Scottish Road Research Board

# SETTING APPROPRIATE SENSOR MEASURED TEXTURE REQUIREMENTS

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CONFIDENTIAL

Scottish Road Research Board

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# SETTING APPROPRIATE SENSOR MEASURED TEXTURE REQUIREMENTS

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# EXECUTIVE SUMMARY


The texture depth of a road surface is a key property that contributes to road traffic safety and influences other factors such as noise, ride quality and durability. Currently, the texture depth of a road is measured by hand when it is newly laid and by a vehicle equipped with lasers when it is in service. Research in the UK is currently in progress to harmonise the measurement of the texture depth when new and in service. The key benefits of this initiative include the optimisation of future surface texture specifications and removing the need for road technicians to work near live traffic.

As part of the above proposal, it has been proposed that the current laser-based measurement, Sensor Measured Texture Depth (SMTD), be replaced by the measurement of Mean Profile Depth (MPD). The latter is recognised to have a broad relationship with the existing manual method and is an international ISO standard, which permits direct comparisons with other countries. Transport Scotland is interested in adopting the proposed approach and commissioned WSP to provide advice on adopting MPD to estimate texture depth. The study involved examining profile and texture data collected from the Scottish Trunk Road network to understand the relationship between SMTD and MPD, and how the latter measure, if adopted, would affect the categorisation of the network in terms of maintenance thresholds associated with safety.

Based on the analysis of dataset that comprised texture data gathered over 4,563 lane km of the Scottish trunk road network, the key conclusions were as follows:

- A general linear relationship exists between SMTD and MPD for all the material types, particularly in the SMTD texture range of 0 to 1.5mm.
- The relationship is dependent on surface type.
- A single relationship, weighted to the proportion of each surface type present, could be used to move from the use of SMTD to MPD.
- An exercise to assess the impact of moving from SMTD to MPD as a measure of texture depth indicated that an additional 271km of road surfacing would be categorised as Amber. These sections would be added to Transport Scotland's site ranking score and be considered along with friction (SCRIM) and accident data to determine whether any corrective action would be required.
- A comparison with similar data collected by National Highways showed that the relationship between SMTD and MPD was similar but that the ratio or slope of the line was found to be greater in the NH study. Likely factors affecting the observed difference include the fact that Scottish materials possess different surface characteristics and that higher trafficking levels are experienced in England.

It is recommended that prior to adopting MPD, its use should be assessed within Transport Scotland's current skid policy. Initial indications suggest that the proposed conversion factor from SMTD to MPD is likely to result in a more conservative approach to assessing the risk of skidding accidents.



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# 1

# INTRODUCTION

# 1. INTRODUCTION

Texture depth or macrotexture are terms used to describe the profile of a road surface at a millimetre scale. Texture depth contributes to removing water at the interface between the tyre and surface, and supports the generation of skid resistance at high speeds. Texture depth can also influence material durability, rolling resistance and road noise. Ideally, texture depth needs to be optimised to produce a road surface that is quiet, smooth, safe, and durable.

Traditionally, for acceptance purposes, the texture depth of a new surface coarse has been measured using the Volumetric Patch Test (VPT) described in BS EN 13036-1[1]. The test involves spreading a measured volume of glass beads into a circle on a road surface and calculating the average depth. In contrast, the in-service texture depth is measured using a laser-based system that currently calculates Sensor Measured Texture Depth (SMTD), which is used to monitor performance and assess any maintenance requirements. As these two measurement systems differ, it is difficult to optimise specifications as it is unclear how changing the requirement on new surfaces will affect in-service performance. It is also recognised that the VPT method provides a limited assessment of the length and width of a newly paved surface, and requires technicians to work near live traffic. There is therefore a desire to replace the VPT method with a laser-based contactless method.

Following recent research on transitioning from VPT to a laser-based alternative[2], National Highways (NH) have proposed the measurement of Mean Profile Depth (MPD). Both MPD and SMTD are measurements calculated from raw texture (laser-based) profile. It was decided to use the MPD as it has a broad relationship with VPT and is an international ISO standard measurement[3]. As a result, levels of MPD have been suggested for new roads, and the long-term aim is to also measure MPD on in-service roads. Transport Scotland is interested in adopting the same approach. However, it is important that the proposed MPD values are also appropriate for surface coarse materials used in Scotland. In certain instances, Transport Scotland control high and low speed surface friction in a different way and in general use different, lower textured, materials.

