40 Years of Lessons, Innovation & Progress

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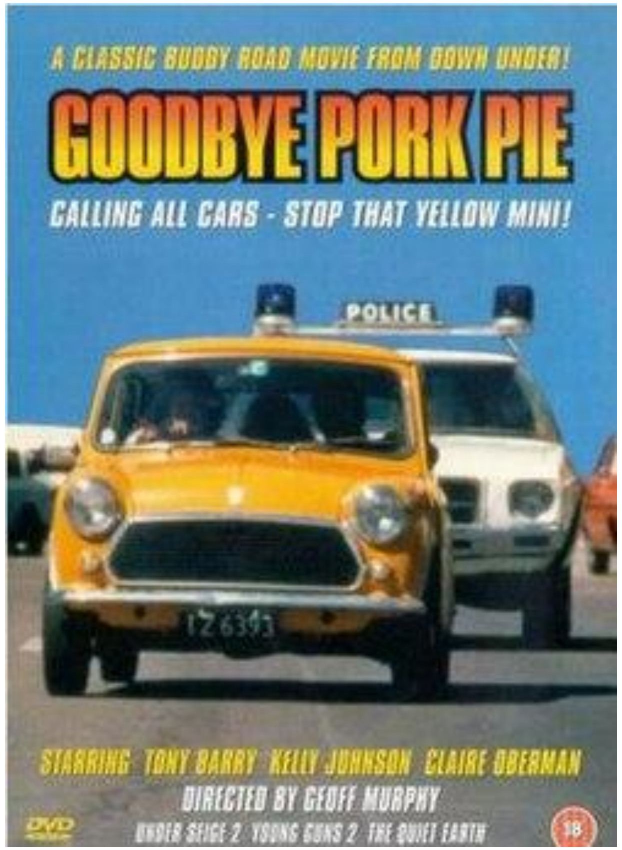
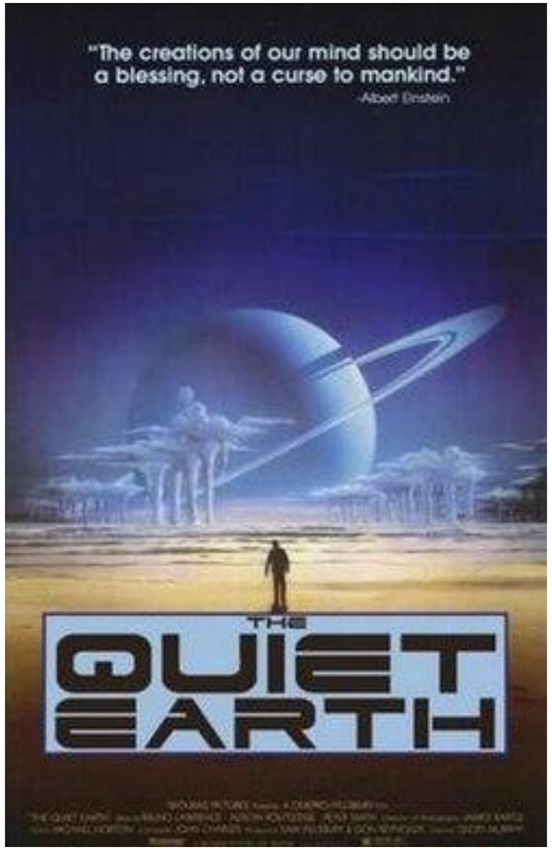
Outline

- Why I moved to New Zealand 40 years ago
- One of my favourite tales from a quarry
- What’s in a pavement layer?
- How the Repeat Load Triaxial test can help you
- Bitumen & sand – the perfect mix!
- Recent changes to M04 – why??
- DGBANZ+
- Another way to skin a cat
- Where to from here?

