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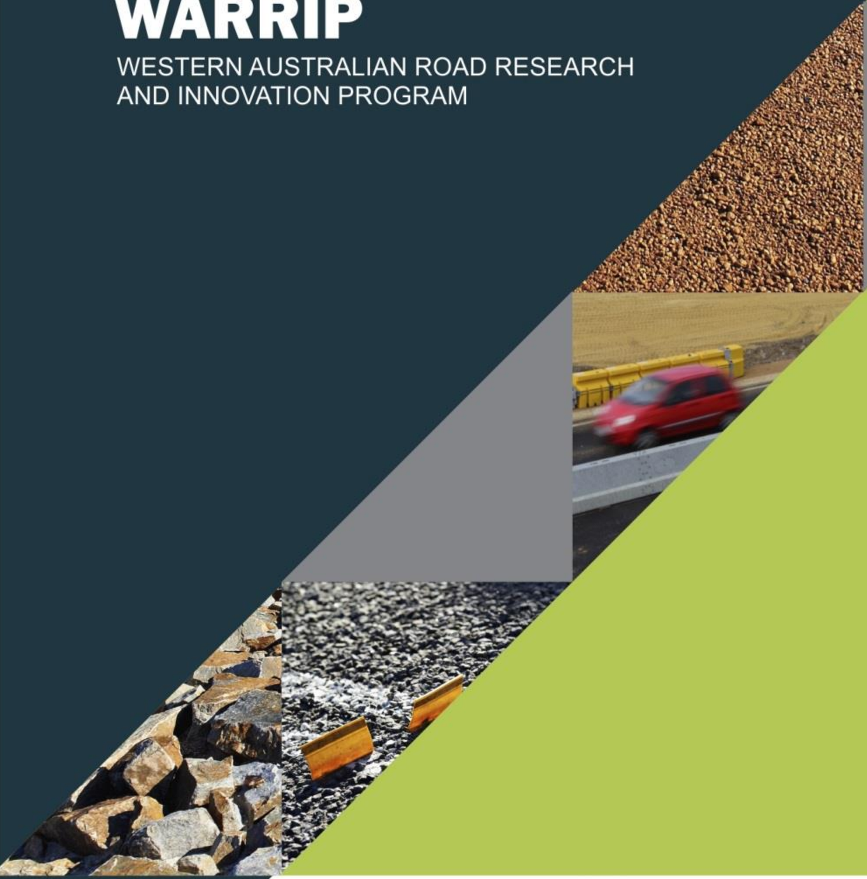


Investigation of Tonkin Highway, Reid Highway and Kwinana Freeway Trial Sections

WAPG May 2018

AN INITIATIVE BY:

THE GOVERNMENT OF WESTERN AUSTRALIA

mainroads WESTERN AUSTRALIA

arrb AUSTRALIAN ROAD RESEARCH BOARD

Project Overview

- Investigate granular trial pavements with thin asphalt surfacings
  - Tonkin Highway, Maddington
  - Reid Highway, Caversham
  - Kwinana Freeway, Karnup

- Pavements conform to Clause 1.2(c) material criteria
  - CRB/BSL base
  - Limestone subbase
  - Sand subgrade

- Project Aim
  - ➢ Reduce conservatism of current procedure
  - ➢ Re-work the presentation of Clause 1.2(c) in ERN9
  - ➢ Improve value-for-money outcomes

Tonkin Highway- 1980

• Design granular thickness of	300 mm	297- 298 mm
– CRB and BSL base	75 mm	60 – 77 mm
– Limestone subbase	225 mm	220 – 238 mm
– White sand subgrade		

- Non-conforming to 3/5th base rule

• Surfacing		
• OGA/DGA surfacing on T2	30/30 mm	39/46 mm
• DGA surfacing on T4 and T6	30 mm	39 – 42 mm

Tonkin Highway- Construction

- Some non-conformances with specifications
  - Density of base, subbase and subgrade typically below specification by 1 to 5%
  - Mean bitumen content of BSL below specification at 1.6%

- Limestone subbase grading finer than current 501 spec

- Moisture ratio at construction typically 35 to 60% OMC for all materials
  - Moisture of granular and subgrade materials fairly constant over pavement life (37 years)