## 1.1. BRIEF

The aim of the study is to analyse profile and texture data collected from the Scottish Trunk Road Network to understand the implications of transitioning to MPD. The work includes examining comparisons of SMTD and MPD at both a network and material type level, including Cl942 Thin Surfacing, TS2010 and HRA. An examination of data is also required to assess the impact of transitioning to MPD, rather than SMTD, with respect to how the new measure might affect the categorisation of the network in terms of maintenance thresholds.

[1] BS EN 13036-1. Test methods - Measurement of pavement surface macrotexture depth using a volumetric patch technique (BSI, 2010)
[2] Initial Investigation into the Effect of Transitioning to MPD, Unpublished report, TRL, 2020.
[3] ISO 13473-1. Characterization of pavement texture by use of surface profiles. Part 1: Determination of mean profile depth (ISO, 2019).

# 2

# TEXTURE MEASUREMENTS

# 2. TEXTURE MEASUREMENTS

## 2.1. MANUAL VOLUMETRIC PATCH TEST (VPT)

This simple volumetric measurement technique consists of spreading a known volume of material on the surface of a pavement and measuring the area covered. The mean texture depth is then calculated by dividing the volume by the area. Originally sand was used but this has been replaced by glass spheres which have a more regular shape. The main advantage of the test method is that it is simple to carry out. However, limitations include the fact that the test is carried out over a relatively short section of the pavement and may not be representative of the entire paved surface. In addition, it is a slow process and potentially dangerous as it requires technicians to work near live traffic.

## 2.2. TRAFFIC SPEED CONDITION SURVEYS

Over the last 30 years, traffic speed condition surveys have been developed to collect information up to 100 km/h. The vehicles are equipped with lasers, video image collection, inertial and GPS apparatus. In Scotland, traffic-speed surveys are carried out using the Surface Condition Assessment of the National Network of Roads (SCANNER)[4].

### 2.2.1. SCANNER surveys

Transport Scotland commission annual SCANNER surveys of their network. WDM are the current survey contractor and condition data is collected from Lane 1 of the Trunk Road network using their Road Assessment Vehicle (RAV), which is shown in Figure 2-1. This accredited SCANNER survey vehicle collects images and laser profile data and the raw data is converted into a range of condition parameters including texture depth.


**Figure 2-1 - RAV survey vehicle[5]**

[4] Technical Requirements for SCANNER Survey Parameters and Accreditation [UK Roads Board, 2009]
[5] Road Assessment Vehicle [WDM]

## 2.3. LASER-BASED TEXTURE INDICATORS

Both SMTD and MPD are indicators of texture depth along the length of a pavement. This section provides some background information on how they are calculated from raw laser-based measurements and how the relationship between the two is complex.

### 2.3.1. Collection of SMTD and MPD

As stated in the introduction, SMTD is currently used in the UK to monitor the texture of in-service pavements and is used to define various condition categories in terms of deterioration[6]. Although available as an output from laser-based surveys, MPD is not generally used but it is recognised as the most commonly applied measure of texture depth internationally[3].

Both measurements are based on laser-based profile data that is collected in a single line located in the nearside wheelpath. In addition, it should be noted that many systems are also capable of measuring in the centre of the lane and the offside wheelpath. Research is ongoing to determine whether the latter can be used to identify defects associated with general road surface deterioration[7].

As the vehicle moves along the road the sensors measure changes in vertical height to the road surface, due to the surface texture. Measurements are recorded at short intervals, typically 1mm spacing. However, the raw data requires to be processed and filtered dependent on the required means of reporting. The different algorithms used to calculate SMTD and MPD are described below.

### 2.3.2. Processing SMTD and MPD

Prior to reporting SMTD or MPD, algorithms are used to process the laser measurements collected by the survey vehicle. Processing of the data typically includes the following:

- Evaluation over calculation length
  - Data is split into 300mm lengths for SMTD and 100mm for MPD.
- Filtering
  - A best-fit parabolic trend curve is applied to each 300 mm SMTD evaluation length.
  - The slope of each 100mm MPD segment is suppressed by subtracting a linear regression of the segment, providing a zero mean profile.
- Height calculation
  - The standard deviation is calculated using the deviations of the texture profile from the SMTD trend curve (see Figure 2-2).
  - The height is determined as the arithmetically averaged two peak levels minus the average MPD profile level (see Figure 2-3).
- Aggregation to longer length
  - In both cases the average texture height for all evaluation lengths within each 10m length are calculated.

