CAPTIF Road Research Centre

Pavements, road building, and axle weights

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NZ TRANSPORT AGENCY
WAKA KOTAHI

Te Kāwanatanga o Aotearoa
New Zealand Government

Outline

- Why
- Pavement Design
- Our People
- Construction
- Simulated Loading and Vehicle Emulator
- CAPTIF Outputs
- Conclusion

The transport system touches the lives of all New Zealanders

- We manage 11,200km of sealed and unsealed state highways.
- There are over 4,800 bridges and major culverts on the state network.
- Valued at $85.3 billion, our state highway network is our largest value social asset.

New Zealand is connected by **98,000km** of roading network.

Austroads Empirical Design

Most sealed NZ roads - Asphalt < 40mm

- Empirical UBG (LDE = 4)

$$ESA_{ij} = \left(\frac{L_{ij}}{SL_i}\right)^4$$

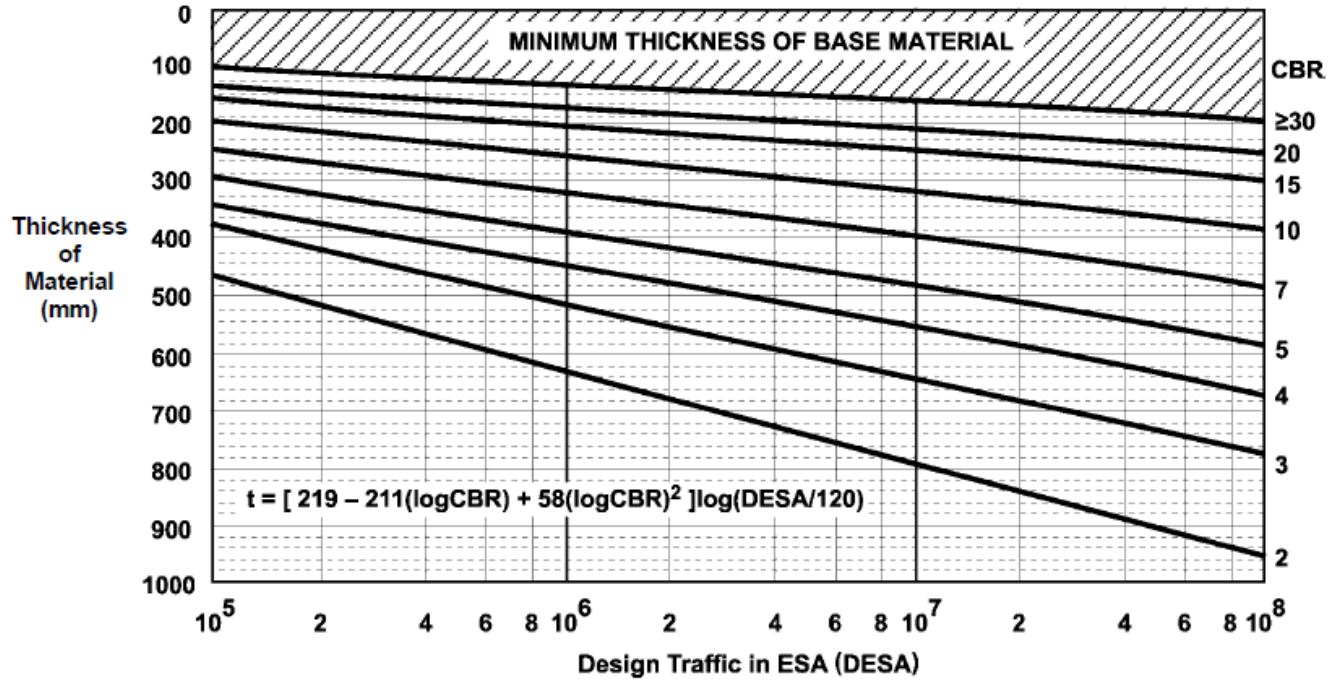
where

ESA_{ij} = number of repetitions of a Standard Axle which causes the same amount damage as a single passage of axle group type i with load L_{ij}

SL_i = Standard Load for axle group type i (from Table 7.7 and Table 7.8)

L_{ij} = j^{th} load magnitude on the axle group type i

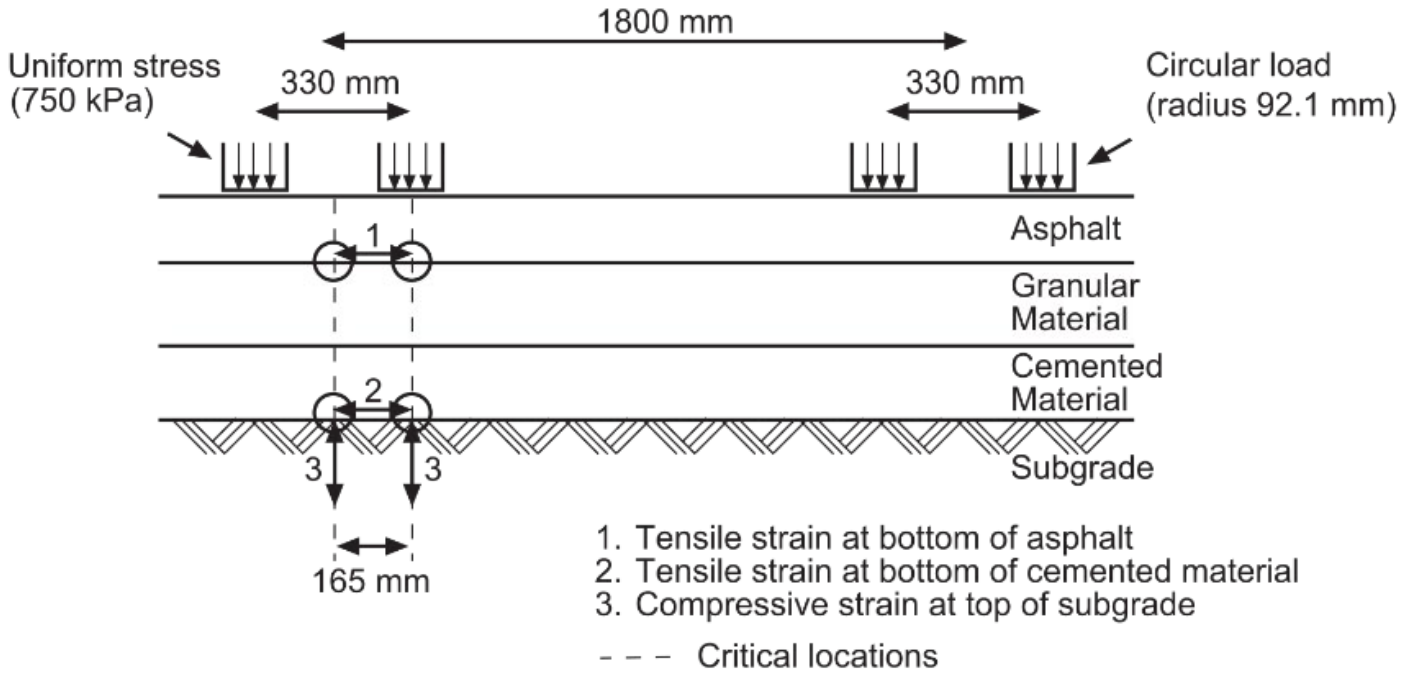
Figure 8.4: Design chart for granular pavements with thin bituminous surfacing



