Best Practice in Pavement Design – What is it?

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Outline

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- Pavement design principles & practicalities
- Pavement design & quality factors
- Pavement performance prediction
- Case studies
- Conclusion/summary

AUSTROADS Pavement Design Guide

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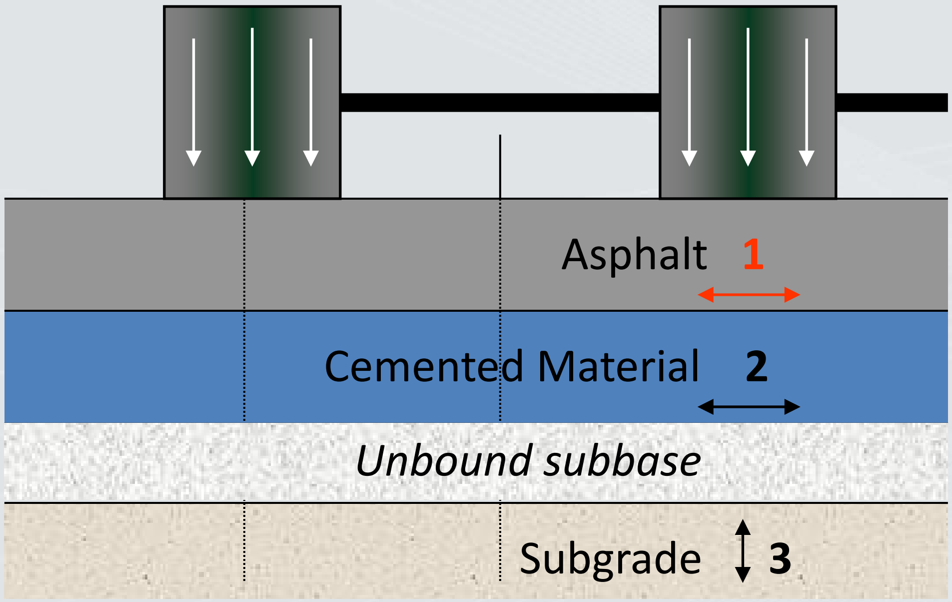
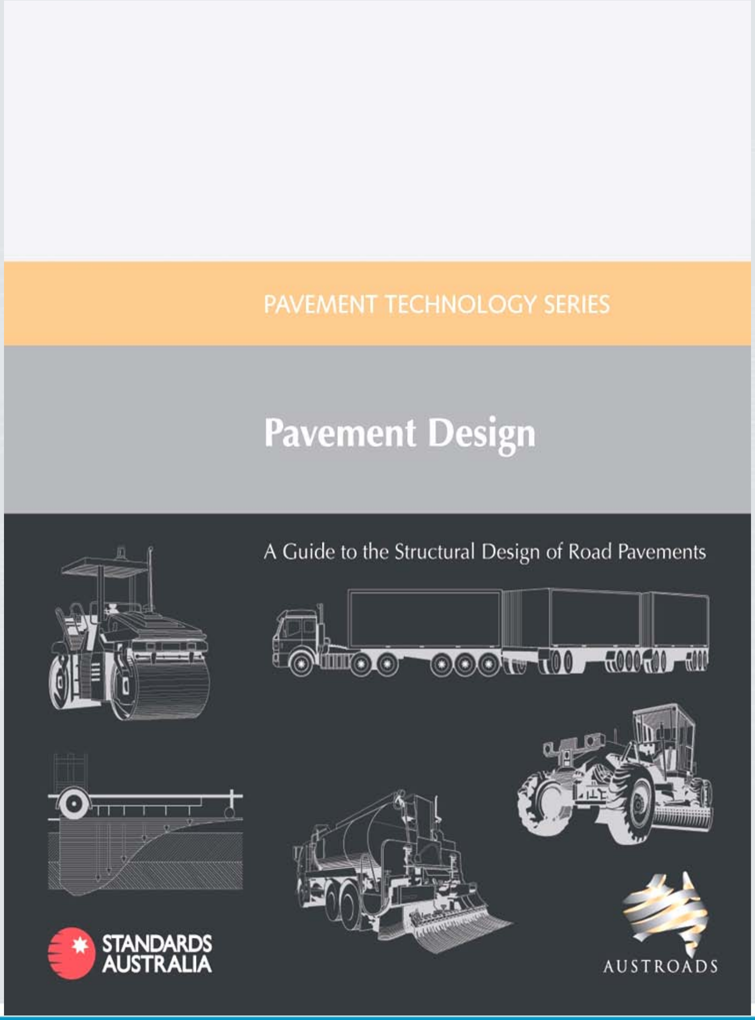