[6] CS 230 Pavement maintenance assessment procedure [DMRB]
[7] Developing a Road Condition Indicator for Fretting. PPR911 [E Benbow et al, 2018]

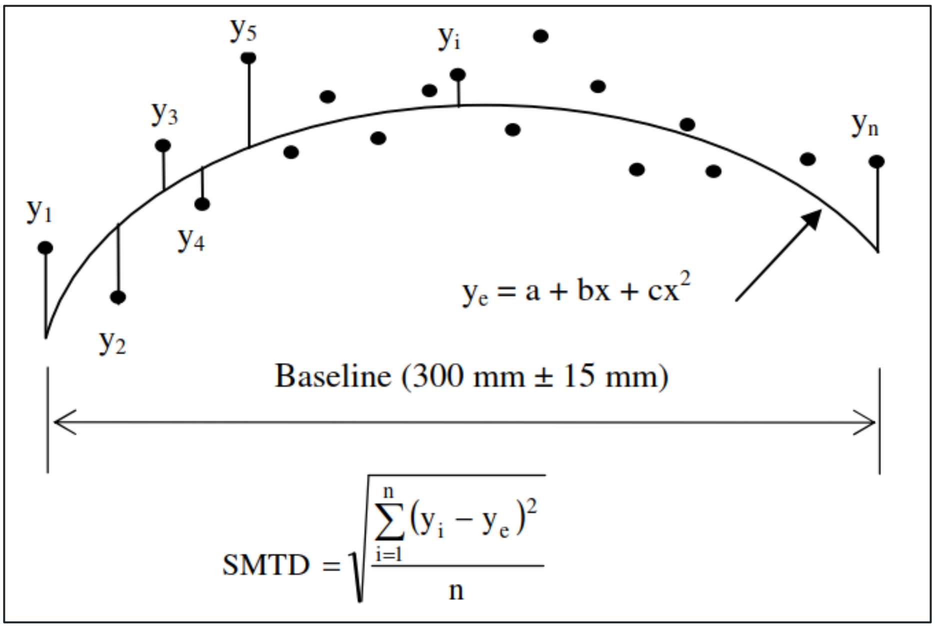
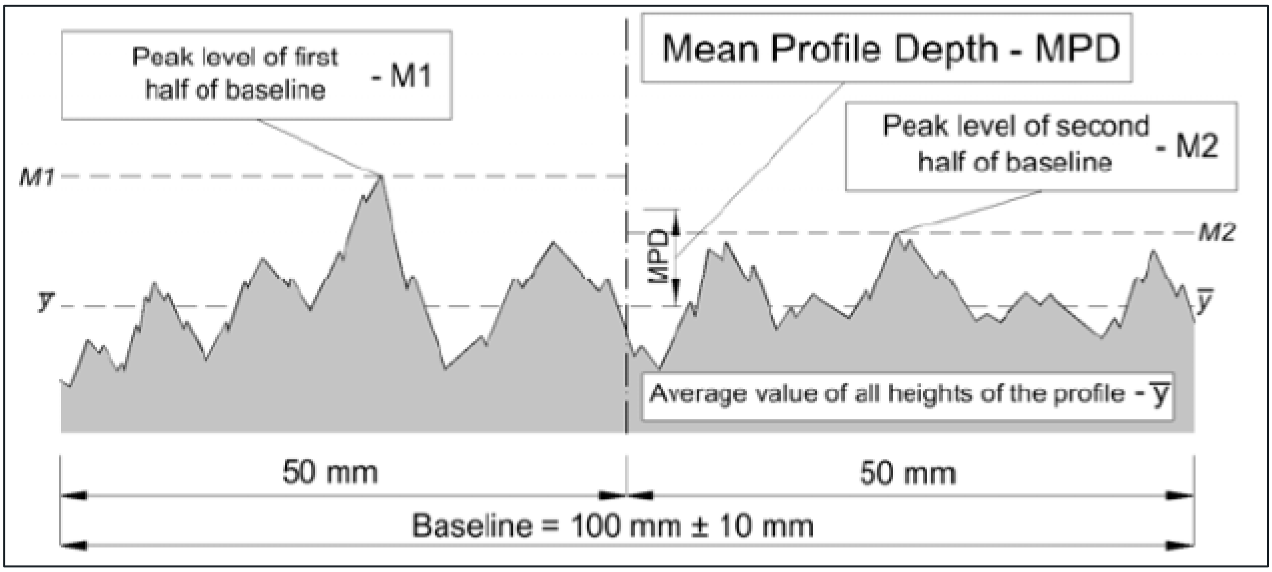