Austroads Mechanistic-Empirical Design

High Volume Roads – Asphalt > 40mm

- Asphalt $N = \frac{SF}{RF}\left[\frac{6918(0.856V_b + 1.08)}{E^{0.36}\mu\varepsilon}\right]^5$
- Cemented $N = RF\left(\frac{K}{\mu\varepsilon}\right)^{12}$
- Subgrade $N = \left[\frac{9150}{\mu\varepsilon}\right]^7$

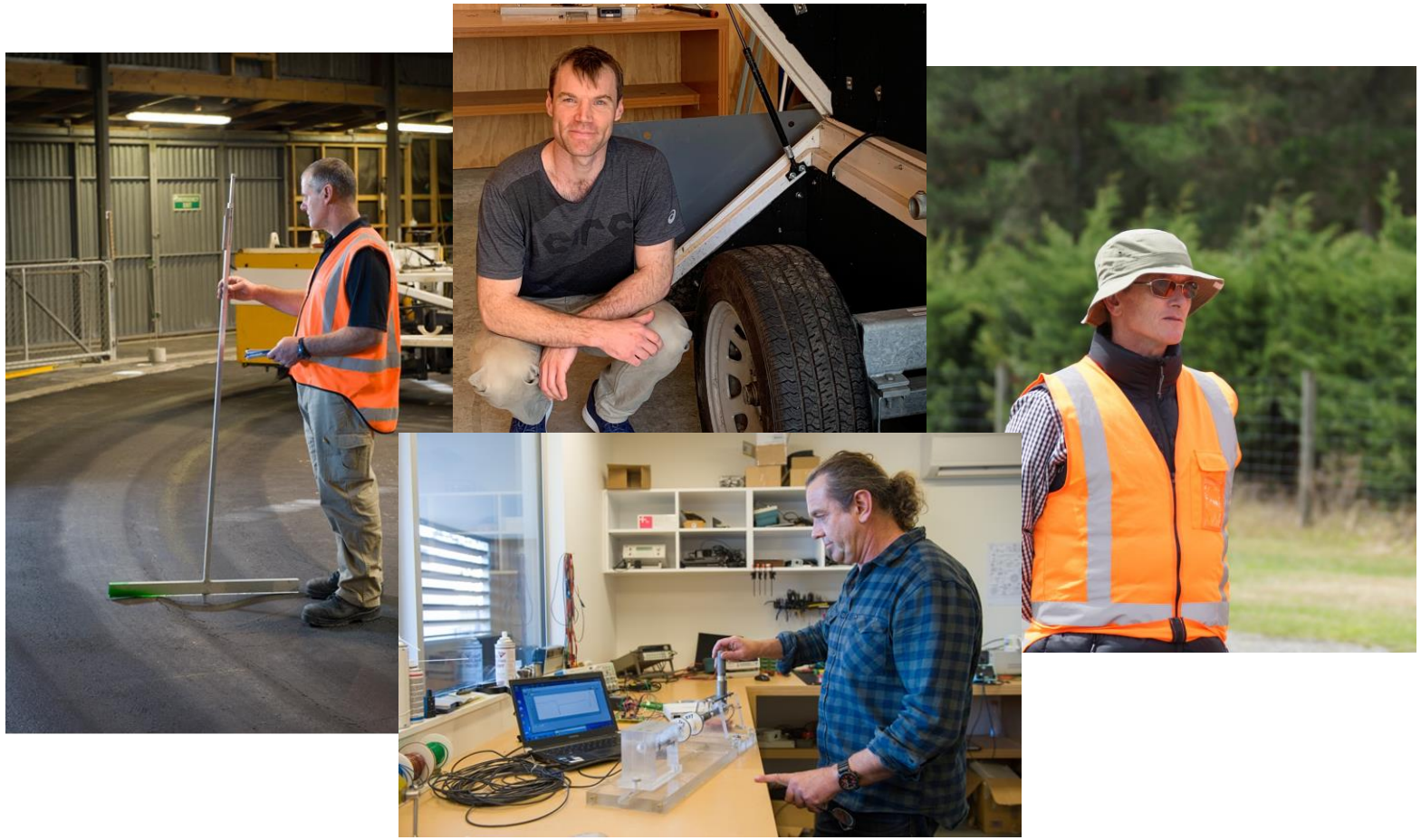


TRL Review – (Newton and Ramdas 2009)

Mode of deterioration		Range of exponents
Flexible pavements		
	Non-structural rutting	1.0 – 1.5
	Cracking	1.3 – 3.1
	Serviceability	4.4
	Rutting	4.0 – 9.6
	Asphalt fatigue	4 – 5
Rigid pavements		
	Rigid pavement cracking	5.5 – 18.0
	Faulting at joints	0.7
Subgrade		
	Deformation	4.0 – 7.4

