Temperature Effects on SCRIM Skid Resistance Measurements

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Acknowledgements

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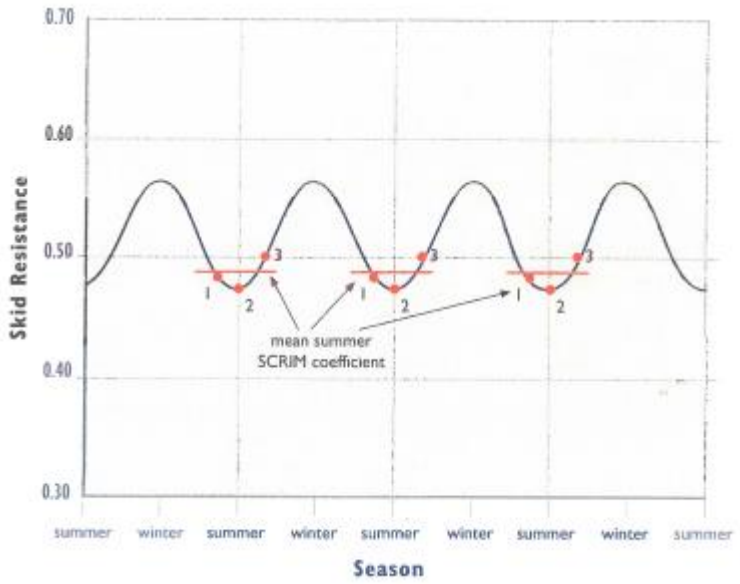
- Dr Robert Henderson and Morgan King for performing the correlation studies

Presentation Outline

- Research Need
- On-Road Trials Performed
- Temperature Correlations with Measured Skid Resistance
- Key Findings

Research Need (1)

- ***Issue with seasonal corrections***
  - Seasonal corrections over the past few years going against expectations of MSSC < 1 for a wet summer season and > 1 for a dry summer season.



At each seasonal site, 3 SCRIM measurements (1,2,3) are made at different times during the summer period. The average skid resistance for the summer for each site is calculated to obtain the Mean Summer SCRIM Coefficient (MSSC).

Research Need (2)

