Use of Bituminous Treated Base (BTB) in Pavement Rehabilitation

by
Ian van Wijk, Phil Hunt, Chris Cleary - Aurecon
Mike Harris – Harrison Group
Trevor Distin - Boral

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Issues

- Relatively unknown product
- Very little performance results available
- Specifications
- Properties/performance
  - Voids
  - Film thickness
  - Stripping

Contents

- Description of BTB
- Design – structural and mix
- Project
- Construction
- Quality
- Properties
- Performance
- Summary

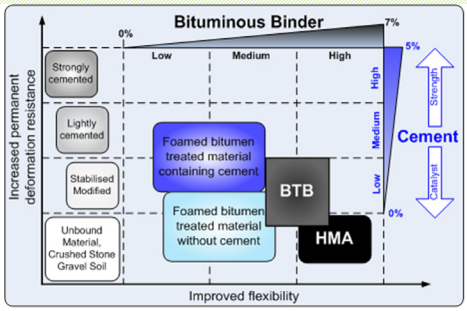
Description of BTB

- Definition
- Benefits
- Comparison

Definition

- **Non-standard** asphalt mix
- Many of the **properties** of a conventional asphalt mix
- Non-designed and controlled **grading (single** crusher run)
- Lower **binder content** (2.5 to 4.5% by mass)
- **Strength**
  - structural coefficient: 0.35 vs. Granular (0.12) and HMA (0.44)
  - Thickness: vs. Foamed bitumen (115 to120%) and DG20 (80 to 90%)

Stabilisation Framework



Comparison

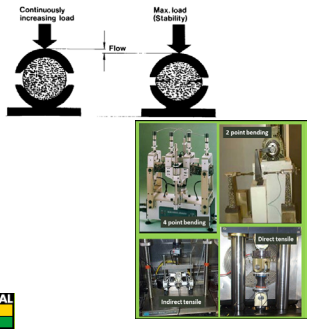
Property	Conventional asphalt (DG20, C320)	BTB	Foamed bitumen
Grading	High quality grading controlled aggregate	Good quality graded aggregate (single crusher run)	Good quality aggregate (in-situ process)
Fatigue relationship	Austroads	**Austroads**	Austroads
Volume of bitumen (%)	10 to 11%	**8 to 10%**	7%
Bitumen content, by mass (%)	4.5 to 5.5%	**3.5 to 4.5%**	2.5 to 3.5%
Volume of air voids (%)	4 to 6%	**4 to 10%**	10 to 15%
Stiffness (MPa) at 25^0 C and 80 km/h	4,000 to 4,500	**3,000 to 4,000**	1,000 to 3,000
Indirect tensile strength, ITS (kPa)	>500	**>500**	300 to 500
Ratio wet ITS to dry ITS	>75 to 80%	**>75%**	> 40 to 50%
Marshall stability (kN)	>7.5	**>6 to 7.5**	n/a
Marshall Flow (mm)	<2	**<2**	n/a

Benefits

- Reduced **construction times** (volumes, curing, DoS)
- Lower cost and **emissions** than conventional asphalt
- High **stability** (at intersections or restricted areas)
- Significantly reduced effect of **wet weather** on construction.
- Thinner pavement depths - utilise existing **formation** widths
- Allow construction **under traffic**
- **Cost** (15% less than DG20 for same thickness)

Design

- Structural
- Mix

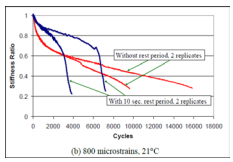


Structural design

- Austroads fatigue relationship

$$N = RF\left[\frac{6918(0.856\,V_b + 1.08)}{S_{mix}^{0.36}\,\mu\varepsilon}\right]^{5}$$

- Modulus = 2,000 MPa (at 33ºC)
- Volume of binder = 9%
- SAR/ESA = 1.1



Mix design (Marshall)

Property	Unit	Limit	Value	
			PSBTB20	PSBTB28
Air Voids in the compacted job mix	%	Minimum Maximum	4.5 5.5	4.5 5.5
Stability	kN	Minimum	7.5	7.5
Flow	mm	Minimum	2.0	2.0
Stiffness	kN/mm	Minimum	2.0	2.0
Voids in mineral aggregate (VMA)	%	Minimum	13.5	13
Maximum density	t/m^3	-	Tbr	Tbr

Mix design (other)

Property	Unit	Limit	Value	
			PSBTB20	PSBTB28
Wheel Tracking rut rate rut depth	mm/kCycle mm	Maximum Maximum	≤ 0.35 ≤ 5.0	≤ 0.35 ≤ 5.0
Indirect tensile resilient modulus @25ºC	MPa	Range	To be reported	To be reported
Sensitivity to Water	%	Minimum	80	80
Fatigue life of compacted bituminous mixes subject to repeated flexural bending	Cycles to Failure at 50% decrease in initial modulus	Report	Report	Report

