High Modulus Asphalt (HiMA) trial
Mix & pavement design

Prepared for presentation at the 22nd meeting of the Roads Pavements Forum (RPF)

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Outline

- HiMA
- Description of trial site,
- Mix design,
- Pavement design

High Modulus Asphalt ?

Origin: France early 90s
“Enrobés à Module Elevé” (EME)

Typical characteristics:

- High binder content ≈ 6% by mass of aggregate,
- Hard binder: Pen 10-25,
- Low air voids content,
- High Modulus > 14 GPa at 15°C, 10 Hz,
- High resistance against permanent deformation,
- Good fatigue resistance,
- Impermeable,
- Increased mixing temperature.

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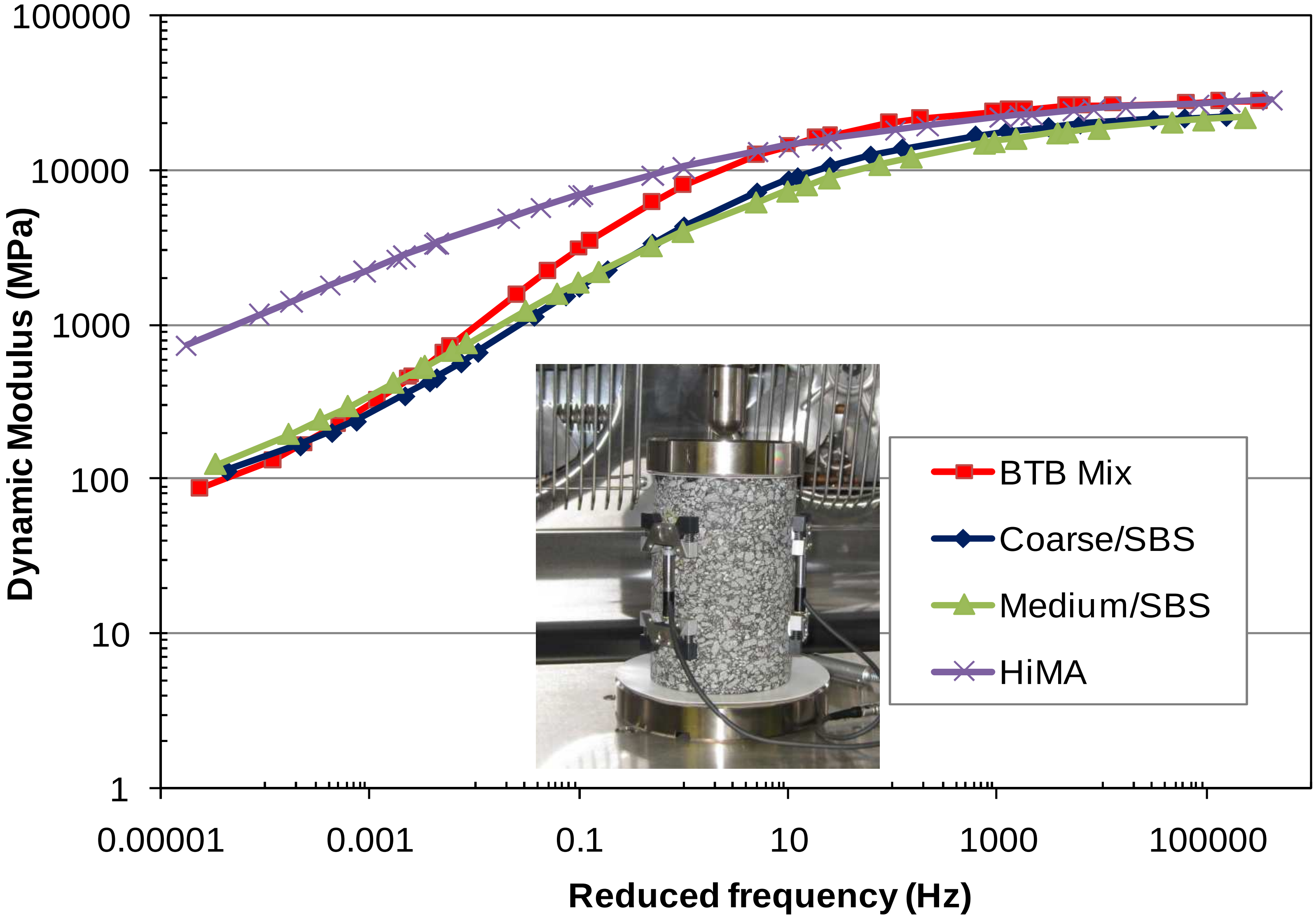
Background: The properties of HiMA



