ISAP TC APE
Working Group 2
Cold Recycling of RA(P)

Kim Jenkins
Chair

Drakensberg, South Africa (CAPSA 2011)
11th September 2011

Stellenbosch

Outline

- Objectives of ISAP WG2 Cold Recycling
- Global perspective – CR research
- Progress to date
- TODAY'S PROGRAMME

Minutes from TRB 2010: ISAP TC Asphalt Pavement and Environment

- WG1 on Recycling (Chantal de la Roche)

WG1
Hot Recycling-RAP
(Peter Sebaaly)

WG2
Cold Recycling-RAP
(Kim Jenkins)

Purpose of ISAP WG2

- Global interface for needs analysis regarding cold recycling
- Coordinate research by sharing findings, identifying needs and technical solutions
- Promote CR technology by:
  - Coordinate publications, guidelines, specifications
  - Create a database of research/ project data
  - Gather & share info on enviro & sustainability

ISAP WG2 Members 2011

WG2 Membership = 32

Continent	Members	Countries
Africa	3	1
Asia	9	2
Australasia	1	1
EU	14	5
North America	3	1
South America	2	1

Focus of WG2 discussions

- Research focus areas (Global)
  - Laboratory
  - Field (APT and LTPP)
- Key findings and developments
  - Mix design
  - Structural design
  - Specifications
- Publications, documents and manuals

Activities of WG2 in 2010
Meet at Conferences

- Meeting and workshop at EATA (European Asphalt Technology Association) Conference, Parma, Italy on 11th June 2010
- Regional Workshop at MRC (Malaysia Roads Conference) Kuala Lumpur, Malaysia on 9th October 2010

Programme: WG2 Regional EU Workshop in Parma

- Workshop structure with 6 presenters
  - Global perspective on Cold Recycling
  - USA: UC Davis
  - Italy: Pisa & Anconna Uni - France: LCPC
  - Asia : Chang'an Univ SE Asia: Malaysia
  - Africa: Practitioner and Researcher
- Global representation
- Broad research perspective, projects

Programme: WG2 Regional Asian Workshop in KL

- Workshop structure with 4 presenters
  - Global perspective on Cold Recycling and feedback from Parma
  - China: RIOH (Research Inst)
  - Thailand: Road authority
  - Malaysia: Contractor HCM /R&D
- Regional representation
- More applications, less research

Re-use of asphalt in Europe (2009)

Country	Available RAP (ton)	Re-used HOT (%)	Re-used COLD (%)	%New HMA production
Germany	$14 * 10^6$	82	18	60
Spain	$2.25 * 10^6$	8	4	3.5
Italy	$14 * 10^6$	18	2	
France	$6.5 * 10^6$	13	< 2	< 10
Norway	$0.59 * 10^6$	7	26	8
Netherland	$3 * 10^6$	75		63

(source: Molenaar)

Use of RAP Worldwide (2005)

COUNTRY	RAP in HMA
South Africa	< 5%
France	13%
Australia	50%
Netherlands	75%
USA	70%
Germany	82%
Japan	99%

CAPSA 2007

Lots of talk but how much action?

Way forward of WG2

Synthesis of Global Research and Publications

FOCUS AREA	RESPONSIBILITY
1. Research	• D Jones
2. Mix Design	• K Jenkins
3. Structural design	• G Tebaldi & F Long
4. Construction & QC	• D Collings

"State of the Art"??

Is this going anywhere?

- Where are the challenges in research?
- How to manage these challenges?

So where can new tech go wrong? …remember 3 P's of Innovation

One Recycler Manufacturer alone

Cold Recyclers and Soil Stabilizers

Can we afford to ignore the technology?

How to address the recycling needs (manage the process)

1. Awareness
2. Acquiring knowledge
3. Develop the tools
4. Implementation

1. Awareness: Issues to address

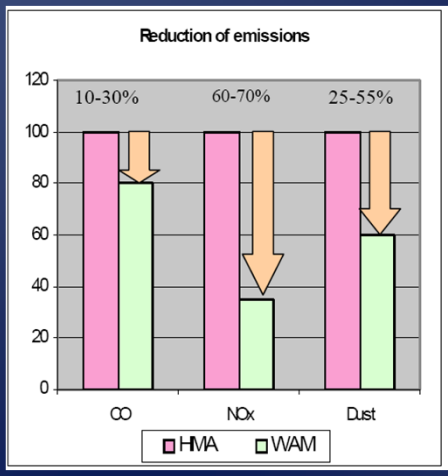
- Challenges for Cold Recycling of RA?
- Distress mechanisms (rutting, fatigue, durability)?
- Key areas for future research to address needs
  - High percentage RA
  - Appropriate tests
  - Lab versus field behaviour

