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ISAP WG2

Meeting and Workshop on Cold Recycling including RA

11 September 2011

Foamed Bitumen Stabilisation

A review of the design, application, research and characterisation in New Zealand

Thorsten Frobel – Fulton Hogan

An Overview of FBS in New Zealand

- Historical FBS site and performance
- Typical Applications - Rehabilitation
- Recent acceptance by NZTA – “Green Fields”
- Pavement Design – NZ Supplement to APDG
- CAPTIF Research
- Draft NZTA T/19 – New Mix Design Spec

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Typical Applications of FBS in New Zealand:

Steady growth in rehabs:
2004: 30,000 m^2 – trials
2010: 400,000 m^2 - tendered

SH - Hybrid Maintenance contracts

SH - PSMCs

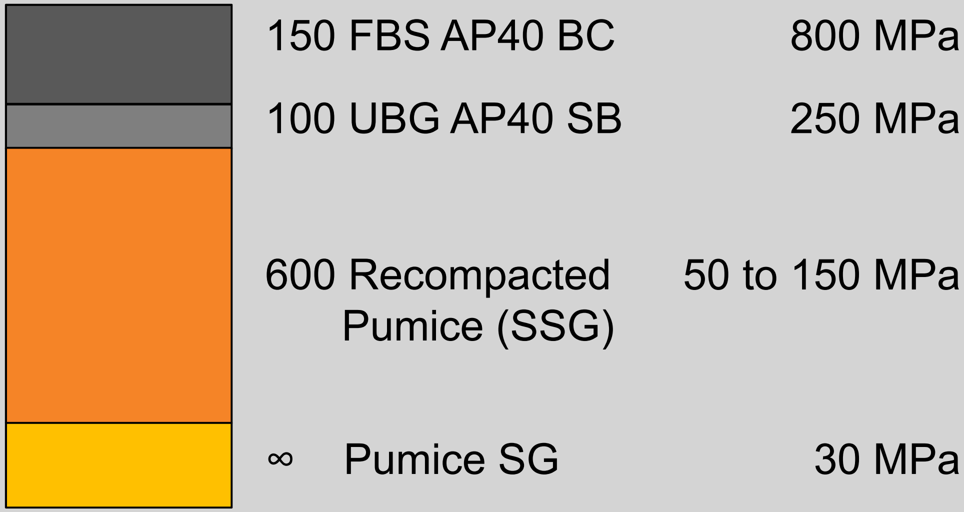
Heavily trafficked urban arterial roads for various City Councils
(DUSTLESS addition of cement)

Auckland Motorway Alliance

Alpine SH with freeze / thaw distress

East Taupo Arterial:

Length:	16 km
Area:	180,000 m^2
Construction:	Jan'10 – Sep'10
Opened:	8th October 2010
Design Load:	10×10^6 DESA



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Christchurch Southern Motorway:

Length: 12 km

Area: 125,000 m^2

Construction: 2011 – 2012

Design Load: 15 x 10^6 DESA

150	FBS AP40 BC	800 MPa
170	UB-RCC SB	250 MPa
∞	Silty Gravel SG	100 MPa

Greenfields projects using FBS pavements

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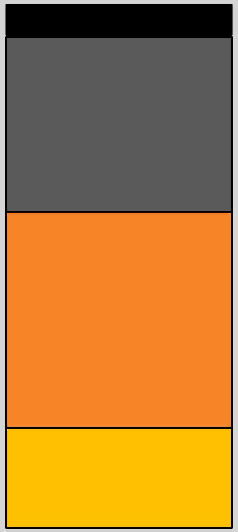
Tauranga Eastern Link:

Length: 22 km

Area: 220,000 m^2

Construction: 2012 – 2013

Design Load: 12 x 10^6 DESA



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New Zealand Supplement (2007) to the APDG (2004) gives guidance for the pavement designer:

- Two phases: “Seating-in” and “Steady State”
- Only design for the “Steady State” with the following parameters:
  - Elastic modulus in the order of 800 MPa,
  - Poisson’s ratio = 0.3,
  - Anisotropic layer,
  - No sub-layering
- Limit cementitous binders to prevent cracking
- Designers to seek assistance from industry for mix design and layer thickness analysis

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May 2004 – Before FBS

June 2011 – 7 years after FBS

SH 26 – Kurere Stream Road – First Foamed Bitumen Project in NZ

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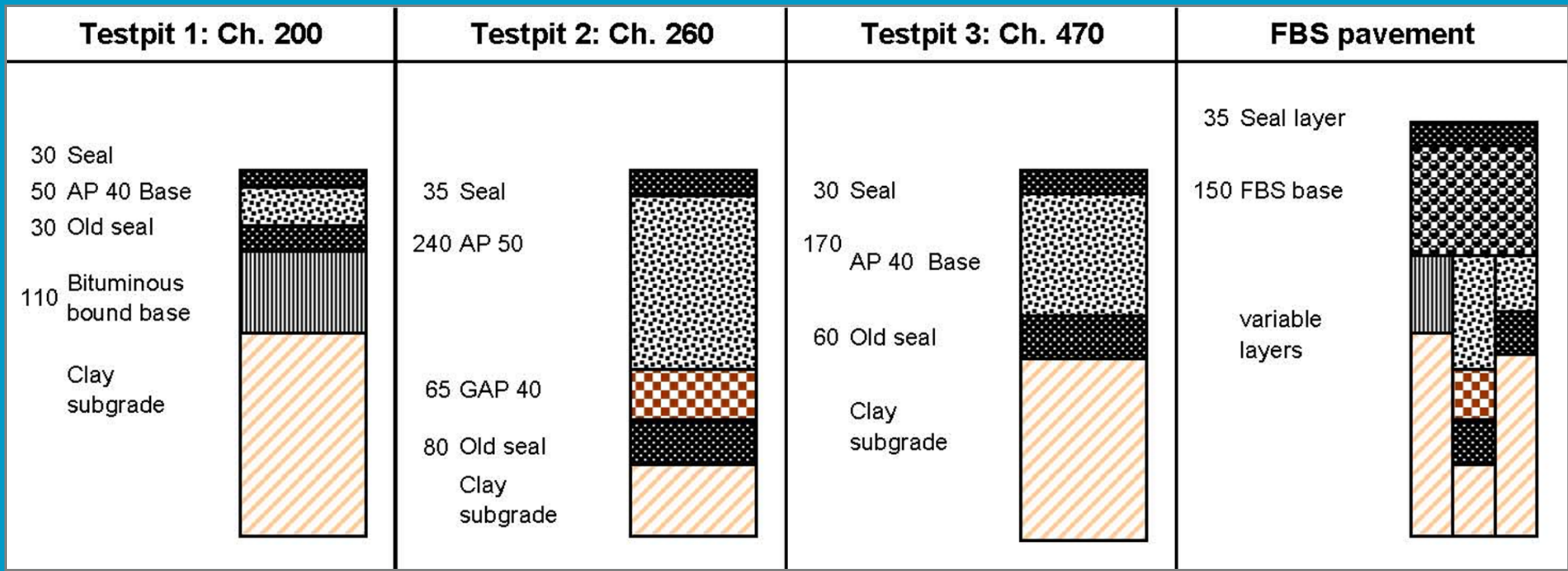
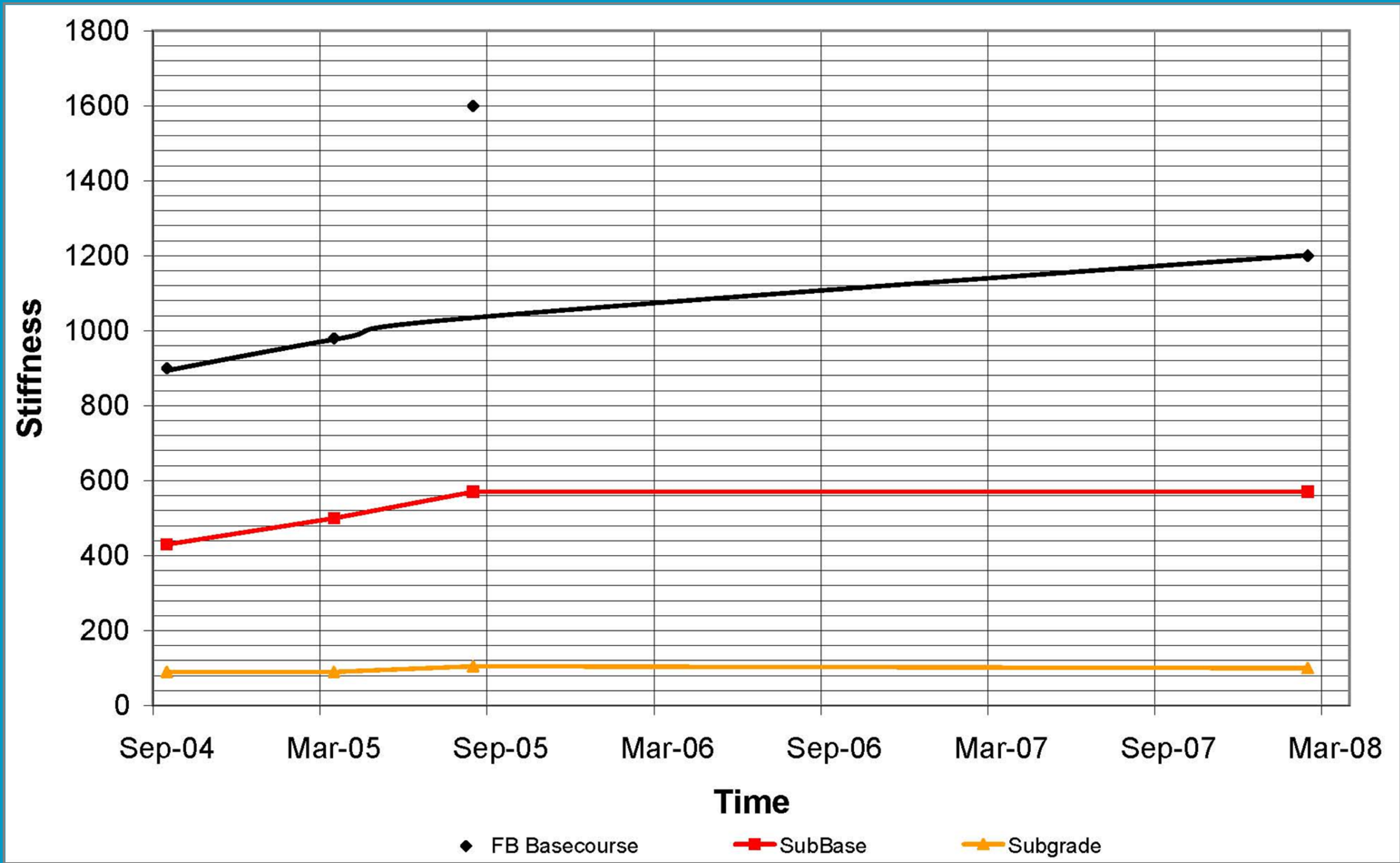