Background: Structure of SABITA T^2 project

Phase I
Feasibility study
Phase II
Preliminary mix and structural design guidelines
Phase III
Implementation: APT, LTPP and lab study
Phase IV
Final guidelines and specifications

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Performance related mix design

Property	Test	Method	Performance requirements				
			HiMA base course		HiMA binder course		
			Class 1	Class 2	Class 1	Class 2	Class 3
Workability	Gyratory compactor, air voids after 100 gyrations	ASTM D6926	≤ 6.3%	≤ 3.8 %	3.2 to 6.3 % for D = 10, 2.5 to 5.7 % for D = 14		
Moisture sensitivity	Modified Lottman	ASTM D4867	Refer Table 10	Refer Table 10	Refer Table 10	Refer Table 10	Refer Table 10
Permanent deformation	RSST-CH, 55℃, 30 000 reps	AASHTO 320	≤ 1.7% strain	≤ 1.7% strain	≤ 2.3% strain	≤ 1.7% strain	≤ 1.1% strain
Dynamic modulus	Dynamic modulus test at 10 Hz, 15℃	AASHTO TP 62	≥ 14 GPa	≥ 14 GPa	≥ 9 GPa	≥ 14 GPa	≥ 14 GPa
Fatigue	Beam fatigue test at 10 Hz, 10℃, to 70% stiffness reduction	AASHTO T 321	≥ 330 με for 10 E^6 reps	≥ 430 με for 10 E^6 reps	≥ 360 με for 10 E^6 reps	≥ 330 με for 10 E^6 reps	≥ 330 με for 10 E^6 reps

Implementation

t home

T pending...

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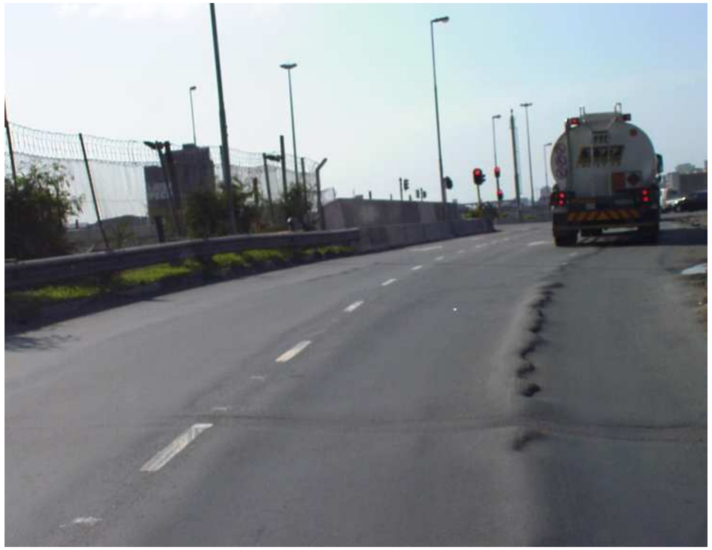
Implementation