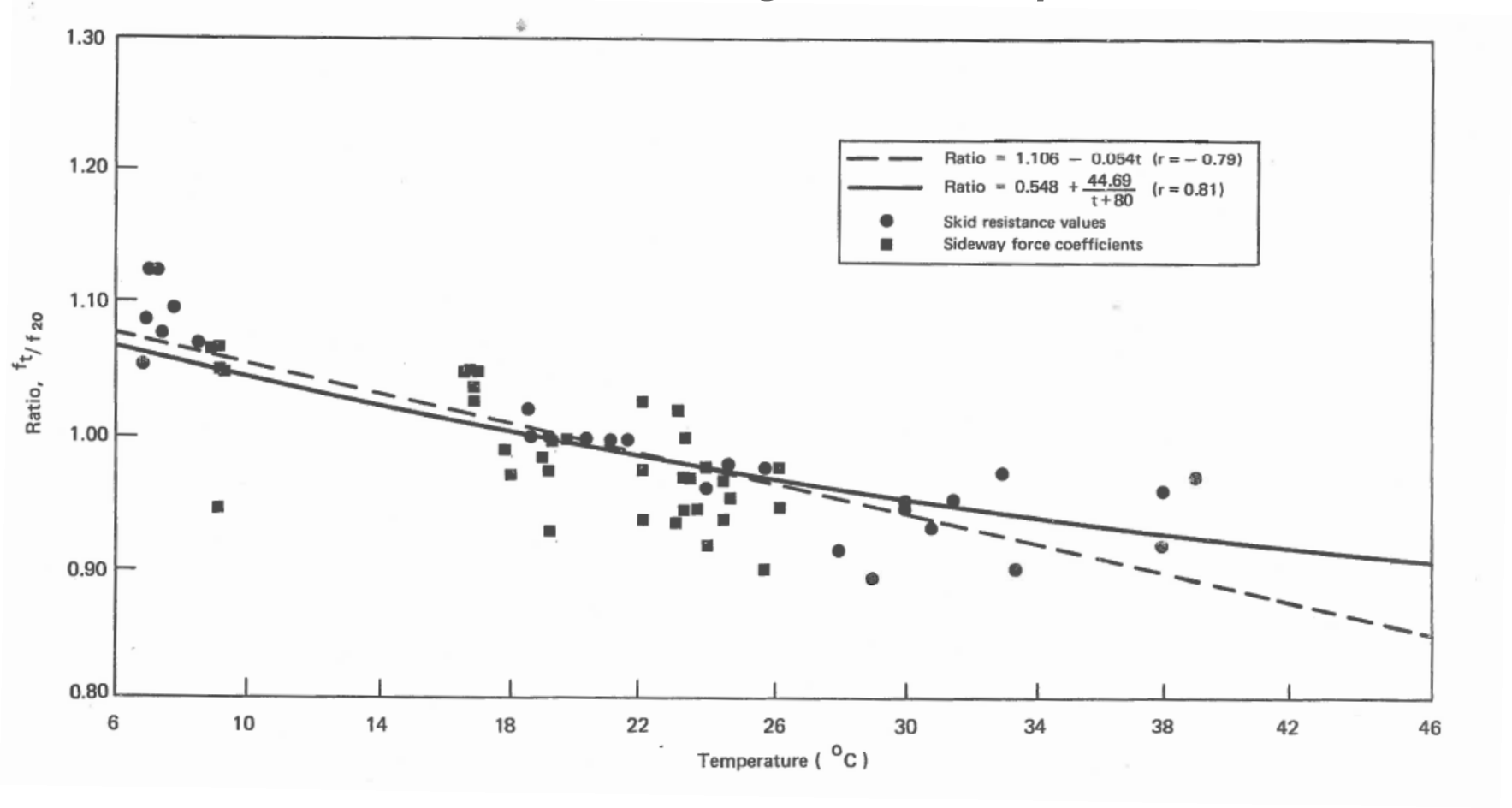
International Experience

- Conclusion from Mulry, Brennan & Sheahan (2012) “A Model for Adjusting SCRIM Skid Resistance Data to Reflect Seasonal Variation”

  “The regression model for surface type and average daily temperature, without accumulated rainfall, is also presented. The resulting R^2 value was 0.719, indicating that the model explained 71.9% of the variation in the data. This regression model also performed very well in predicting the SFC data for a sixth year of data with R^2 value of 85.4%. Accordingly, it is equally arguable that this simpler behavioural model could be used to correct for seasonal effects using the regression coefficient of -0.00824 for average temperature (ºC) alone. <u>These findings would indicate that temperature may be the major factor affecting seasonal variation of skid resistance.</u>”

Research Need (3)

Doubts concerning suitability of existing SCRIM temperature correction



Research Need (4)