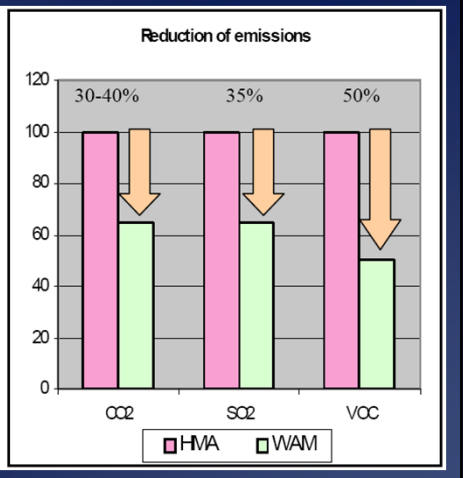
Variability

- Harmonisation of mix & structural design
- Global research cooperation? Energy?

Changing Technologies helps Environment

Emissions at the Chimney



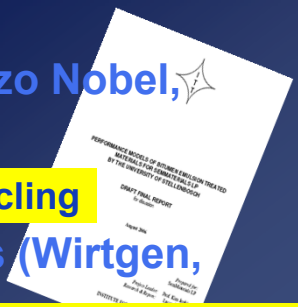


BSM -emulsion versus -foam

Who is the custodian of strategic research?

- **Emulsion:** Koch/Sem, Akzo Nobel, Cola[illegible] Mead Westvaco
- **Foam:** Recycler suppliers (Wirtgen, Bomag etc)…who else?

ISAP WG2 Cold Recycling



Awareness ☻ ☻ ☻ ☻ ☻

2. Acquiring knowledge

- Universities and Research Institutes
- Research initiatives
  - Laboratory research
  - Accelerated Pavement Testing
  - LPTT
- International Cooperation? (WG2)
- Database of research?

New LTPP Sections (SA)

- Very limited background info
  - Mix designs?
  - As built details?
  - Traffic
- BSM-emulsion all on CTSBs
- BSM-foam all on granular
- Some new LTPP sections planned
  - Same materials, subgrade, climate
  - Cement, emulsion, foam binders

Acquire knowledge ☻ ☻ ☻ ☻ ☻

3. Develop the Tools
4. Implementation

- Role of ISAP WG2 for inputs into Manuals, Guidelines, Specifications
- Training / Education / Updating practitioners (3 C's)

Acquire Knowledge & Develop Tools ☻ ☻ ☻ ☻ ☻

Workshop Programme

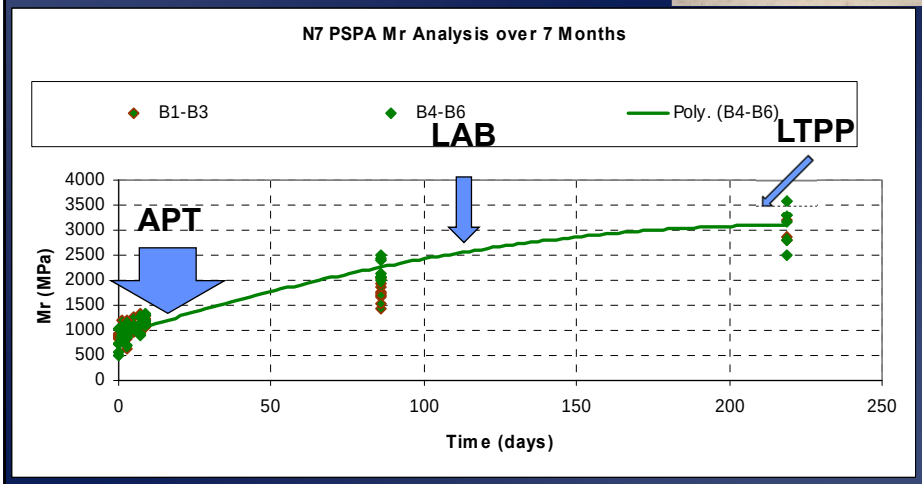
- Rilem TG6 – Gabriele Tebaldi
- CR Projects: Climate – Dave Collings
- Enviro, Energy, Emissions – Martin vdV
- SusCoM, Wuhan – Liantong & Andre Mol
- Deflections on BSMs – Alessandro Mar
- Marginal materials – Mohd Hizam
- Discussion (incl Allen Browne)

THANK YOU AND ENJOY THE WORKSHOP!!