Tonkin Highway- Traffic and performance

- 37 years in service at the end of 2017 and 2.9E7 ESAs

- Predicted 40 year traffic 3.2E7 ESAs
- Average annual growth 2.8 %

- Recorded resurface in 2011 31 years

- Deflection, D_0 0.37 – 0.44 mm (2016 OWP)
- Curvature 0.15 – 0.20 mm (2016 OWP)
  - ➢ CRB section has lowest values
- Rutting 1.6 – 5.9 mm (2009 OWP)
  - ➢ BSL section has lowest rut values

Reid Highway- 1996

• Design granular thickness of	330 mm	
– CRB and BSL base	100 mm	90 – 113 mm
– Limestone subbase	230 mm	259 – 271 mm
– "White" sand subgrade		

- Non-conforming to 3/5th base rule

• DGA surfacing on all sections	30 mm	44 – 65 mm

- Excludes R4 data post 2010 due to reconstruction for intersection works

Reid Highway- Construction

- Minor non-conformance with specifications
  - Density of R3 subbase below by 0.6%
  - Dryback of CRB R4 short by 4%
  - Mean bitumen content of BSL below specification at 1.9%

- Moisture of granular and subgrade materials fairly constant over pavement life (21 years)

Reid Highway- Traffic and performance

- 21 years in service at the end of 2017 and 1.1E7 ESAs

- Predicted 40 year traffic 2.5E7 ESAs
- Average annual growth 3.1 %

- No resurfacing to date and no signs of surfacing fatigue

- Deflection, D_0 0.46 mm (2017 OWP)
- Curvature 0.16 mm (2017 OWP)
  - Both CRB and BSL show similar values
- Rutting 0.9 – 2.0 mm (2012 OWP)
  - CRB sections had lowest rut values

Kwinana Freeway- 2009

• Design granular thickness of	<u>380 mm</u>	
– CRB and BSL base	230 mm	255 – 270 mm
– Limestone subbase	150 mm	160 mm
– Yellow sand subgrade		
• Section K2 (non-conforming to 3/5th rule)		
– CRB base	125 mm	160 mm
– Limestone subbase	255 mm	250 mm
• OGA/ DGA surfacing	30/30 mm	64 – 65 mm

Kwinana Freeway- Construction

- Good conformance with specifications at construction
  - Mean bitumen content of BSL above specification at 2.1 – 2.3%

- Dryback of granular and subgrade well within specification
  - CRB base 53% OMC
  - BSL base 51% OMC
  - Limestone subbase 30 – 50% OMC
  - Subgrade 21 – 27 % OMC

Kwinana Freeway- Traffic and performance

- 8 years in service at the end of 2017 and 7.4E6 ESAs

- Predicted 40 year traffic 1.7E8 ESAs
- Average annual growth 7.6 %

- No resurfacing to date and no signs of surfacing fatigue

- Deflection, D_0 0.27 – 0.36 mm (2017 OWP)
- Curvature 0.07 – 0.10 mm (2017 OWP)
  - BSL section has lowest values
- Rutting 1.6 – 2.6 mm (2014 OWP)
  - BSL section had lowest rut value