Doubts concerning suitability of existing SCRIM temperature correction

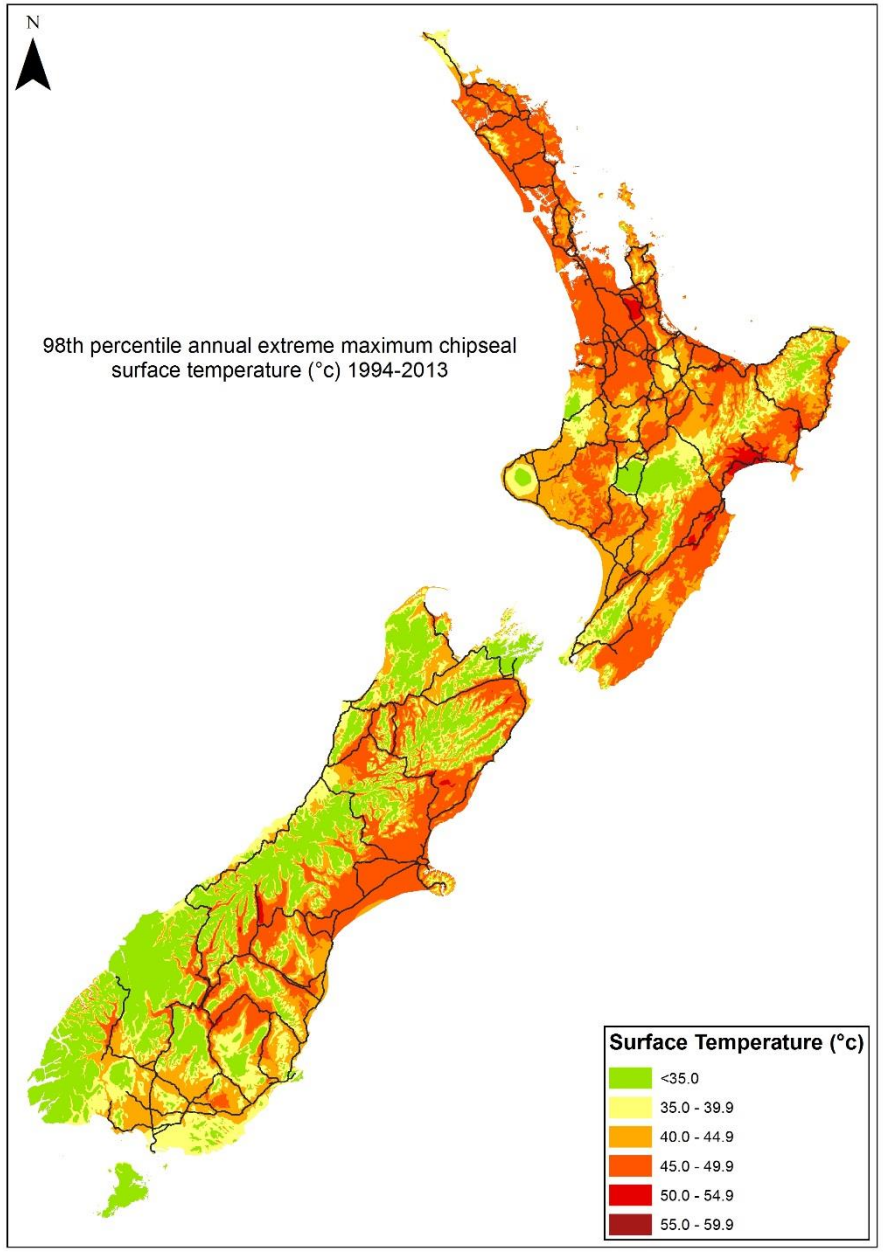
- Plot largely follows expectation as rubber resilience increases (i.e. hysteresis losses become smaller) as temperature rises and so resistance to skidding tends to decrease.
- With reference to the plot, largely derived from British Pendulum SRV values
- SCRIM SFC values obtained by heating (and cooling) a test tyre to a range of temperatures between 9˚C and 26˚C and testing a range of different surfacings (concrete and bituminous)
- Tyre temperature also shown to correlate well with air and road surface temperatures i.e.

$$\textit{Tyre Temp (˚C)} = 12.3 + 0.96 \times (\textit{Mean of Air and Road Temps (˚C)}) \quad (r^2 = 0.76)$$

Research Need (5)

Doubts concerning suitability of existing SCRIM temperature correction

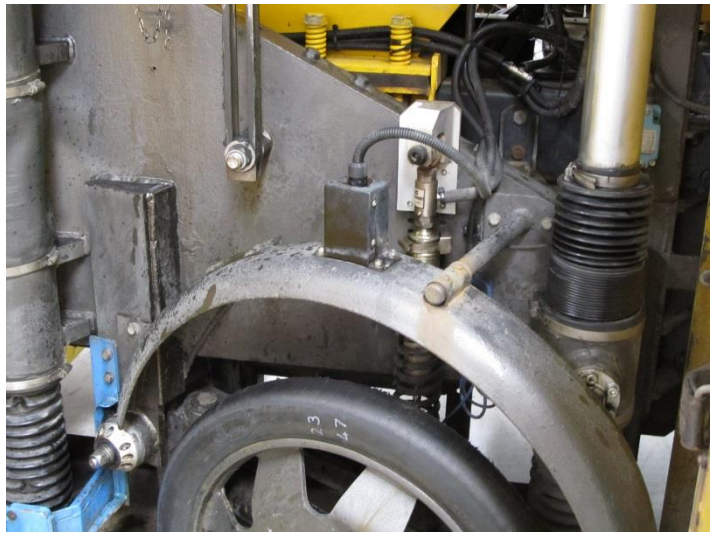
- SFC values only for 9˚C≤ Tyre Temp≤ 26˚C, corresponding to a maximum air/road temperature of 14˚C.
- By comparison, maximum (98th percentile) air and chipseal road surface temperatures in New Zealand are estimated to be 30˚C and 55˚C respectively (Herrington and Wu, 2016), giving a calculated tyre temperature of 53˚C.