Test pits - variable pavement structure before and after FBS

FBS Project Performance

SH 26 Kurere Road



Back calculated Stiffness for the past 4 years

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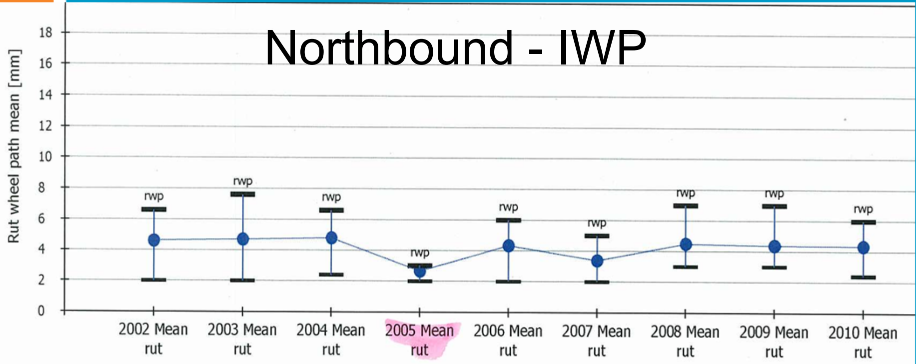
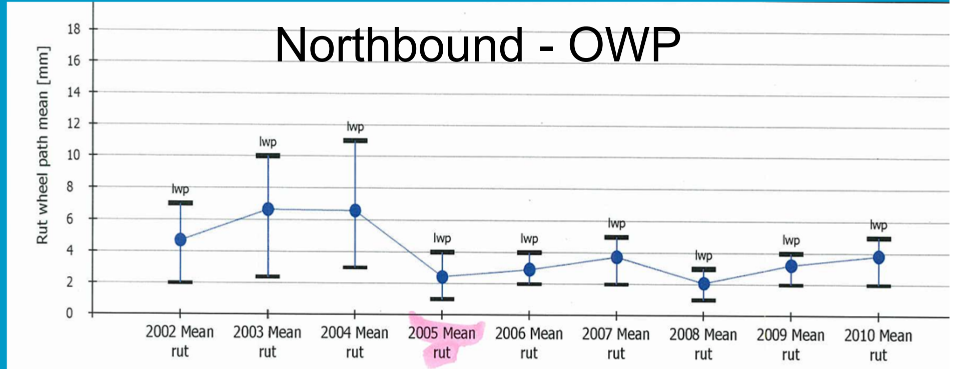
Northbound - IWP



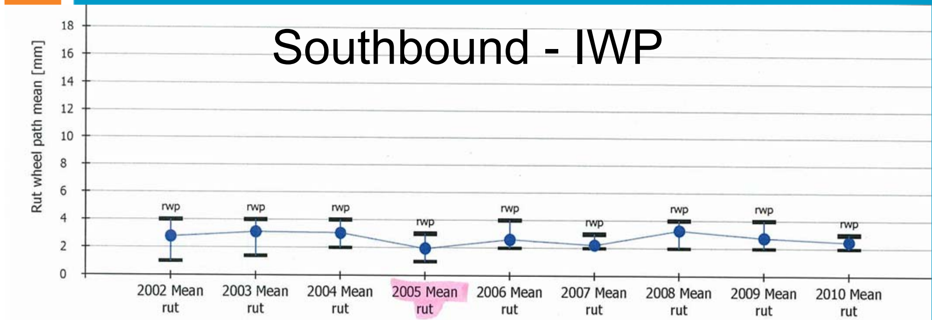
	2002 Mean rut	2003 Mean rut	2004 Mean rut	2005 Mean rut	2006 Mean rut	2007 Mean rut	2008 Mean rut	2009 Mean rut	2010 Mean rut
15th Percentile	2.00	2.00	2.40	2.00	2.00	2.00	3.00	3.00	2.40
Mean Value	4.59	4.68	4.78	2.65	4.32	3.38	4.49	4.38	4.35
85th Percentile	6.60	7.60	6.60	3.00	6.00	5.00	7.00	7.00	6.00
95th Percentile	11.00	9.40	10.40	4.00	7.00	6.00	7.20	7.20	7.20
Maximum Value	12.00	12.00	13.00	4.00	7.00	7.00	8.00	8.00	9.00

