Shell Fatigue Transfer Function Underestimates the Fatigue Life of Structural Highways

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Problem

Currently, the Austroads design guidelines have adopted the Shell Fatigue Transfer Function to calculate the fatigue life for asphalt concrete pavements.

The Shell Fatigue Transfer Function estimates the number of heavy axle vehicles required until cracking occurs.

$$N_f = \left[\frac{6918(0.856\,V_B + 1.08)}{E^{0.36}(\mu\varepsilon)}\right]^5$$

The **problem** in the New Zealand roading industry is the **suitability** of this function for **predicting fatigue cracking** for NZ asphalt concrete pavements. This is because the Shell function was based on many different asphalt mixes from various countries.

A **natural question** that follows is, are these **pavements too thick or too thin ?**

Findings

Shell Fatigue Transfer Function underestimates the life of this asphalt mix by 5.5 times (range 3.1 - 8.8).

The CIRCLY analysis between the two fatigue models shows there is a material savings of 50 mm.

Hence, for a one way, 1 kilometre pavement system there is a potential **savings** of **$87,500** - When using a bulk density of 2.5 tonnes per cubic meter and an indicative cost of $200 per tonne.

Case Study Summary Table

Shell Function	Strain Model	Material Saving	Cost Saving
Asphalt Thickness 325 mm	Asphalt Thickness 275 mm	50 mm	$87,500 per one-way per 1 Km

Impacts on Pavement Designs

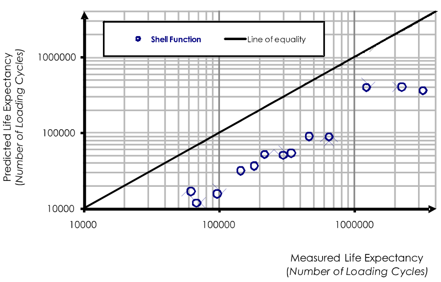
The Shell Fatigue Transfer Function
Used to estimate the expected life span of the asphalt mix.

$$N_f = \left[\frac{6918(0.856\,V_B + 1.08)}{E^{0.36}(\mu\varepsilon)}\right]^5$$

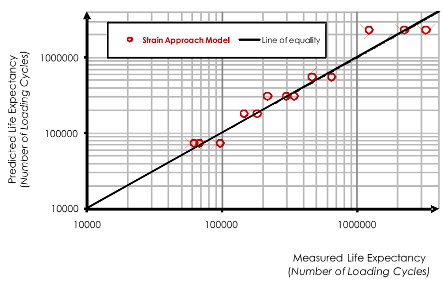
The Strain Approach Model
used to estimate the expected life span of the asphalt mix.

$$N_f = 4.42 \text{ x } 10^{18}\ (\mu\varepsilon)^{-4.96}$$

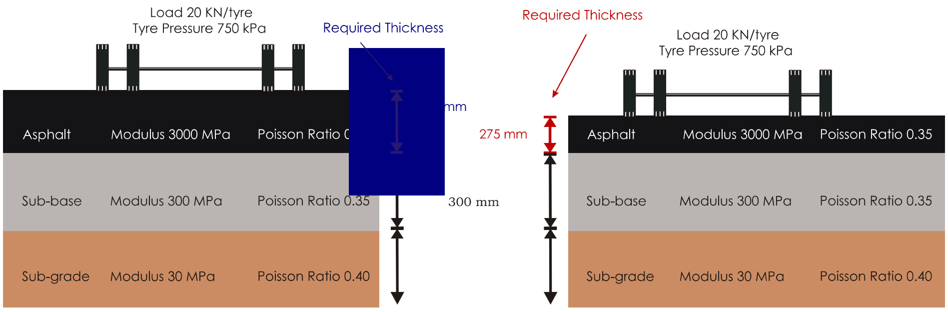
Shell Function **Underestimates** the Life Span of the Asphalt Mix



Strain Approach **Accurately Predicts** the Life Span of the Asphalt Mix



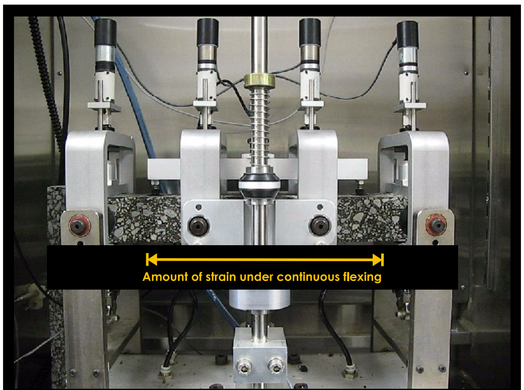
A CIRCLY analysis was used to determine the required asphalt thickness for each fatigue model.
100 million equivalent standard axles applied to each roading section.



Procedure

Thirteen AC14 B60/70 asphalt fatigue beams were tested using a four point loading scheme. Different constant strain levels were then applied to the beams until failure.

Strain levels were: 300, 400, 450, 500, 600 microstrains.



Four-Point Dynamic Loading

All fatigue tests were conducted at:
- Constant temperature of 20°C
- Constant loading rate 10 Hz

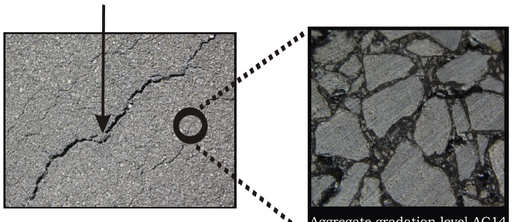
Fatigue failure was defined as a 50 % reduction in the initial flexural stiffness.

Regression analysis was used to determine an empirical relationship of the number loading cycles required to fatigue.

Beam fatigue apparatus in a controlled temperature cabinet

Characteristics of Asphalt's Survival

Fatigue cracking is caused by the repetitive stress from heavy vehicles.



Aggregate gradation level AC14

Fatigue cracking is influenced by a variety of factors including:
- Type of bitumen
- % Air voids, bitumen and aggregate
- Level of aggregate gradation
- Loading time and temperature
- Magnitude of stress/strain
- Asphalt stiffness

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