- Mix designs prepared for Cape Town international airport and OR Tambo

Much Asphalt

- South Coast road Durban

NA National Asphalt

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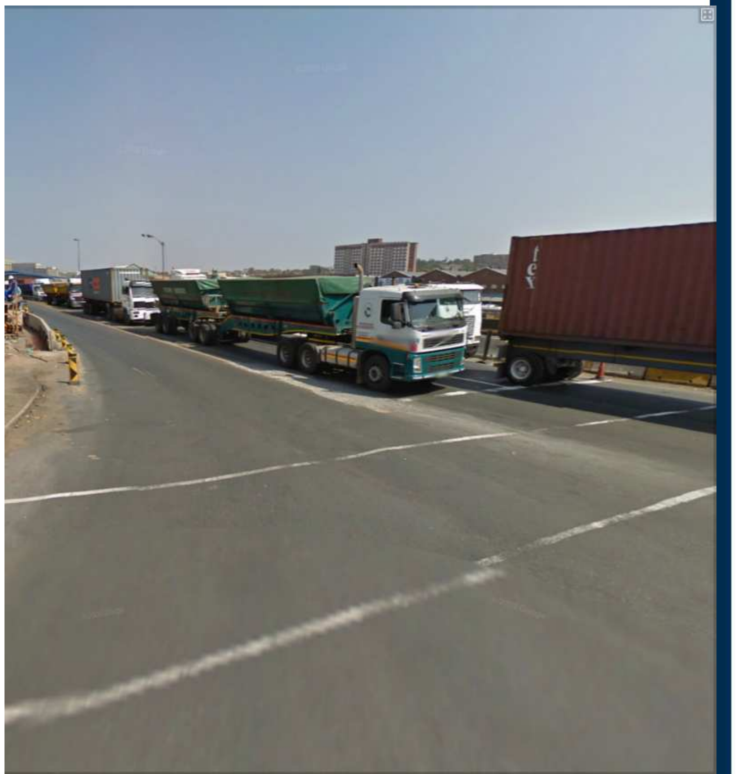
Trial section

Trial section



- Road owned by eThekwini municipality,
- Major access road for DBN harbour,
- Frequent maintenance to pavements required,
- Road too busy and constricted to use concrete,
- Estimated number of standard axels: 8000 per lane per day (60 Million E80s in 20 years),
- CSIR tasked by SABITA to provide implementation advice.

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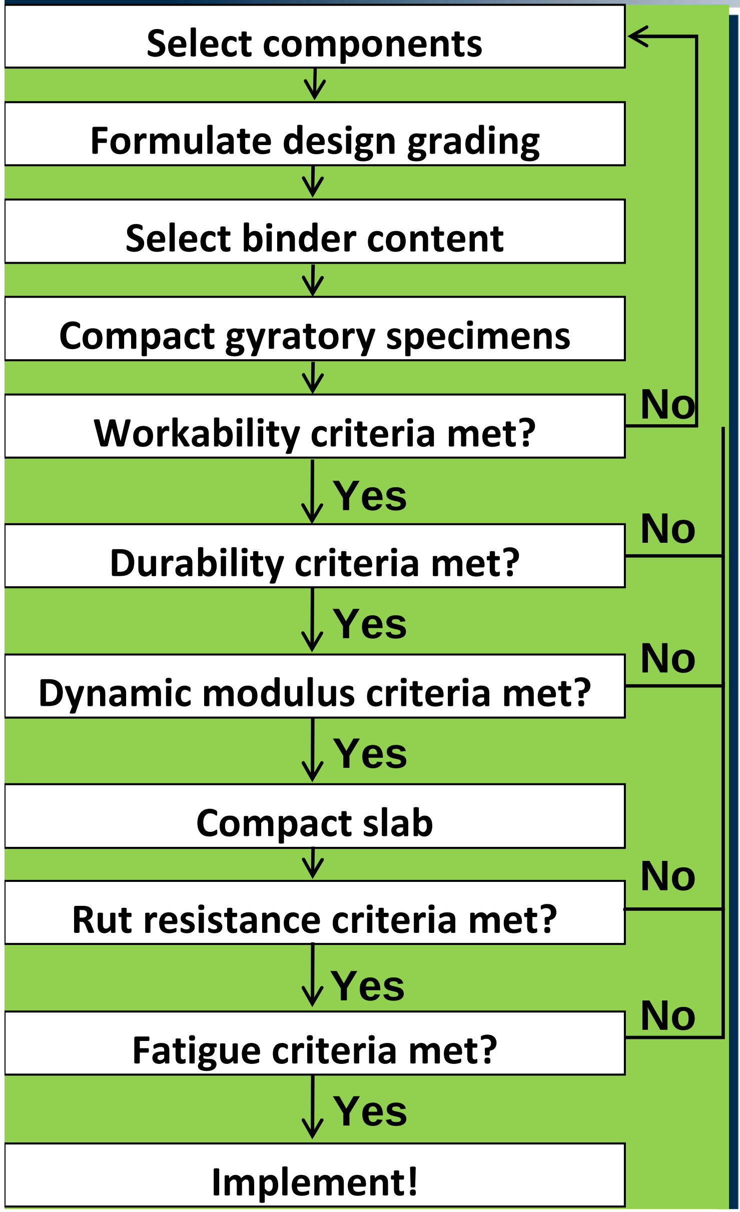
Interim guide: Performance related mix design