Why I moved to New Zealand 40 years ago

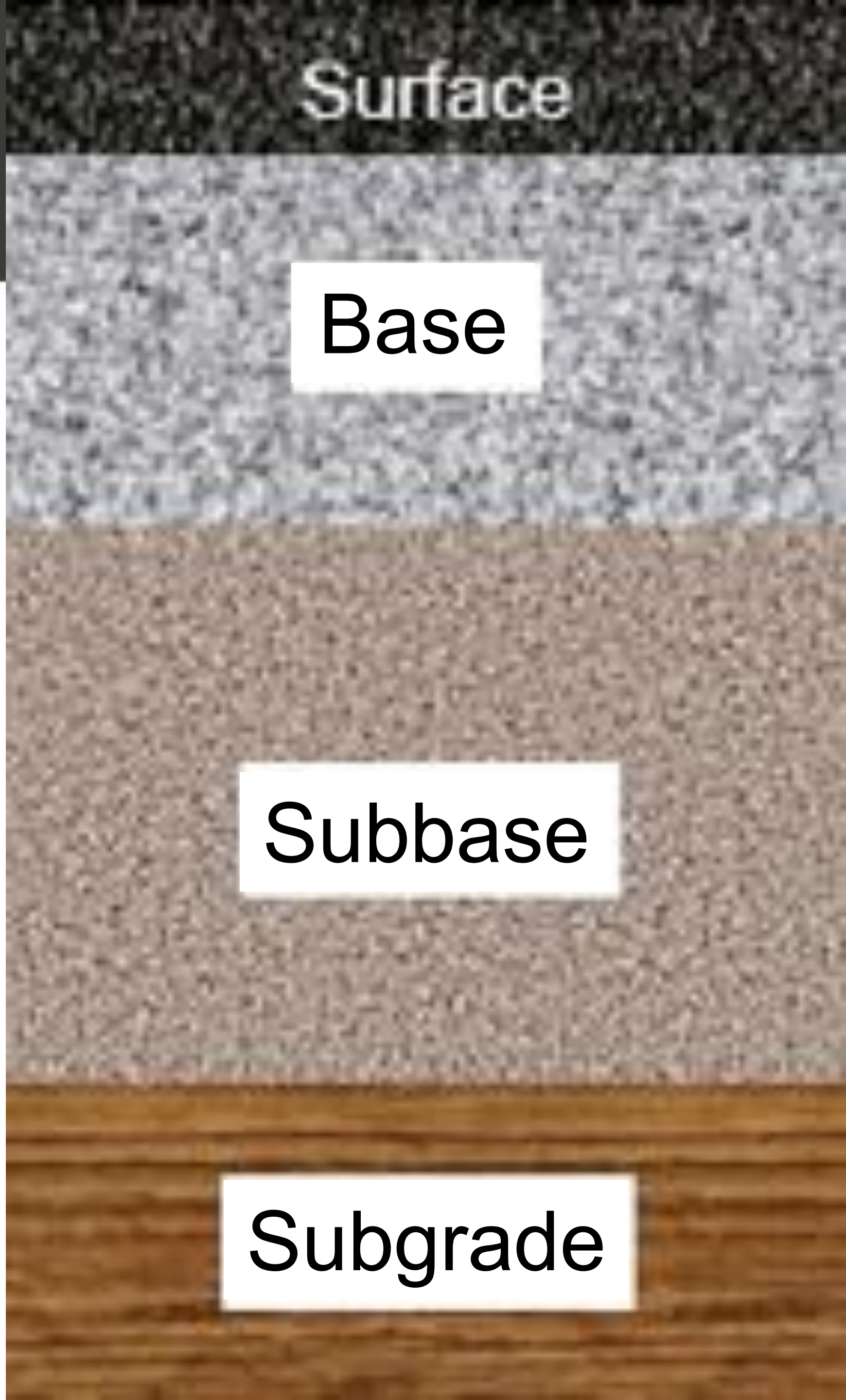




What do we want from a premium basecourse aggregate?

What's in a Pavement Layer?

- Basecourse requirements:
  - Rut resistance
  - Resists loading from heavy trucks, aircraft or heavy port forklifts
  - Durable – doesn't break down under loading &/or when water infiltrates
  - Doesn't shear
  - M4 is permeable, so contains voids



How to get good basecourse performance?

- Durable rock
- Broken faces
- Compaction
- Keep water out!

Broken faces in basecourse aggregate

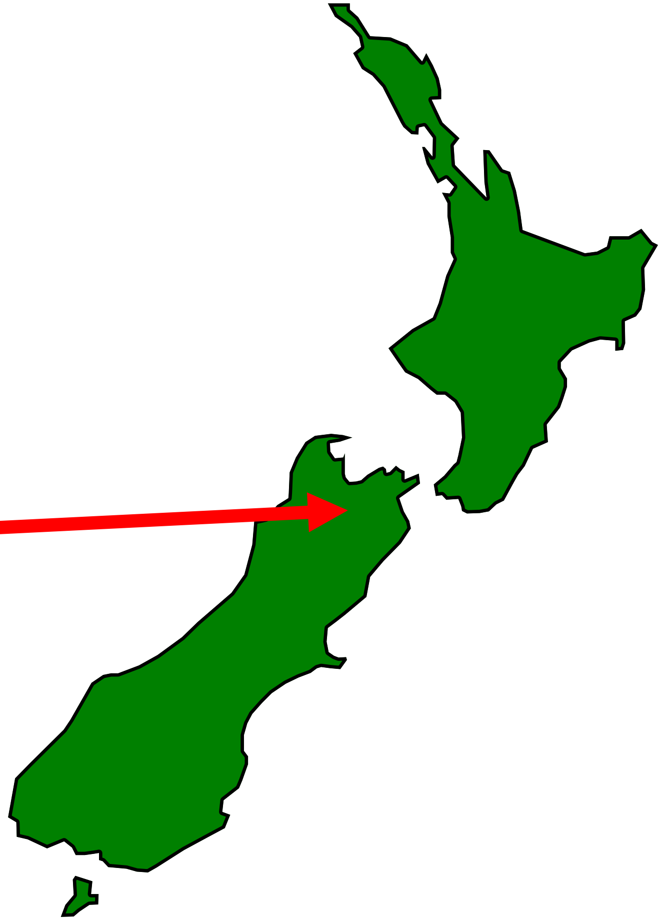
- Important for locking up & strength
- What is optimum % broken faces?
- Trials of 0%, 30%, 50%, 70%, 100%
- When well compacted, no difference in performance between 50% & 70%

Case Study

Broken faces

Glenhope Realignment

Case Study – Local aggregates, minimising waste & cartage



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Proving an alternative to M04 worked

- M04 spec required > 70% broken faces
- Local pit aggregate complied with standard premium crushed (M04) aggregate in all respects, except 70% broken faces required 50% of raw feed to be scalped
- Confirmed expected performance of alternative with Repeat Load Triaxial test (RLTT)

Sieve Sizes (mm)	M04	Target	Achieved
19.0 to 37.5	> 70	> 60	64
9.5 to 19.0	> 70	> 40	52
4.75 to 9.5	> 70	> 40	43

