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Effect of temperature on asphalt pavement strain responses: APT data and thermo-viscoelastic pavement modelling

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Introduction

The thickness design of asphalt flexible pavements is generally constrained by a fatigue performance criterion of the asphalt base and intermediate layers, which is a function of the material characteristics and the pavement maximum tensile strain developed in the asphalt layers. The calibration of the fatigue performance relationship in a range of temperature conditions requires a good understanding of the effect of climatic conditions on pavement response.

The paper focuses on the simulation of the effect of traffic speed and asphalt temperature on tensile critical strains, including numerical modelling and comparison with APT pavement measured strains.

APT response to load data

IFSTTAR's accelerated pavement testing (APT) facility simulates traffic loadings on full-scale test pavements. The device applies full truck axle loads in different configurations on the full-scale instrumented pavements. Longitudinal, transverse and vertical strains are monitored in the different pavement layers.

Pavements: Two asphalt pavement structures

Loading: single, tandem and a tridem (triauxle) with 42.5 kN wheel load and speeds between 4 km/h and 50 km/h.

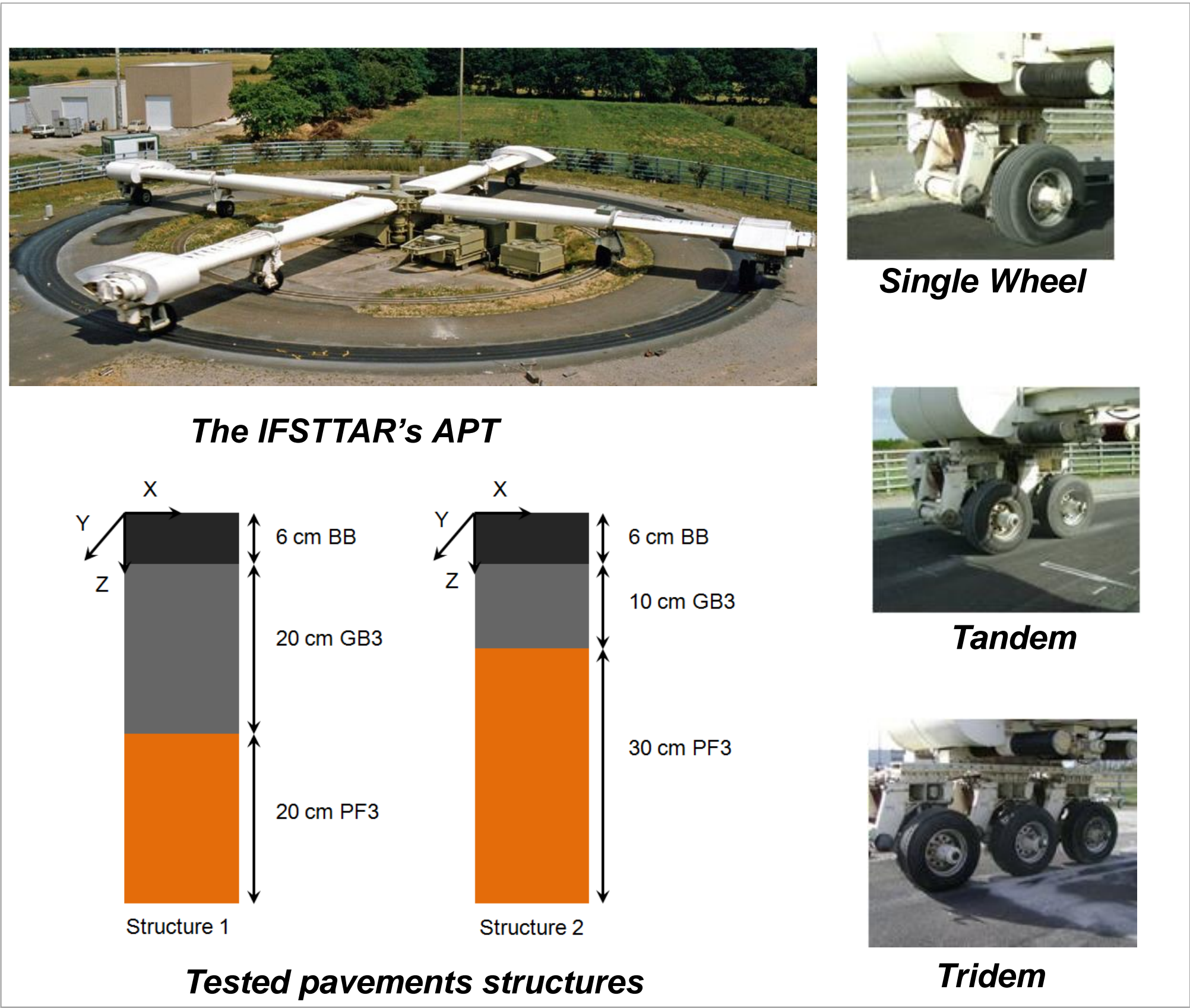
Environment: the average temperature of the base course layer varied between 4°C and 38°C.