Pavements Research – our people

The core CAPTIF team

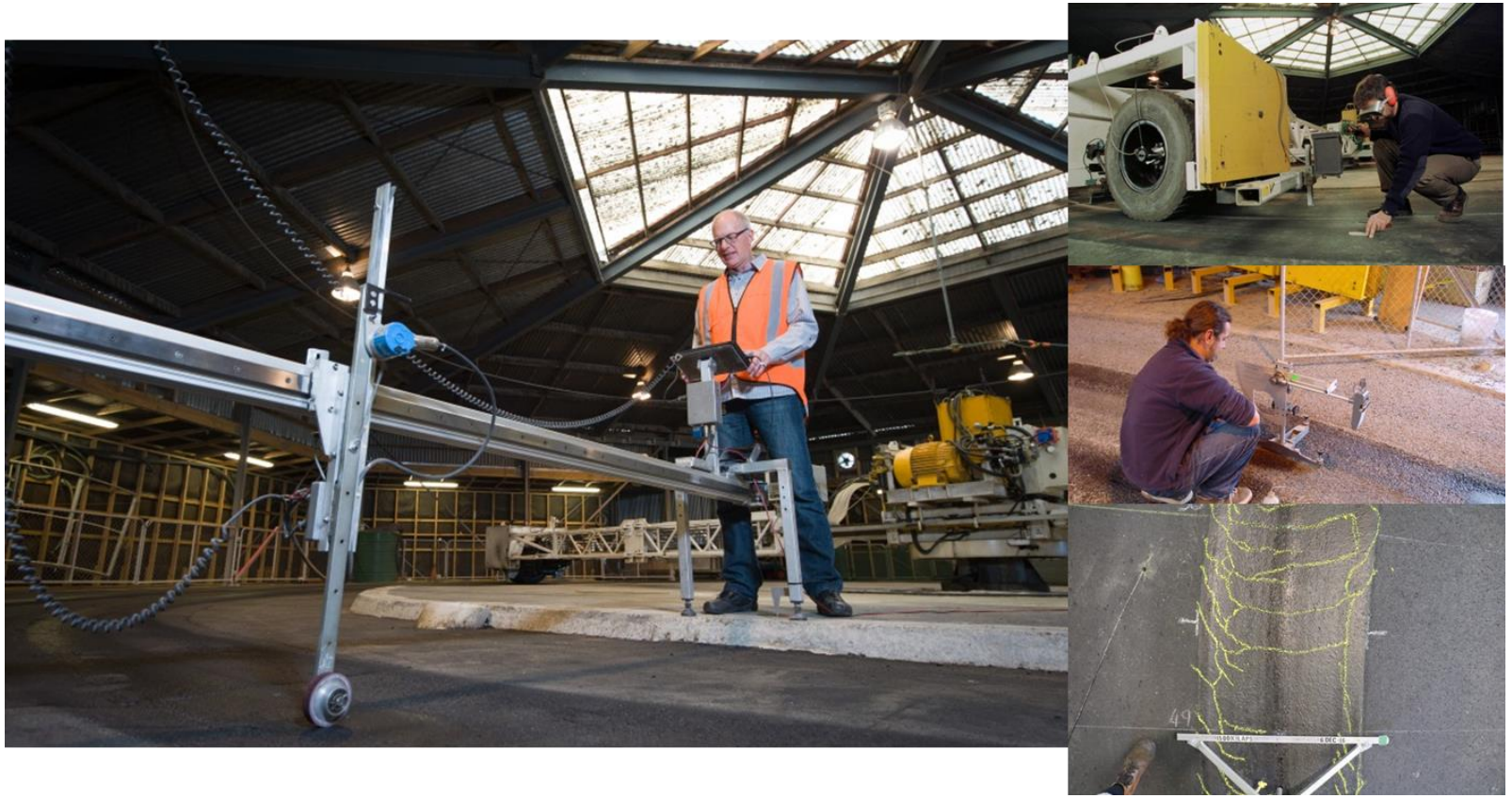


Construction Process

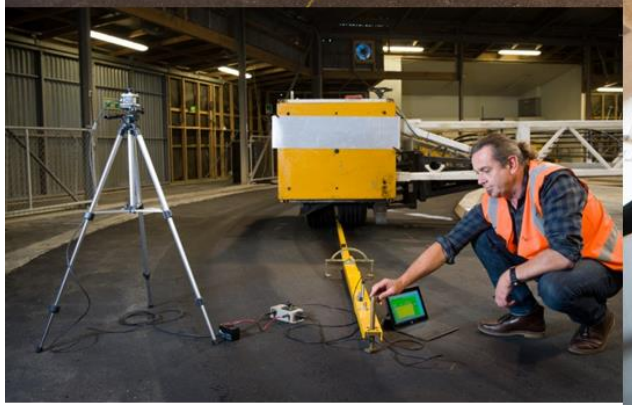
Simulated Loading and Vehicle Emulator

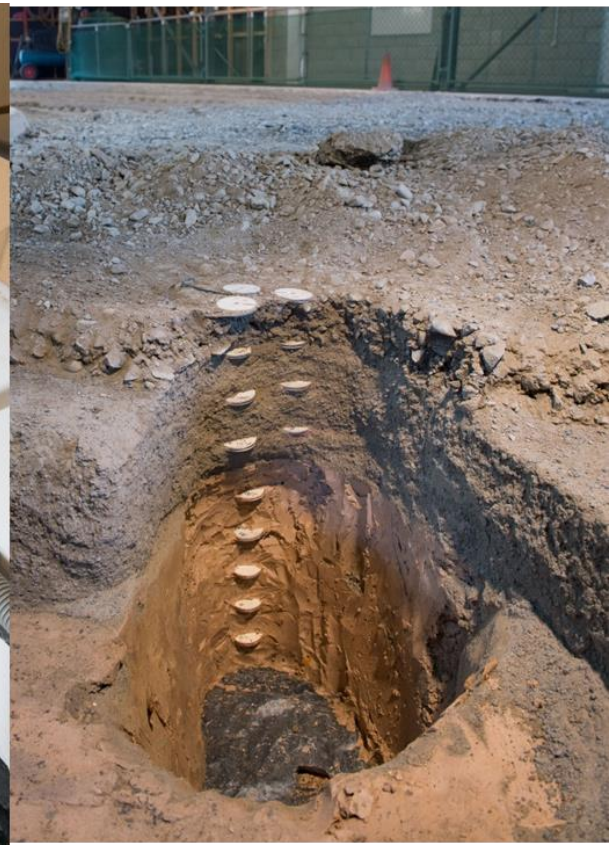
- Operates 24/7
- PLC Controlled
- Extensive Safety Sensors
- 100,000 ESA/week
- 2 separate wheel paths
- 6x 10m test sections
- Realistic dynamic loads
- Standard HCV axles
- Steel or Air Bag suspension