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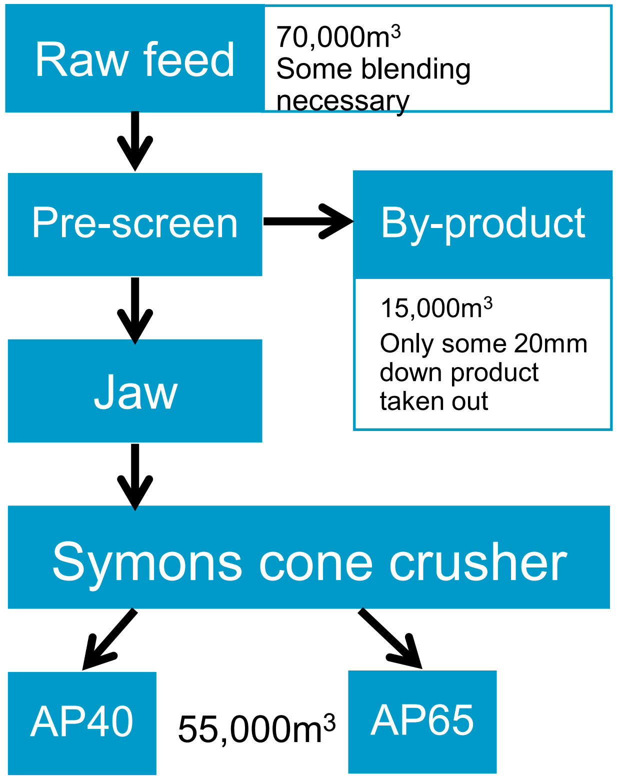
What is the RLT doing?

