BITUMEN STABILISED MATERIALS

Recycling Technology Update

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Stellenbosch

Outline

- Developments of ISAP WG2 Cold Recycling
- Global perspective – CR research
- Application of research to improve technology
- Manuals, specifications, guidelines
- Overcoming barriers to recycling
- Future needs for research

Minutes from TRB 2010: ISAP TC Asphalt Pavement and Environment

- WG1 on Recycling (Chantal de la Roche)

WG1	WG2
Hot Recycling-RAP	Cold Recycling-RAP
(Peter Sebaaly)	(Kim Jenkins)

Purpose of ISAP WG2

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

ISAP WG2 Members

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

Use of RAP Worldwide (2005)

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

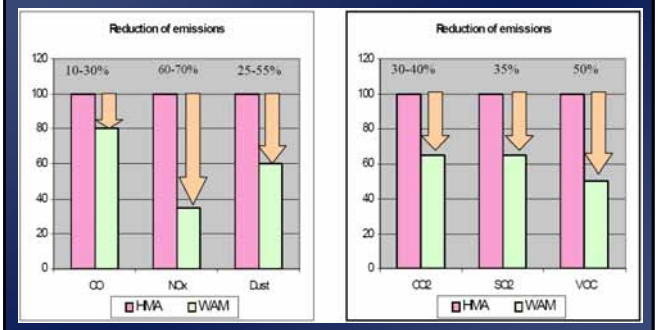
Re-use of asphalt in Europe (2009)

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)

Changing Technologies helps Environment

Emissions at the Chimney

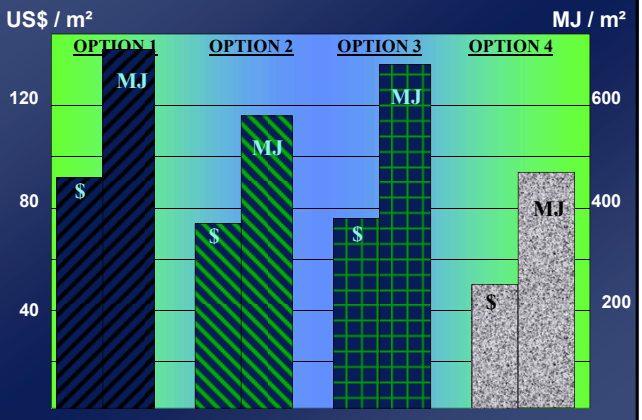


Energy consumed in procuring materials and in executing primary construction activities

Material procurement / Construction activity	Unit	Energy consumed (Mj)
Material procurement		
Graded crushed stone (GC.)	Mj / t	5
HMA manufacture	Mj / t	[illegible]
Cement	Mj / t	7000
Bitumen	Mj / t	6000
Material haula[illegible]	[illegible]	1
Construction activity		
Milling [1]	Mj / t	5
In situ recycling / stabilising	Mj / t	10
Processing aggrega[illegible]e la[illegible]er	Mj / t	66
Ditto per m² f[illegible]r 150[illegible]m thick layer	Mj / m²	10
Compacting and [illegible]inishing layer [2]	Mj / m²	10
HMA paving and compaction	Mj / t	20

ENERGY CONSUMPTION

WHOLE OF LIFE ENERGY & COST



Concrete and Masonry Recycling

- Re-use and recycling of e.g. concrete and masonry rubble is at embarrassing low level
- Some countries are really front runners; in the Netherlands 90% of the concrete/masonry rubble is recycled as base course for roads
- Much can be gained

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

How to address the recycling needs (manage the process)

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

Cold Recycler and Soil Stabilizer WR 2500 / S / SK

Worldwide distribution

Cold Recycler and Soil Stabilizer

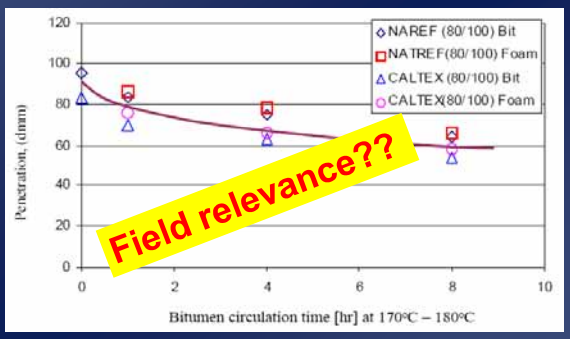
WR 2000, WR 2400, WR 2500 / S / SK - Worldwide distribution

1. Awareness: Issues to address

- Barriers to 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
- Harmonisation of mix & structural design
- Global research cooperation?