**Figure 2-2 - Principle of SMTD calculation[8]**




$$Mean\ Profile\ Depth\ (MPD) = \frac{Peak\ Level\ (M1) + Peak\ Level\ (M2)}{2} - Average\ Value\ (y)$$

**Figure 2-3 - Principle of MPD calculation[9]**

### 2.3.3. Differences between SMTD and MPD

The difference between the two measures is in the way the height of the texture is estimated, with the SMTD comprising a root mean square measure and the MPD a measure of the highest peak

[8] Analysis of Test Methods for Texture Depth Evaluation Applied in Portugal [E Freitas *et al*, 2008]
[9] Conventional and Non-Conventional Equipment for Pavement Surface Macrotexture Measuring [M Kovac *et al*, 2015]

above the mean level. It has been reported[10] that the two measures are influenced by the type of road surface, particularly the shape of the surface and this is illustrated in Figure 2-4. The figure contains two hypothetical surface shapes: the top surface has sharp peaks and the bottom surface has more rounded and flatter peaks. The figure illustrates that the SMTD may be quite different from the MPD.

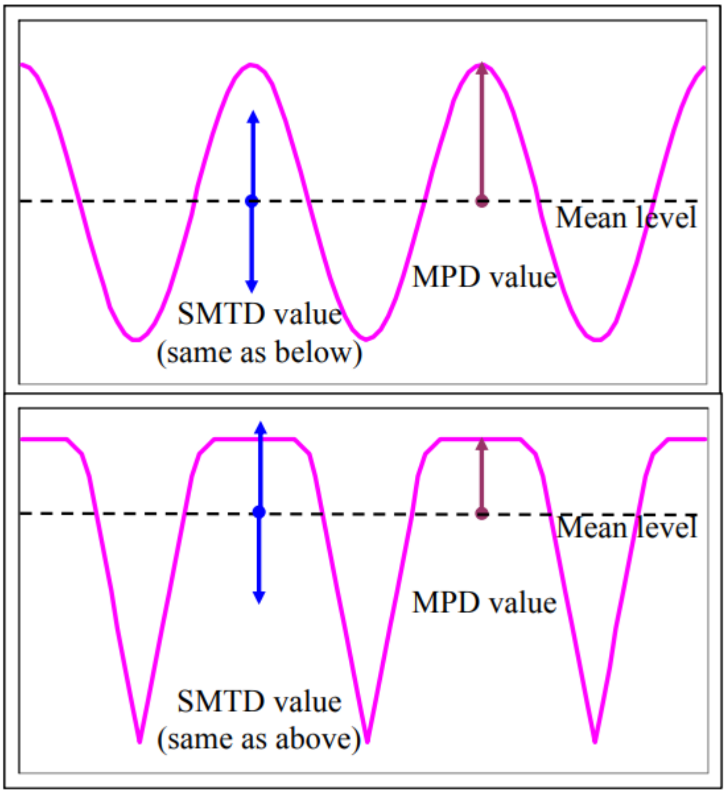



**Figure 2-4 - Effect of surface shape on SMTD and MPD[10]**

[10] Surface texture measurement on local roads. Published Project Report PPR148 [H Viner et al, 2006]

# 3

# DATA ANALYSIS

# 3. DATA ANALYSIS

## 3.1. DATASET

SCANNER survey data collected on the Scottish trunk road network in 2020/21 was processed to obtain SMTD and MPD values. The dataset comprised texture data gathered over 4,563 lane km of surfacing and the SMTD and MPD were reported in 10m averages. Table 3-1 provides a summary of the surface type and what proportion of the dataset it represented.