Crushing Flowchart

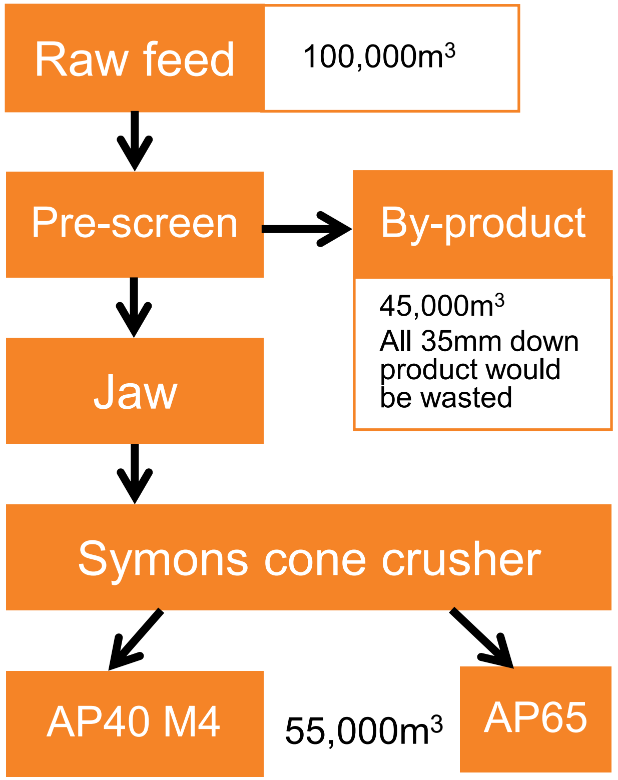
B3 AP40

What actually happened



M4 AP40

What would have happened



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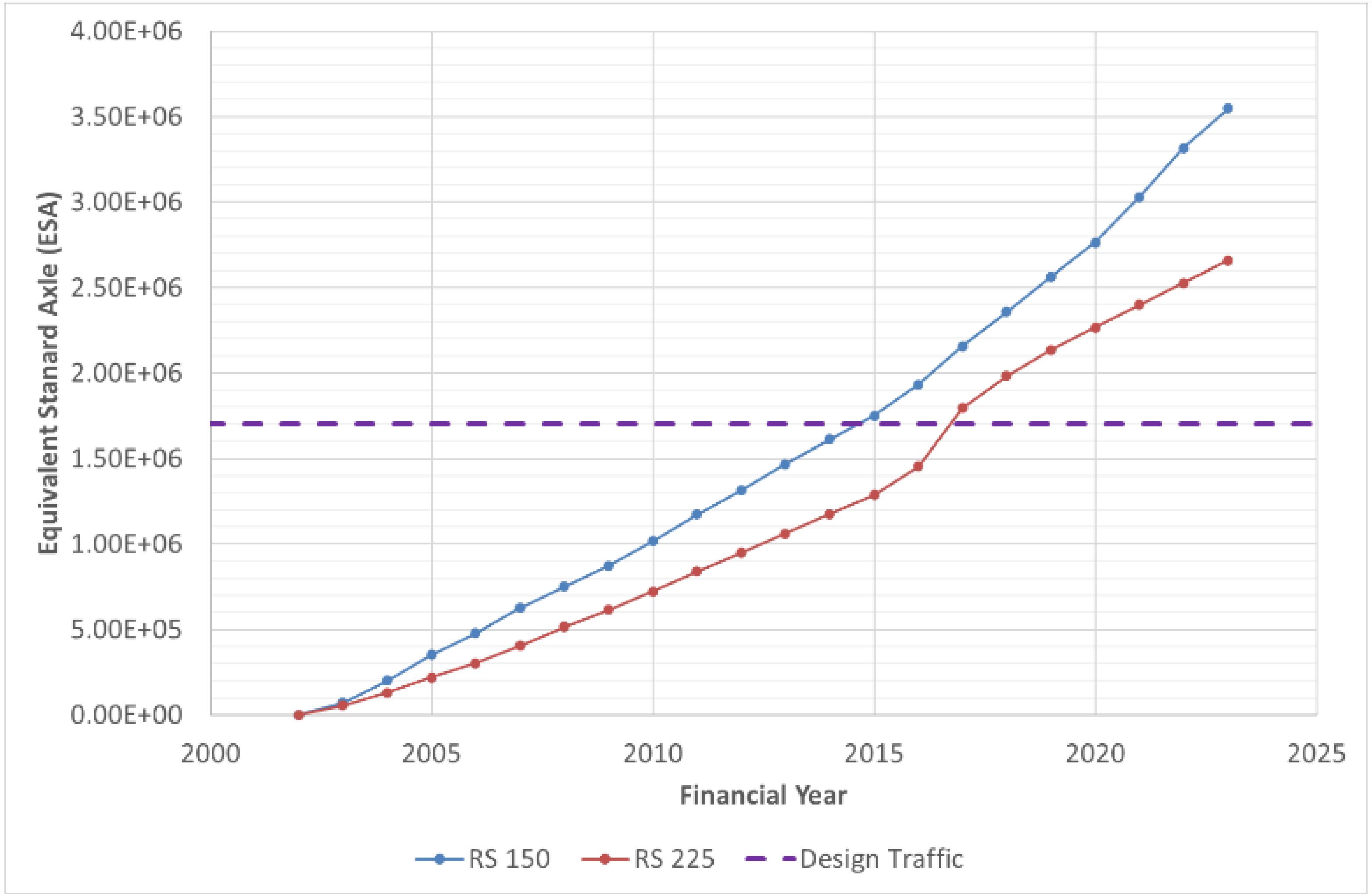
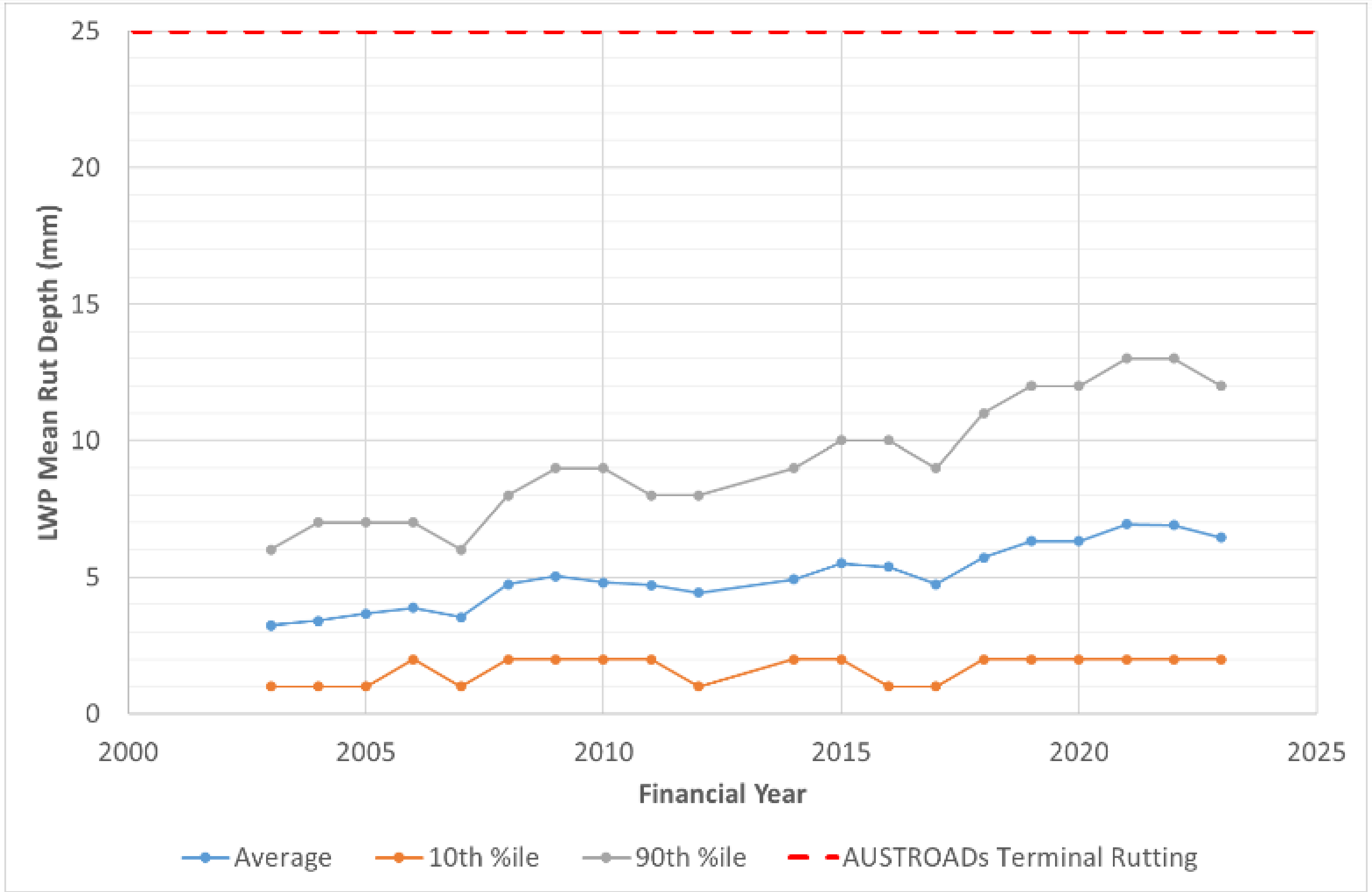
Design Traffic vs. Actual Traffic (Allowing for Logging)