Variability

Findings-short term ageing
Pen vs. time for (80/100) foam



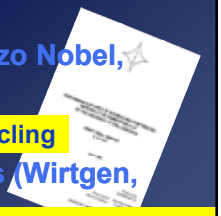
Twagira

BSM -emulsion versus -foam

Who is the custodian of strategic research?

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

ISAP WG2 Cold Recycling

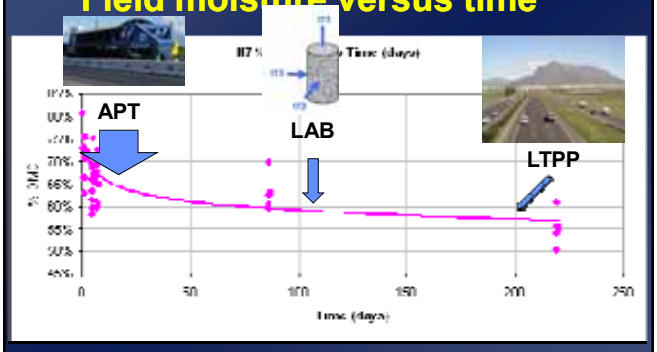


Awareness ☻☻☻☻☻

2. Acquiring knowledge

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

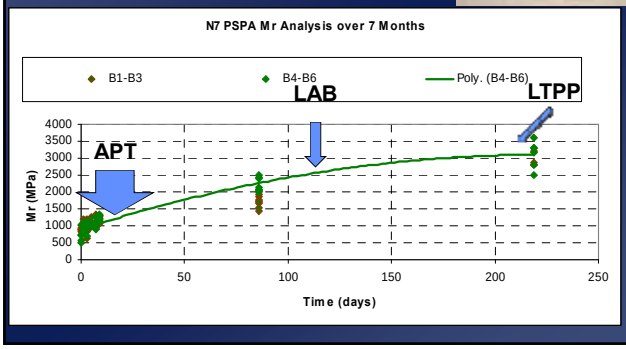
Curing
Field moisture versus time



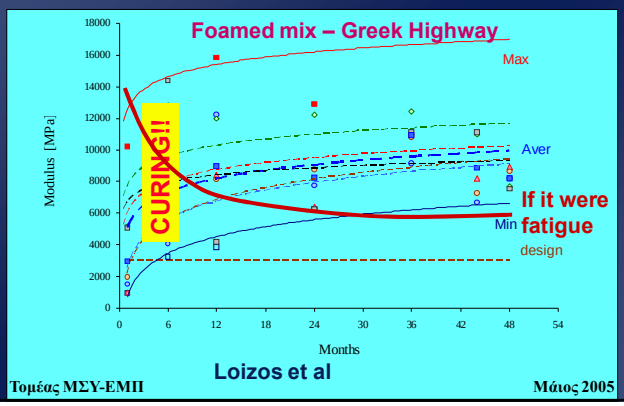
Moloto (BSM-emulsion)

Mr (field) versus cure

PSPA

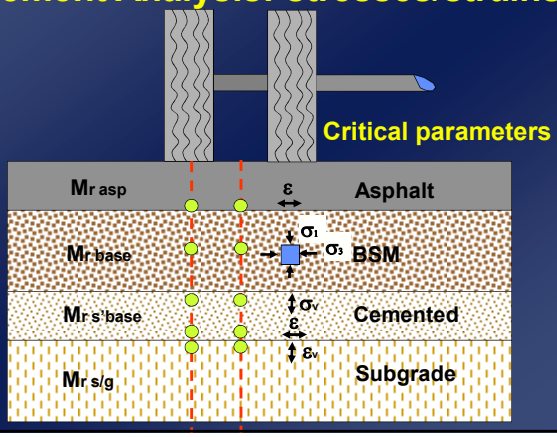


BSM Modulus (back analysis)

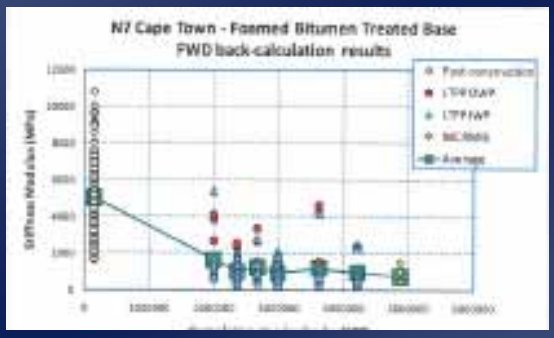


Τομέας ΜΣΥ-ΕΜΠ Μάιος 2005

Pavement Analysis: stresses/strains



What are others' analyses finding?