- Design process similar to what is now proposed for general asphalt design in SA,
- Direct link between mix design and pavement performance,
- Requirements set for SA test methods:
    - Workability,
    - Durability,
    - Stiffness,
    - Rut resistance,
    - Fatigue.

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Mix Design

- Interim design guide used to develop mix,
- Trial blends developed at National asphalt
- Mix includes 20% Reclaimed Asphalt Pavement (RAP),
- 10-20 penetration grade binder,
- Aggregate packing optimized,
- Several iterations to optimise design,
- Relatively low binder content to optimise permanent deformation resistance.

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Aggregate properties

Property	Test	Method	Design	Interim guide
Hardness	Fines aggregate crushing test: 10 %FACT	TMH1, B1	303	≥ 160 kN
	Aggregate crushing value ACV	TMH1, B1	13.3	≤ 25%
Particle shape & texture	Flakiness Index test	SANS 3001	≤ 13.1	≤ 25
	Particle index test	ASTM D3398	-	>15
	Polished stone value	SANS 3848	N/A: base course	>50
Water absorption	Water absorption coarse aggregate (>4.75mm)	TMH1, B14	≤ 0.4	≤ 1.0 %
	Water absorption fine aggregate	TMH1, B14	≤ 0.8	≤ 1.5 %
Cleanliness	Sand equivalency test	TMH1, B19	68	≥ 50

