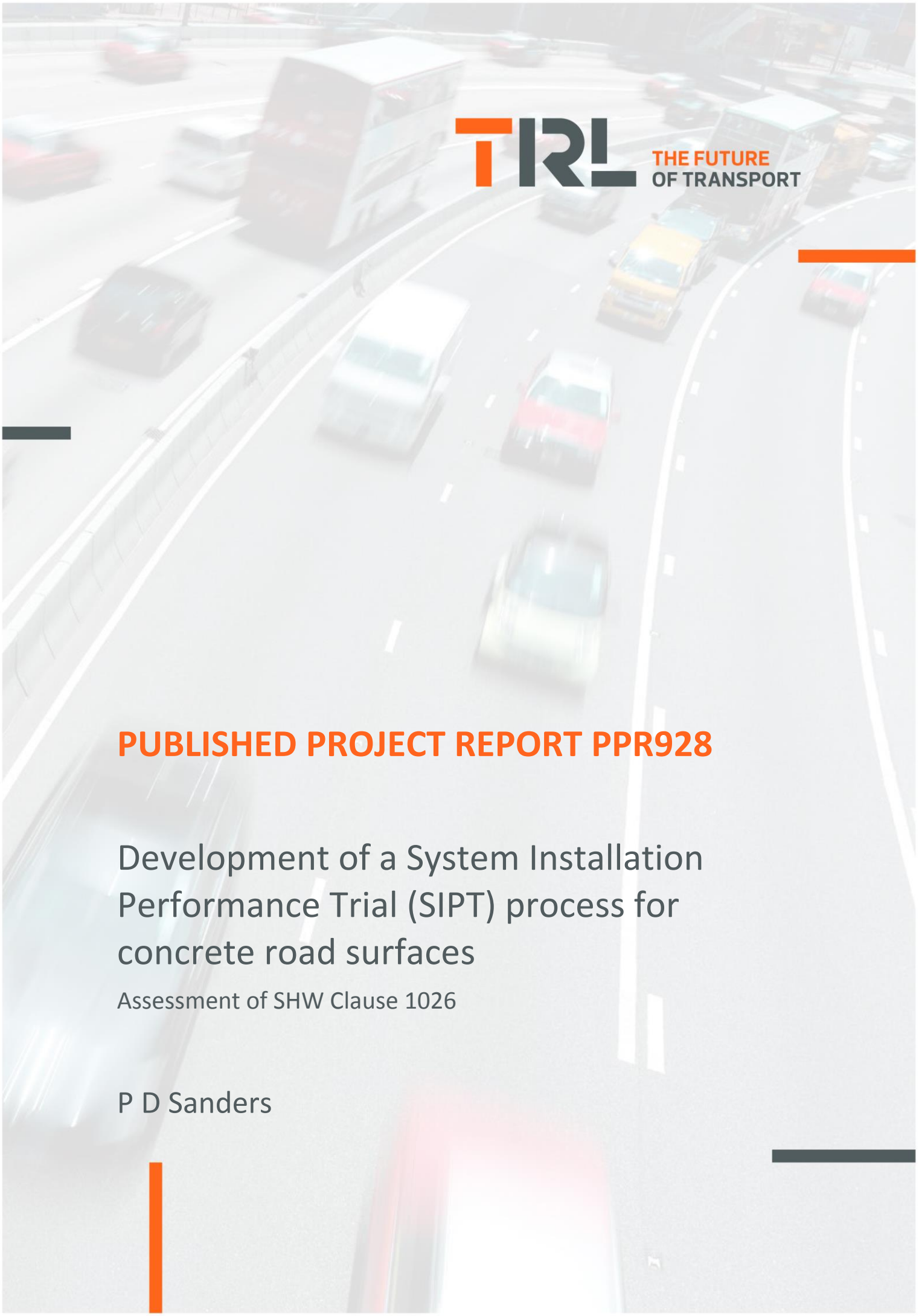

THE FUTURE OF TRANSPORT

PUBLISHED PROJECT REPORT PPR928

Development of a System Installation Performance Trial (SIPT) process for concrete road surfaces

Assessment of SHW Clause 1026

P D Sanders

Report details

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Table of Contents

Executive summary

The work reported in this document seeks to update the knowledge and specifications for concrete roads on the English Strategic Road Network (SRN). Highways England recognises that there are discrepancies in the Specification for Highways Works (SHW) between the requirements for asphalt and concrete materials. Furthermore the current SHW documents require updating to take into account modern construction techniques and advances in technology and the understanding of road surface properties on user safety.