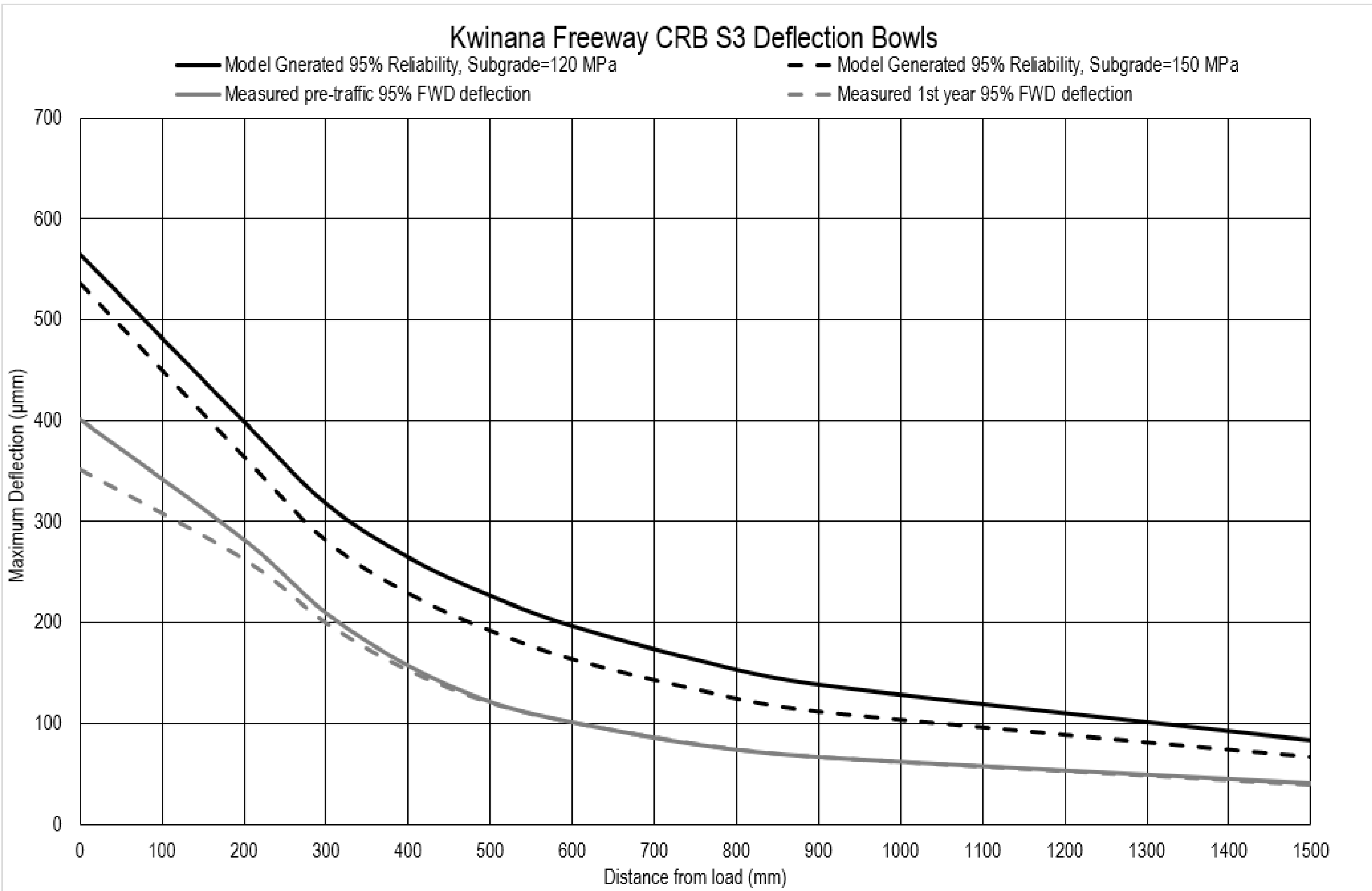
General observations

- No signs of asphalt fatigue within the first 15-20 years in service
- Some non-conformances with specifications at each trial
- Granular material still performing well
- Moisture of granular and subgrade materials constant over pavement life
- The current design system typically produced an asphalt fatigue life much lower than what has been observed

RLTT and back-calculation

Material	Stress scenario	Mean RLTT modulus (MPa)	EFROMD3 modulus (MPa)
BSL	Base	730	510 – 1000
CRB	Base	705	600 – 750
Limestone	Subbase	690	260 – 510
Sand	Subgrade	350	180 – 220