Binder properties

Table 4: Binder properties

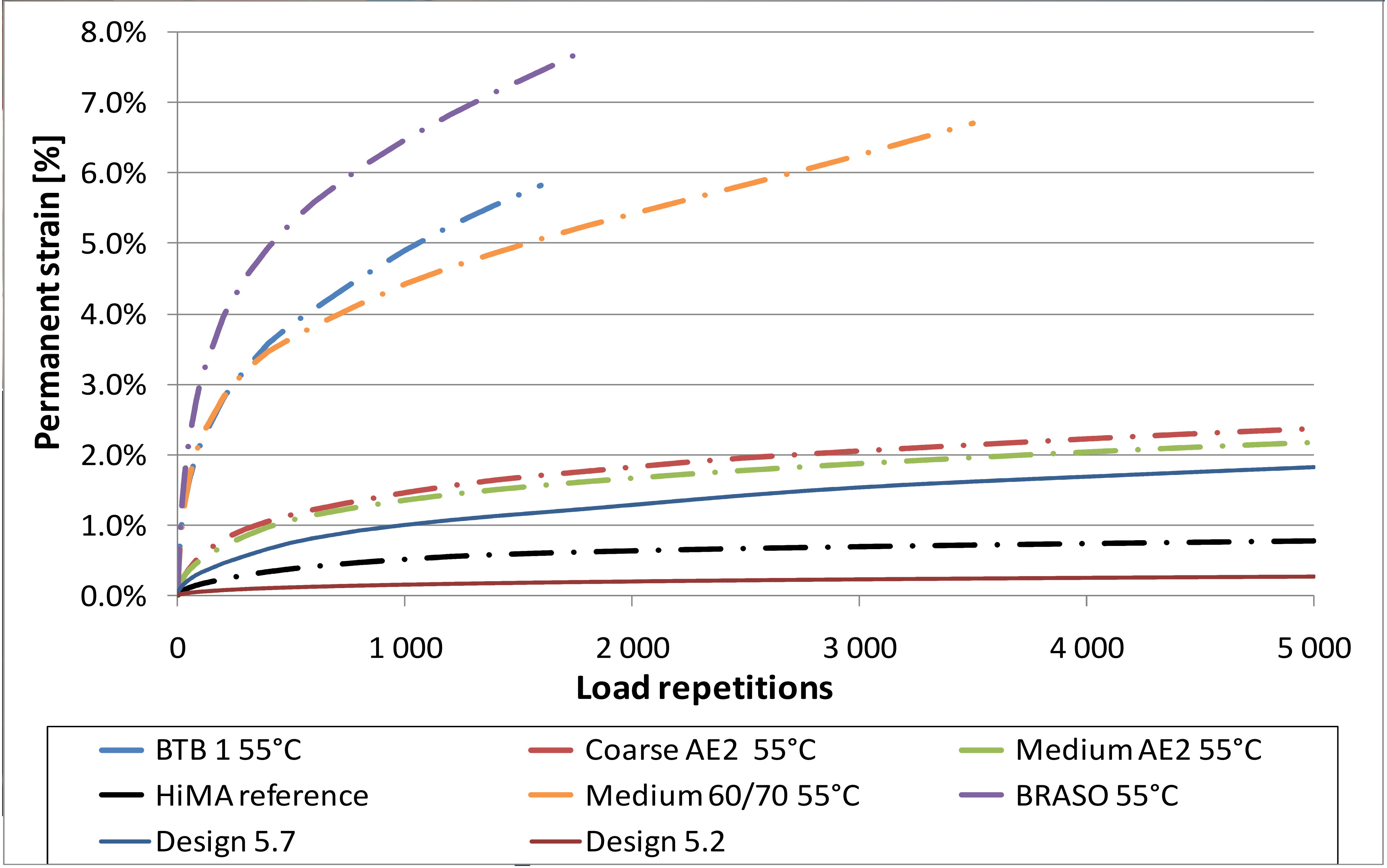
Property	Test method	Unit	Result for binder	Penetration grade		
				10/20	15/25	20/30
Before RTFOT						
Penetration at 25 °C	EN 1426	0.1 mm	**22**	10-20	15-25	20-30
Softening point	EN 1427	°C	**62.2**	58-78	55-71	55-63
Viscosity at 60 °C	EN12596	Pa.s	**2375**	>700	>550	>440
After RTFOT						
Increase in softening point	EN 1427	°C	**5.4**	< 10	< 8	< 8
Retained penetration	EN 1426	%	**72.7**	-	> 55	> 55
Mass change		%	**0.066**		< 0.5	< 0.5

	HiMA base course			HiMA binder course	
	Class 1	Class 2			
D (mm)	10,14,20	10,14	20	10	14
$P_{b\,min}\ \rho = 2.65\ g/cm^3$	3.8	5.1	5.0	5.2	4.9
$P_{b\,min}\ \rho = 2.75\ g/cm^3$	3.8	4.9	4.9	5.0	4.8
Richness modulus K	2.5	3.4	3.4	3.5	3.3