Instrumentation: Strain gauges were embedded in the materials at the interface of the layers during the construction of the pavement.



Strain gauges

Database: 967 longitudinal and 1054 transverse strain signals.



Thermo-viscoelastic pavement model

Pavement analysis software: ViscoRoute 2.0©, developed by IFSTTAR (The French institute of science and technology for transport, development and networks).

General: a semi-infinite multilayered medium subjected to one (or several) moving loads at a constant speed in the x-direction.

Pavement structure: n horizontal homogeneous layers perfectly bonded and stacked up in the z direction.

Material model: linear elastic or thermo-viscoelastic.

Pavement modelling conditions

Flexural (complex) modulus measured on specimen extracted from the road bed.

Master curve built from the measured laboratory data

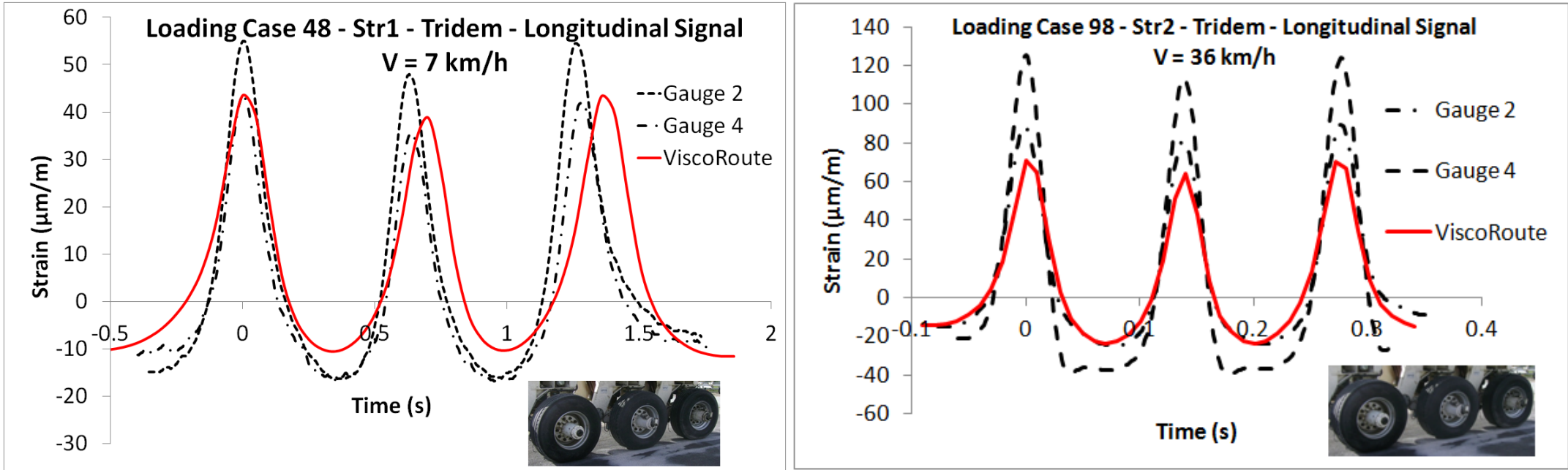
Thermo-viscoelastic model: Huet-Sayegh model used in ViscoRoute 2.0 © fitted using ViscoAnalyse (IFSTTAR software) .

Asphalt Type	Thickness (mm)	E_0 (MPa) ⁽¹⁾	E_∞ (MPa)	k	h	δ	A_0	A_1	A_2
BB (Structure 1)	70	20	29840	0.2168	0.65821	2.194	3.896	-0.3782	1.582e-03
GB (Structure 1)	170	20	22980	0.1739	0.57757	1.985	4.325	-0.3923	1.960e-03
BB (Structure 2)	70	20	29940	0.1929	0.6250	2.003	3.982	-0.3977	2.239e-03
GB (Structure 2)	90	20	20550	0.1981	0.6029	2.306	6.018	-0.3882	1.507e-03

(1) The minimal moduli E_0 has been removed from the parameter fitting options and assigned as 100 MPa