Rutting



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Case Study

Sand Basecourse

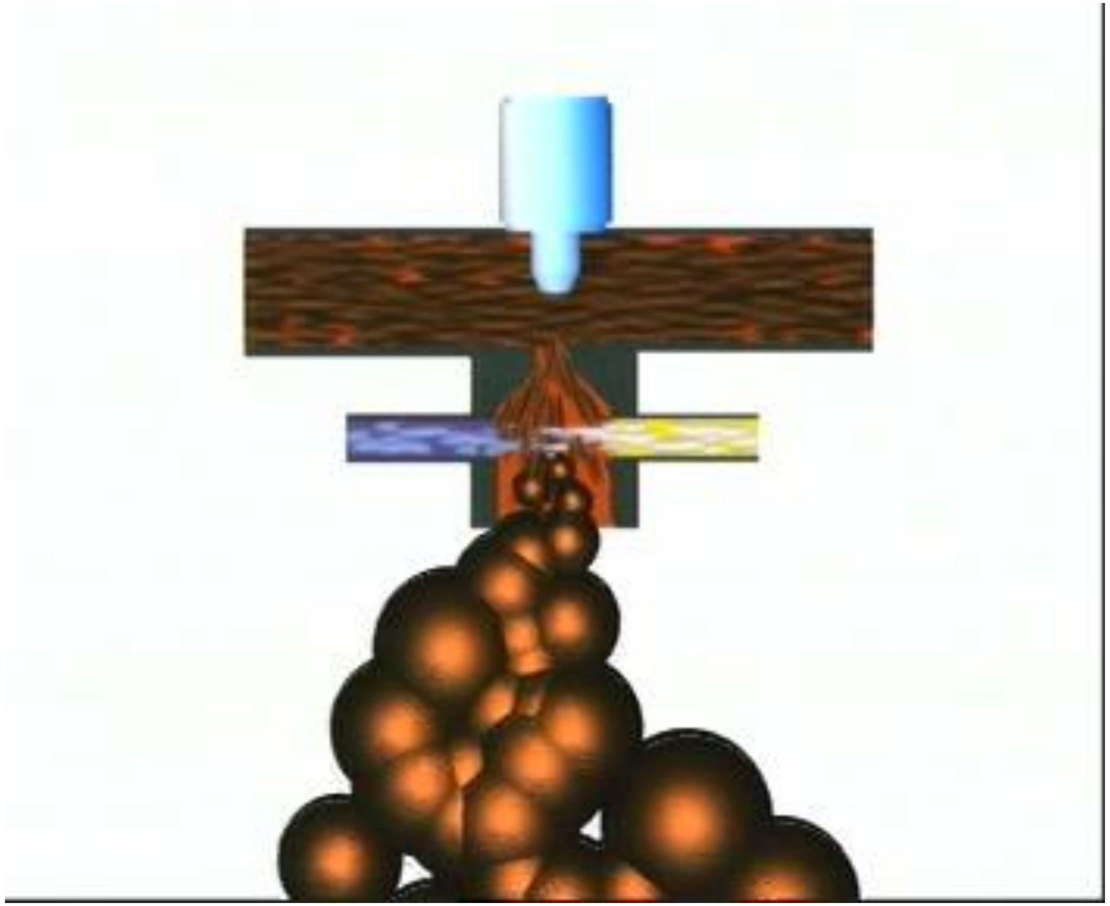
Bitumen Stabilised

How is bitumen foamed?

2 – 3 % water injected into hot bitumen

Bitumen expands 10 to 20 times its original volume

Increased surface area makes it possible to mix hot bitumen with cold & damp aggregates