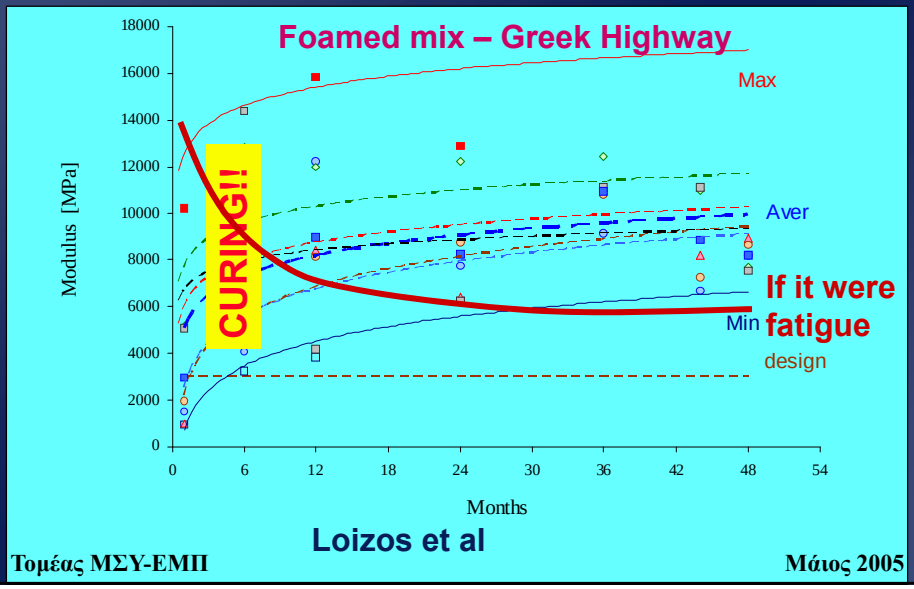
Curing
Field moisture versus time

Moloto (BSM-emulsion)

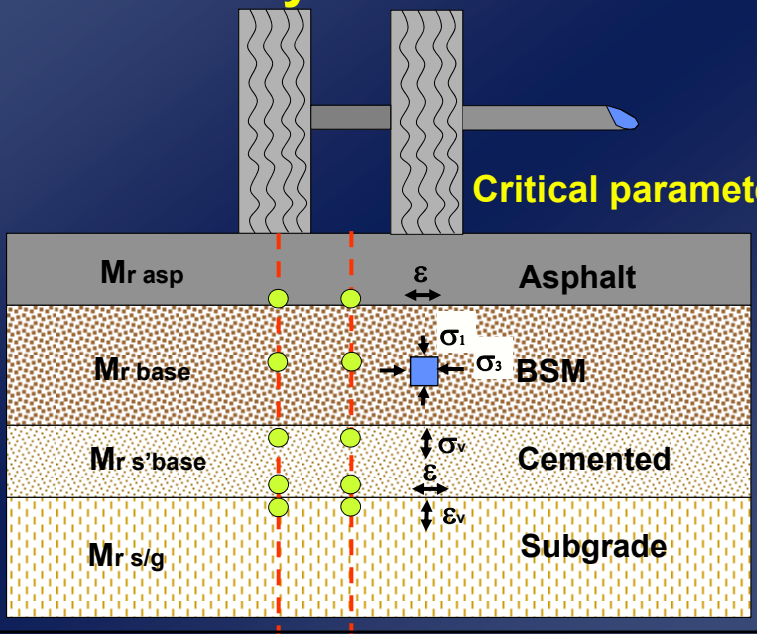
Mr (field) versus cure



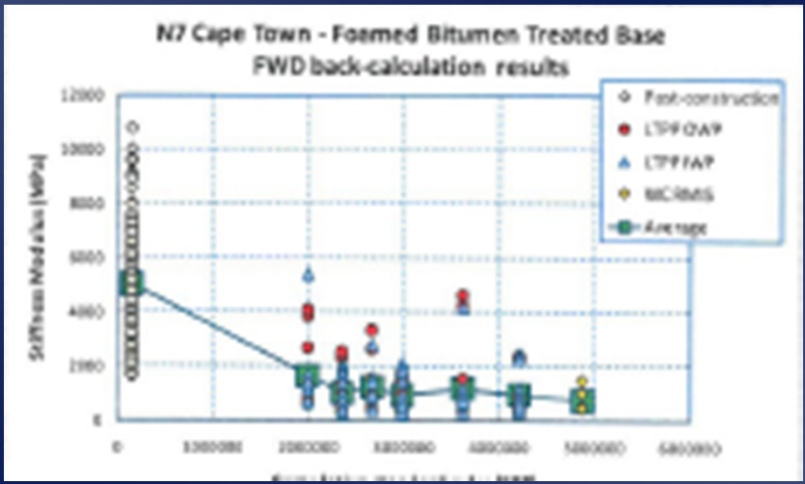
BSM Modulus (back analysis)



Pavement Analysis: stresses/strains



What are others' analyses finding?