1 Horizontal tensile strain in bottom of asphalt – fatigue cracking
2 Horizontal tensile strain in bottom of cemented material - cracking
3 Vertical compressive strain in top of subgrade - rutting & shape loss



Mechanistic Design Process

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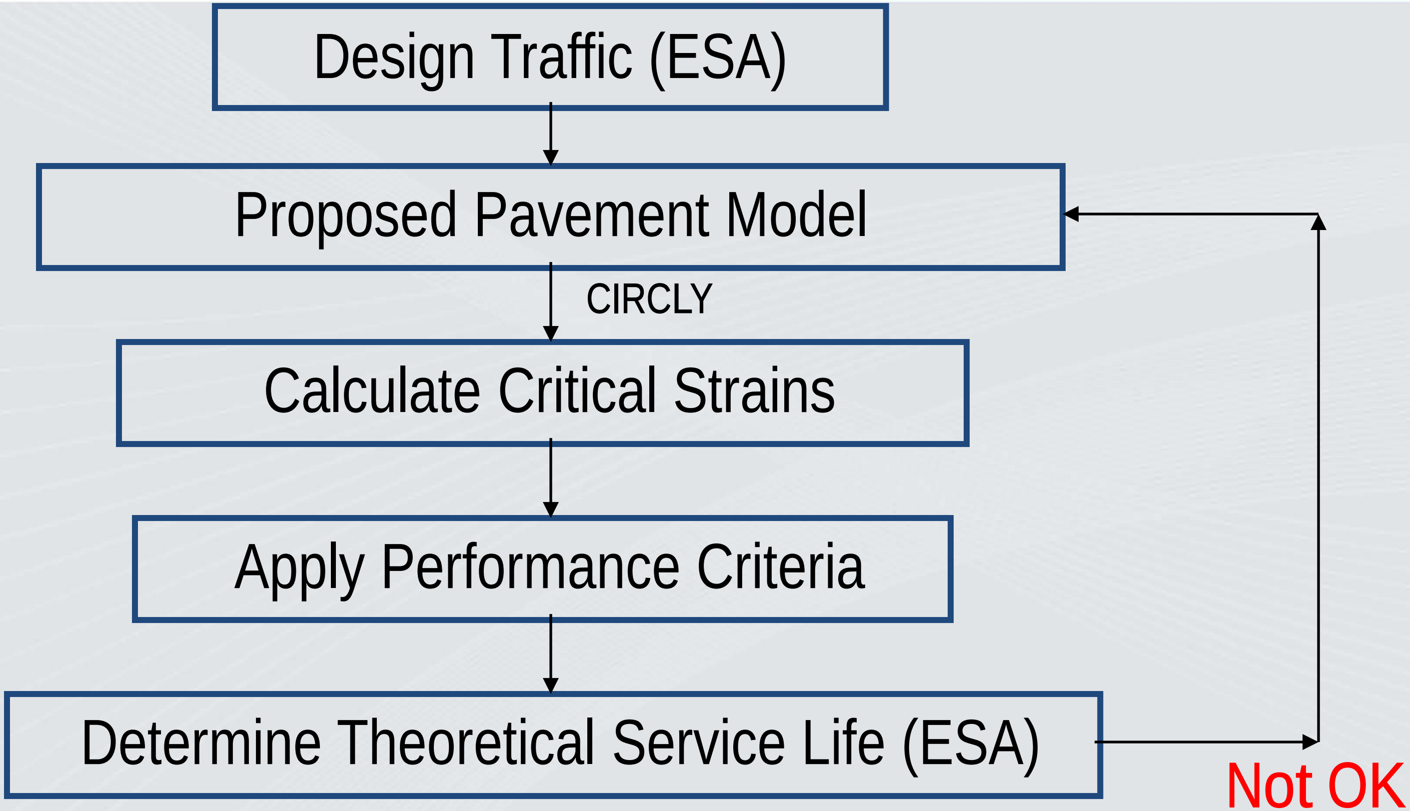