Deflection bowl comparison



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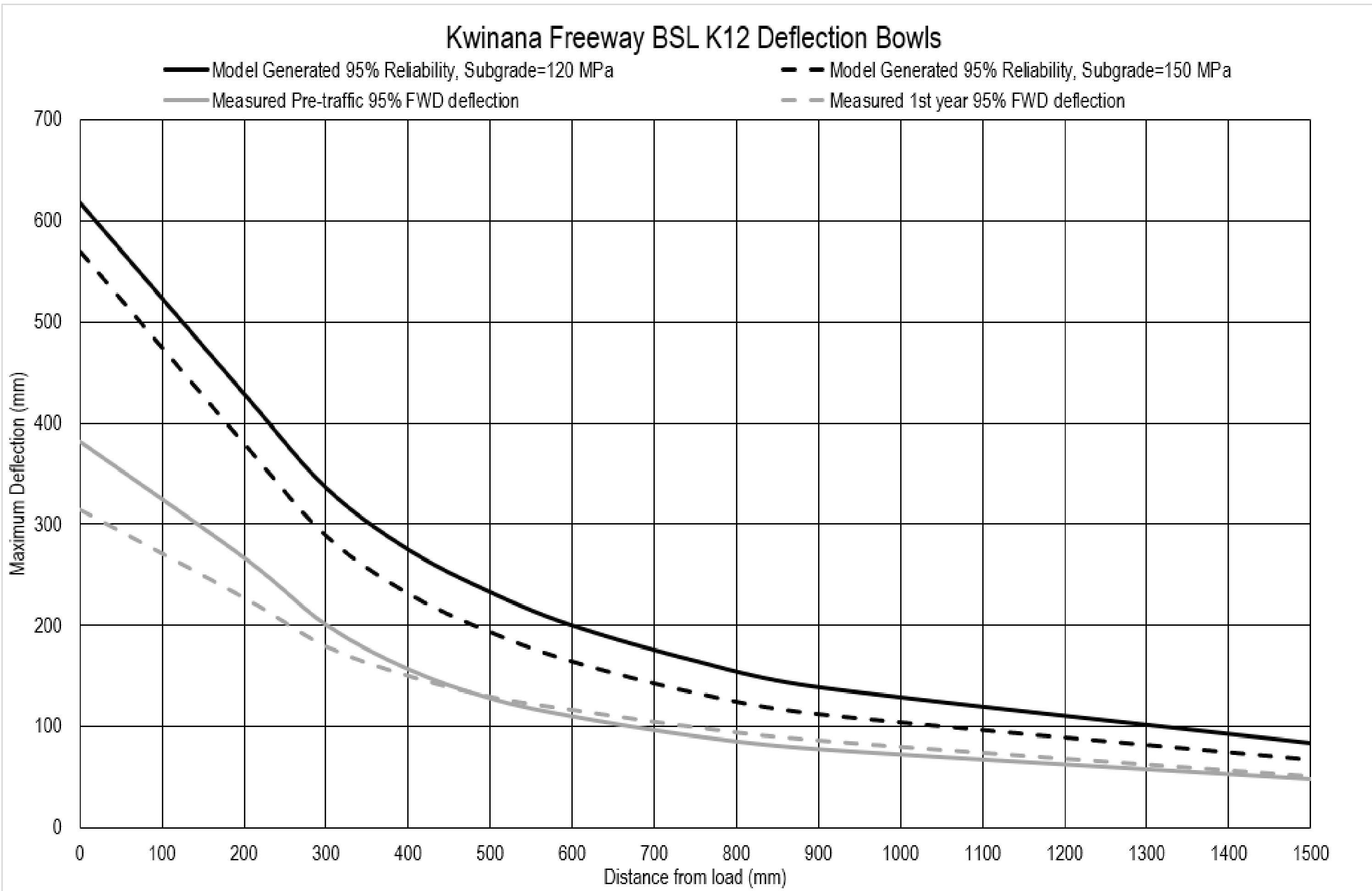
Deflection bowl comparison



Performance trends and phases

- Within the standard thin asphalt fatigue design period of 15 years, there are three similar phases of performance behaviour:
  - Phase 1 (1^{st} year)
    - pavement system strengthens with the application of the first year of traffic
  - Phase 2 (1st to 5^{th} year)
    - strength eventually evens out
  - Phase 3 (5^{th} to 15^{th} year)
    - pavements continue perform