Research Questions

- How do air, road surface, tyre, and applied water temperatures affect SCRIM skid resistance measurements made on chipseal road surfaces ?
- Is the temperature correction presently used for correcting SCRIM skid resistance measurements appropriate for NZ SH road surfaces and summer temperatures?

Experimental Design



- SCRIM machines S10 and S15 modified to allow measurement of test tyre temperatures in addition to air and road surface temperature.
- Measurements to be made at regular intervals on a lightly trafficked site over a 12 hour period starting early in the morning and finishing late at night.
- Surface of test site to be washed before trial to remove detritus
- Measuring tyres to be brought up to operational temperature for each survey of the site by travelling a minimum of 700m before commencing the survey.
- Measurements of water temperature made manually with non-contact infrared thermometer at outlet nozzle on completion of each survey.
- Two situations of interest:
  - Test tyre temperature > Road surface temperature
  - Test tyre temperature < Road surface temperature

Expected Result

If temperature and speed corrections appropriate, there should be very close agreement between runs because the test site is lightly trafficked and 30 minute time interval between runs should be sufficient for road surface to dry.

Trials

- Two test sites utilised:
  - Ulric and Northpoint Streets, Plimmerton; and
  - Taupahai Road, Turangi.
- Measurements made with SCRIM S10 (Plimmerton) and S15 (Turangi).
- Runs repeated as soon as road was dry at intervals not shorter than 30 minutes when possible.
- Performed on:
  - Plimmerton and Turangi, 22nd October 2016, 5am to 5pm, during an extreme cold spell.
  - Turangi, 1st March 2017, 11:15am to 7pm and 2nd March 2017, 8:15am to 11:15am, during hot spell
  - Plimmerton, 3rd March 2017, 11:45am to 6:45pm and 4th of March 2017 8:25am to 11:25am, during warm spell

Test Sites

Ulric and Northpoint Streets in Plimmerton

- Test Section Length = 610 m
- 0-470m chipseal, 470-610m asphaltic concrete

Test Sites

Tuapahai Road, Turangi

- Test Section Length = 790 m
- Chipseal surface

Start

End

Result Summary

- 1st Trial

Parameter	Plimmerton	Turangi
Air Temperature	8°C - 14°C	9°C - 15°C
Road Surface Temp	10.3°C – 27.5°C	7°C – 28.6°C
Tyre Temperature	26.4°C – 31.2°C	26.1°C – 27.5°C
Lane SR	82.8 – 71.6 (Diff = 11.2)	64.3 – 54.2 (Diff = 10.1)