Mechanistic Design Process

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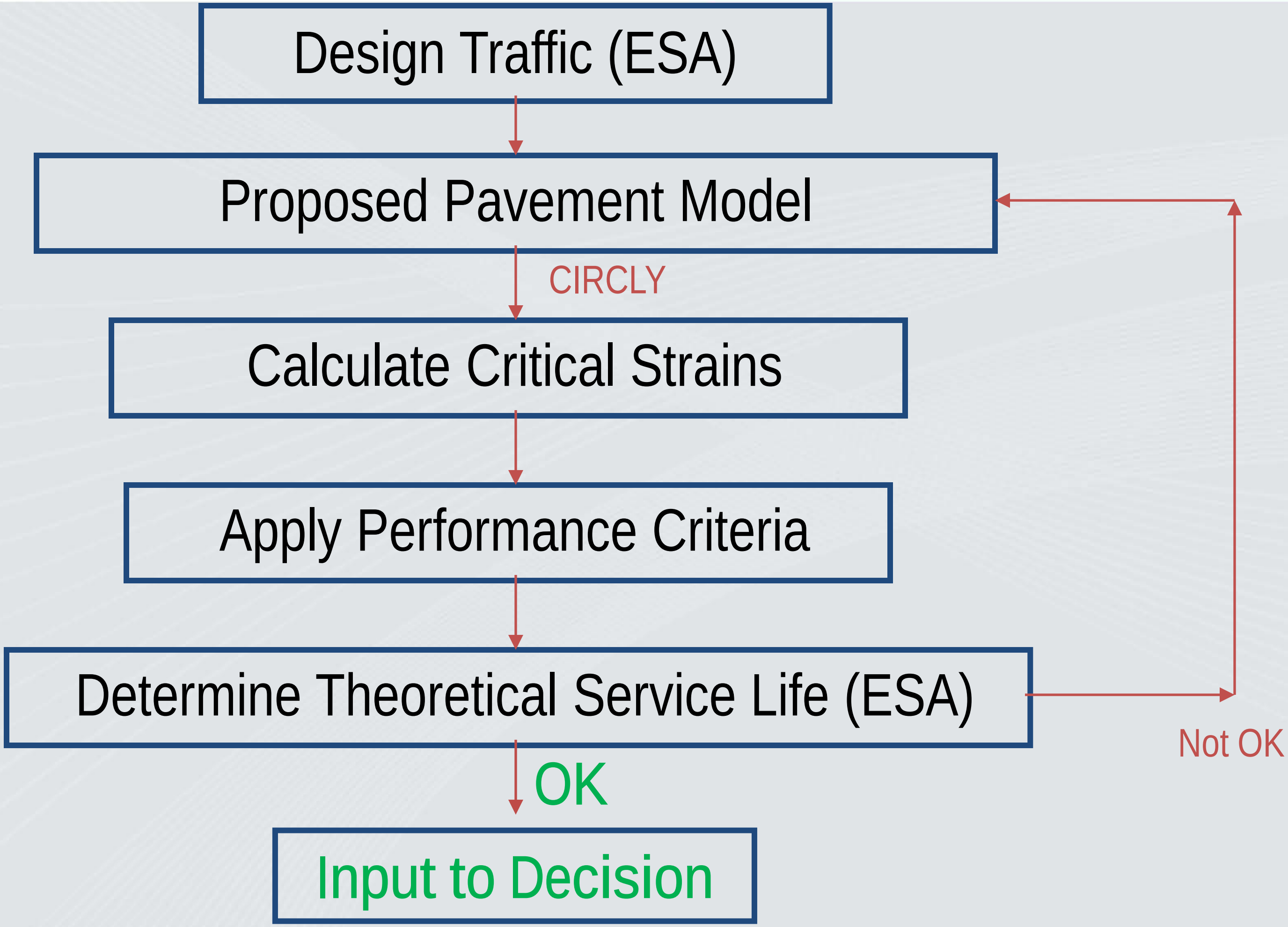

Key factors

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- Pavement design assumptions have to be validated by field & lab testing
  - early identification of risk areas such as pavement variability & subgrade strength
- Allow modification of design to suit variability of in-situ material & construction methodology
- Designer works closely with construction crews
- After pavement is constructed, designer must check whether it is performing as expected

Norm Major (1996)