**Table 3-1 – SMTD and MPD dataset**

| Surface Designation | Length (Km) | Proportion of total dataset |
|---|---|---|
| Surface Course Clause 942 – 6mm | 71.8 | 1.6% |
| Surface Course Clause 942 – 10mm | 1,313.3 | 28.8% |
| Surface Course Clause 942 – 14mm | 1,424.5 | 31.2% |
| | | |
| Surface Course TS2010 – 6mm | 89.4 | 2% |
| Surface Course TS2010 – 10mm | 1,346.2 | 29.5% |
| | | |
| HRA | 318.0 | 7% |
| | | |
| **Total** | 4,563.2 | 100% |

## 3.2. SMTD & MPD COMPARISON

As described in section 2, SMTD and MPD estimate texture depth in a different way. Figure 3-1 represents a random 10km section of 6mm Clause 942 material and is based on 100m averaged data. It can be seen that the measures display similar trends but the difference in values changes over the length of the selected section. For example, it can be seen that the values are aligned for the first 3km (chainage 30-33km) but thereafter the MPD generally produces a higher estimate of texture.

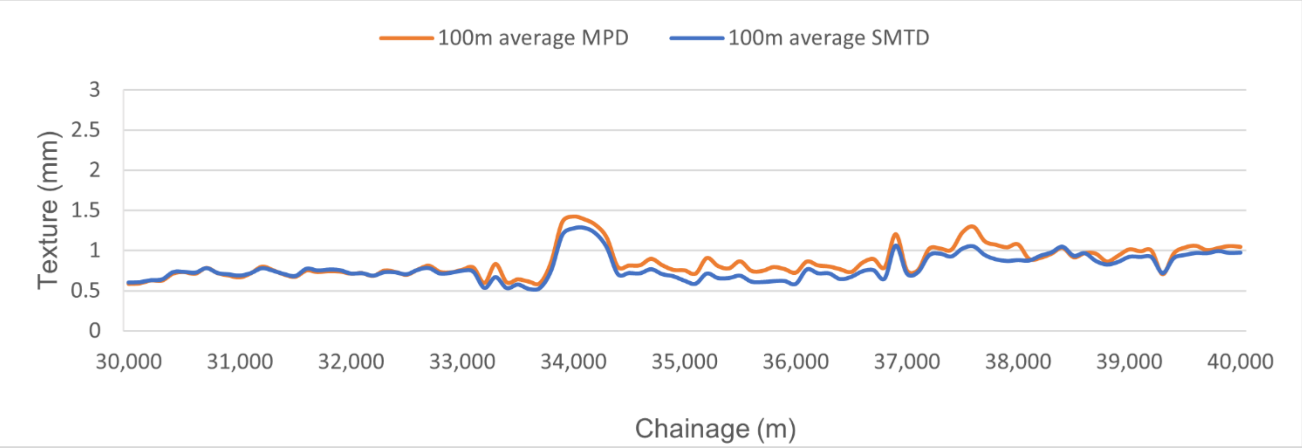



**Figure 3-1 - Example of difference between SMTD and MPD**

### 3.2.1. SMTD versus MPD for all materials combined

Figure 3-2 compares the SCANNER values of SMTD and MPD for the six surfacing materials tested, i.e. the whole 4,563 km dataset. The graph contains a significant number of data: 456,311 points (10m average), represented by the blue dots; and 45,631 points (100m average) in orange. A general linear relationship appears to be present and there is less scatter when the 100m average values are used. If a line of best fit, which is forced through zero, is applied, then the slope of the line is around 1.096 (10m average) and 1.094 (100m average). A visual inspection suggests the data points cease to be linear at higher SMTD texture depths and they appear to curve upwards from around 1.5mm. As the figure represents a very dense point cloud (0.5M points) and contains six different material types, it seems sensible to look at the spread of data and further examine the SMTD and MPD relationship for individual material types.