Result Summary

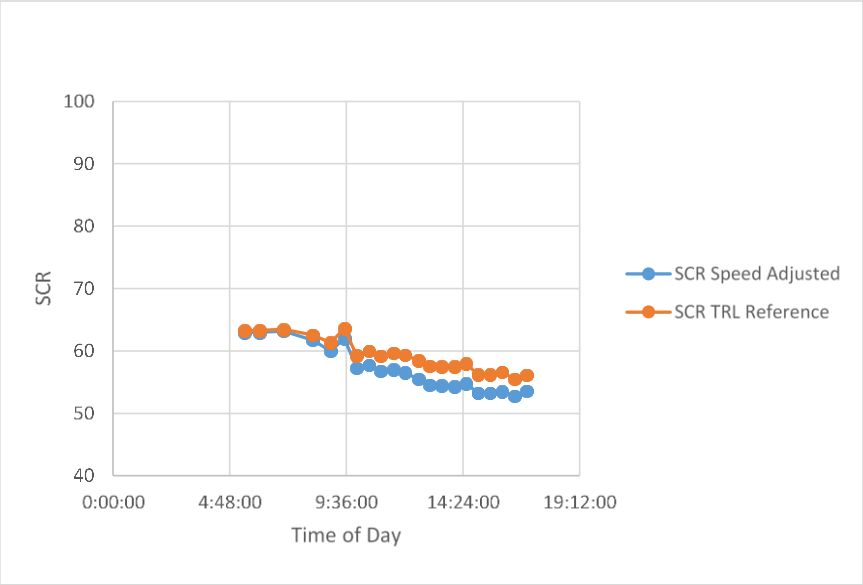
- 2nd Trial

Parameter	Plimmerton	Turangi
Air Temperature	16.8°C – 19.7°C	12.2°C – 22.6°C
Road Surface Temp	18.8°C – 31.9°C	15.0°C – 40.2°C
Tyre Temperature	30.5°C – 36.3°C	23.7°C – 36.5°C
Water Temperature	18.2°C – 20.6°C	14.1°C – 21.7°C
Lane SR	77.8 – 72.1 (Diff = 5.7)	56.0 – 51.9 (Diff = 4.1)

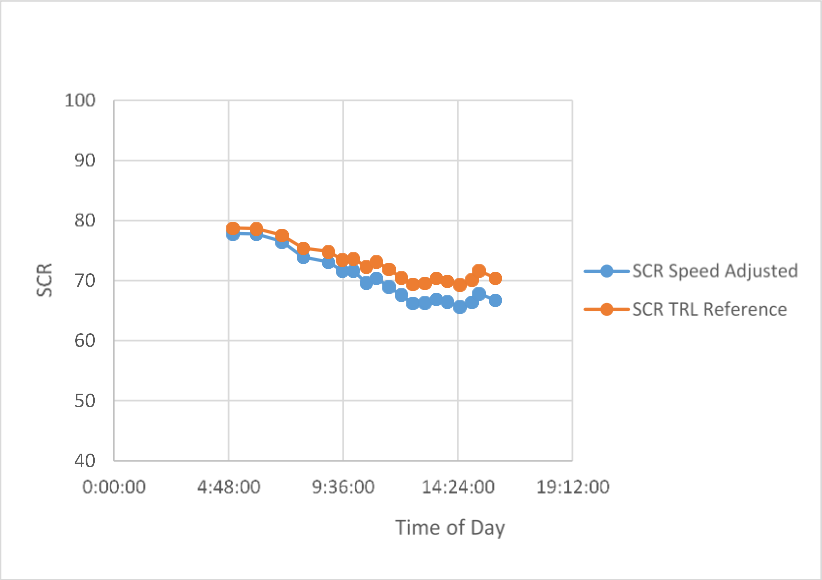
Application of TRL Temperature Correction

- 1st Trial

Turangi (200m – 210m) – Chip Seal



Plimmerton (300m – 310m) – Chip Seal



Alternative Temperature Correction

Methodology:

- Developed solely on basis of data from Plimmerton and Turangi trials.
- Trialling a number of temperature correction equation models. Dependent variable speed-corrected SC wheelpath data. The independent variable(s) were/was a combination of up to three temperatures: T_a = air temperature, T_s = surface (road) temperature & T_t = tyre temperature.
- Two curve fitting software packages were used: (1) Oakdale Engineering's 'DataFit 9' software package, and (2) MicroSoft's Excel 2013.
- The “best” temperature correction equation was selected on the basis of the one that gave the highest R^2 between skid resistance ratio (i.e. measured wheelpath skid resistance : wheelpath skid resistance at T =20±2.5 (or sometimes ±3) degrees) and the combination of T_a, T_s and T_t

Best Fit Temperature Correction

The equation giving the highest R^2 of those trialled is:

$SC_T/SC_{20} = 0.0011*T^2 - 0.0135*T + 1$

where:

SC_T = the SCRIM Coefficient measured at some general T.