The aim of the work reported in this document is to assess an amendment to Clause 1026 of the SHW made in February of 2016 (Highways England, 2016). The amended document aimed to bring the requirements for new concrete roads in line with those required of asphalt roads by specifying texture depth and high speed locked-wheel friction performance criteria.

At the time of writing, this document was made available to Highways England as an unpublished report. However, three years later, it is prudent for this document to become more widely available as the information within underpins some of the changes in the revised MCHW 1000 series, which should be available within the following months.

For each criterion the appropriateness of the values quoted in Clause 1026 are assessed by comparing the values to those presented in other road surfacing standards. The reasonability of the criteria are assessed by comparing the requirements for each criterion with the distribution of values observed from measurements of texture depth and high speed friction.

Based on the analysis carried out, the following amendments to the current SIPT process are recommended:

- TABLE 10/8: (11/03) Macro texture Depths:
    - The tolerance for the required macrotexture depth measured between 24 hours and 7 days after the construction of the slab or until the slab is first used by vehicles be amended to +0.25MTD, - 0.10MTD.
    - The tolerance for the required macrotexture depth measured not later than 6 weeks before the road is opened to public traffic be amended to +0.25MTD, - 0.10MTD.

1 Introduction

The work reported herein addresses Task 3.1 of Highways England work package 484(4/45/12)HALC. The overall aim of this work package is to update the knowledge and specifications for concrete roads on the Strategic Road Network (SRN). Highways England recognises that there are discrepancies in the Specification for Highways Works (SHW) between the requirements for asphalt and concrete materials. Furthermore the current SHW documents require updating to take into account modern construction techniques and advances in technology and the understanding of road surface properties on user safety.

The aim of the work reported in this document is to assess an amendment to Clause 1026 of the SHW made in February of 2016 (Highways England, 2016). The amended document aimed to bring the requirements for new concrete roads in line with those required of asphalt roads by specifying texture depth and high speed locked-wheel friction performance criteria.

The high speed friction and texture criteria are assessed in Chapter 3 and Chapter 4 respectively. For each criterion the appropriateness of the values quoted in Clause 1026 were assessed by comparing the values to those presented in other road surfacing standards. The reasonability of the criteria were assessed by comparing the requirements for each criterion with the distribution of values observed from measurements of texture depth and high speed friction.

2 Background

This chapter presents key information and procedures that were used in the analysis of the proposed SIPT criteria. The two themes discussed here are the relationship between texture and high speed friction and the different texture depth measurement methodologies used in highways standards.

2.1 The relationship between texture and high speed friction

The relationship between high speed friction and texture depth for road surfacings in the UK was first investigated during the 1990s and the outcomes of those studies are reported in TRL Report 367 (Roe, et al., 1998). Since the completion of that work research into high speed friction and road surface properties has continued and a summary of the pertinent knowledge gained through this research is presented in Figure 2-1.

This figure summarises all of the locked wheel friction measurements made at a 90 km/h test speed (presented as values of L-Fn90) on a variety of road surfacing materials. These measurements have been presented in relation to the corresponding Sensor Measured Texture Depth (SMTD) values for the pavements measured.

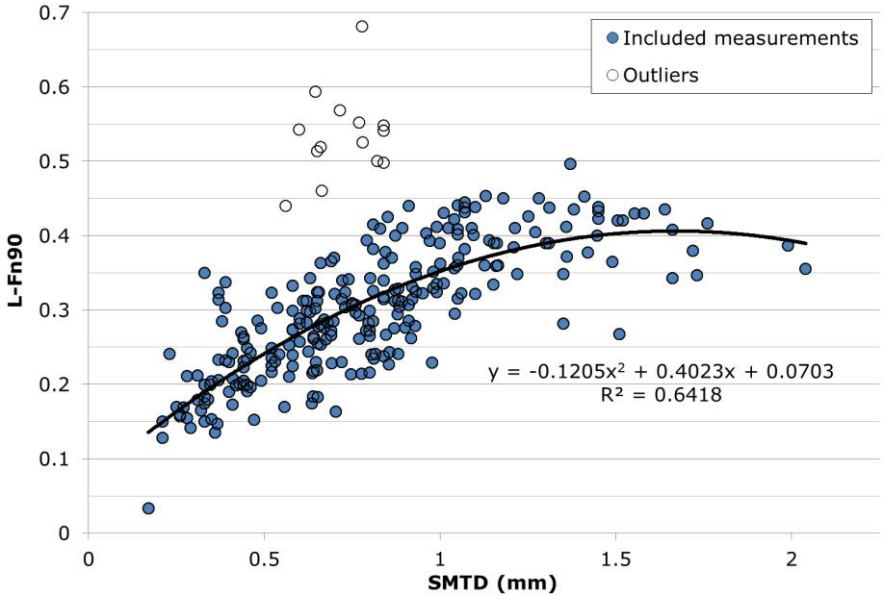

Figure 2-1 The relationship between texture depth and locked-wheel high speed friction