Northbound - OWP



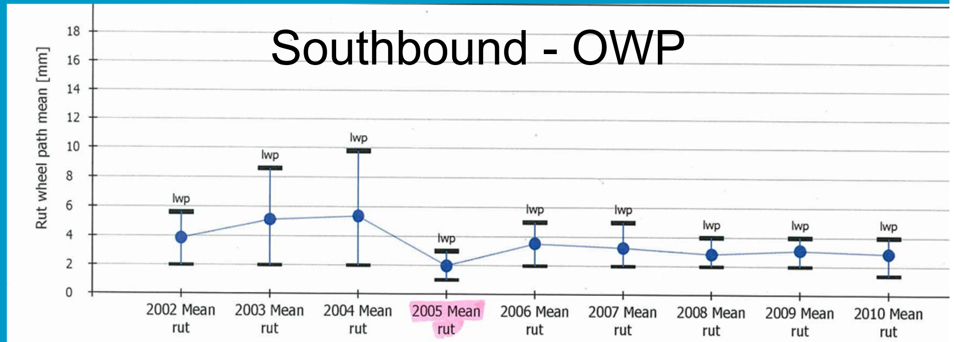
	2002 Mean rut	2003 Mean rut	2004 Mean rut	2005 Mean rut	2006 Mean rut	2007 Mean rut	2008 Mean rut	2009 Mean rut	2010 Mean rut
15th Percentile	2.00	2.40	3.00	1.00	2.00	2.00	1.00	2.00	2.00
Mean Value	4.68	6.65	6.59	2.43	2.92	3.73	2.08	3.24	3.84
85th Percentile	7.00	10.00	11.00	4.00	4.00	5.00	3.00	4.00	5.00
95th Percentile	10.00	15.60	16.00	4.40	4.40	6.20	4.20	6.00	8.00
Maximum Value	14.00	20.00	17.00	7.00	9.00	12.00	9.00	12.00	14.00

Southbound - IWP



	2002 Mean rut	2003 Mean rut	2004 Mean rut	2005 Mean rut	2006 Mean rut	2007 Mean rut	2008 Mean rut	2009 Mean rut	2010 Mean rut
15th Percentile	1.00	1.40	2.00	1.00	2.00	2.00	2.00	2.00	2.00
Mean Value	2.76	3.08	3.03	1.95	2.59	2.22	3.27	2.76	2.49
85th Percentile	4.00	4.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00
95th Percentile	5.20	6.00	6.00	4.00	4.20	3.20	5.00	4.20	4.00
Maximum Value	7.00	7.00	6.00	4.00	5.00	5.00	6.00	5.00	5.00

Southbound - OWP



	2002 Mean rut	2003 Mean rut	2004 Mean rut	2005 Mean rut	2006 Mean rut	2007 Mean rut	2008 Mean rut	2009 Mean rut	2010 Mean rut
15th Percentile	2.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	1.40
Mean Value	3.84	5.11	5.35	1.97	3.51	3.24	2.84	3.11	2.89
85th Percentile	5.60	8.60	9.80	3.00	5.00	5.00	4.00	4.00	4.00
95th Percentile	7.20	12.40	12.40	3.20	6.00	5.20	5.00	5.20	6.00
Maximum Value	10.00	14.00	14.00	4.00	6.00	7.00	5.00	6.00	6.00

HSD – Rutting over the last 6 years

FBS Research in NZ - NZTA sponsored

Section	Design Parameter	Constructed Parameter	Designation
A	1.5 % Foam Bitumen, 1% Cement	1.2 % Foam Bitumen, 1% Cement	B12C10
B	2.7 % Foam Bitumen, 1% Cement	1.4 % Foam Bitumen, 1% Cement	B14C10
C	4 % Foam Bitumen, 1% Cement	2.8 % Foam Bitumen, 1% Cement	B28C10
D	1% Cement	1% Cement	B00C10
E	Unbound (No Binder)	Unbound (No Binder)	B00C00
F	2.7 % Foam Bitumen	2.2 % Foam Bitumen	B22C00

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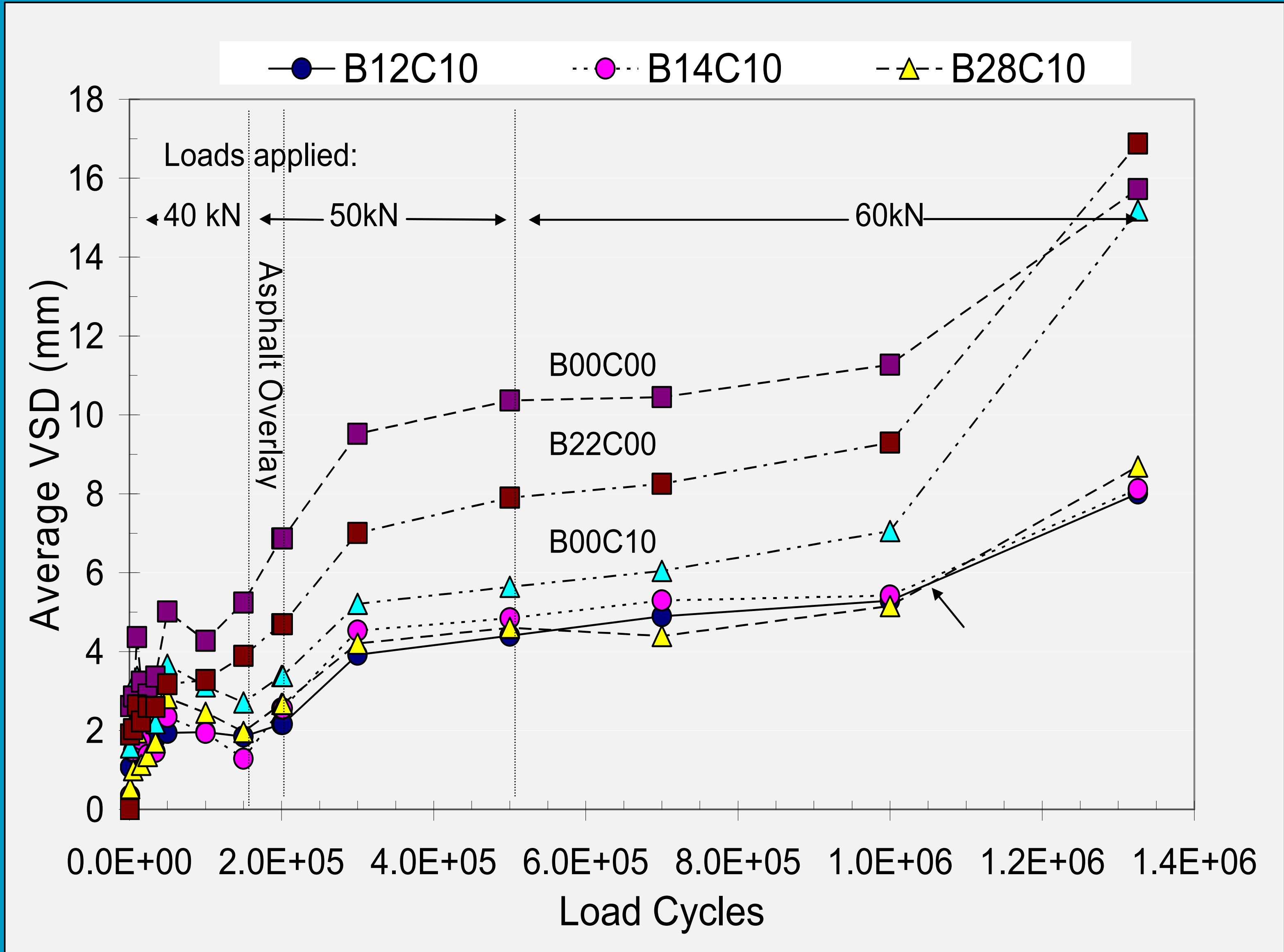