Short-term

Long-term

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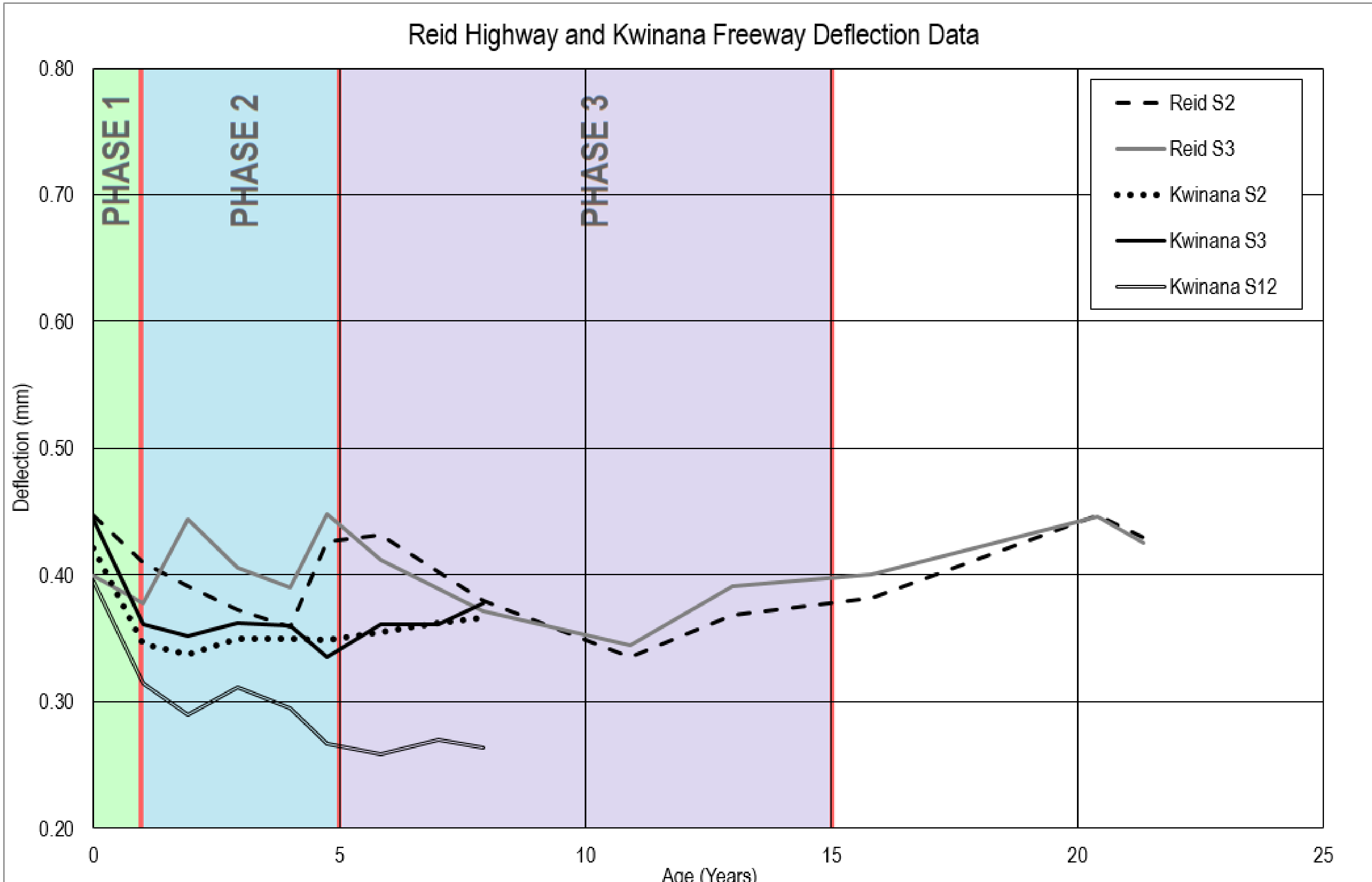