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- *There needs to be integration of field experience with design capability & asset management understanding. Current separation of responsibilities is great, but has a high risk of sub-optimising.*
- *When a local maintenance engineer was also the designer & had a direct link to the execution of the work, it was practicable to operate at a significant level of risk if economies outweighed the costs of a small proportion of unpredicted early distress*
- *Risk sharing must be regarded as a proper tool in seeking economy*

Optimisation

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- Pavement design principles
- Materials & their respective performance criteria
- Constructability
- Levels of service & expected performance
- Whole of life costs
- Risk assessment
- Engineering judgement
- All of above + more must be considered as part of a holistic approach to flexible pavement design

Causes of Cracking in Asphalt

- Inadequate load supporting capacity:
  - Loss of base, subbase or subgrade support (eg water ingress) → high deflection and/or deformation
  - Inadequate thickness of the pavement to take the loads
  - Increase in loading
  - Poor construction

Causes of Cracking in Asphalt

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- **Classic fatigue-induced cracking is rare**
- Cracks normally start at top of asphalt
  - Start as very fine cracks created during roller compaction
  - Largest tensile strain is at top of asphalt
  - rarely bottom up

Asphalt criterion is too conservative

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- Due to confusion about what constitutes fatigue cracking
- In majority of cases, crack-induced failures are actually due to excess deflection/flexure of underlying pavement &/or subgrade, causing significant tensile strain in asphalt that exceeds its tensile strain capacity, not fatigue

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

	Desired project reliability				
	80%	85%	90%	95%	97.5%
RF	7	6	5	4	2.5

Most important properties to check during construction of an unbound or stabilised granular pavement:

Compaction densities (both low & high values)

Shear strength of basecourse/subbase aggregates

Moisture content

Layer deflections with appropriate tools

Coefficient of Variation (CoV)

Uniformity in construction reduces development of roughness, as roughness contributes to premature failure of a pavement

Case Studies

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SH 6 Glenhope to Kawatiri

10.5 km realignment

Constructed in 2002

Rut Depth

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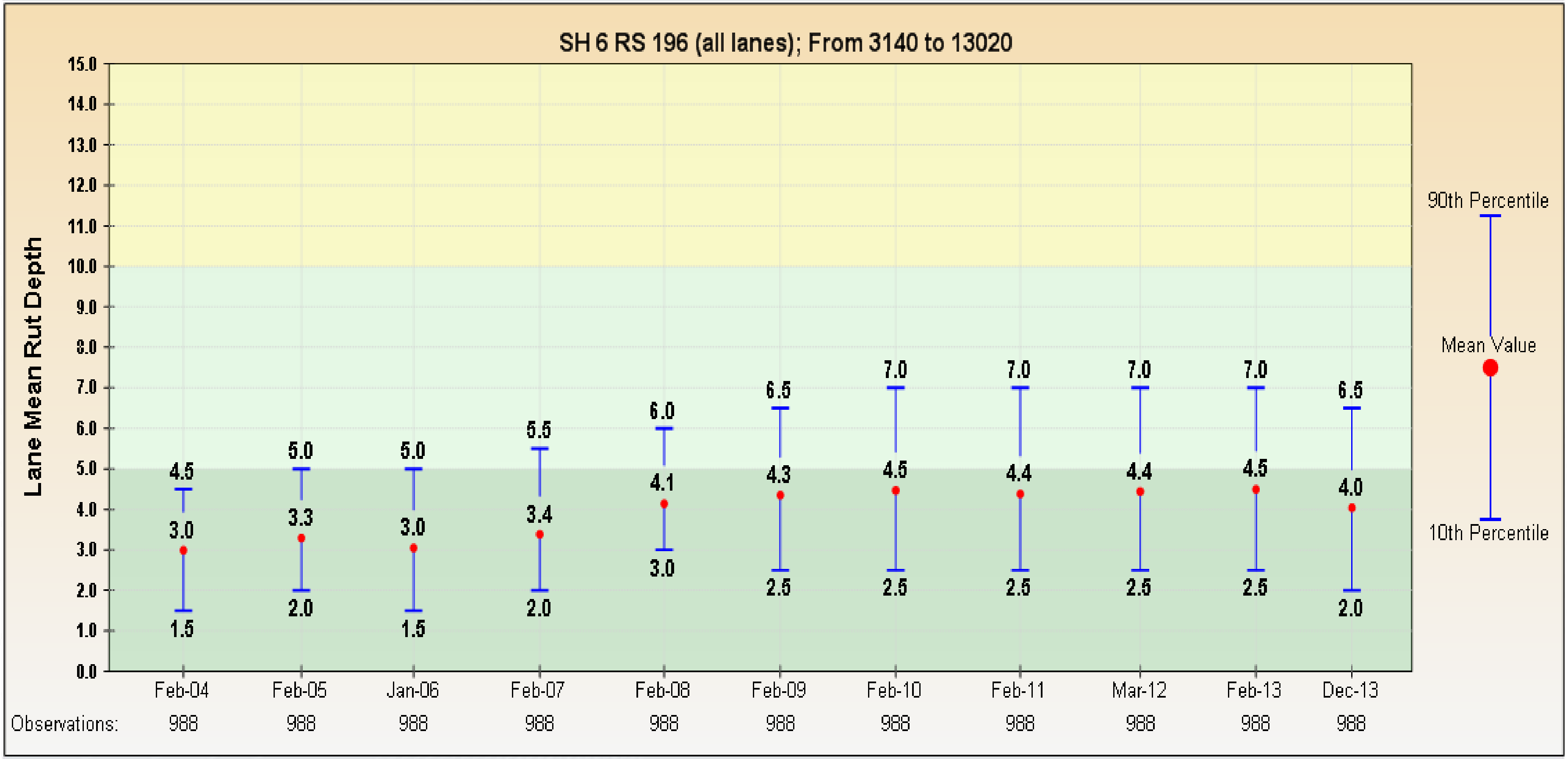