Pavement Performance



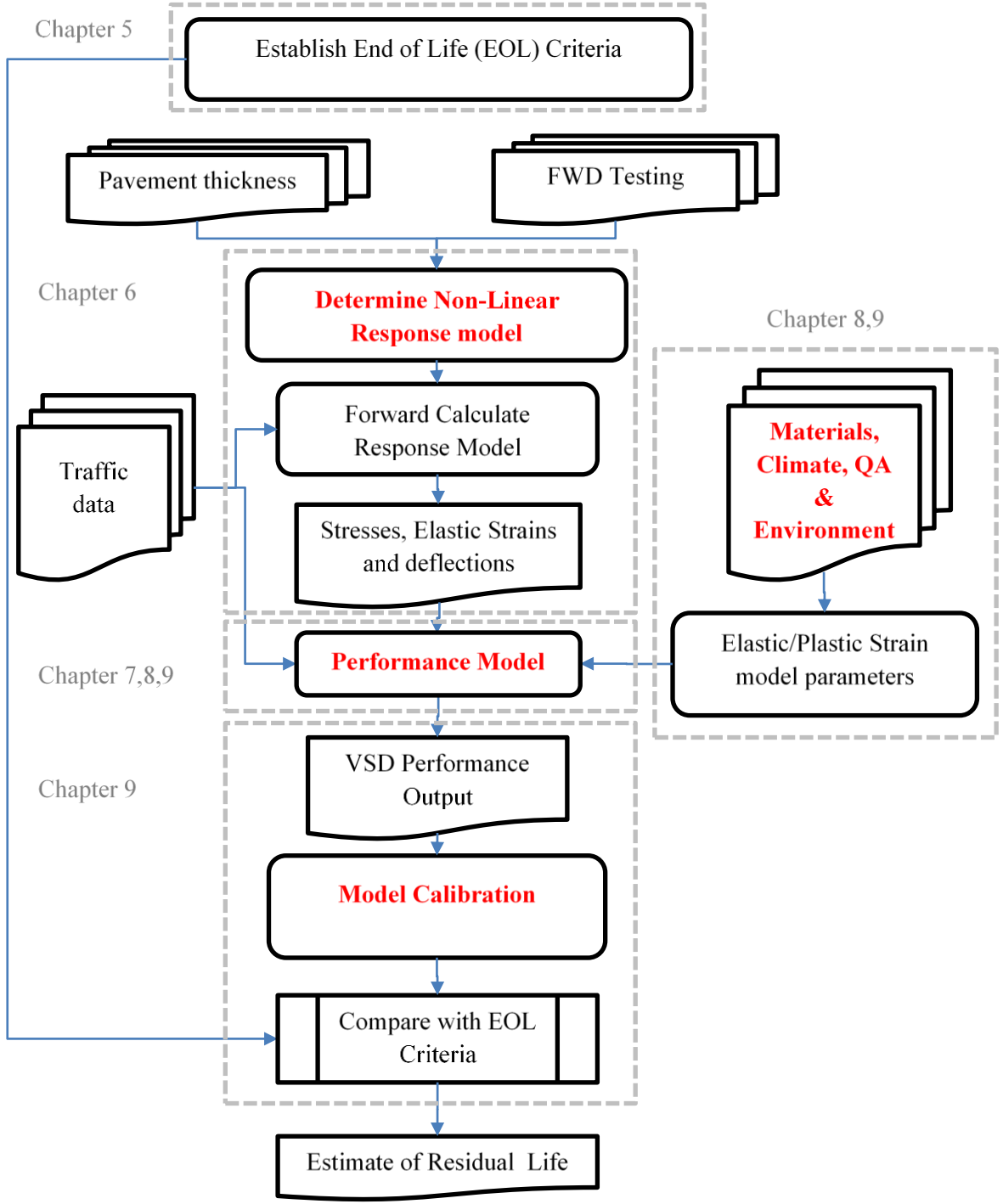
Structural Testing





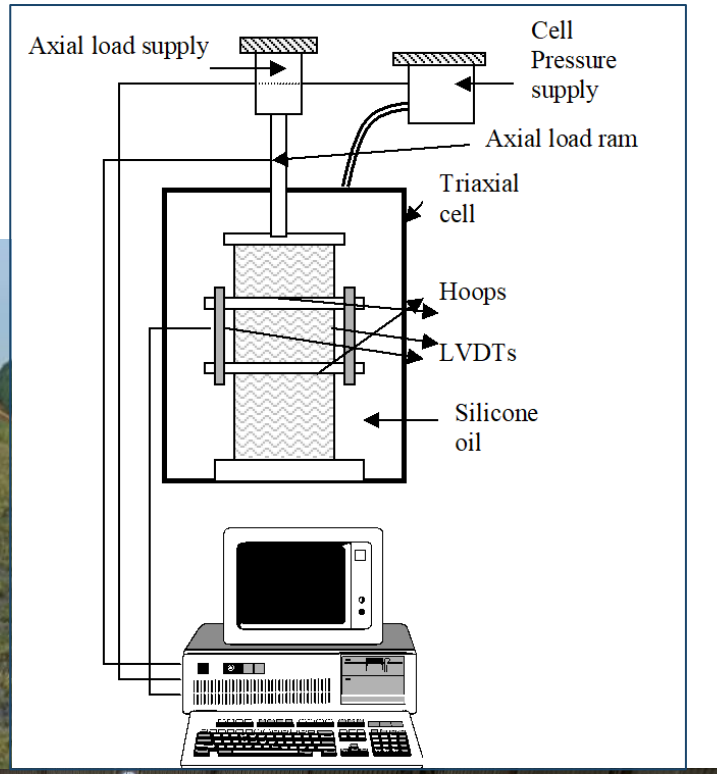
Residual Life Methodology

- Exploratory Data Analysis (EDA)
  - Exploration of the data graphically before developing a model
- ATOM model - “Accept uncertainty, Be thoughtful, open and modest”.
- No single index should substitute for scientific reasoning
- No bright line p value statistical tests