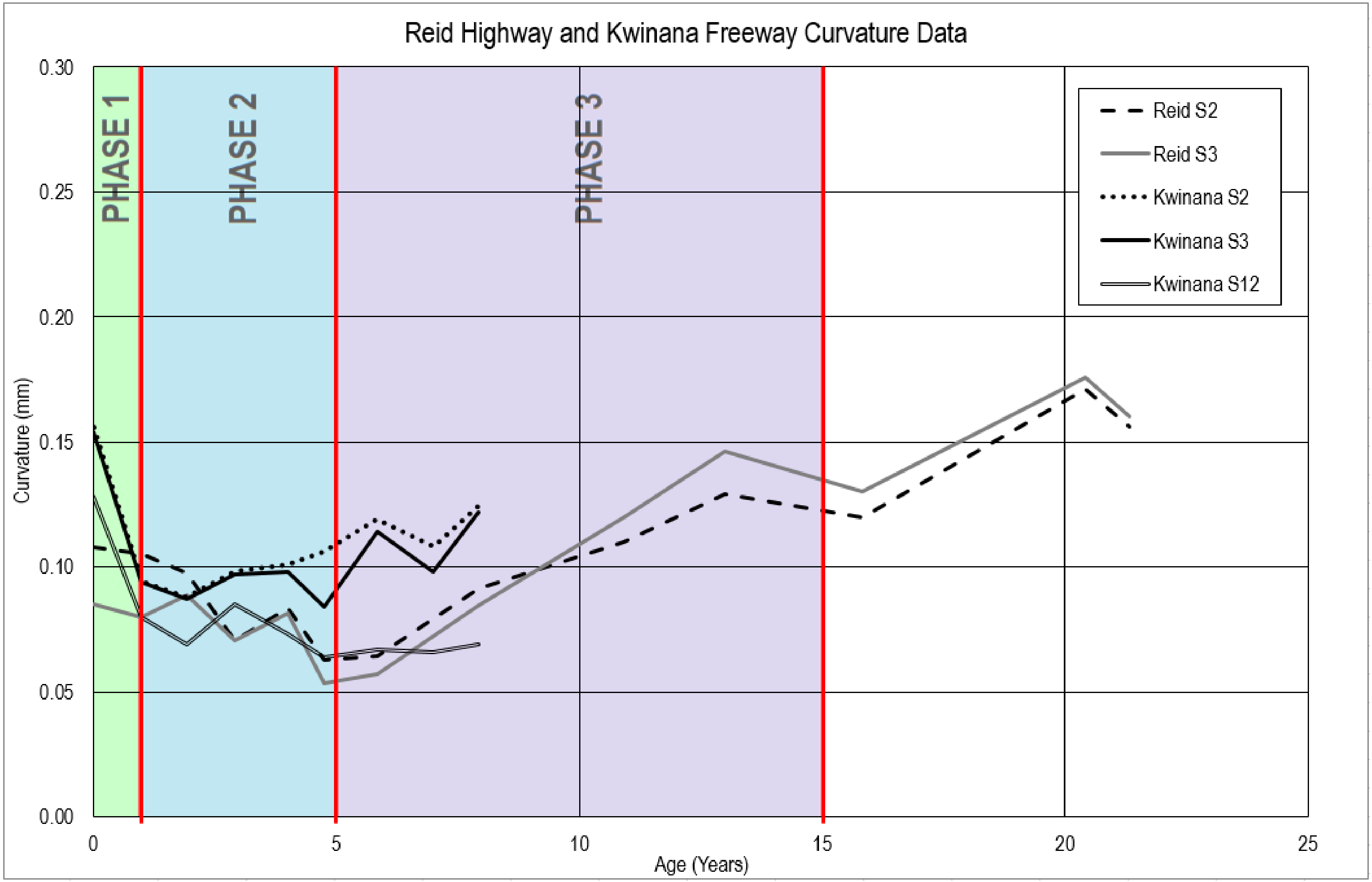
Reid Highway and Kwinana Freeway Curvature Data
PHASE 1
PHASE 2
PHASE 3
Reid S2
Reid S3
Kwinana S2
Kwinana S3
Kwinana S12
Curvature (mm)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
Age (Years)

Combining the findings

Step 1: Short term design

– Short term fatigue relative to 1st year design traffic

$$STF = \frac{1^{st}\ \text{year design traffic}}{\text{short term allowable traffic}_{95\%}} \leq 1.0$$

Step 2: Long term design

– Long term fatigue relative to remaining design traffic 15 years period
– Change in the elastic characterisation and strength of granular materials

$$LTF = \frac{1^{st}\ \text{year design traffic} - 15\ \text{year design traffic}}{\text{long term allowable traffic}_{95\%}} \leq 1.0$$

Step 3: Overall fatigue check

$$STF + LTF \leq 1.0$$

Going forward

- Investigate applicability of short term/long term design method over metropolitan network

- Identify a suitable 1st year traffic limit and an annual average growth criteria

- Determine long term granular moduli

- Determine/revise elastic characterisation of granular materials for long term design

- Revise sand subgrade moduli

How?

- Investigate a range of non-trial pavements
  - CRB and BSL base
  - Limestone subbase
  - Sand subgrade
  - DGA and OGA/DGA thin surfacing systems
  - Varying ranges of traffic

- Focus on
  - Original design
  - Performance observations
  - Performance trends
  - Back-calculation
  - Traffic analysis

Use the field and observation data to calibrate the new design system

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Questions?