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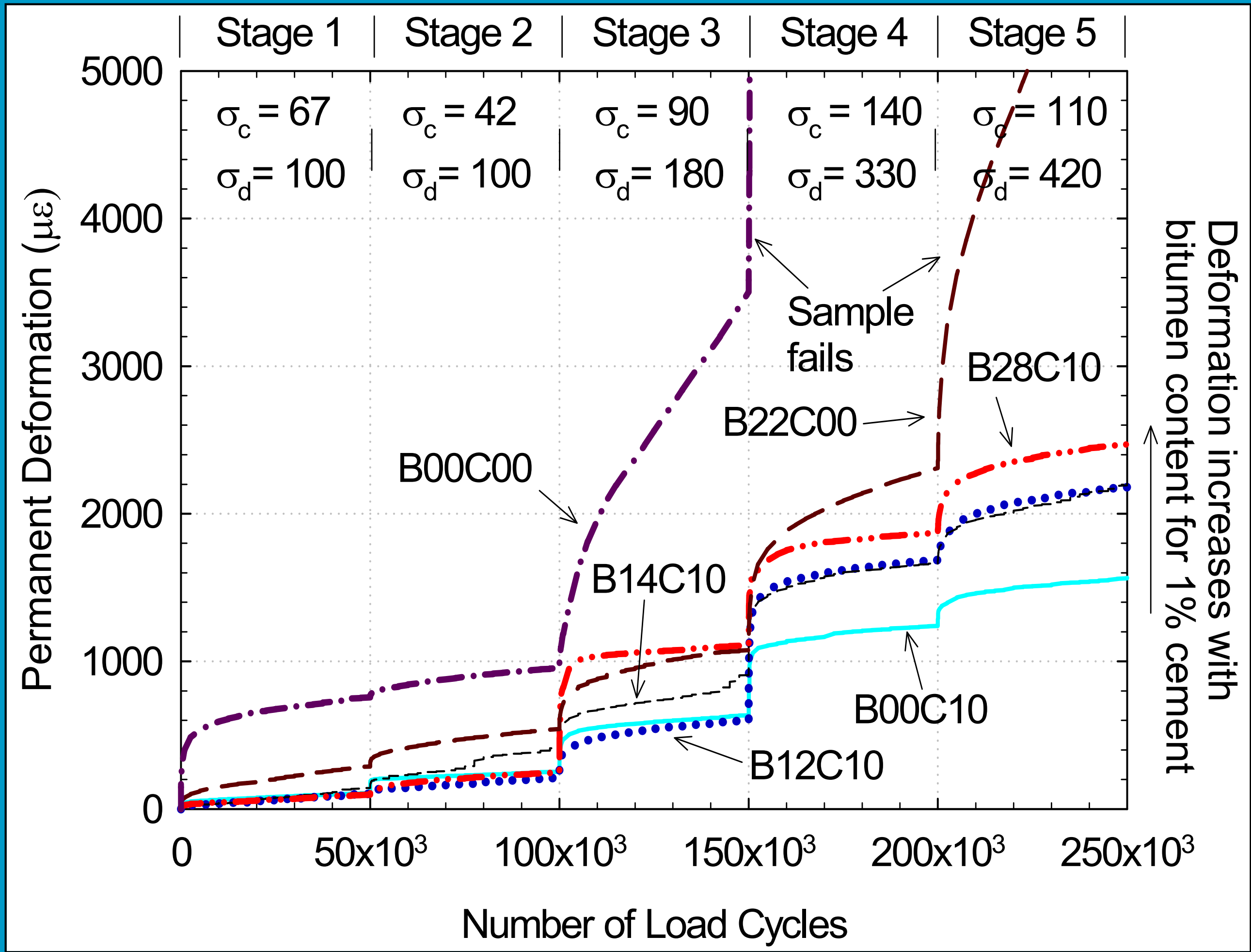

RLTT used for research and major Greenfields projects

Interaction between Pavement Design and Laboratory Mix Design Testing

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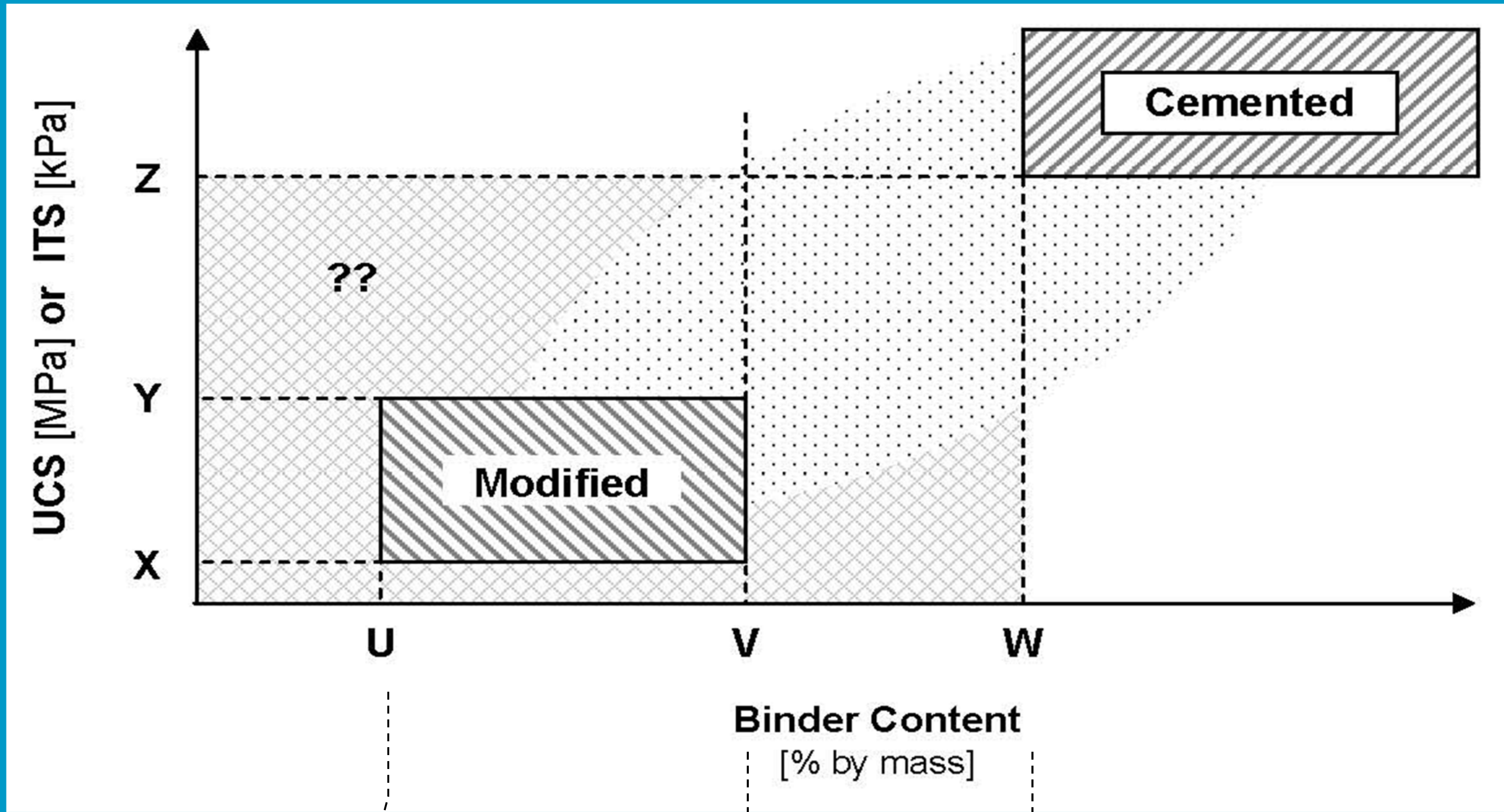
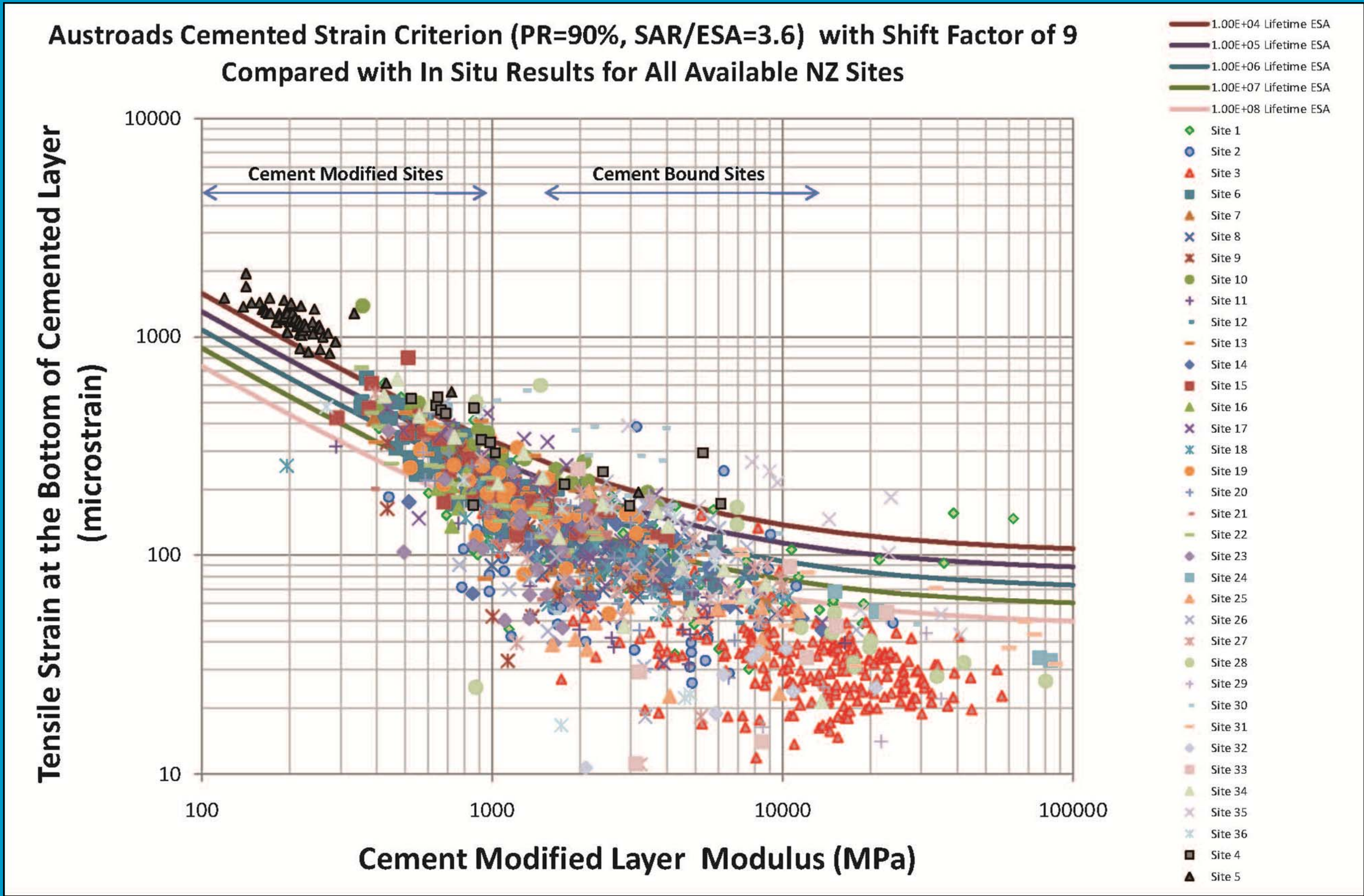


