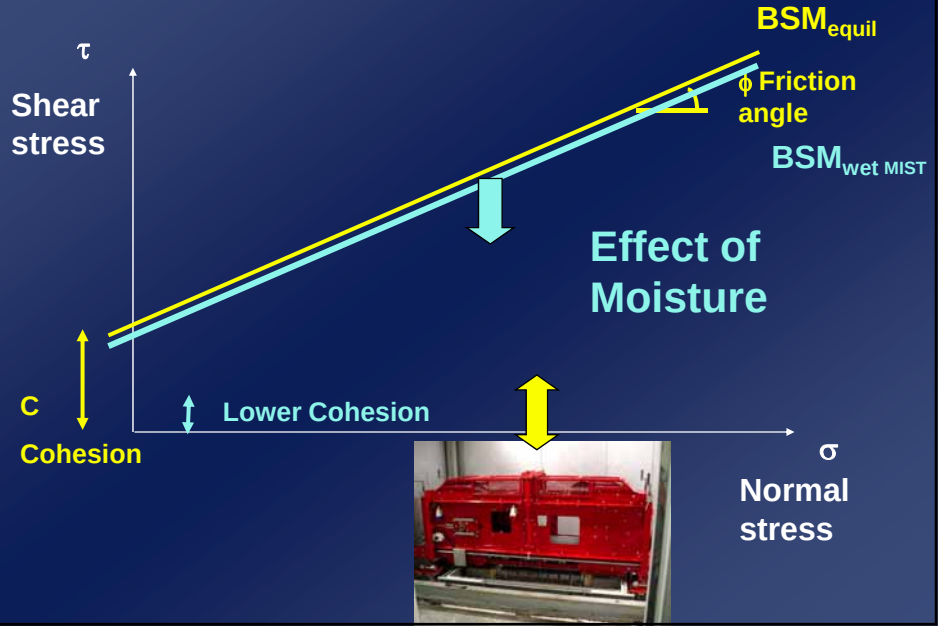
Level 1 and 2 Testing

	Test	Dia ϕ mm	BSM1 (kPa)	BSM2 (kPa)	BSM3 (kPa)	Comments
Level 1	ITS_{dry}	100	>225	175 to 225	125 to 175	Indicates OBC
Level 1	ITS_{wet}	100	>100	75 to 100	50 to 75	Indicates active filler type & amt
Level 1	TSR	100	Not applicable			Prob mat TSR < 50 % ITS_{dry} > 400 kPa
Level 2	ITS_{equil}	150	>175	135 to 175	95 to 135	OBC refined
Level 2	ITS_{soaked}	150	>150	100 to 150	60 to 100	Check for ITS_{wet}

Level 3 Testing
Triaxial Tests

Equivalent BSM Class	Angle of Internal Friction (º)	Cohesion (kPa)
BSM 1	> 40	> 250
BSM 2	30 to 40	100 – 250
BSM 3	< 30	50 – 100

Effect of moisture



BSM Classification ito Moisture Resistance

Equivalent BSM Class	Retained Cohesion (%)
BSM 1	> 75
BSM 2	60 – 75
BSM 3	50 – 60
Unsuitable	< 50

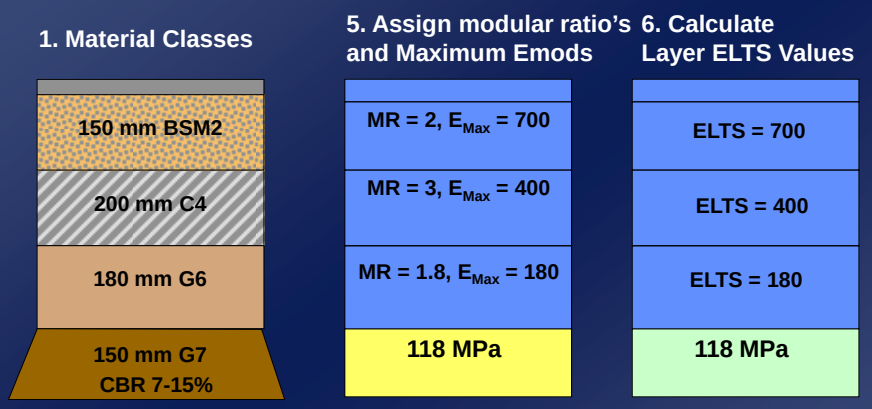
Structural Design Methods

1. TG2 Method (Pavement Number)
2. Mechanistic (Stress Ratio)

Method 1: Pavement Number Knowledge Based Approach

- Gather all available field performance data
- Utilise best elements of mechanistic analysis
- Robust and easy to use
- Validated!
- Develop clear, strong links to field testing (material classification) and specifications
- Data Sets
  - 20 field sites
  - 7 HVS Sites (22 test sections)
  - Construction, maintenance & performance information