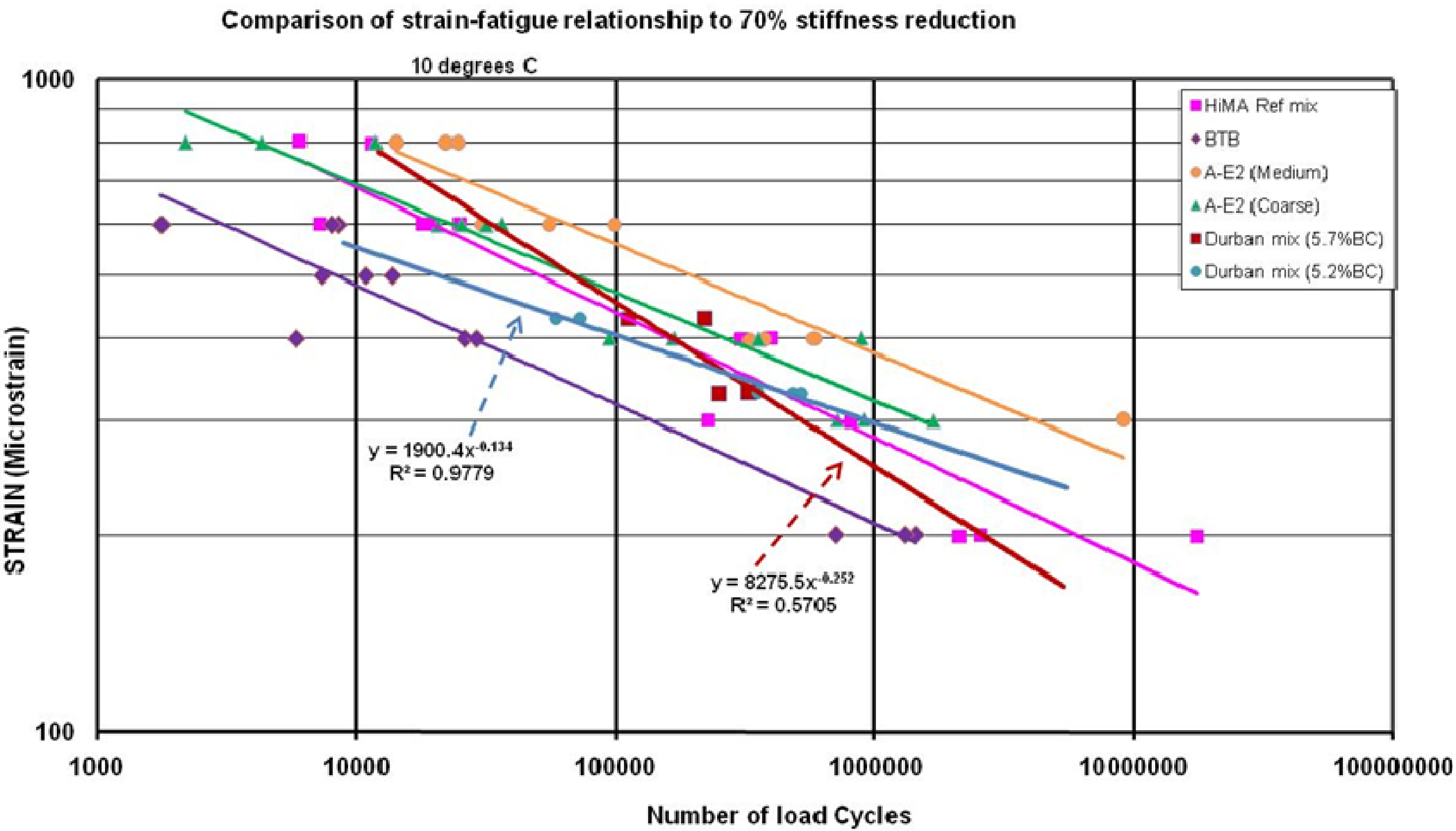
Performance related tests: results

Property	Test	Method	Design binder content		Interim Performance requirements	
			5.2%	5.7%	Class 1	Class 2
Workability	Gyratory compactor, air voids after 45 gyrations	ASTM D6926	2.9%	4.4%	≤ 10%	≤ 6%
Moisture sensitivity	Modified Lottman	ASTM D4867	0.77	0.77	0.7	0.7
Permanent deformation	RSST-CH, 55°C, 5 000 reps	AASHTO 320	0.24 % (slab) 0.18 (gyratory)	1.83% (slab) 0.6% (gyratory)	≤ 1.1% strain	≤ 1.1% strain
Dynamic modulus	Dynamic modulus test at 10 Hz, 15°C	AASHTO TP 62	24.4 GPa	23.5 GPa	≥ 14 GPa	≥ 14 GPa
Fatigue	Beam fatigue test at 10 Hz, 10°C, to 70% stiffness reduction	AASHTO T 321	66 500 @430 με	165 905 @430 με		≥ 10^6 reps @430 με
			752 900 @310 με	457 560 @310 με	≥ 10^6 reps @310 με	