Project

- Description
- Specifications
- Structural design
- Grading and mix design

Description

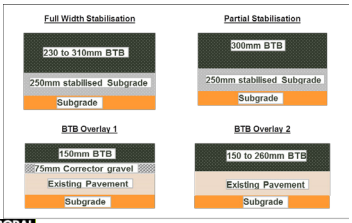
- Section of Warrego Highway about 100 km east of Roma (500 km west of Brisbane)
- Severely distressed – deformation, potholes/ failures
- Compressed design and construction process
- Traffic accommodation considerations
- Options:
  - Full depth replacement
  - Overlays

Specifications

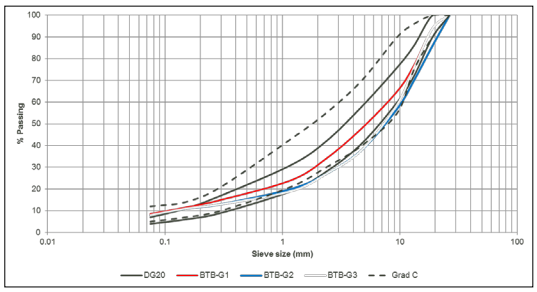
- Project specifications developed by TMR, industry (AAPA) and project team
- Based on Queensland **TMR MRST30** for dense-graded asphalt (DG20 or DG28)
- Main differences
  - **Grading** (single run crushed stone) and tolerances
  - **Air void** content (target)
  - **Compaction** (target)

Structural design

- 20 year design traffic loading of 6 E+06 ESAs
- WMAPT of 33ºC
- Subgrade CBR 3 to 5%



Grading



Mix design

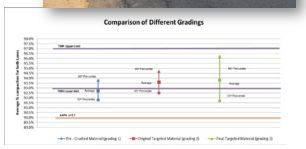
Property	Design mix	First production mix (average values)
Binder Content (%)	4 to 4.3	4.08
Initial flexural stiffness at 20ºC (MPa)	9,530	
Cycles to failure at 400 µm and 20ºC	12,400	
Resilient modulus at 25ºC/30ºC (MPa)	5,500/4,100	
ITS Modulus at 30ºC (MPa)	4,000	
Rut rate (mm/k Cycle)	0.04 to 0.08	
Rut depth (mm)	2.5	
Air Voids (%)	Varied (to suit test)	5.9
Stability (kN)	10.5	17
Flow (mm)		2.8
Stiffness (kN/mm)		6
VMA (%)		13.3
Maximum Density (t/mm³)		2.607
ITS ratio	80% (4.3% bitumen) and 66% (4% bitumen)	

Construction

- 2 or 3 layers
- Seal
  - 7 mm Armour coat (C320 binder at 0.8 l/m^2) applied within 2 to 3 days
  - 14 mm Single/single (S0.3B binder at 1.2-1.4 and 1.63-1.93 l/ m2) after about 3 months
- Low ingress of water during rain

Quality

- In general complied
- Density: Average about 93%
- Variability
- Good riding quality



Properties

- Volumetrics & Marshall
- Moduli
- Deformation properties
- Fatigue
- Moisture susceptibility & permeability

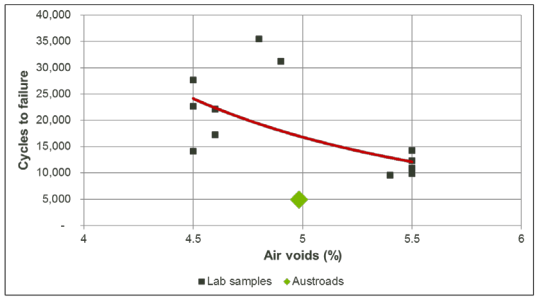
Volumetrics & Marshall

Property	Specification	Minimum	Maximum	Average
Stability (kN)	>7.5kN	4.2	29.5	11.7
Flow (mm)	>2mm	1.7	5.7	2.9
Stiffness (kN/mm)	>2	1.3	8.1	4.1
Air Voids (%)	4.5 - 5.5% (target)	2.4	10.5	5.7 5.7%
Voids in mineral aggregate (VMA) (%)	>13.5%	9.8	17.3	13.2
Voids Filled with Binder (VFB) (%)		39	85	57
Compaction density (CV)				93%
Layer (top)	>93%	90.3	97.0	93.1
Layer (middle)	>93%	90.0	95.7	93.1
Layer (bottom)	>93%	90.0	96.3	92.9