Theyse

New LTPP Sections

- Very limited background info
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- BSM-emulsion all on CTSBs
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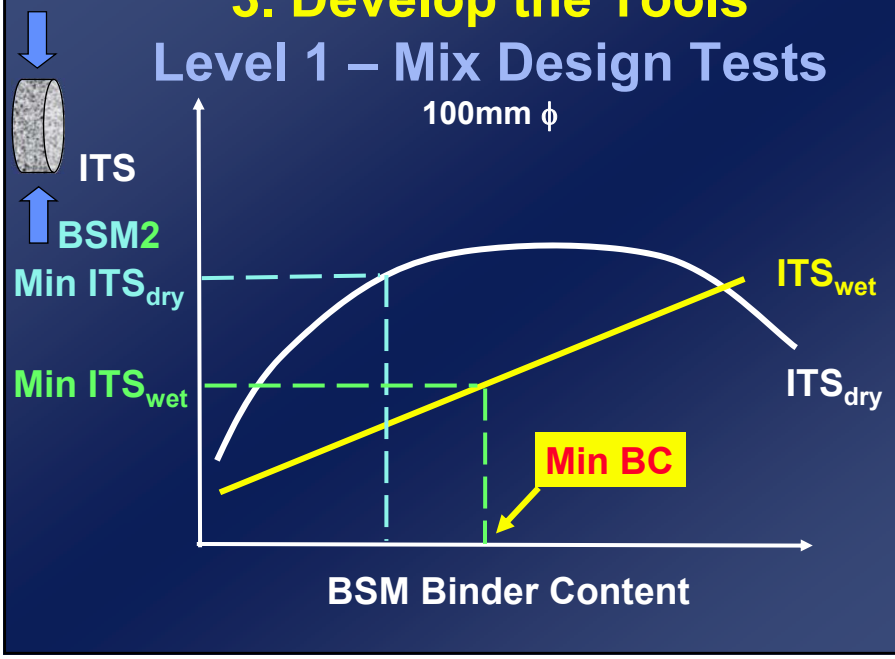
Acquire knowledge ☻ ☻ ☻ ☻ ☻

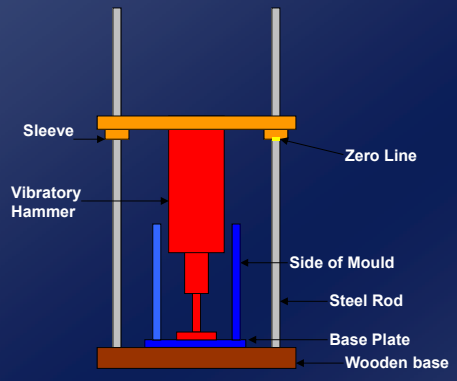
3. Develop the Tools

Level 1 – Mix Design Tests



Vibratory Compaction Hammer

To prepare specimens



Rear View of Frame

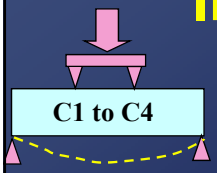
Kelfkens

Compaction time (vibratory)

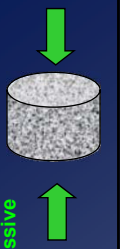
Phase	Level 1	Level 2		Level 3
Test	ITS	ITS	UCS	Triaxial
Foot ϕ	100mm	150mm	150mm	150mm
Height	65mm	95mm	125mm	300mm
Layers	1	2	2	5
Surchg	5 kg	10 kg	10 kg	10 kg
Foam	10 sec	25 sec	25 sec	25 sec
Emuls	10 sec	15 sec	15 sec	15 sec