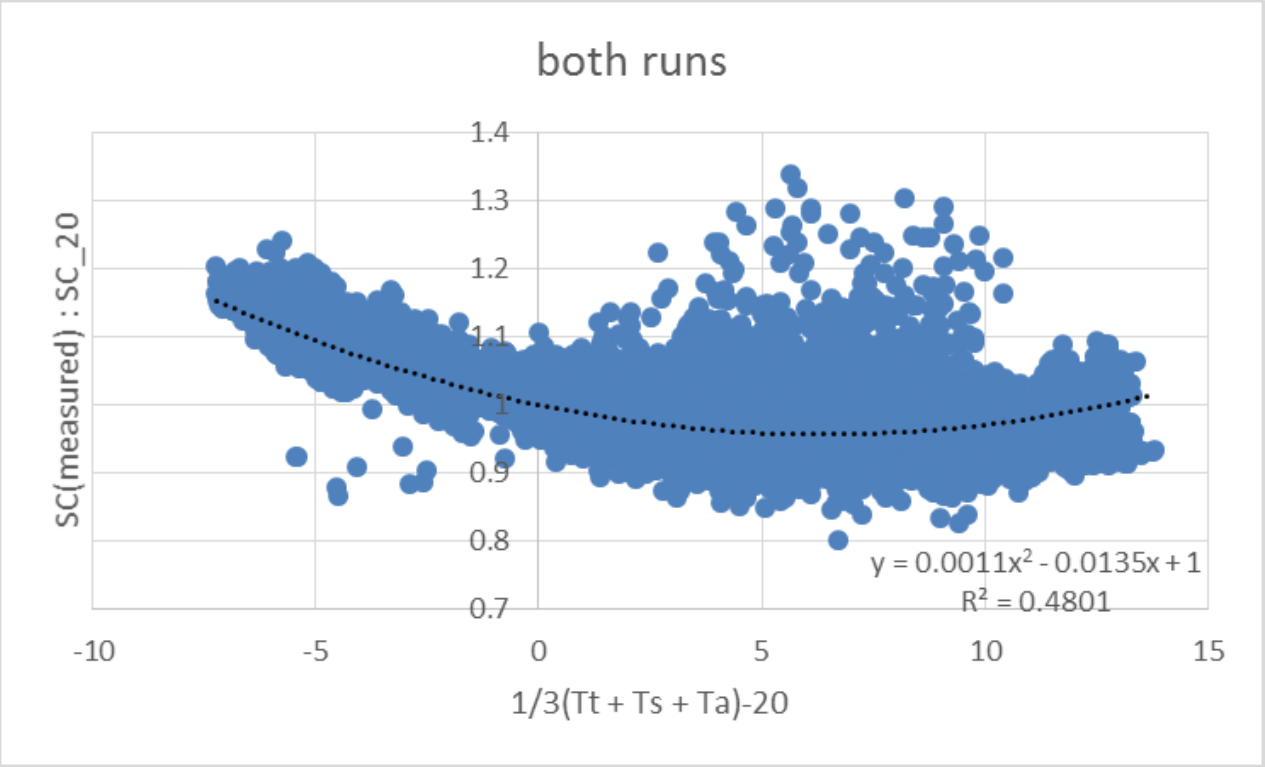
SC_{20} = The SCRIM Coefficient at T=20 degrees.