Pavement Design	**APDG 6.2** Unbound Materials	**APDG 6.3** Modified Materials	**????** Lightly Bound	**APDG 6.4** Cemented Materials
Performance	RLTT ?	RLTT, UCS or ITS ?	????	ITS, RL-ITS or UCS ?


Austroads Cemented Strain Criterion (PR=90%, SAR/ESA=3.6) with Shift Factor of 9
Compared with In Situ Results for All Available NZ Sites
Cement Modified Sites
Cement Bound Sites
Tensile Strain at the Bottom of Cemented Layer (microstrain)
10000
1000
100
10
100
1000
10000
100000
Cement Modified Layer Modulus (MPa)
1.00E+04 Lifetime ESA
1.00E+05 Lifetime ESA
1.00E+06 Lifetime ESA
1.00E+07 Lifetime ESA
1.00E+08 Lifetime ESA
Site 1
Site 2
Site 3
Site 6
Site 7
Site 8
Site 9
Site 10
Site 11
Site 12
Site 13
Site 14
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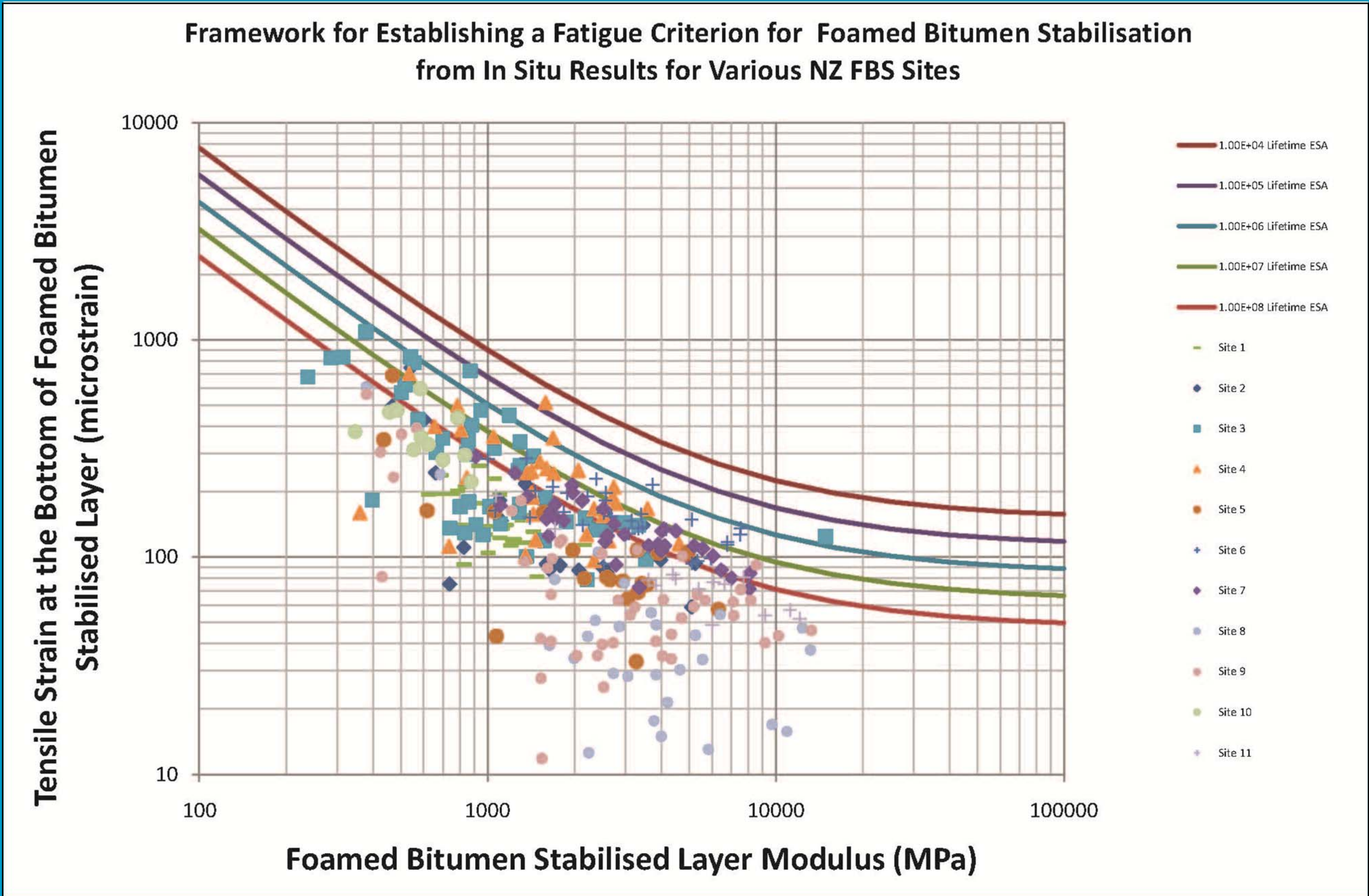
FBS Research in NZ - NZTA sponsored