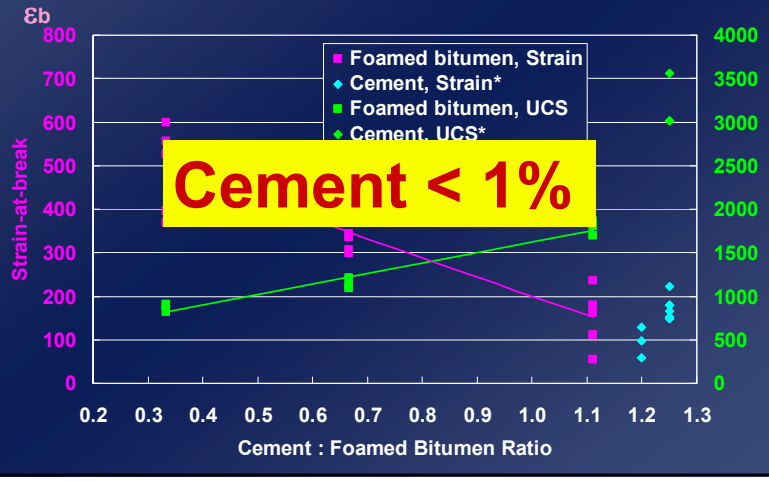
Comp Time

Influence of Active Filler



Strength and flexibility

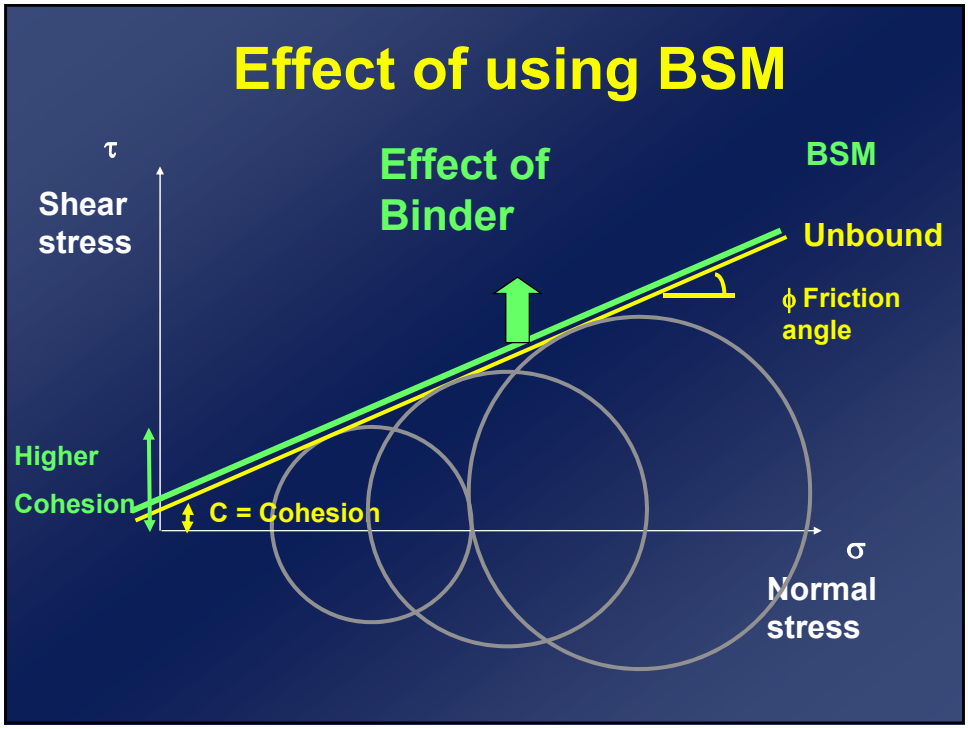




Cement < 1%

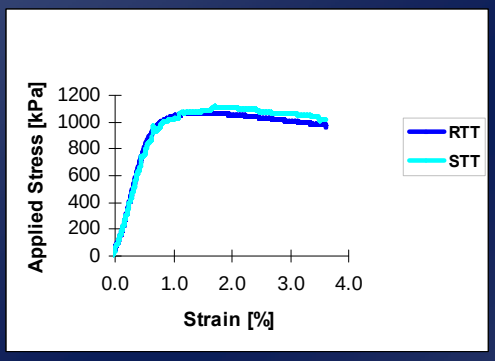
CSIR

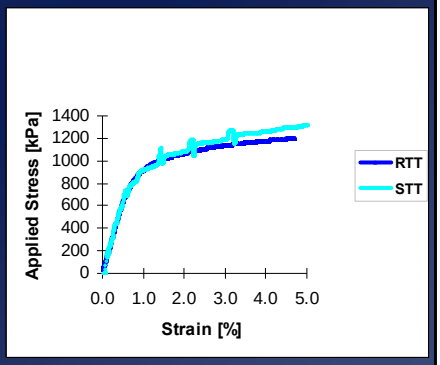
Triaxial Testing


Effect of using BSM
τ
Shear stress
Effect of Binder
BSM
Unbound
ϕ Friction angle
Higher Cohesion
C = Cohesion
σ
Normal stress


New "Simple triaxial"