Roughness

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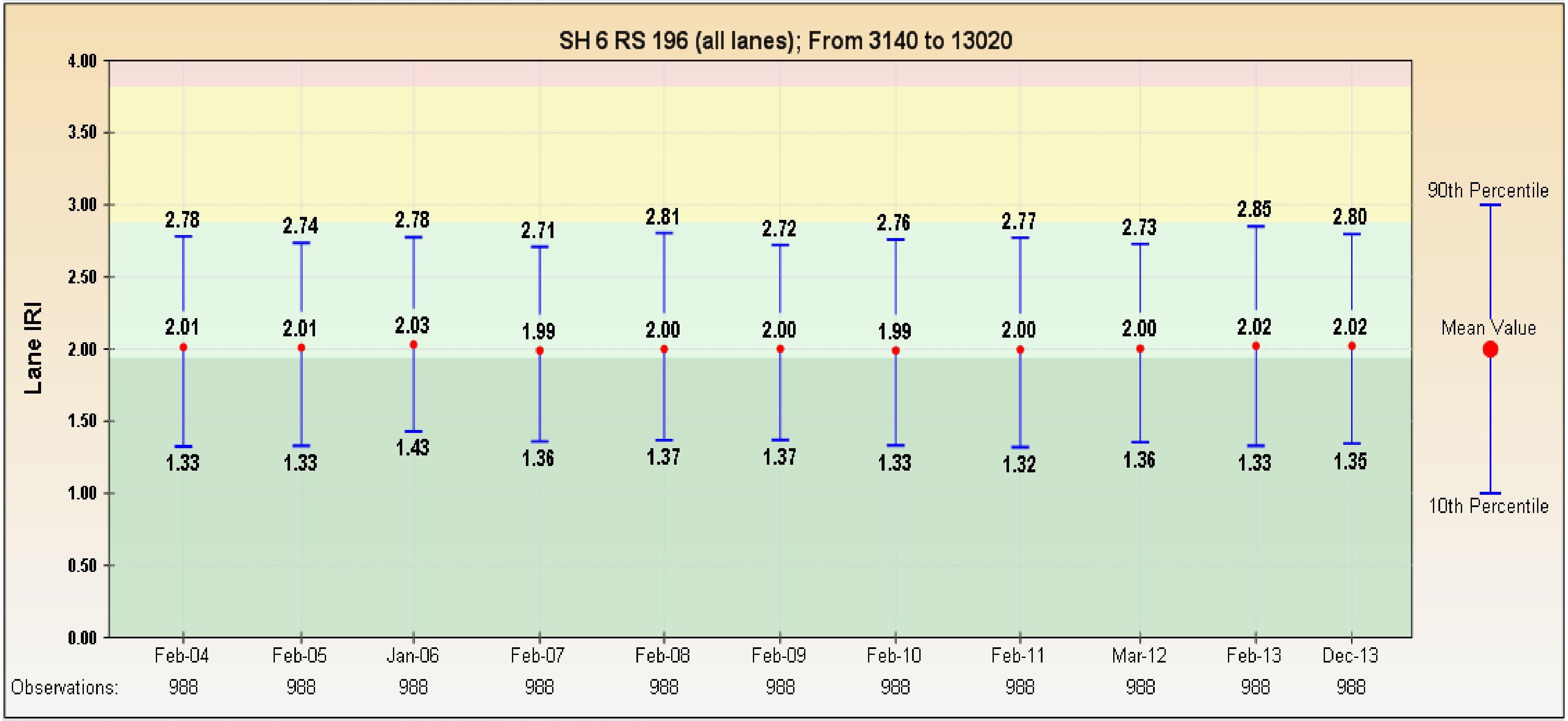