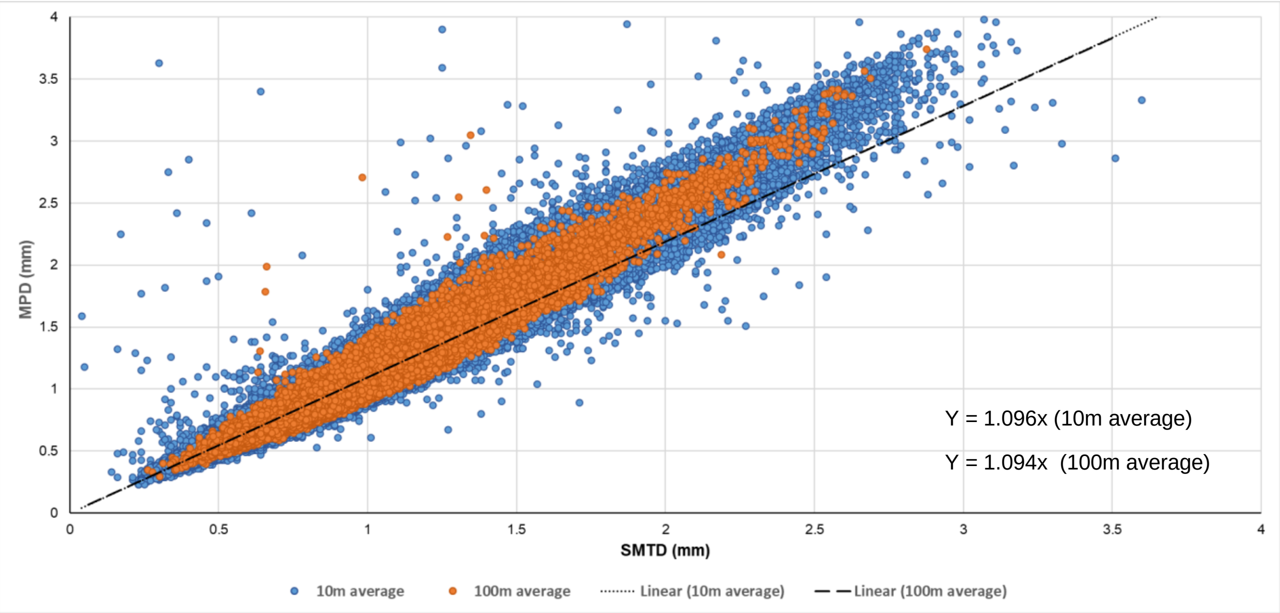



**Figure 3-2 - SMTD v MPD for total dataset**

A cumulative distribution of the data was carried out to ascertain the overall frequency of texture values and the results are shown in Figure 3-3. The chart shows that 93.2% of the SMTD values are less than 1.5mm. This is not obviously clear from Figure 3-2 owing to the density and scatter of data points.

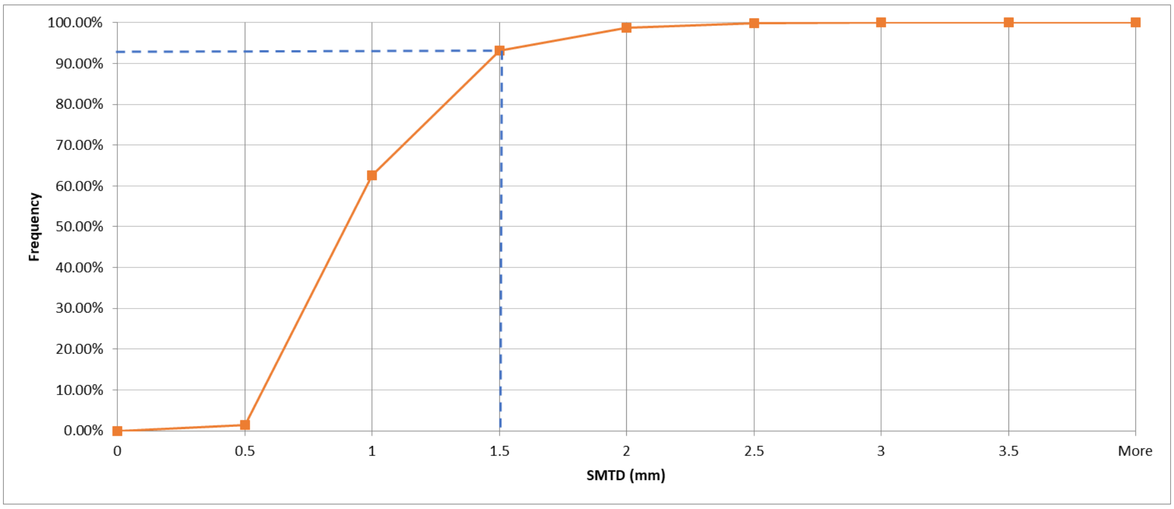



**Figure 3-3 - Cumulative distribution of data points**

### 3.2.2. SMTD versus MPD for individual surface types

Figure 3-4 shows a comparison of SMTD and MPD for all the 100m average data for HRA, which is the only positive textured material. It can be seen that the slope of the line increases from the average of all data 1.094 to 1.146 for HRA.