Bitumen stabilised sand basecourse

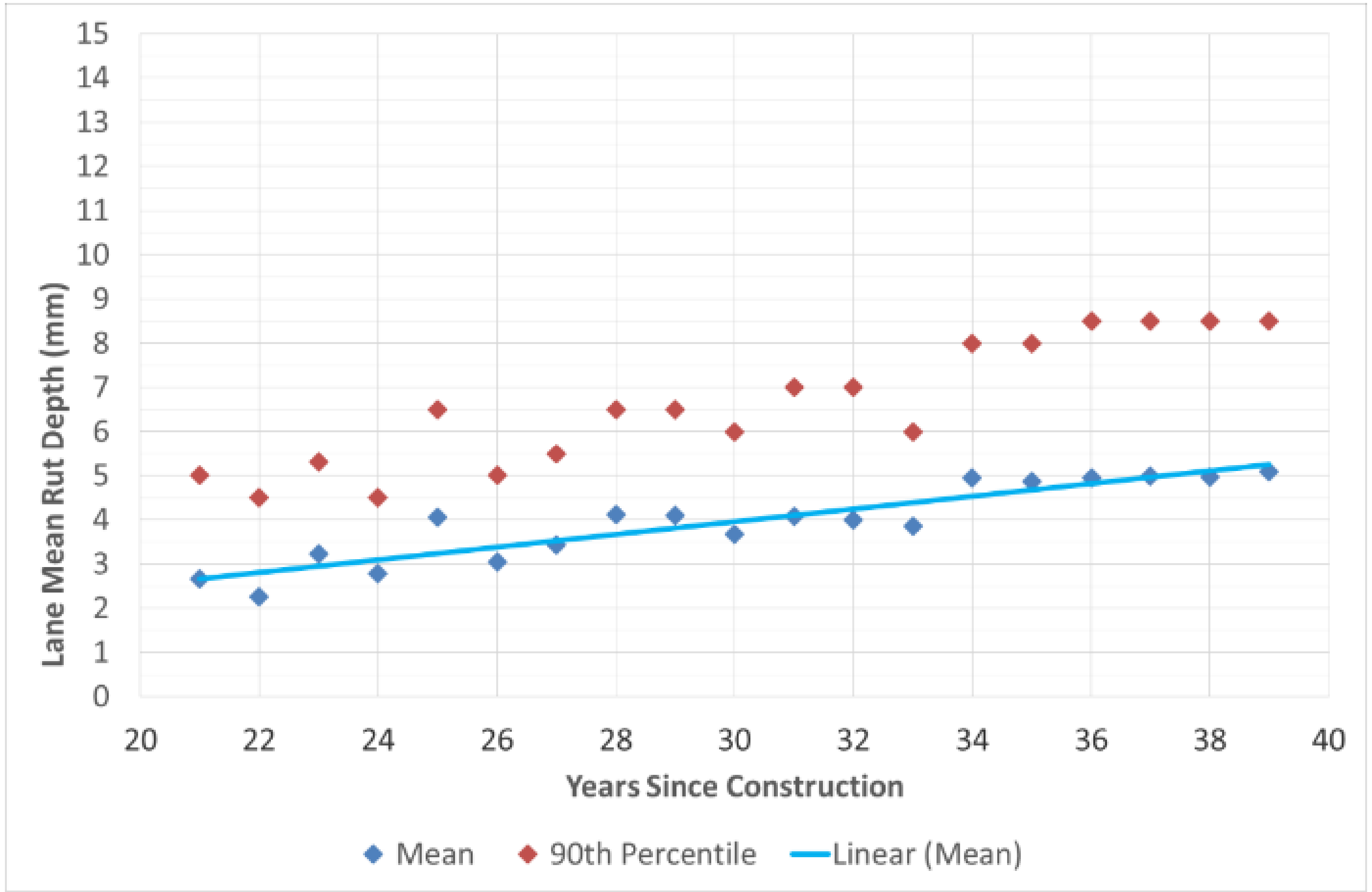
Oldest Foam Bitumen Site in NZ

1975: Mangonui County, Far North – entire pavement is foamed bitumen stabilised dune sand

Since 1990's: State highway carrying heavy forestry traffic

Years after Construction	21	39
	Rut Depth (mm)	
Mean	2.7	5.1
90^{th} Percentile	5	8.5

Rut Depth over Time



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Allow greater use of local aggregates

Recent changes to M4

Changes to M04

3 Aggregate Classes

This specification describes four aggregate classes to be selected on the basis of expected loading in the pavement. The Classes are defined in Table 1 below.

Table 1: Aggregate Classes

Aggregate Class	Duty
Class 1	Very Heavy
Class 2	Heavy
Class 3	Medium
Class 4	Light

- Aggregate classes
- Class system allows lesser quality material to be used in lower volume roads & footpaths etc
- Old M04 aligns with Class 2 in all testing requirements
- Classes based on heavy truck loading

Aggregate Class	Duty	Loading (ESA)
Class 1	Very Heavy	$5 \times 10^6 - 10^7$
Class 2	Heavy	$10^6 – 5 \times 10^6$
Class 3	Medium	$10^5 – 10^6$
Class 4	Light	$<10^5$

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Properties vary with Class

Table 2: Maximum Fines and Wet/Dry Strength Variation Achieved During Crushing Resistance Test

Aggregate Class	Specified Load (kN)	Percentage Fines Achieved (%)	Maximum Wet/Dry Strength Variation (%)
Class 1	180	10 maximum	30
Class 2	130		
Class 3	130		
Class 4	80		Report

Table 3: Weathering Quality Index Requirements

Aggregate Class	Weathering Quality Index
Class 1	AA, AB or BA
Classes 2, 3, 4	AA, AB, AC, BA, BB or CA

Table 4: Ethylene Glycol Accelerated Weathering Test Requirements

Aggregate Class	Test Requirements
Classes 1, 2	30% maximum
Classes 3, 4	Not required

New grading envelopes

Adds Statistical process control

- Rolling average PSD
- Process control limits
- PSD Characteristic value (CV) for each sieve
- Shape control CV

Table 12: AP 40 Aggregate Particle Size Distribution Envelopes

Sieve Size (mm)	Particle Size Distribution Limits	
	Classes 1 and 2	Classes 3 and 4
53.0	100	100
37.5	98 - 100	98 – 100
19.0	66 - 81	62 – 81
9.50	43 - 57	38 – 60
4.75	28 - 43	24 – 45
2.36	19 - 33	15 – 35
1.18	12 - 25	8 – 27
0.600	7 - 19	4 – 21
0.300	3 - 14	1 – 16
0.150	0 - 10	0 – 12
0.075	0 - 7	0 - 9

Performance-related properties

		TNZ AP40 M4:2006	TNZ AP40 M4:2024			
		AP40	AP40 - Class 1	AP40 - Class 2	AP40 - Class 3	AP40 - Class 4
	Traffic Class	All	Very Heavy	Heavy	Medium	Light
Performance Properties	RLT Soaked Undrained	Not Required	1.5	Not Required		
	RLT Dry Drained	Not Required	0.5	0.5		
	CBR	>80%	Not Required		>80%	
	MDD & OMC		Report			
	Solid Density	Not Required	Report			