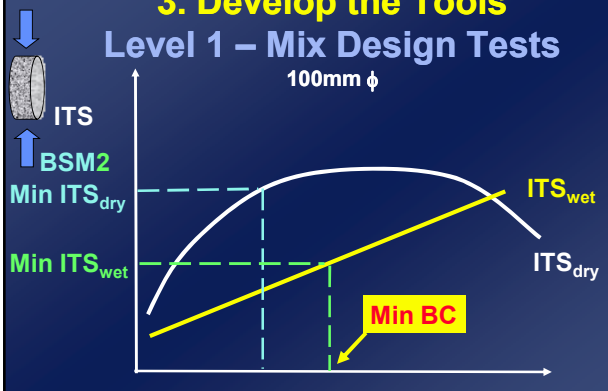
Theyse

New LTPP Sections

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

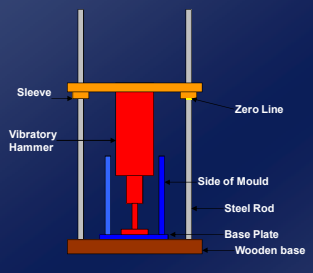
Acquire knowledge ☻☻☻☻☻

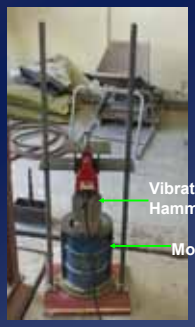
3. Develop the Tools
Level 1 – Mix Design Tests



Vibratory Compaction Hammer

To prepare specimens





Kelfkens

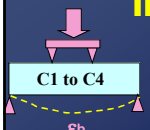
Rear View of Frame

Compaction time (vibratory)

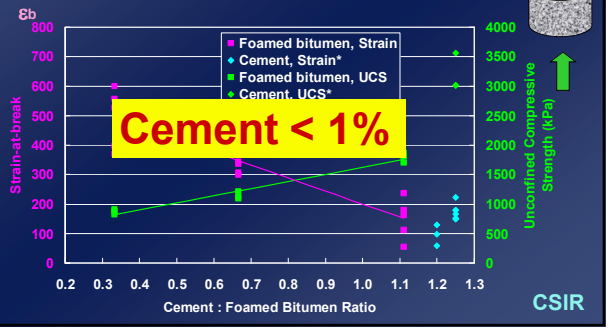
Comp Time

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

Influence of Active Filler



Strength and flexibility

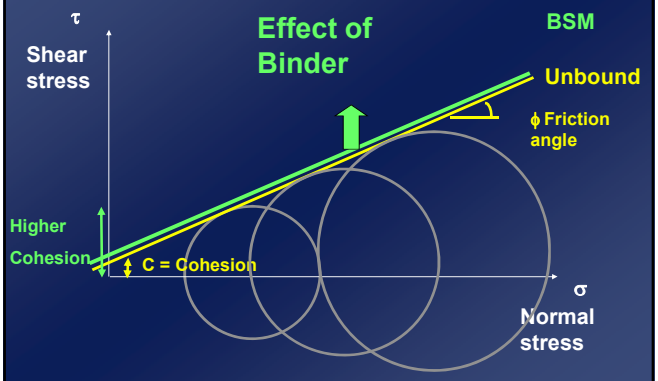


Cement < 1%

CSIR

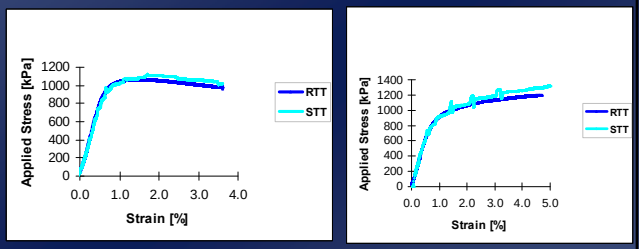
Triaxial Testing

Effect of using BSM



New "Simple triaxial"