Data

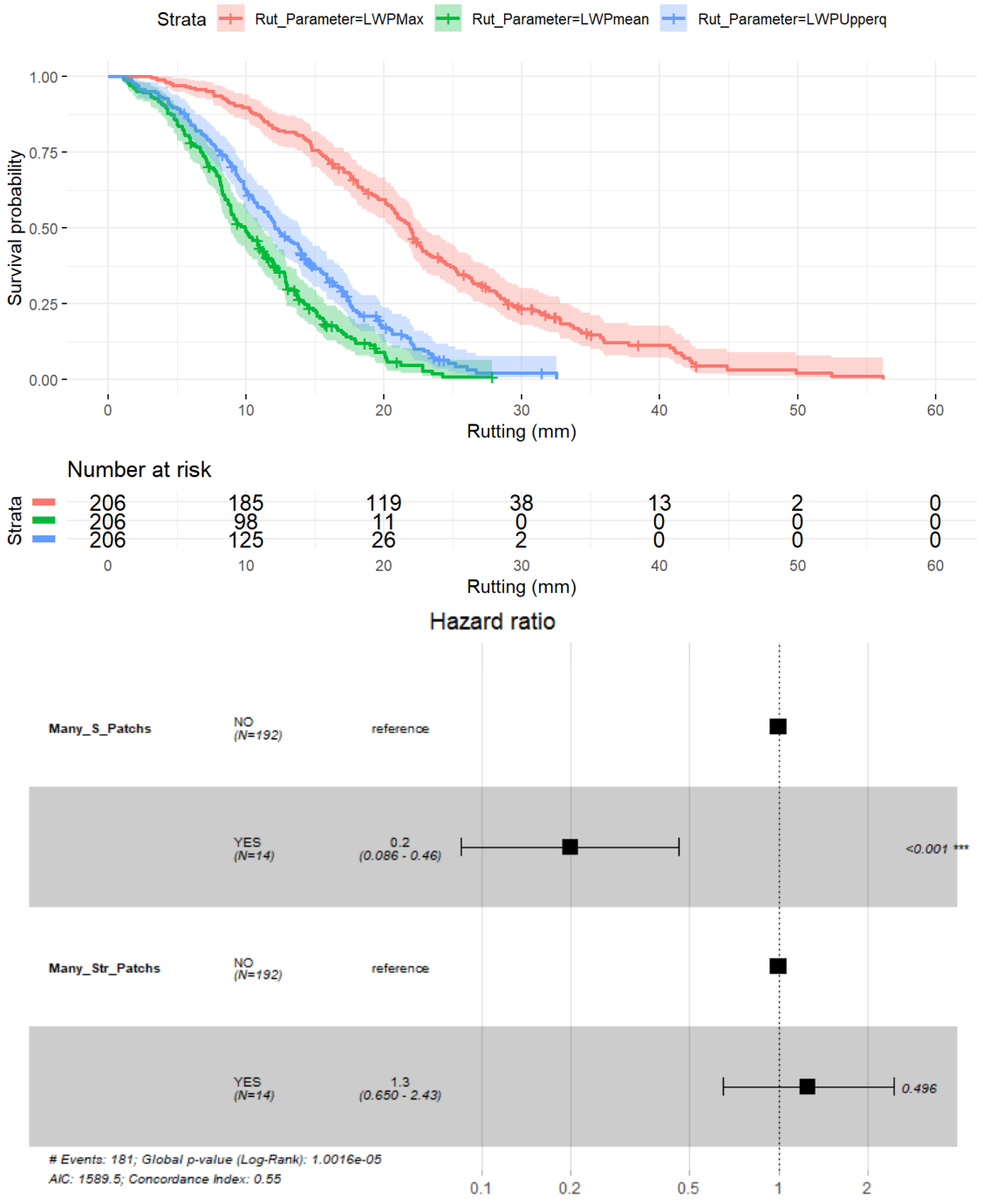
- APT Testing
  - 10 projects
  - 64 datasets
- RLT Testing
  - 3 databases
  - 146 tests
- LTPP Monitoring
  - 145 Sites
  - 18 years data