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Sustainable Pavement Design
Christchurch Southern Motorway

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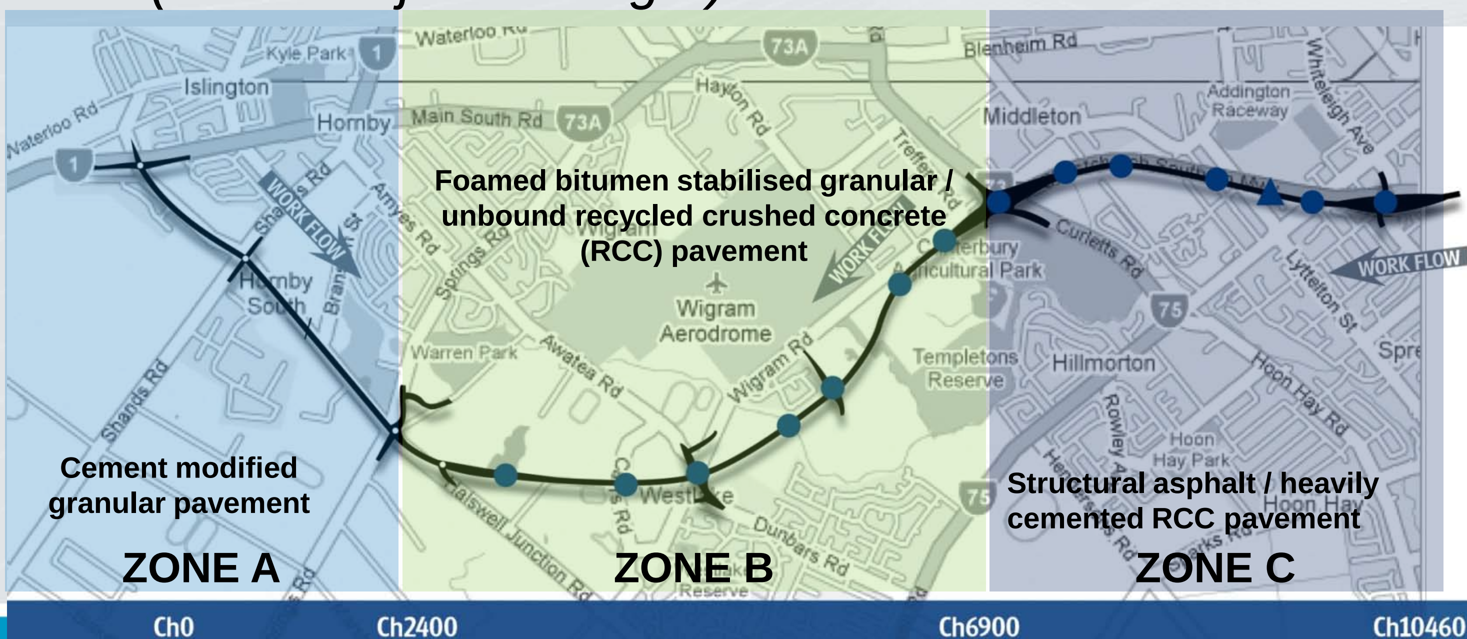
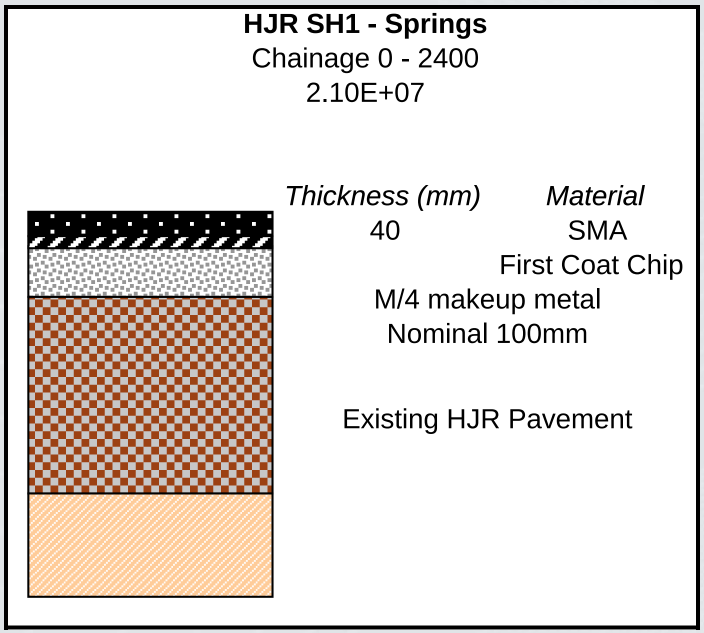
From outset, challenge was to:

- Recognize value of various aspects of sustainability w.r.t. what was specified & what was offered
- Spend time to get specific project requirements right
- Identify and actively engage with people who can add value

G Griffiths (NZTA Project Manager)



Halswell Junction Road – Zone A



Existing pavement well compacted & low deflections but low % broken faces

Removed upper 100 mm

Placed 100 mm AP40

Stabilised 150 mm deep with 1.5% cement

Greenfields section – Zone B

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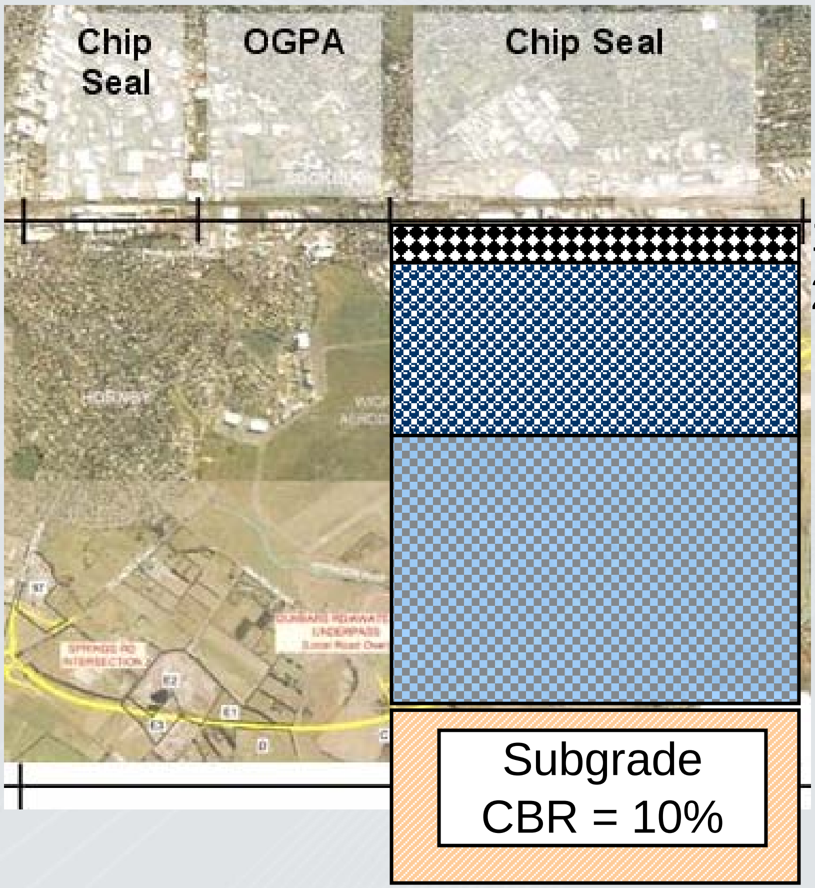