Research Triaxial Test RTT versus Simple Triaxial Test STT



BSM Crushed Hornfels with 3.3% Emulsion

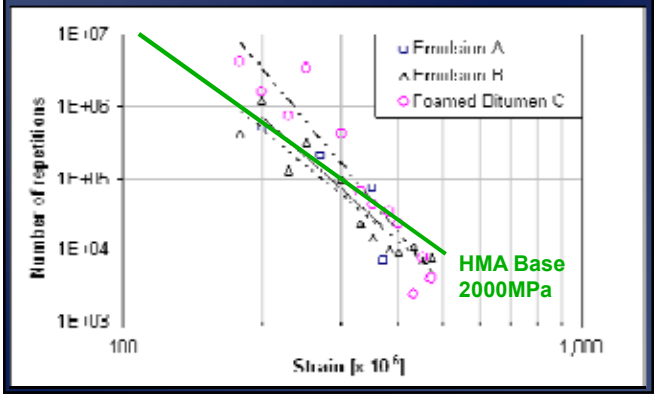
σ_3 =50 kPa and 1% Cement σ_3 = 200 kPa and 0% Cem

BSM Classification ito Shear Properties

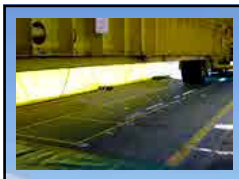
Equivalent BSM Class	Angle of Internal Friction (º)	Cohesion (kPa)
BSM 1	> 40	> 250
BSM 2	30 to 40	100 – 250
BSM 3	< 30	50 – 100

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

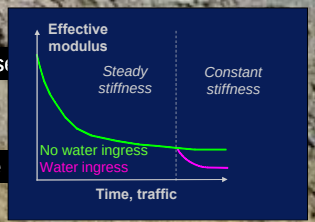
35mm HMA binder layer

No cracking
6mm rutting

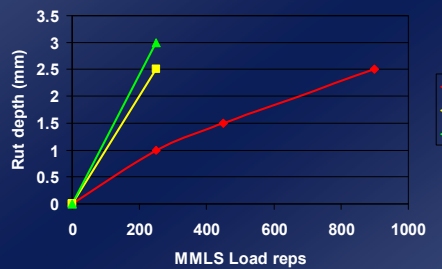
250mm foamed bitumen stabilis

150mm crushed stone subbase

Sand subgrade



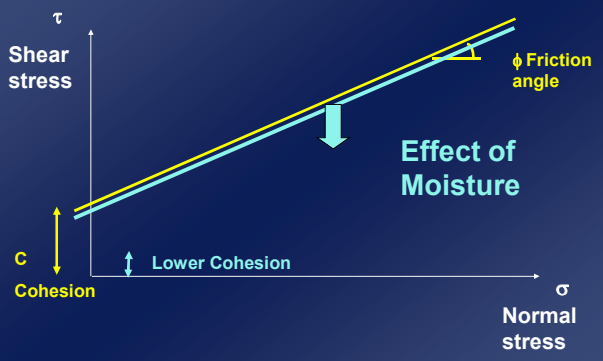
Lab APT



Durability: New, Improved Tests
- Untreated Material Properties
- Moisture sensitivity tests

Moisture Induction Sensitivity Test MIST (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

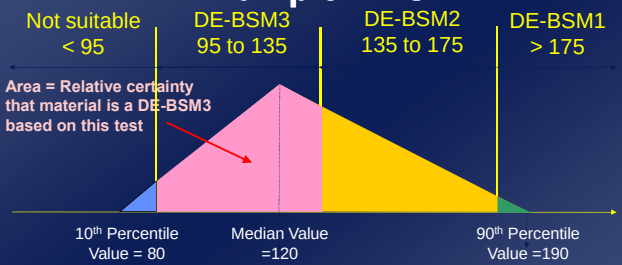
Materials Classification BSMs - Similar to granular

Test or Indicator	Samples	Test Limits for Material Class BSM1	BSM2	BSM3	Cumulative Certainty for Material Class BSM1	BSM2	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	No	Test Limits BSM1	BSM2	BSM3	NSuit	Cumulative Certainty 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!!