End of Life Conditions

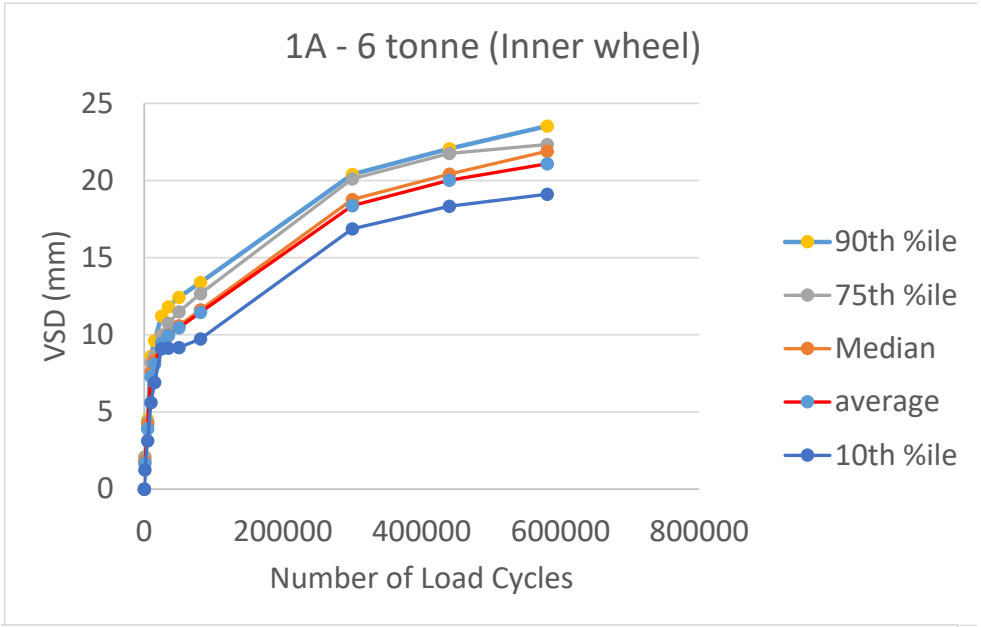
LTPP Data

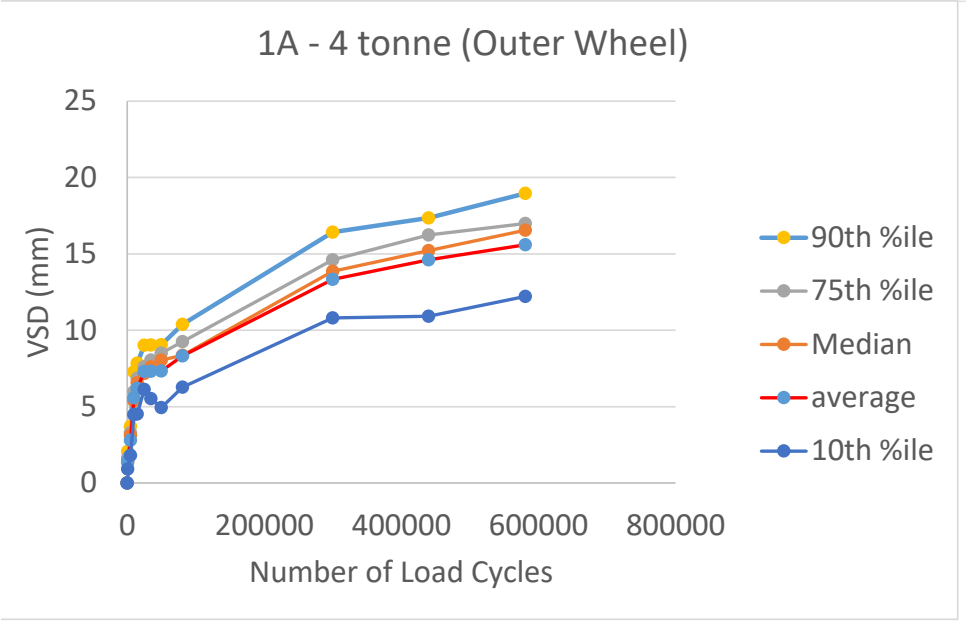
- “End of life” is generally “set” rut depths to avoid safety issues.
- Balancing rehabilitation costs against ongoing maintenance costs.
- 12mm upper quartile rut depth was the preferred median survival estimate.
- No clear influence from any of the other defect parameters.



Rutting

Example Results

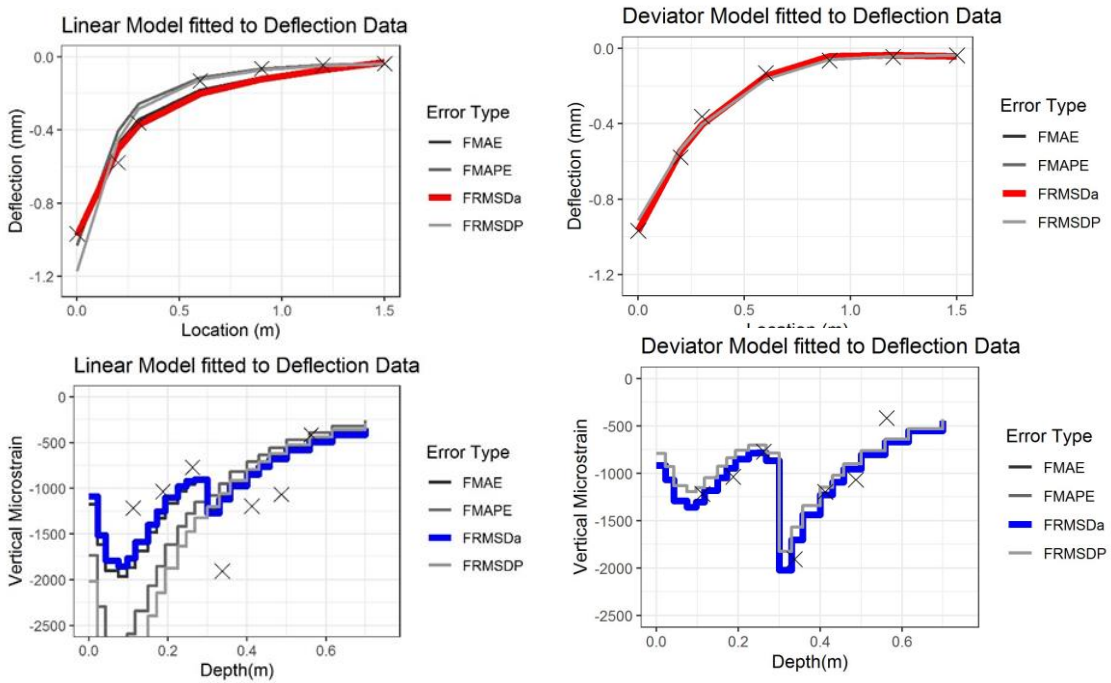




Response Models

Developments

- Non-linear model better than linear elastic model used by AUSTROADS.
- Modulus as a power function of deviator stress best for the basecourse and subgrade.
- A Root Mean Square Error (FRMSda) created the best fits