Huet-Sayegh's model parameters

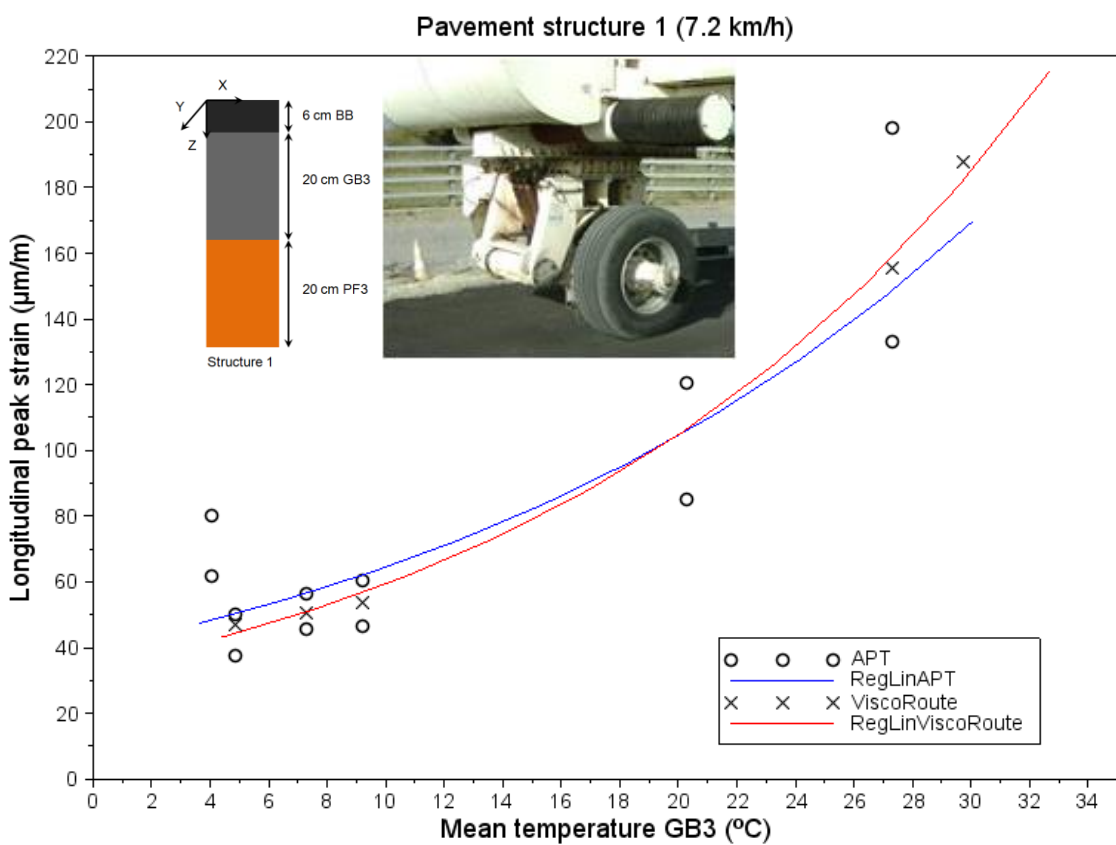
APT vs. pavement model comparison



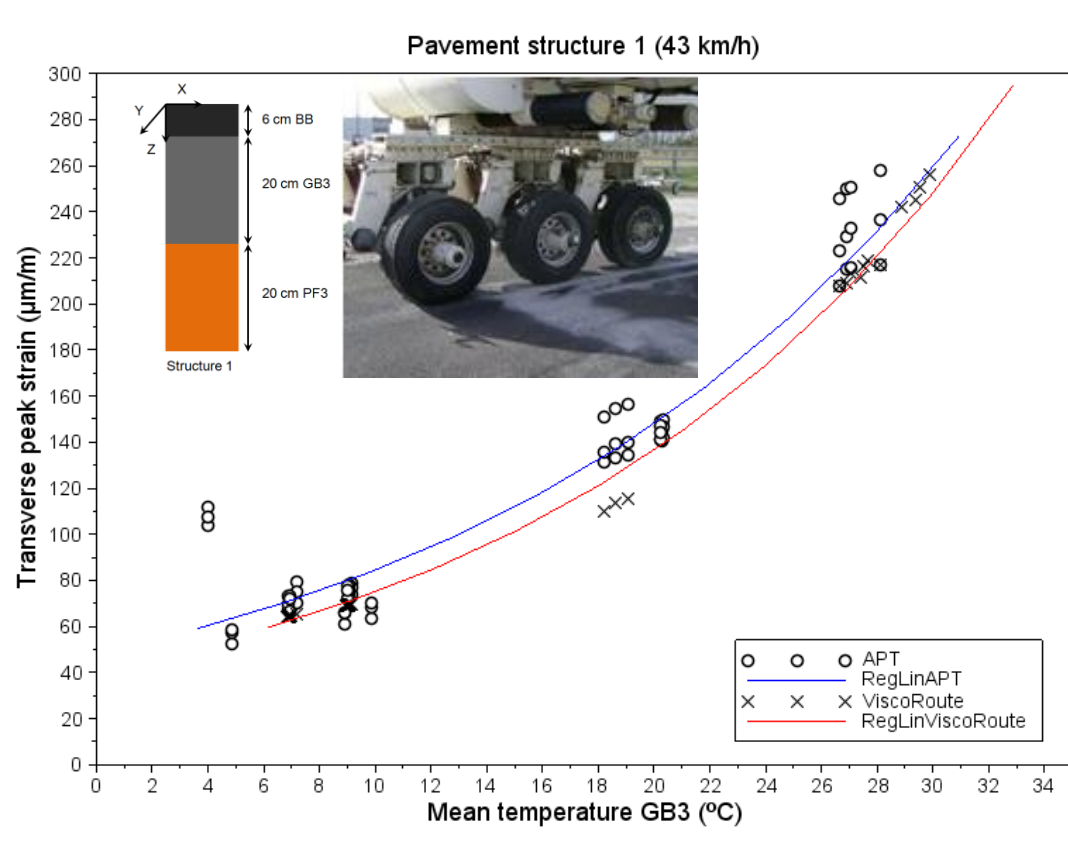
Superposition APT signals – Viscoroute Signals