$T = 1/3*(T_t+T_a+T_s)-20$

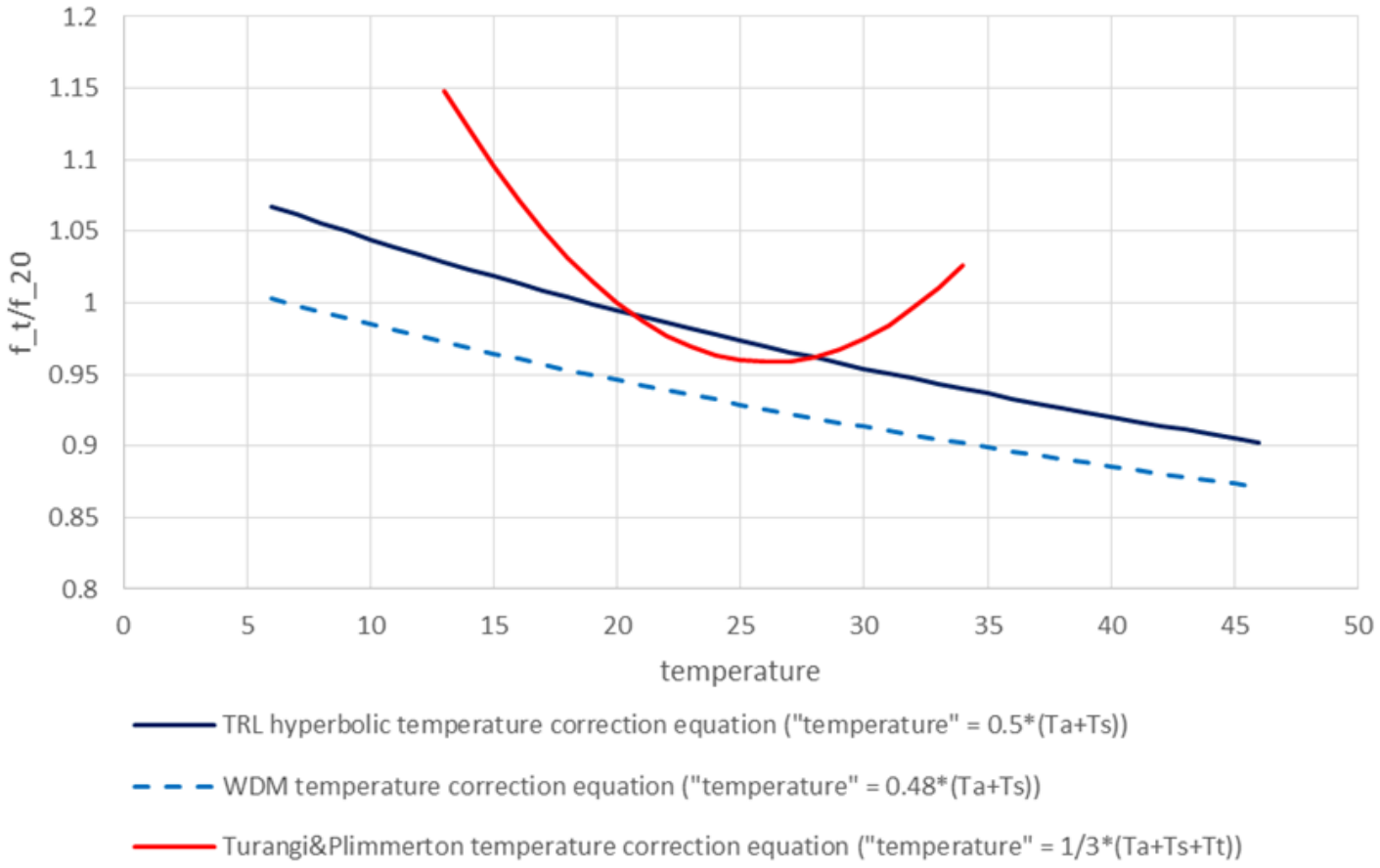
T_t = tyre temperature (°C)

T_s = surface (road) temperature (°C)

T_a = air temperature



Graphical Comparison of Corrections



Key Findings

- Existing temperature correction significantly under-corrects when air/road/test tyre temperatures are low.
- The TRL equation for relating test tyre temperature to air and road surface temperature does not appear to be suitable for New Zealand conditions.
- The alternative temperature correction model has a modest R^2 of 0.48 when both trial 1 and 2 datasets are used. When solely trial 1 data is used the R^2 increases to 0.78 but when solely trial 2 data is used the R^2 is an unsatisfactory 0.004.
- More investigation is required to determine the cause of differences between trials 1 and 2 but it is suspected that a 0.7 km “run-in” may not be sufficient for a “steady” tyre temperature to be reached. This is on the basis of the test tyre temperature ranges observed during the trials, with the range being least for Turangi trial 1 and largest for Turangi trial 2.

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