(a) Repeat Load Triaxial Testing is for unbound or unmodified aggregate materials

(b) Maximum RLT Average Slope %/1M 1st 5 stages

Regional Variations in M4

- Napier River Gravels
- Rotorua Rhyolite & River Gravels
- Wanganui Shellrock
- Taranaki Andesites
- Wellington Greywacke
- Canterbury Uncrushed Alluvial Greywacke
- Recycled Crushed Concrete
- Glenbrook Melter Aggregate AP40
- Reclaimed Glass

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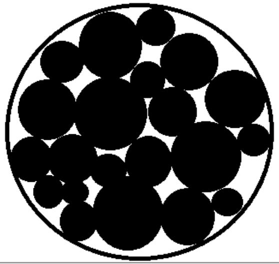
Dense graded basecourse aggregate

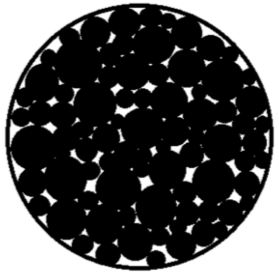
Overseas best practice to New Zealand

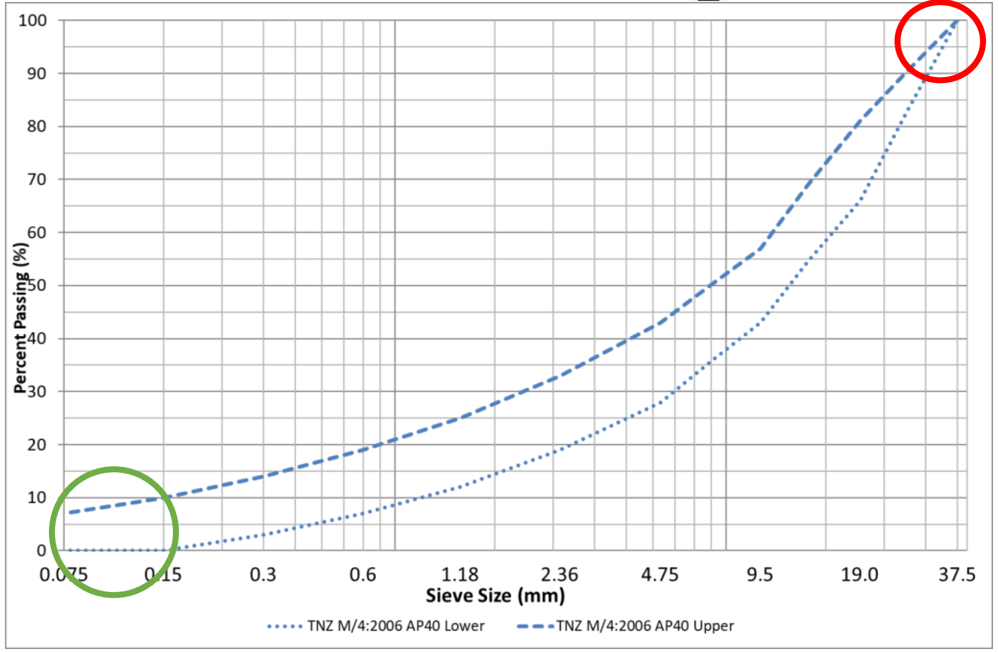
What is Dense Graded Basecourse Aggregate?

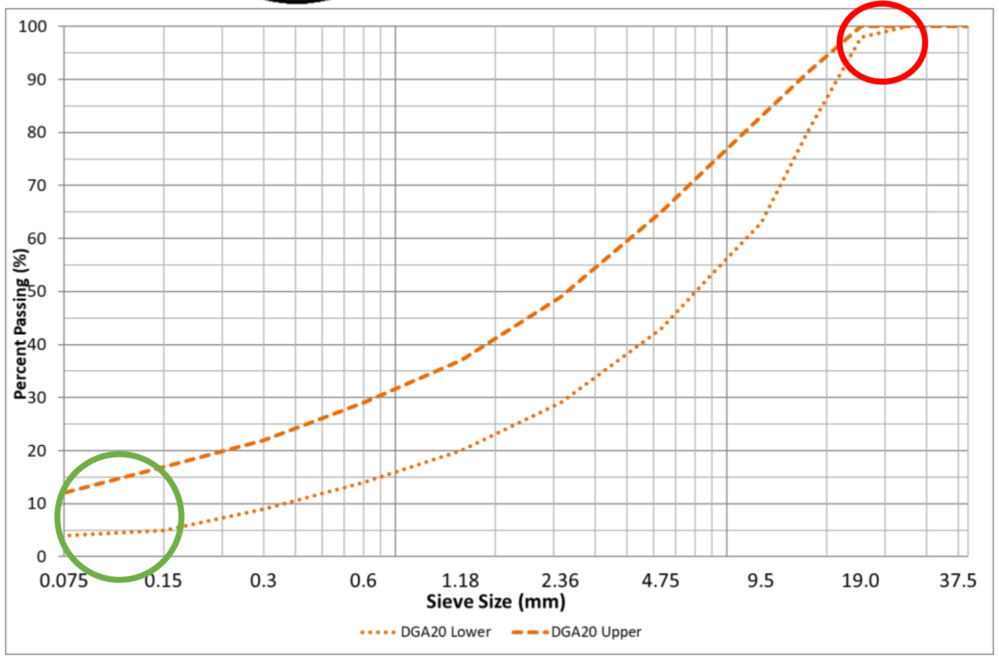
M04 AP40



DGB20







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Overseas use of dense graded basecourse aggregate