Effect of asphalt temperature on tensile strains

$$\epsilon_{\max} = e^{(aT_{\text{Asphalt}} + b)}$$

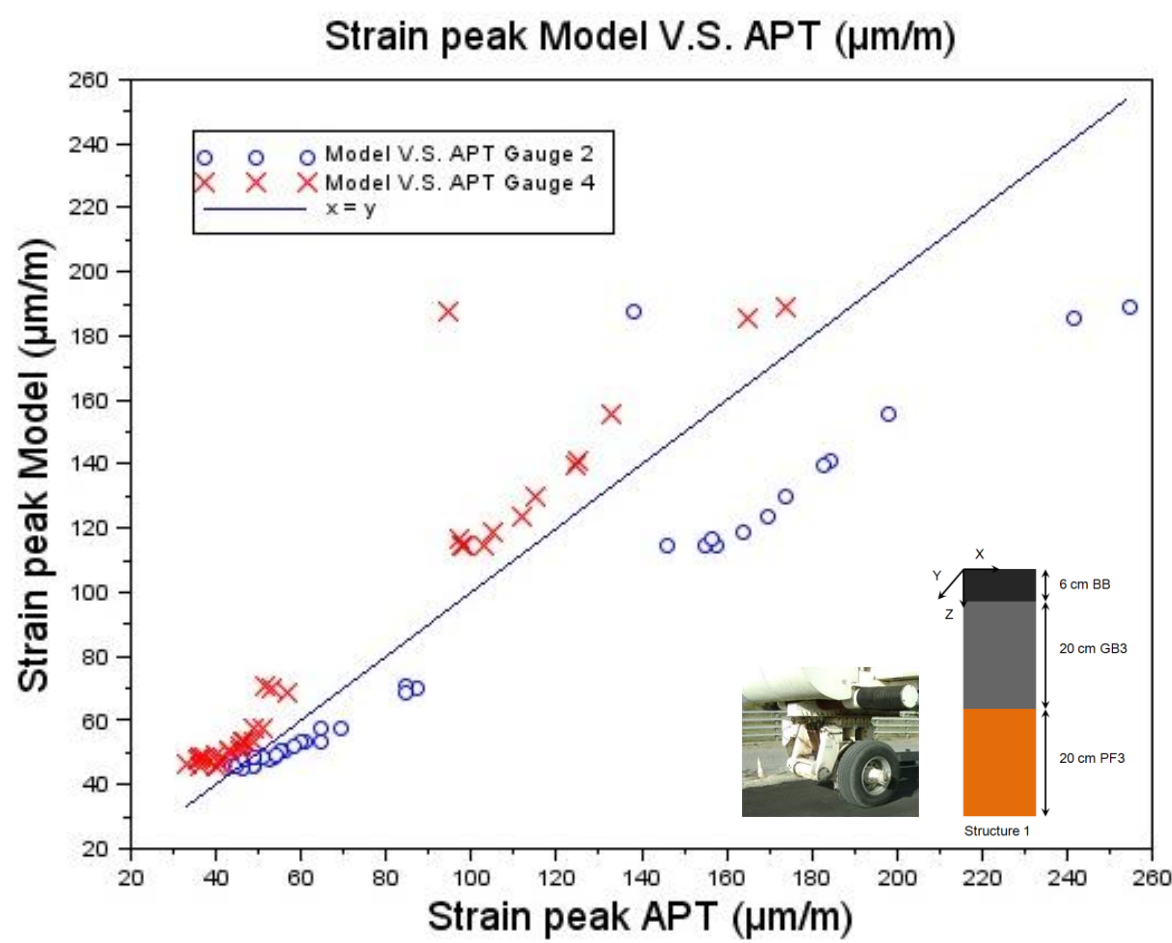


Long. Strain as function of mean GB3 temperature – Single Axle, Str 1 – V = 7.2 km/h

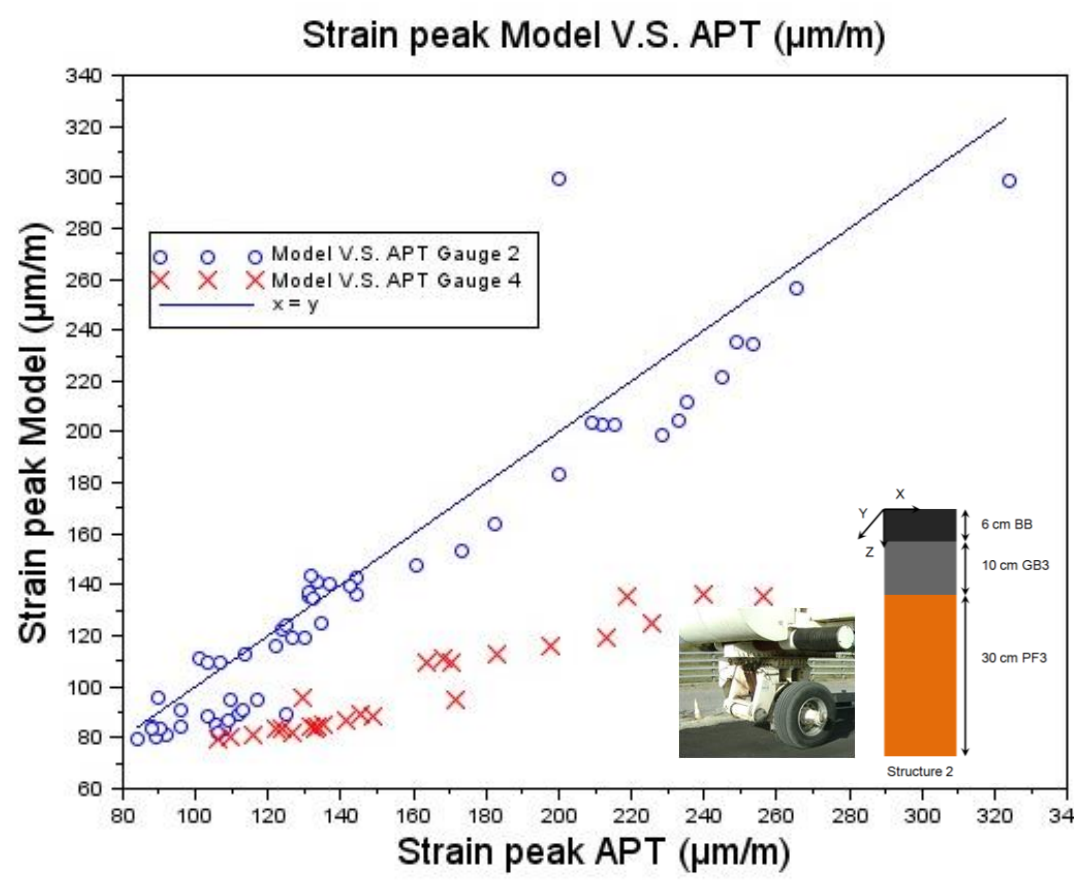


Trans. Strain as function of mean GB3 temperature – Tridem Axle, Str 1 – V = 43 km/h

Measured tensile strains vs prediction



Calculated vs. measured long. Peak strain – single axle – str1



Calculated vs. measured long. Peak strain – single axle – str2

Conclusion

Thermo-viscoelastic pavement modelling validated against measured pavement strains for wide range of loading and environmental conditions

Challenges:

- Variability of the response measurements
- Simplification/validation of unbound and subgrade materials models

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