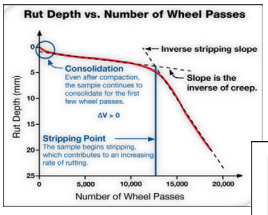
Other properties

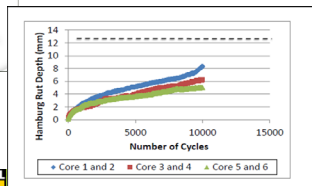
- **Rut depth**: < 3 mm at binder contents up to 5%
- Dry and wet modulus (at 25ºC and 6% voids): ±6,000 MPa
- **Dry/wet ratio > 90%**
- Initial flexural modulus (at 20ºC and 5% voids): ±13,000 MPa
- Wet core ITS (at 6% voids): ±1,100 kPa
- Reduction in modulus with increase in air voids

Fatigue



Hamburg wheel tracking device

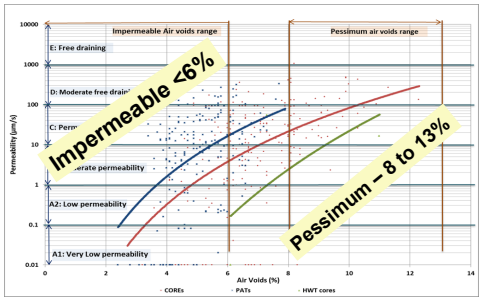




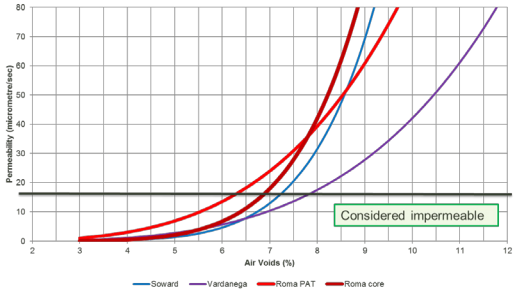
HWTD results

core no	RDD	Air Voids	Stripping value (point of inflection) > 10,000	Rut depth (mm) <12.5 mm	Comment
1	94.5%	5.5%	18,600	8.3	cores not sealed in the field
2	90.6%	9.4%			
3	92.4%	7.6%	20,000	6.22	One core not sealed
4	97.6%	2.4%			
5	95.5%	4.5%	20,000	4.97	Both cores sealed
6	96.6%	3.4%			

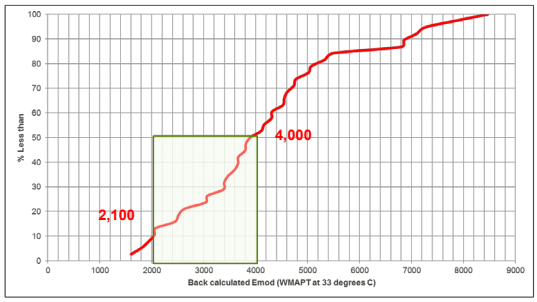
Permeability measurements



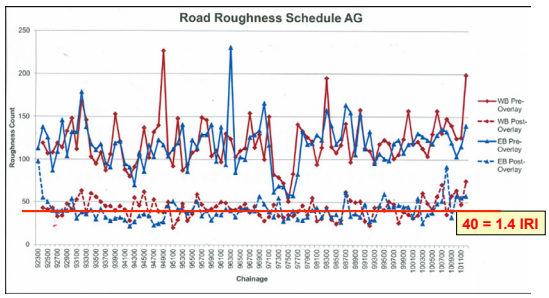
Permeability - comparisons



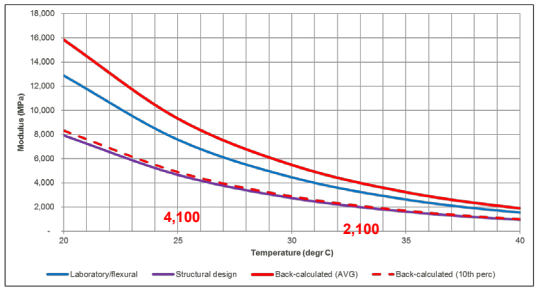
In-situ moduli



Roughness



Design moduli



Performance

- Functional
  - Visually very good condition with no defects except isolated bleeding
  - Good riding quality
  - No rutting
- Structural/Remaining life
  - All >20 years
  - Most >30 years

Summary

- Met design and construction **objectives**
- BTB has **benefits if applied appropriately**
- One of a number of bituminous bound pavement layer **options**, e.g. dense-graded, foamed bitumen
- Design approach and moduli – probably **conservative**

Thank you