All series markers in Figure 2-1 represent the average L-Fn90 and SMTD measurement for an individual test site. The clear markers represent outlying measurements (for the purposes of this work) that have been identified as being influenced by pavement porosity and so have been excluded from this analysis. The black line represents the line of best fit for the remaining measurements and is presented with the relevant statistics.

A methodology for estimating the amount of friction that should be measured on a surface with a specific texture depth performance was used for this work and is summarised as:

- For the given texture depth value calculate the mean friction value using:

$$\bar{y} = -0.1205x^2 + 0.4023x + 0.0703$$

- Add 10% to $\bar{y}$ to account for seasonal variation errors in the friction measurement.
- Add 0.0169 to this value to account for repeatability and reproducibility measurement error.

This process is summarised in Equation 2-1.

$$L - Fn90 = \left((-0.1205 \times SMTD^2 + 0.4023 \times SMTD + 0.0703) \times 1.1\right) + 0.0169$$

Equation 2-1 Estimation of required high speed friction based on texture depth

It should be noted that the purpose of Equation 2-1 is to estimate the amount of friction that should be measured on a given site, rather than estimating the friction that should be provided by a site, hence the inclusion of the seasonal variation and measurement error terms.

2.2 Texture measurement methodologies

A number of methodologies exist for characterising the texture depth of road surfacings; those characterisations salient to this work are the volumetric patch method for characterising Mean Texture Depth (MTD) and the Sensor Measured Texture Depth (SMTD) method. These methodologies are fundamentally different and so comparing measurements made using each technique should be carried out with caution.

The comparison of different texture depth measurements is required for this work and so an estimation of the values expected from one methodology based on the other was required. Whilst no definitive methodology exists for comparing MTD and SMTD values, one can be created by using a third parameter Mean Profile Depth (MPD) to allow the substitution of one value for the other.

TRL Report PPR148 (Viner, et al., 2006) provides the following correlation between MPD and SMTD.

$$MPD = 1.42 \times SMTD^{0.84}$$

Equation 2-2

British Standard BS EN ISO 13473-1:2004 (British Standards, 2004) provides the following correlation between MTD and MPD.

$$MTD = 0.2 + 0.8 \times MPD$$

Equation 2-3

Equation 2-2 and Equation 2-3 can be combined to provide Equation 2-4

$$MTD = 0.2 + 0.8 \times (1.42 \times SMTD^{0.84})$$

Equation 2-4

Equation 2-4 can be simplified and resolved to estimate the SMTD value expected from a surface for a given MTD value, Equation 2-5.

$$Estimated\ SMTD = \left(\frac{MTD - 0.2}{1.136}\right)^{\frac{1}{0.84}}$$

Equation 2-5

For clarity, estimations of SMTD based on MTD values will be referred to as E-SMTD.

To reduce the effect of hysteresis error in the relationship between SMTD and MTD, values of SMTD were estimated based on MTD measurements, but the reverse was not carried out.

3 Review of the proposed locked-wheel friction performance

The first stage in assessing the SIPT was to review the proposed level of high speed friction to be achieved. The SIPT states that the surfaces should be able to achieve a locked-wheel friction performance (L-Fn90) of >0.3 measured at 0, 12 and 24 months of service.

To assess the appropriateness of this value, the expected high speed friction measurement was calculated based on the in-service texture requirements outlined in IAN154 (Highways England, 2014) and the road pavement condition categories laid out in HD29/08 (Highways England, Transport Scotland, Welsh Government, The Department for Regional Development Northern Ireland, 2008). This approach ensures consistency throughout the Highways England policy with regards high speed friction performance.

IAN154 and HD29/08 provide in-service texture performance requirements, the equivalent expected L-Fn90 measurements were calculated using Equation 2-1, and where necessary Equation 2-5. A summary of this information is provided in Table 3-1.