Research Triaxial Test RTT versus Simple Triaxial Test STT





BSM Crushed Hornfels with 3.3% Emulsion

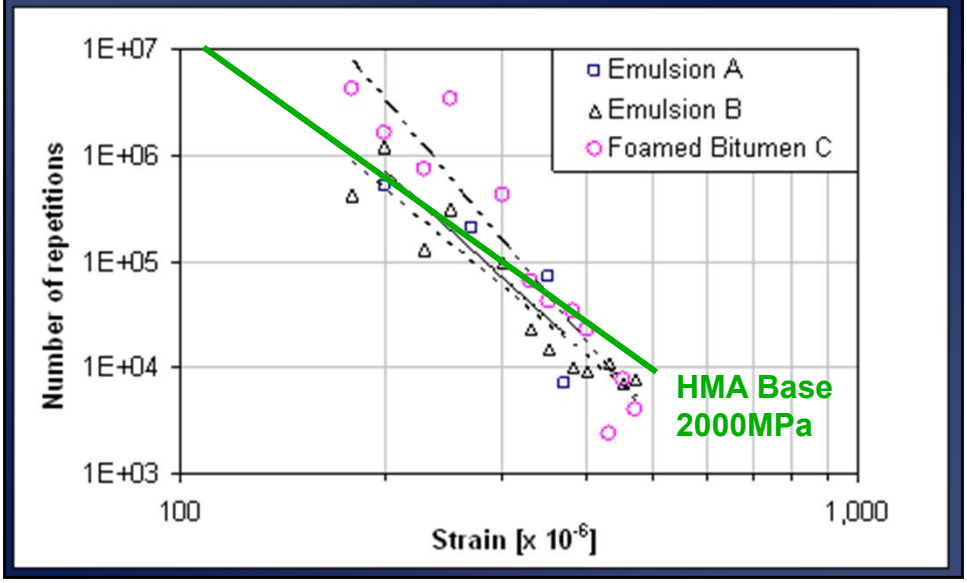
σ_3 =50 kPa and 1% Cement σ_3 = 200 kPa and 0% Cem