Performance Model

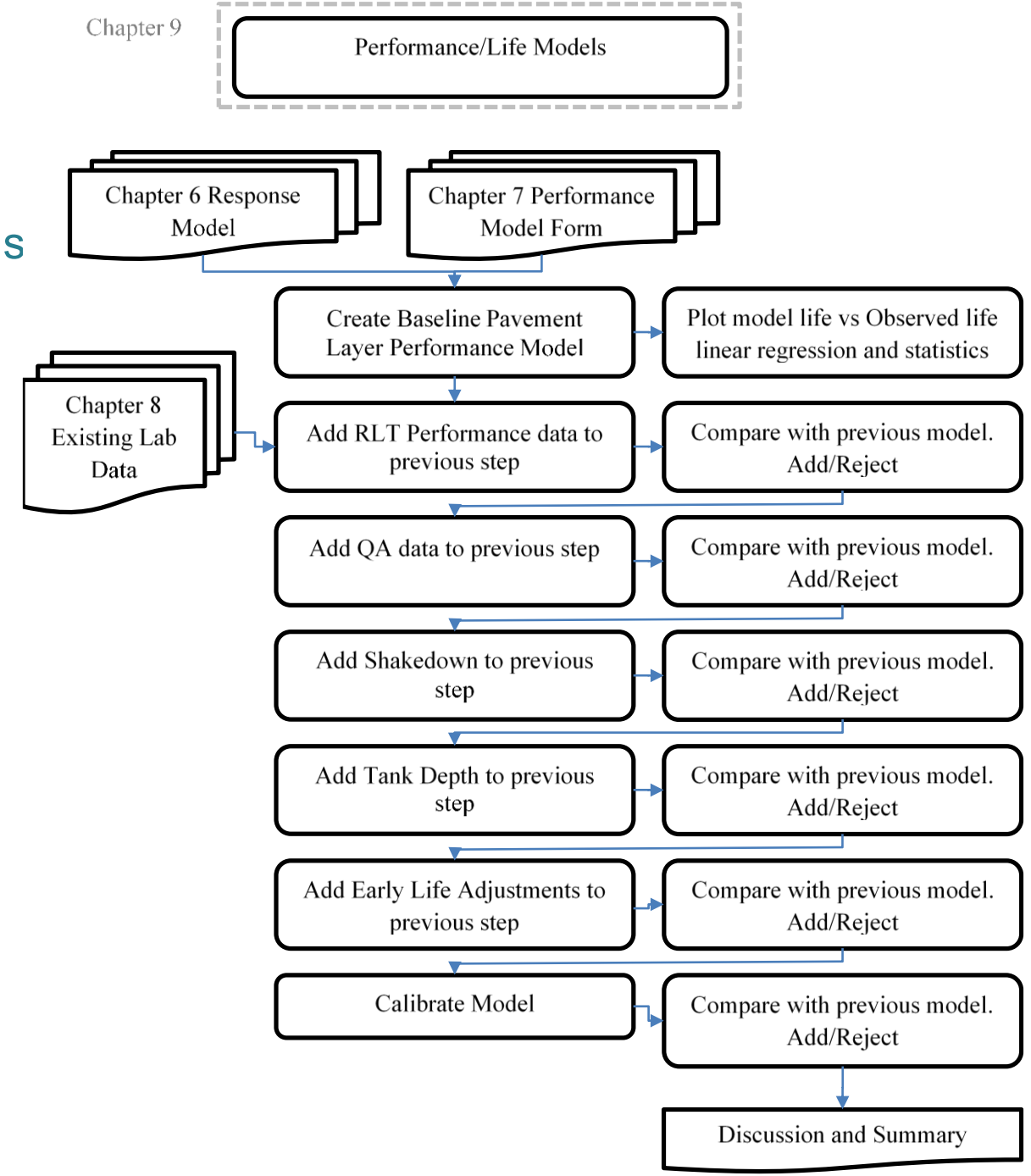
Development of the Performance/Life Models

Pavement Layer Performance Model

$$\varepsilon_{pf}(N) = (c_{fe}N + a_{fe})(1 - e^{-b_{fe}N})$$

Where

$\varepsilon_{pf}(N)$ = the permanent strain for the layer at the N th Load Cycle
e = 2.718282
N = the number of loading cycles
$a_{fe} = e^{(a_e + a_f \varepsilon_{rv})}$
$b_{fe} = e^{(b_e + b_f \varepsilon_{rv})}$
$c_{fe} = e^{(c_e + c_f \varepsilon_{rv})}$
ε_{rv} = the vertical resilient strain from the elastic response model
$a_e, a_f, b_e, b_f, c_e, c_f$ = material constants from RLT testing



Development of the Performance/Life Models

Calibrated Pavement Layer Performance Model

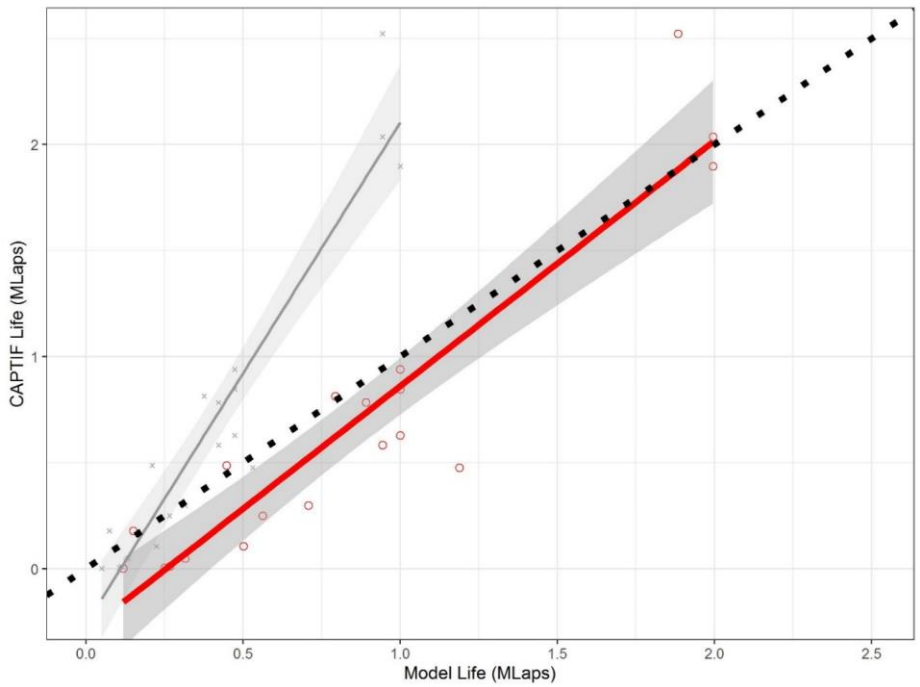
$$\varepsilon_{pf}(N) = \left(D * c_{fe}N + a_{fe}\right)\left(1 - e^{-b_{fe}N}\right)$$