Historical Mix Design / Reactivity Status

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UCS:

Variance in Diameter to Height ratio:	0.7 to 2.0
Variance in compactive effort:	Standard, Heavy & Vibe Hammer
Variance in scalped Stone size:	19mm to 37.5mm

ITS:

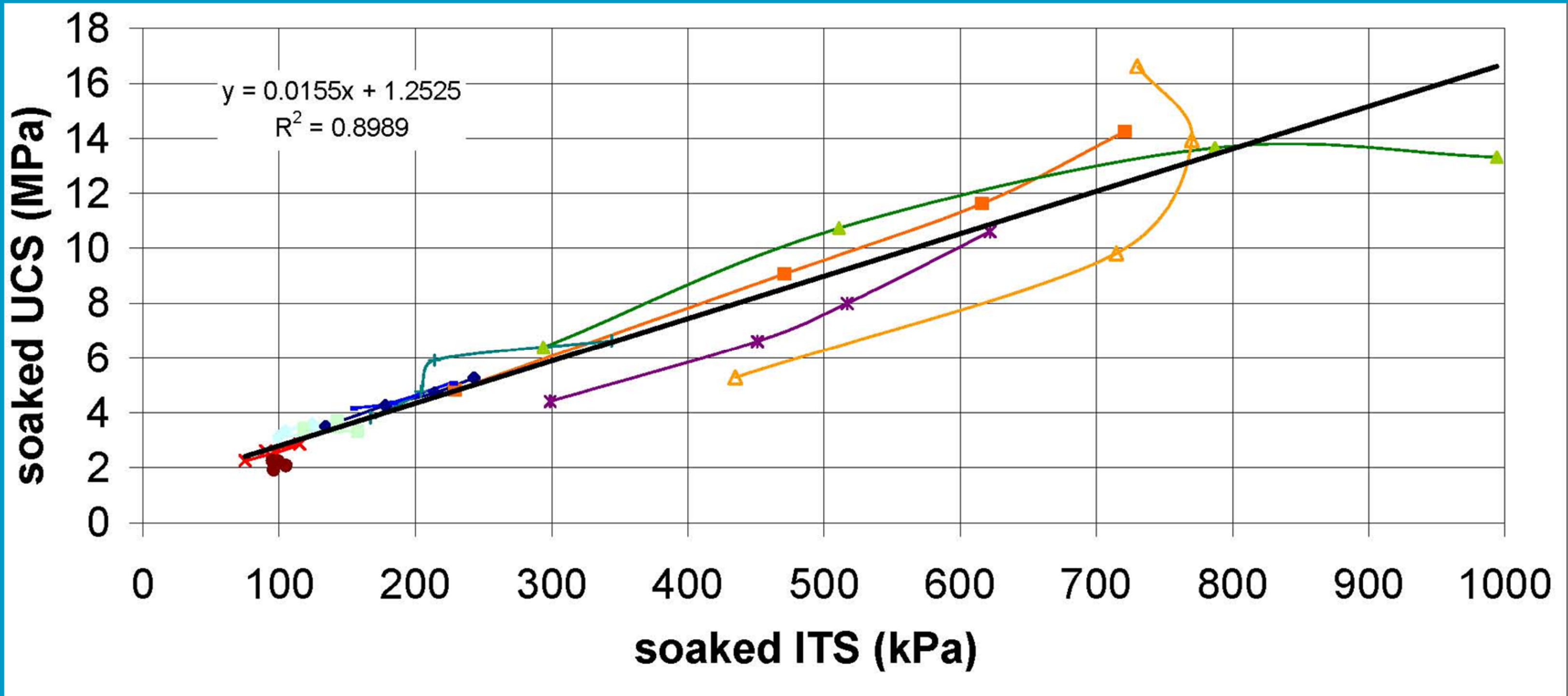
Variance in Diameter to Height ratio:	1.3 to 1.7
Variance in compactive effort:	Marshall & Gyratory
Variance in scalped Aggregate size:	19mm to 26.5mm

State of the nation:

Different strength tests being used all over NZ for C, L & FB

Draft NZTA T/19 aims at standardising this to give pavement engineers a clearer understanding of the test results.

UCS and ITS



UCS and ITS: Testing similar parameters

NPTG discussion of way forward:

- If you want to test 37.5mm aggregate then require 150 dia.
- If you want a H/dia ratio of 2 then require 150dia x 300 high sample!!!!
- You want to have 3 to 4 points - this would requires a lot of sample

Discussion and Decisions by NPTG

- Same test for all stabilised materials (C, L & FB)
- ITS test is specified instead of UCS testing as we found that it is more sensitive to changes in aggregate, binder content and moisture
- Initially up to 37.5 mm to use all the aggregate – this has recently been changed to scalping at 26.0 mm
- 150 mm dia. x 126 mm height mould (std. CBR mould)
- Vibe hammer compaction - all labs in NZ have this
- Typical addition of Stabilising Agents:
  - 1.0 – 2.5 % Cement / Lime for modified layers
  - 4.0 – 6.0 % Cement for strongly bound subbase layers
  - 1.0 & 2.0 % Cement or Lime + 2.5 & 3.5 % FB

    (e.g. 1C/L+2.5FB; 1C/L+3.5FB; 2C/L+2.5FB; 2C/L+3.5FB)

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Specification for the Mix Design Testing of Modified and Bound Pavement Layers

2. Aggregate Preparation and Testing:

- Blend sample according to the depths as required by the pavement design – instructed by the pavement engineer
- Particle size distribution – NZS 4407 : Test 3.8.1
- Plasticity Index – NZS 4407 : Test 3.4
- If required, correct PSD and/or PI
- OWC / MDD using NZS 4402: Test 4.1.3 (NZ Vibe Hammer)