Example, Moderate Region



2. Determine subgrade stiffness (140 MPa)

3. Adjust for climate (126 MPa)

4. Adjust for cover (118 MPa)

6. ELTS = min ($E_{support}$*MR , Emax)

7. Layer PN = thickness * ELTS

8. PN = Σ layer PN

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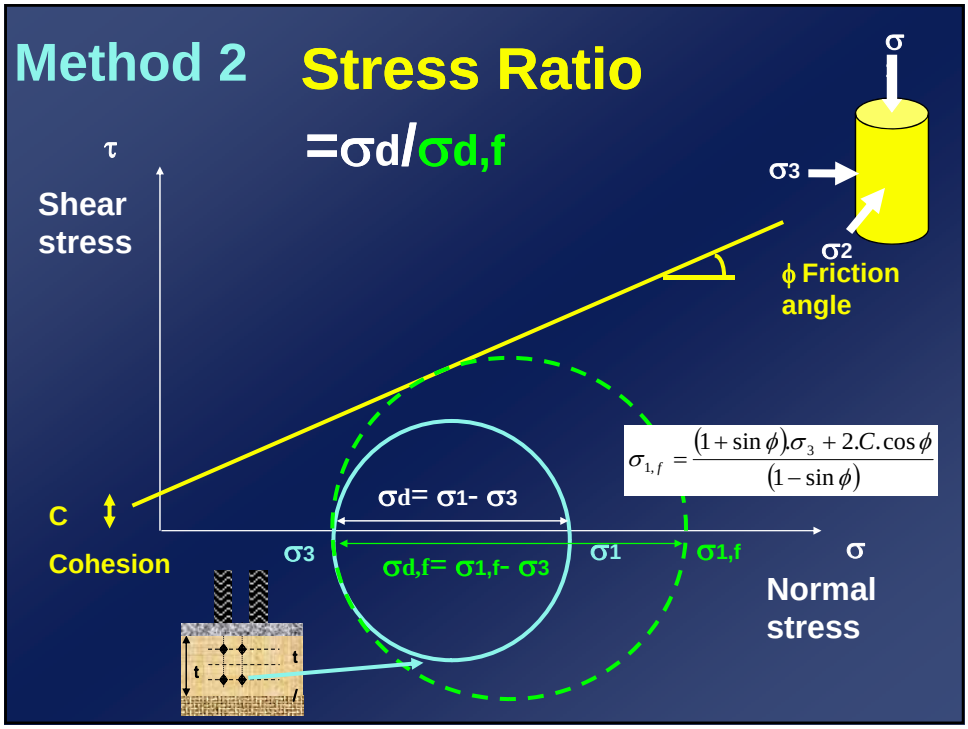
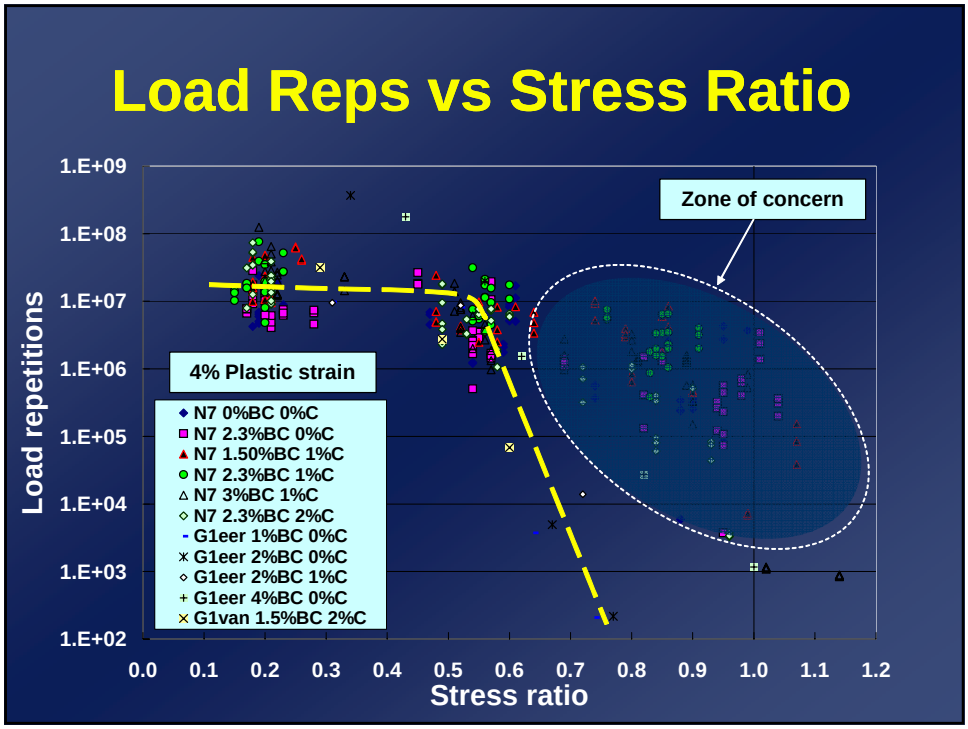

Method 2
Stress Ratio
=σd/σd,f
τ
Shear stress
σ
σ3
σ2
ϕ Friction angle
C
Cohesion
σd= σ1- σ3
σd,f= σ1,f- σ3
σ3
σ1
σ1,f
σ
Normal stress
$\sigma_{1,f} = \frac{(1+\sin\phi).\sigma_3 + 2.C.\cos\phi}{(1-\sin\phi)}$


Load Reps vs Stress Ratio
Zone of concern
4% Plastic strain
N7 0%BC 0%C
N7 2.3%BC 0%C
N7 1.50%BC 1%C
N7 2.3%BC 1%C
N7 3%BC 1%C
N7 2.3%BC 2%C
G1eer 1%BC 0%C
G1eer 2%BC 0%C
G1eer 2%BC 1%C
G1eer 4%BC 0%C
G1van 1.5%BC 2%C
Load repetitions
1.E+09
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Stress ratio

Conclusions

- Understanding of material behaviour of BSMs has increased significantly
- Active filler versus bitumen content in BSM is very important
- Cemented layer is best in subbase
- More advanced test methods (triaxial)
- Mix Design is linked to Structural Design method for BSMs