Table 3-1 Summary of in-service texture performance and expected measured L-Fn90

		Texture depth requirement (mm)	Expected L-Fn90 measurement
IAN154	14mm TSCS	0.9 MTD (0.56 E- SMTD)	0.30
	10mm TSCS	0.8 MTD (0.47 E- SMTD)	0.27
	6mm TSCS	0.7 MTD (0.38 E- SMTD)	0.24
	CAUTS	1.0 MTD (0.66 E- SMTD)	0.33
HD29/08	Category 1 - Sound	>1.1 SMTD	>0.42
	Category 2 – Some deterioration	>0.8 SMTD	>0.36
	Category 3 – Moderate deterioration	>0.4 SMTD	>0.25
	Category 4 – Severe deterioration	<0.4 SMTD	<0.25

Based on this analysis the requirement of >0.3 L-Fn90 stated in the SIPT is considered appropriate. This level is very similar to that expected of a 14 mm TSCS meeting the texture depth requirement in IAN154 and lies between the values expected for surfacings between condition categories 3 and 2 in HD29. The value of 0.3 L-Fn90 is above that estimated for a 6 mm TSCS material meeting the IAN154 texture requirement, but this material type has the caveat that its high speed friction performance should be verified by direct measurement. This is because such materials have been shown to provide greater levels of high speed friction that would be predicted from their texture depth.

Even though a threshold of 0.3 L-Fn90 is an appropriate performance criterion it may not be reasonable to expect concrete surfaces produced using current techniques to be able to

reach this performance level. To ensure that this level of high speed friction is reasonable, the distribution of high speed friction measurements made on concrete surfaces was reviewed, see Figure 3-1.

Figure 3-1 shows the distribution of all high speed friction measurements made on concrete surfaces to date. Here it can be seen that for both un-treated and re-textured concrete there are measurements above the 0.3 unit threshold. The proposed threshold corresponds to the 72nd percentile for un-treated concrete surfacings and the 75th percentile for re-textured concrete.

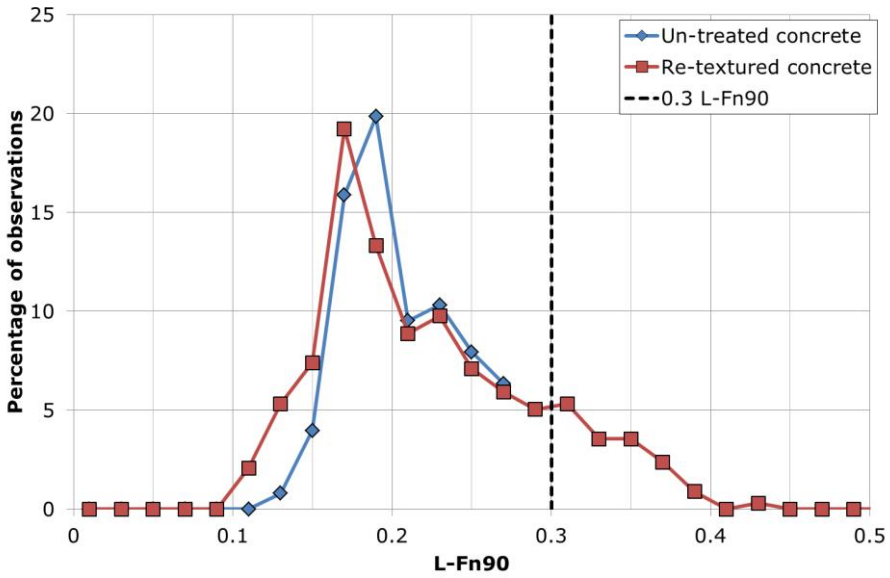

Figure 3-1 Distribution of L-Fn90 values on concrete surfaces

Based on this analysis it is reasonable for a concrete surface in good condition to provide an L-Fn90 value >0.3.

4 Review of the proposed macrotexture performance

The aim of this chapter is to assess the macrotexture requirements in the SIPT; this will be achieved by comparing the requirement to the initial texture depth requirements in IAN154 and comparing the expected high speed friction performance with the 0.3 requirement stated in the previous chapter. This approach ensures that the requirements are in line with those required of other surfacings and that the SIPT is internally consistent.

The SIPT stipulates that the texture depth before the road is opened to the public should be 1.0mm MTD (for the average of 10 measurements) with a tolerance of +0.25 mm and -0.35mm MTD. The minimum initial texture depth for asphalt roads, again for the average of 10 measurements, given in IAN154 is 0.9mm MTD. Table 4-1 summarises the texture depth requirements in the SIPT, and the minimum requirement stated in IAN154. The values of texture depth have been presented in terms of E-SMTD and the expected high speed friction measurement.