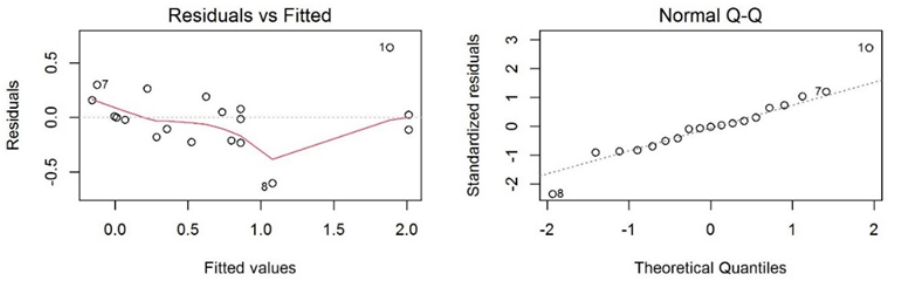
Where

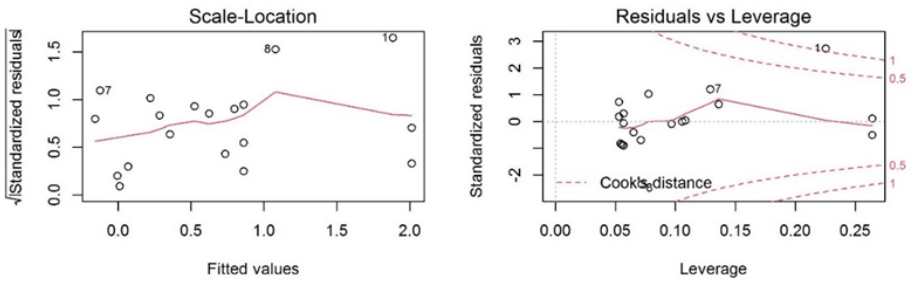
D = Regression slope correction

Note: Shakedown, tank bottom and early life corrected

- Calibrated Model
  - Adjusted R Squared = 0.87, p = 0.000
  - Model Life p = 0.000

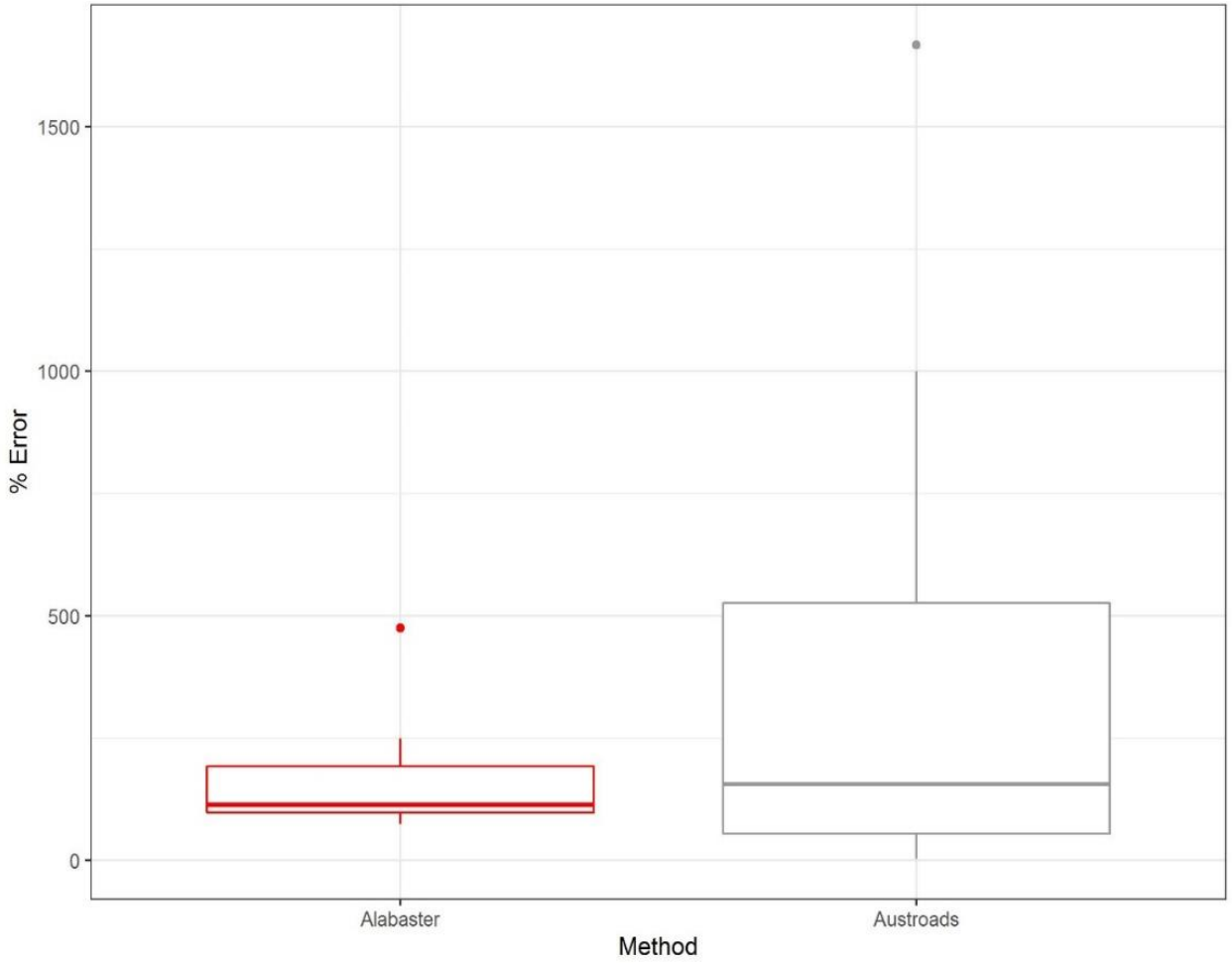






Conclusion

- Network deflection data (Gen 4 TSDD)
- Thickness data (AWM + GPR)
- RLT testing data in NZTA M04 (2024)
- Austpads linear and non-linear capability



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CAPTIF 2.0