No need to re-invent the wheel

- DGA used around the world

Alabaster, D., Patrick, J., Hussain, J., & Henning, T. (2015). Effects of water on chipseal and basecourse on high-volume roads. NZTA research report 564

Arnold , G., Werkmeister , S., & Alabaster, D. (2007). The effect of grading on the performance of basecourse aggregate. Land Transport New Zealand Research Report 325

Bartley, F. (2007). Total Voids in Unbound Granular Pavements. Land Transport New Zealand Research Report 332

Robust development methodology to create a specification

- Comprehensive literature review – NZ & overseas research
- Reviewed research NZTA CAPTIF test track
- Consulted with Australia – decades of experience with DGB aggs
- 2 years of student projects (including RLT lab tests)
- Trial production runs in quarry
- Trials constructed in quarries – compared with M04 performance under heavy loads
- Field trial on state highway site (West Melton, Canterbury)
- Monitored & assessed
- Finalised spec for dense graded basecourse aggregate

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Field trials

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Another way to skin a cat

Liquefaction sand in the basecourse

Pavement Resilience during Canterbury's Seismic Events

Investigation requested by Christchurch Rebuild Alliance to assess performance of various pavement types

Scope: investigate performance of various pavement structures during & after seismic events

Goals: - assess resilience & performance of different pavement structures

- identify which pavement types would provide optimum performance in future seismic events

Liquefaction lenses in pavements

Under surfacing

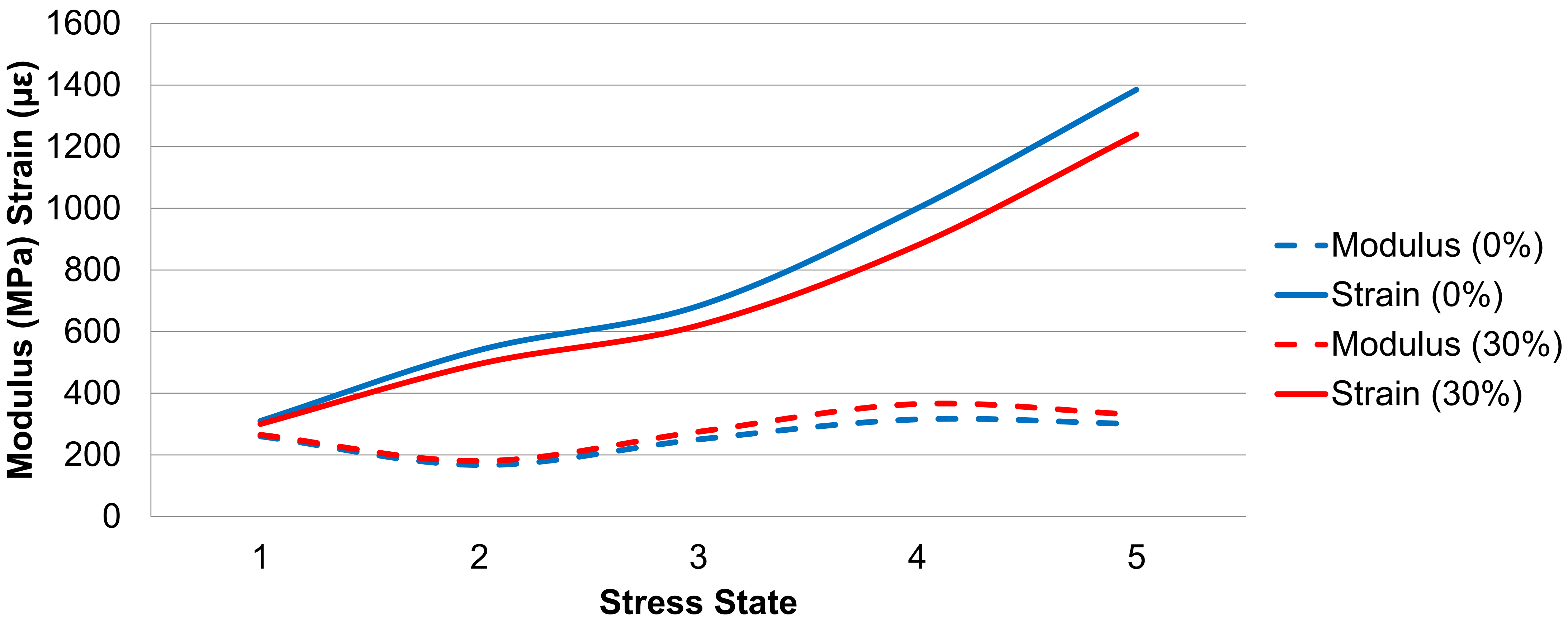
Lower layers

Repeat Load Triaxial Test

Material Testing

- Standard M04 with different % of liquefaction added: 0, 10, 20, 30
- Performance assessment
- Modulus (stiffness)
- Strain (deformation under load)

Repeat Load Triaxial Test Results



What we need to do

- Balance fit for purpose & sustainability
- More engineering to make greater use of local materials while still achieving required performance
- All parties collaborate
- What’s best for NZ Inc

Thanks!

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