Table 4-1 Summary of initial texture depth performance and expected measured L-Fn90

MTD (mm)	E-SMTD (mm)	Expected L-Fn90 measurement
0.65	0.33	0.23
0.90	0.56	0.30
1.00	0.66	0.33
1.25	0.91	0.39

Table 4-1 shows that the lower bound presented in the SIPT of 0.65mm MTD is not likely to provide a L-Fn90 of greater than 0.3. Furthermore this level is 0.25mm below that expected of the lowest value presented in IAN154. Based on these findings it would be pertinent to amend the tolerance in the SIPT to allow surfaces an initial texture depth of 1mm MTD +0.25 mm and -0.10 mm.

Amending the tolerance in this way would bring the lower band up to 0.90 mm, the minimum requirement stated in IAN154, and a value which should provide an L-Fn90 of 0.30. To identify if this is a reasonable performance level for concrete surfaces a similar analysis to that carried out in Chapter 3 was performed. Highways England's pavement management system (HAPMS) was queried to access the most recent TRAffic-speed Condition Survey (TRACS) information for the Highways England network. This provided the most recent texture depth values for all concrete surfaces on the network. These values were grouped into un-treated and re-textured concrete surfaces and used to create the distributions shown in Figure 4-1.

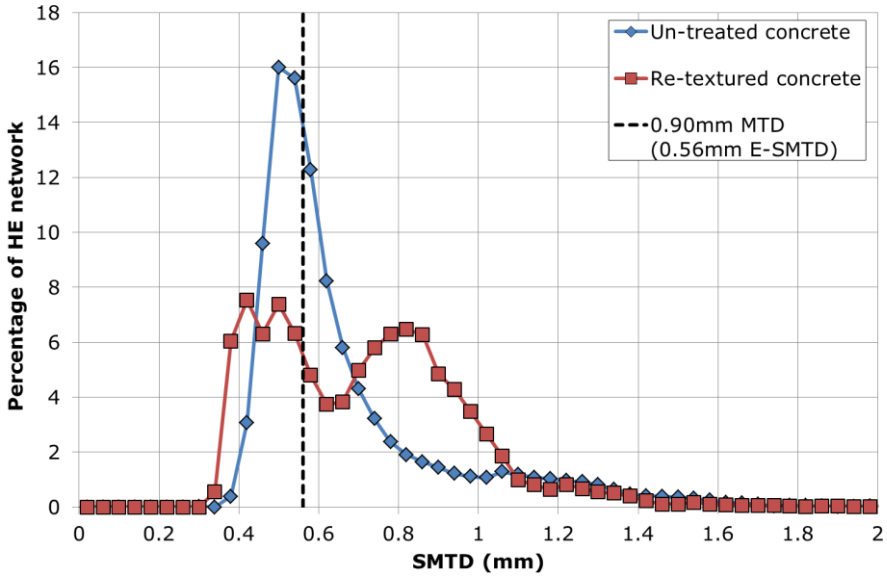

Figure 4-1 Distribution of SMTD values for concrete surfaces

Figure 4-1 shows a substantial number of measurements above the 0.56mm E-SMTD threshold. This threshold corresponds to the 45th percentile for un-treated concrete and the 34th percentile for re-textured concrete. It is therefore reasonable to expect the majority of newly laid concrete surfaces to reach the 0.90mm MTD threshold.

It is interesting to note that the number of measurements above the high speed friction threshold was lower than the number above the texture threshold. Based on the texture and friction relationship it would be expected that the number of measurements above both thresholds should be similar. It is a possibility that this difference has been introduced as the texture distributions were based on measurements of the whole network, whereas the friction distribution was based on measurements made on a much smaller number of sites selected for research purposes.

5 Conclusions

Based on the analysis reported in this document, the following amendments to the current SIPT process are recommended:

- TABLE 10/8: (11/03) Macro texture Depths:
    - The tolerance for the required macrotexture depth measured between 24 hours and 7 days after the construction of the slab or until the slab is first used by vehicles be amended to +0.25MTD, - 0.10MTD.
    - The tolerance for the required macrotexture depth measured not later than 6 weeks before the road is opened to public traffic be amended to +0.25MTD, -0.10MTD.

No other changes to the SIPT are recommended at this stage.

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