1 coat *2nd Seal*
2 coat *1st Seal*
150 FB

200 RCC
unmodified
Subbase
Recycled
Crushed
Concrete AP65

Structural Asphalt – Zone C

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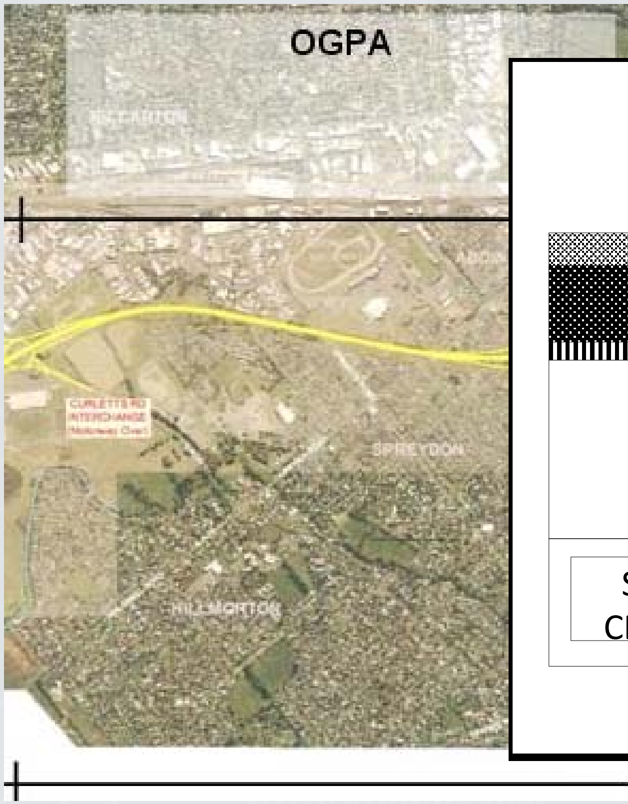

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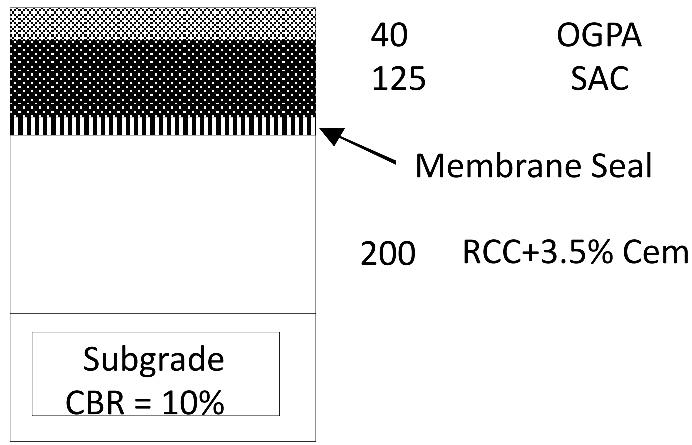

Zone C

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- Grader laid RCC subbase
- RCC bound with 3.5% cement
- Pre-cracked after 4 days using heavy vibrating rollers – high amplitude, low frequency

Holistic Pavement Design

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- Maximised use of RCC
  - Trials to confirm optimum maximum size for stabilising
  - Tests confirmed optimum cement content to add for cemented subbase
- Maximised use of RAP
  - RAP sorting & storage methodology
  - 30% RAP in asphalt mix
- Minimised use of virgin aggregates
  - Maximised use of existing aggregate
  - Relaxed broken faces in Zone B as per B/5 spec
  - Trials of aggregate from 3 different quarries

Practical Rehab Design

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Identify pavement distress failure mechanism(s)

Test pits at representative locations throughout site

Evaluate properties of new &/or in situ materials

Project-level falling weight deflectometer (FWD) analysis

Pavement historical performance data

Local practitioner knowledge & as-built records (if available) on previously undertaken treatments & their performance

Pavement strength requirements - not only for predicted loading, but also surface requirements (eg Deflection requirement for asphalt)

Future demand on the site in terms of use, loading and surfacing

Conclusion/Summary

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AUSTROADS Pavement Design Guide & CIRCLY computer analysis are significant inputs to engineering design

For fatigue cracking in bitumen-bound layers, reliability factors are too conservative

Greater awareness of materials, constructability, environmental factors, maintenance strategies & whole of life cycle costing

Practical holistic approach to pavement design has been successfully applied to a number of projects (greenfields & rehabilitation)

Pavement performance can only be guaranteed by a sound pavement design strategy **PLUS** ensuring design parameters are achieved by direct communication between designer & constructor, including construction methodology, materials & testing