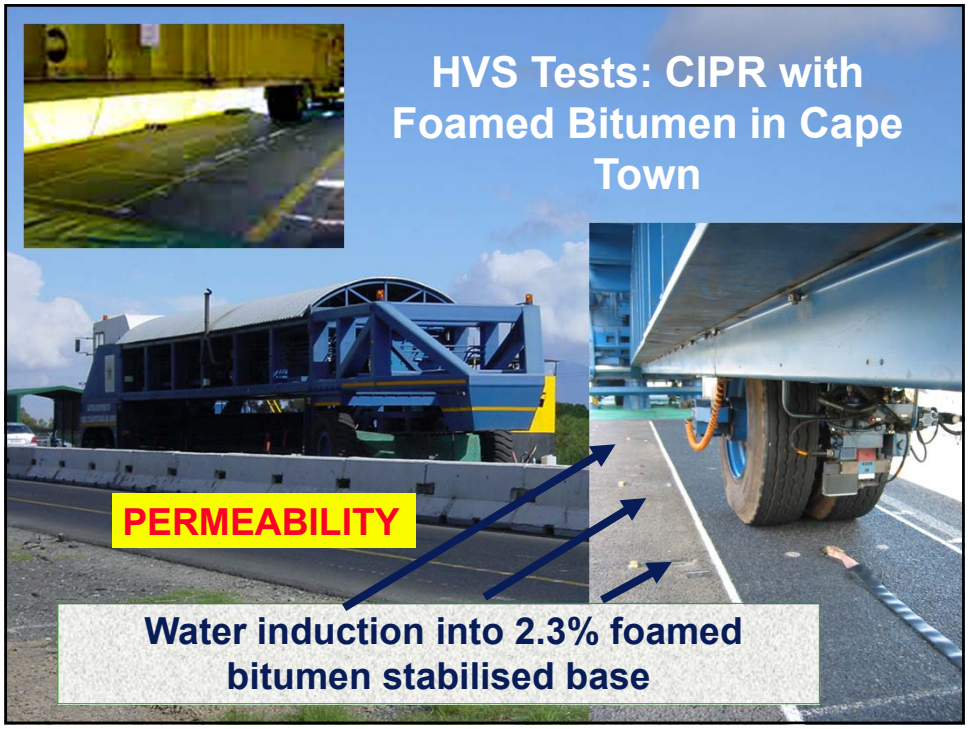
BSM Classification ito Shear Properties

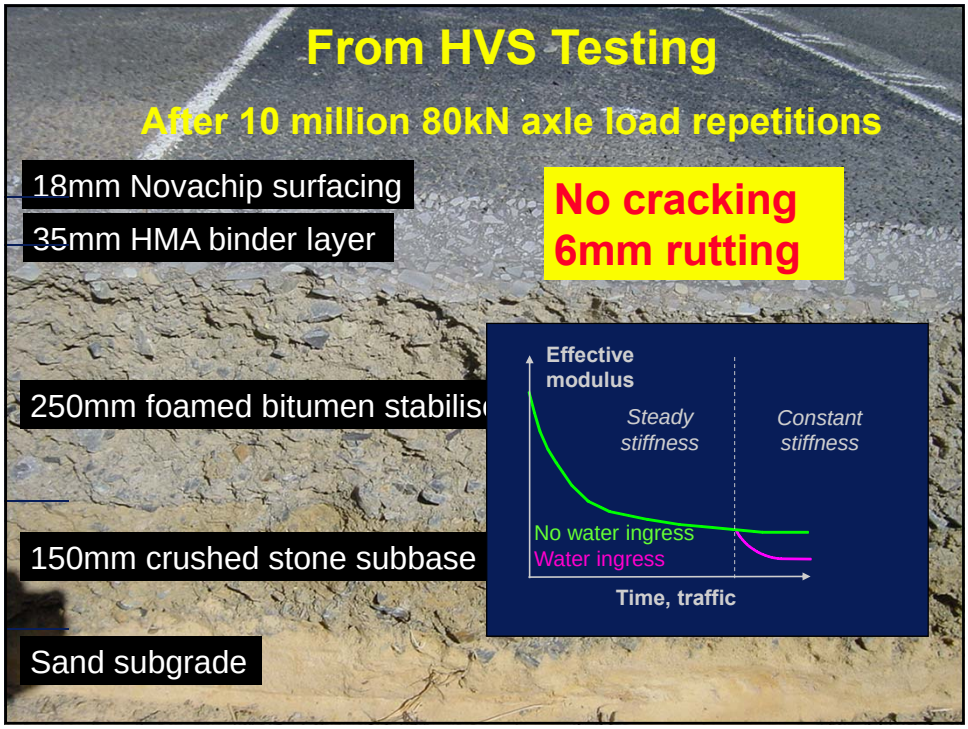
Equivalent BSM Class	Angle of Internal Friction (º)	Cohesion (kPa)
BSM 1	> 40	> 250
BSM 2	30 to 40	100 – 250
BSM 3	< 30	50 – 100

Fatigue?

Fatigue: Crushed stone + 25% RAP




HVS Tests: CIPR with Foamed Bitumen in Cape Town
PERMEABILITY
Water induction into 2.3% foamed bitumen stabilised base


From HVS Testing
After 10 million 80kN axle load repetitions
18mm Novachip surfacing
35mm HMA binder layer
No cracking
6mm rutting
250mm foamed bitumen stabilis
150mm crushed stone subbase
Sand subgrade
Effective modulus
Steady stiffness
Constant stiffness
No water ingress
Water ingress
Time, traffic

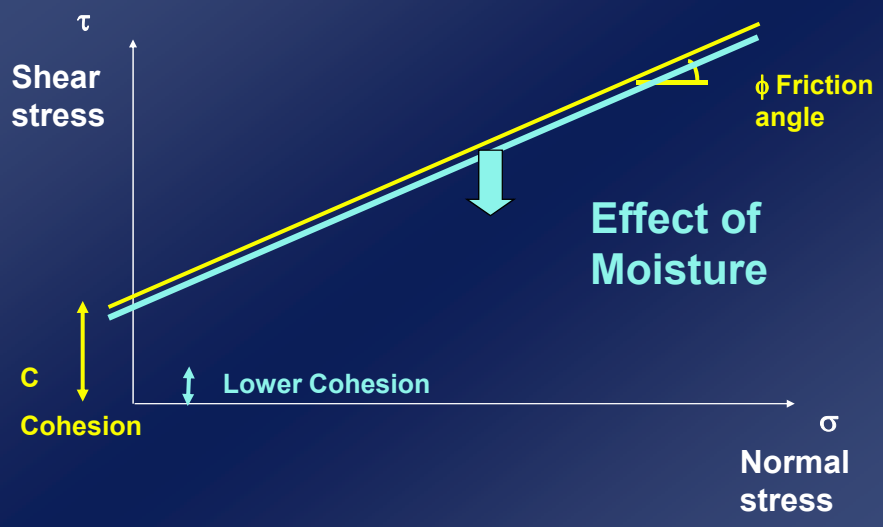
Lab APT

Durability: New, Improved Tests

- Untreated Material Properties
- Moisture sensitivity tests

(Twagira)