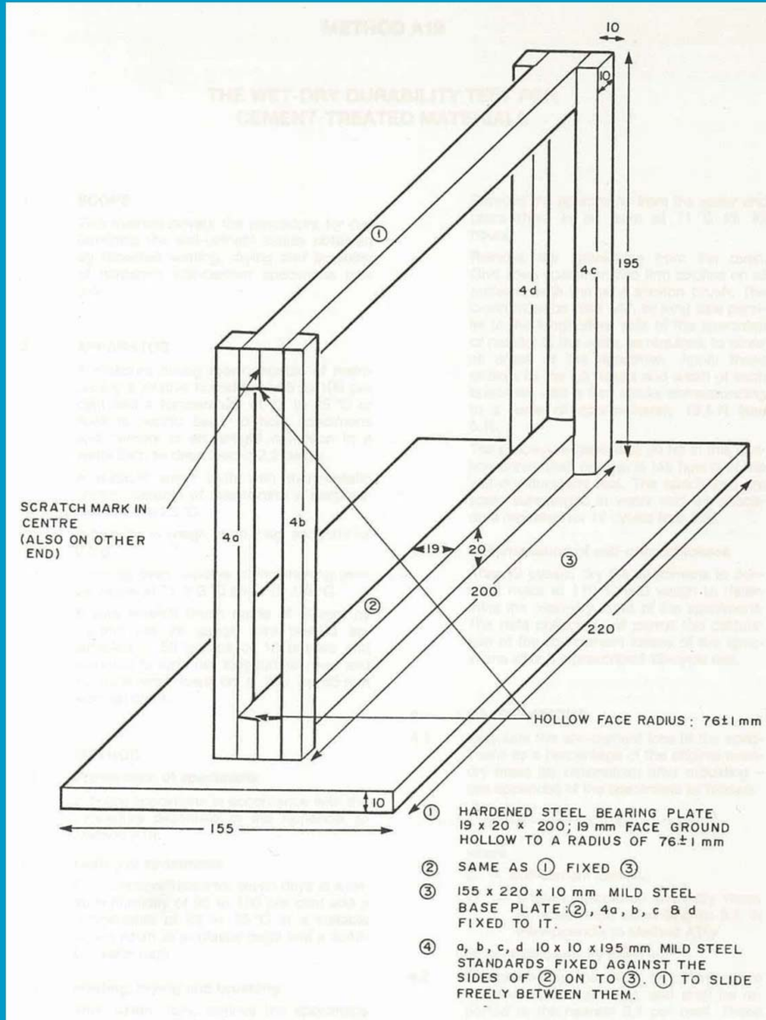
NZTA T/19: Specification

3. Mix Design for Cement / Lime Stabilised Aggregates
4. Mix Design for Foamed Bitumen Stabilised Aggregates

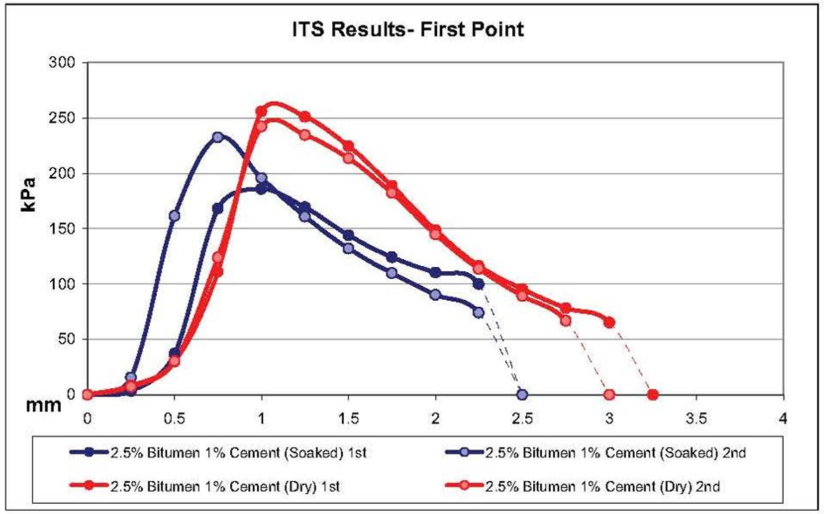
- Same procedure except for mixing portion
- Binder contents – directed by Pavement Engineer
- Compaction: NZS 4402, Test 4.1.3 – NZ Vibe Hammer
- Curing:
  - Cover with damp cloth for 20 hours curing in mould, then extract
  - Dry ITS: 72 hrs @ 40 ºC (sealed bag) + 24 hrs @ 21 ºC in Air
  - Soaked ITS: 72 hrs @ 40 ºC (sealed bag) + 24 hrs @ 21 ºC in Water
- Strength test: ITS with strain measurement
- Tensile Strength Retained = Soaked ITS / Dry ITS

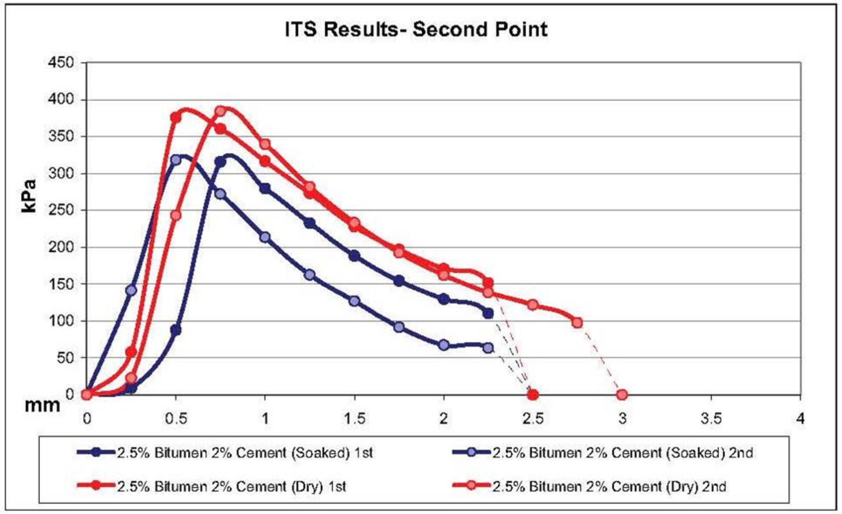
5. Determination of Indirect Tensile Strength (ITS)

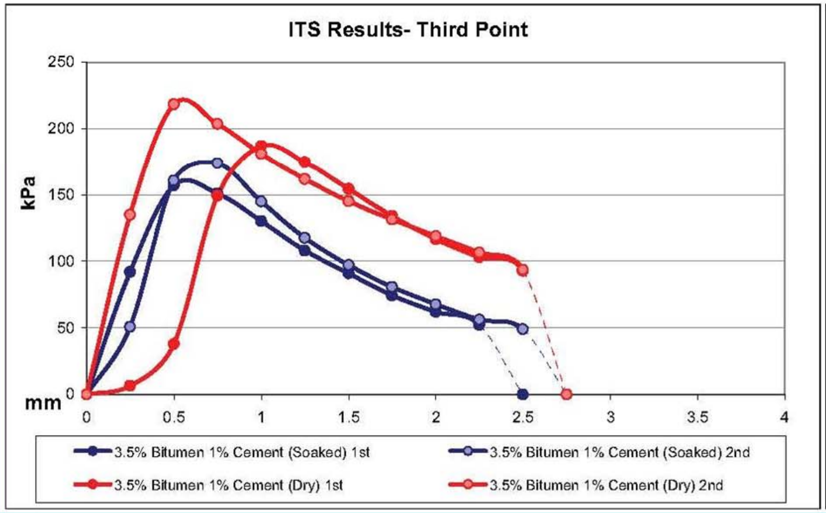
- Compression Testing Machine capable of 1mm / min
- Measure vertical deformation
- Plot ITS vs Strain to assess mode of breakage