Permanent deformation

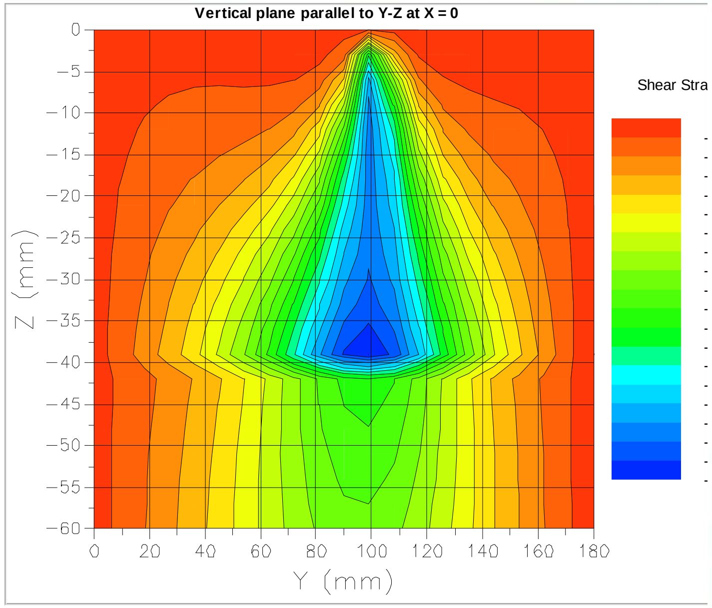


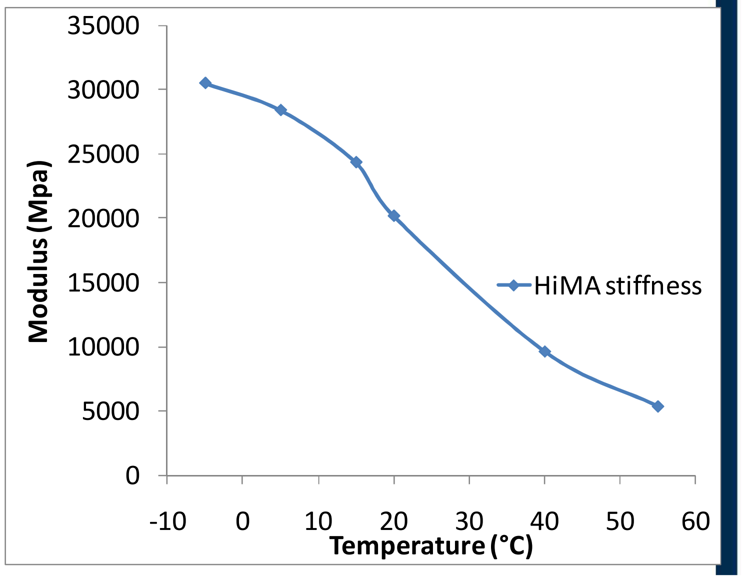
Fatigue



Comparison of strain-fatigue relationship to 70% stiffness reduction
10 degrees C
HiMA Ref mix
BTB
A-E2 (Medium)
A-E2 (Coarse)
Durban mix (5.7%BC)
Durban mix (5.2%BC)
y = 1900.4x^-0.134
R² = 0.9779
y = 8275.5x^-0.252
R² = 0.5705
STRAIN (Microstrain)
1000
100
1000
10000
100000
1000000
10000000
100000000
Number of load Cycles

Structural design





- ThermalPADS Pavement temperature prediction software used,
- ME-PADS used to predict fatigue (conservative
- Use of SAPDM type models for rutting prediction,
- Use of SAPDM approach to determine stiffness of HiMA at combination of loading speed and temperature,
- Preferred option: Two 80 mm HiMA layers, with 30 mm Stone Mastic Asphalt (SMA) surfacing,
- Predicted life of HiMA base layers >100 Million standard axels.

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Thank you


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45G1
SUPAQUICK LOGIS
HAMM
SW25
PT17
DYNAPAC