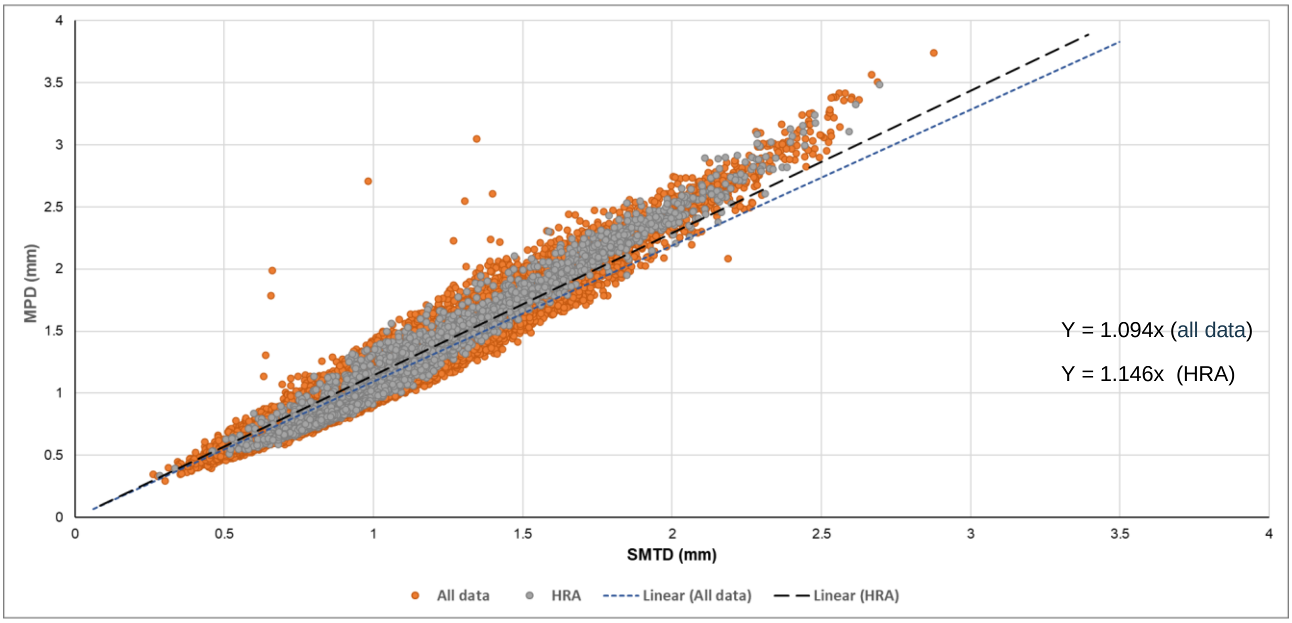



**Figure 3-4 - SMTD v MPA on HRA**

Plots for all the material types are shown in Appendix A (A-1 to A-7). Figure 3-5 shows the gradients achieved for each material type, which range from 1.069 to 1.146.