Effect of moisture

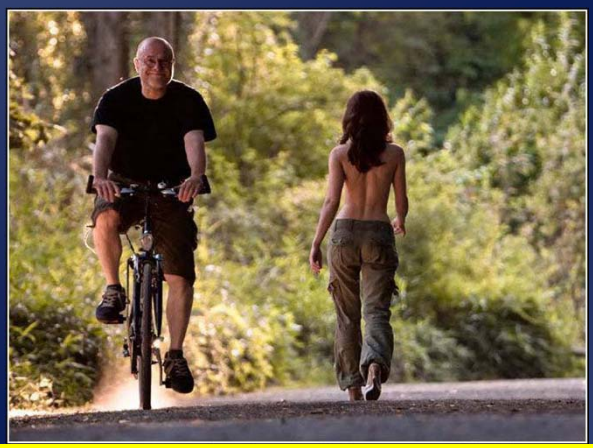


BSM Classification ito Moisture Resistance

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

Develop Tools ☻ ☻ ☻ ☻ ☻

Implementation



Keep your eyes on the road

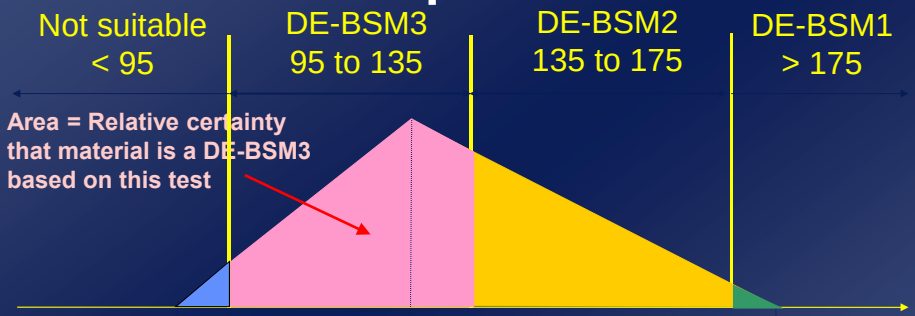
Materials Classification BSMs - Similar to granular

Test or Indicator	Samples	Test Limits for Material Class BSM1	Test Limits for Material Class BSM2	Test Limits for Material Class BSM3	Cumulative Certainty for Material Class BSM1	Cumulative Certainty for Material Class BSM2	Cumulative Certainty for Material Class BSM3
DCP Penetration	12				0.13	0.29	0.06	0.00
FWD Stiffness	67				0.26	0.32	0.11	0.00
Grading Analysis	3				0.37	0.34	0.11	0.00
% Passing 0.075	3				0.43	0.37	0.11	0.00
Plasticity Index	5				0.46	0.47	0.11	0.00
California Bearing Ratio	2				0.49	0.54	0.16	0.03
Relative Moisture Content	4				0.52	0.57	0.19	0.00

Outcome: Material is most likely a **G5** design equivalent

Confidence: Confidence of the assessment is **medium**. For structural rehabilitation, it is recommended that the sample size and number of test indicators be increased.

Materials Classification
Example: ITS



Certainty that falls in class

0.15	*0.48*	*0.32*	*0.06*

Adjusted for test certainty factor

Cumulative Certainty

		Test Limits				Cumulative Certainty			
Test	No	BSM1	BSM2	BSM3	NSuit	BSM1	BSM2	BSM3	NSuit
DCP	10					0.0	0.07	0.03	-
P0.075	12					0.15	0.07	0.03	-
FWD	58					0.23	0.26	0.03	-
PI	10					0.23	0.26	0.06	0.21
Moisture	7					0.27	0.29	0.06	.021
Grading	10					0.27	0.33	0.34	0.25
Cohesion	10					0.27	0.49	0.38	0.26
Friction A	11					0.30	0.60	0.4	0.26
Ret. Coh.	16					0.30	0.62	0.43	0.37

Design: Pavement Number

1. Material Classes

5. Assign modular ratio's and max stiffness

MR = 2, E_{Max} = 450
MR = 3, E_{Max} = 400
MR = 1.8, E_{Max} = 180
118 MPa

6. Calculate Layer ELTS Values

ELTS = 450 BCF = 0.7
ELTS = 400 Thickness Adj = 0.4
ELTS = min(212,180) ELTS = 180
118 MPa

2. Determine subgrade stiffness (140 MPa)

3. Adjust for climate (126 MPa)

4. Adjust for cover (118 MPa)

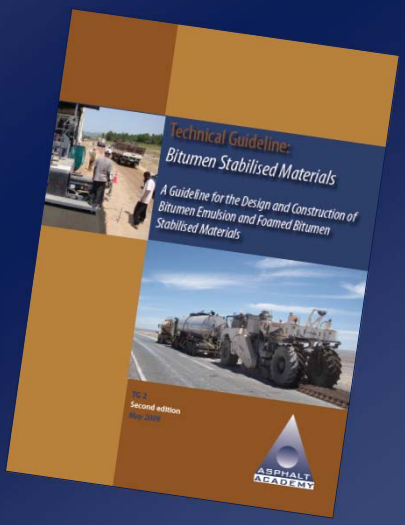
6. ELTS = min ($E_{support}$ * MR , E_{max})

7. Layer PN = thickness * ELTS

8. PN = Σ layer PN

www.bitstab.roadrehab.com

Design Guides



Implementation ☻ ☻ ☻ ☻ ☻

Research needs Perseverance!!