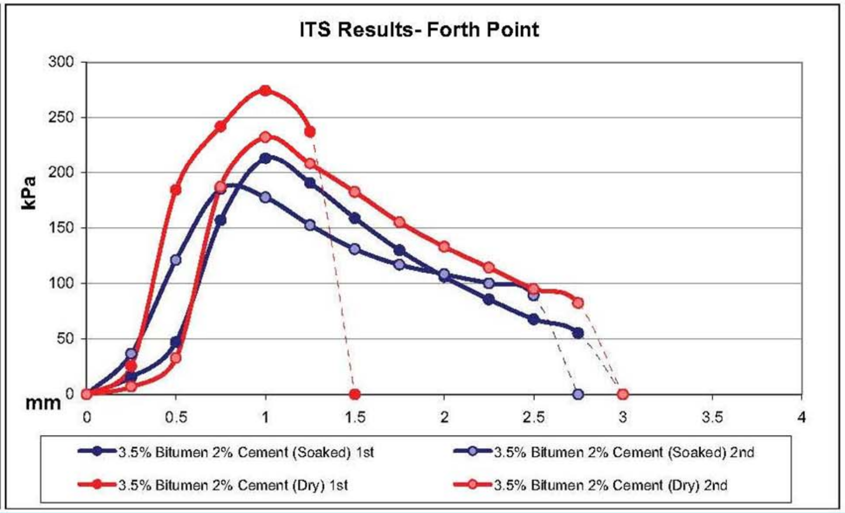


5. ITS vs vertical deformation



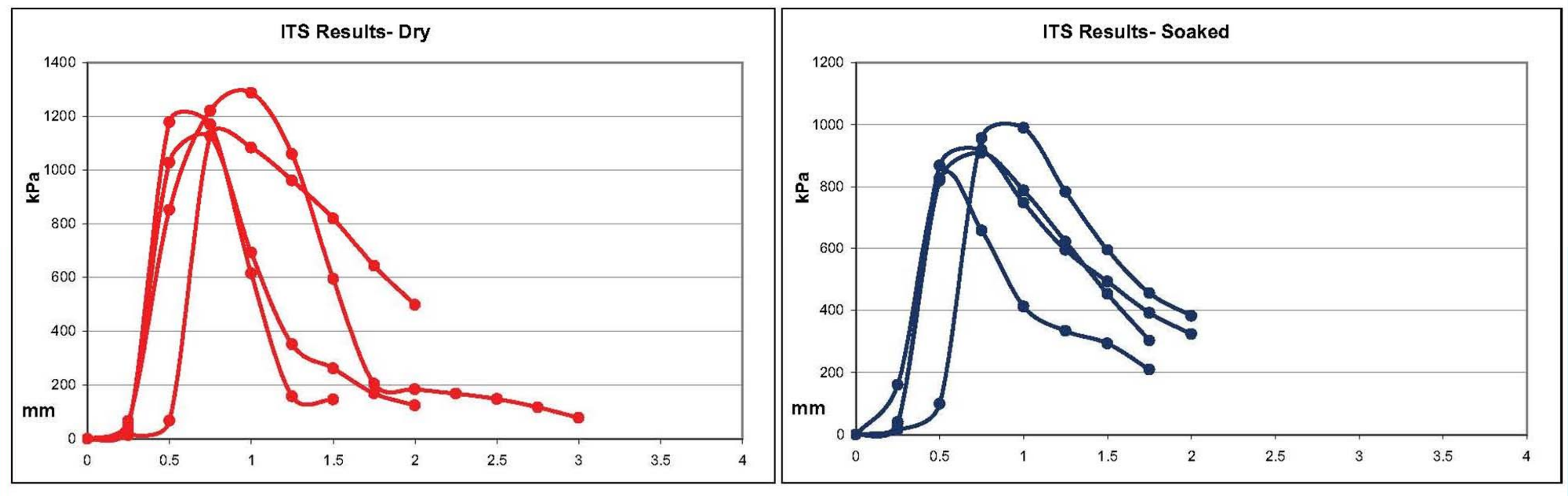






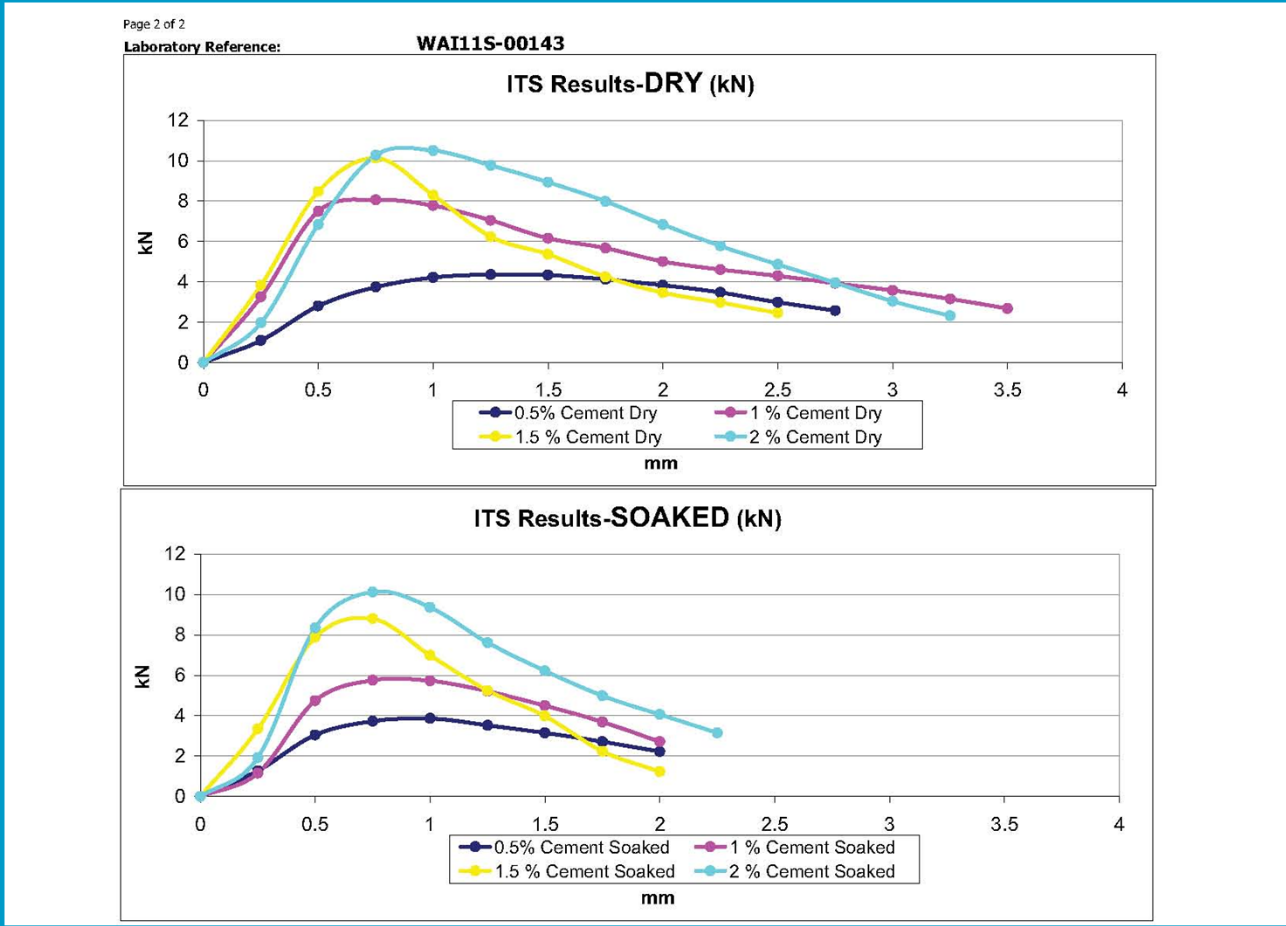
NZTA T/19: Specification

5. ITS vs vertical deformation



4% Cement Bound Subbase Aggregate

5. ITS vs vertical deformation



4% Cement Bound Subbase Aggregate

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Draft ITS Boundaries

	Dry (kPa)	Soaked (kPa)
Modified	< 600	< 500
Bound	> 1000	> 800
FBS	< 600	< 500

- For all types of stabilisation try to keep out of the 600 to 1000 kPa zone
- These values will be refined over the next few years as more actual pavement performance data vs mix design strength is gathered and analysed

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Identifying Moisture Sensitive Mixes

Tensile Strength Ratio,

TSR = (Soaked ITS / Dry ITS) * 100%

Terrain type and drainage	Tensile Strength Ratio (TSR)		
	Dry (Rainfall < 600 mm / annum)	Moderate (Rainfall between 600 and 1000 mm/annum)	Wet (Rainfall > 1000 mm / annum)
Rolling (well drained)	> 50 %	> 60 %	> 70 %
Flat (poorly drained)	> 60 %	> 65 %	> 75 %

Source: Wirtgen Cold recycling Manual


Thank you four your attention
Any questions?