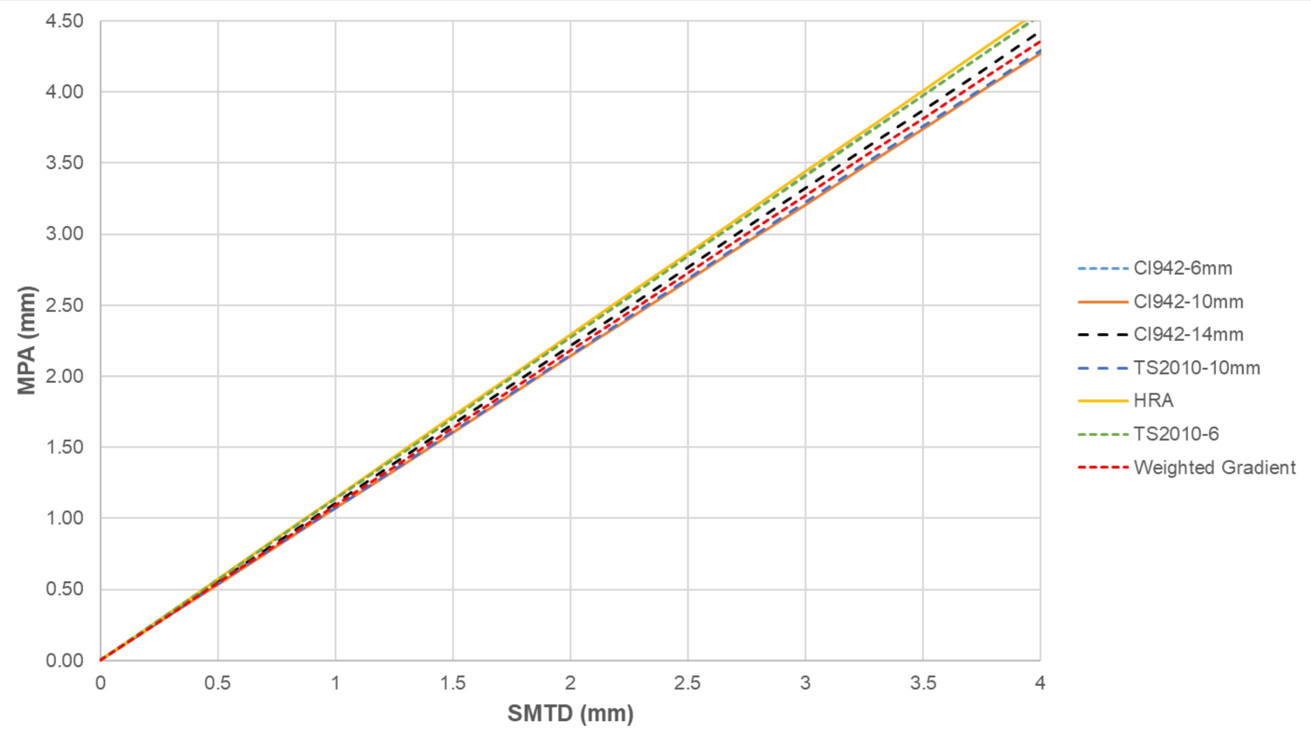



**Figure 3-5 - Linear relationships (SMTD v MPD) for surface types**

**Table 3-2 – Summary of relationships for different surface types**

| Surface Designation | Length (Km) | Dataset proportion | Gradient | Text type |
|---|---|---|---|---|
| Surface Course Clause 942 – 6 mm | 71.77 | 2 | 1.137 | -ve |
| Surface Course Clause 942 – 10 mm | 1,313.25 | 29 | 1.069 | -ve |
| Surface Course Clause 942 – 14 mm | 1,424.50 | 31 | 1.107 | -ve |
| Surface Course TS2010 – 6 mm | 89.39 | 2 | 1.136 | -ve |
| Surface Course TS2010 – 10 mm | 1,346.16 | 30 | 1.074 | -ve |
| HRA | 318.04 | 7 | 1.146 | +ve |
| Average gradient | | | 1.112 | |
| Weighted average gradient | | | 1.090 | |

Table 3-2 summarises the relationships obtained from the different surfacing types examined. The weighted gradient was calculated using the proportion of data that each surface type contributed to the total dataset and is also shown in Figure 3-5.

### 3.2.3. SMTD values less than 1.5mm

In a similar study carried out for National Highways[2] it was observed that more than 90% of SMTD values collected on the English network fell below 1.5mm. Likewise, the Scottish data collected in this study (Figure 3-3) showed that 93.2% of the SMTD values collected were less than 1.5mm. As the relationship between SMTD and MPA changes beyond 1.5mm, i.e. it shows a slight upward curve, or non-linear relationship, it was decided to examine the relationship between 0 and 1.5mm.

Plots for the entire dataset and all the material types for SMTD values less than 1.5mm are shown in Appendix B (B-1 to B-7). Figure 3-6 shows the respective gradients achieved for each material type. Although similar to Figure 3-5, the gradient range has reduced from 1.045 to 1.100. The latter reflects the closer relationship between SMTD and MPA when SMTD values of less than 1.5mm are used.

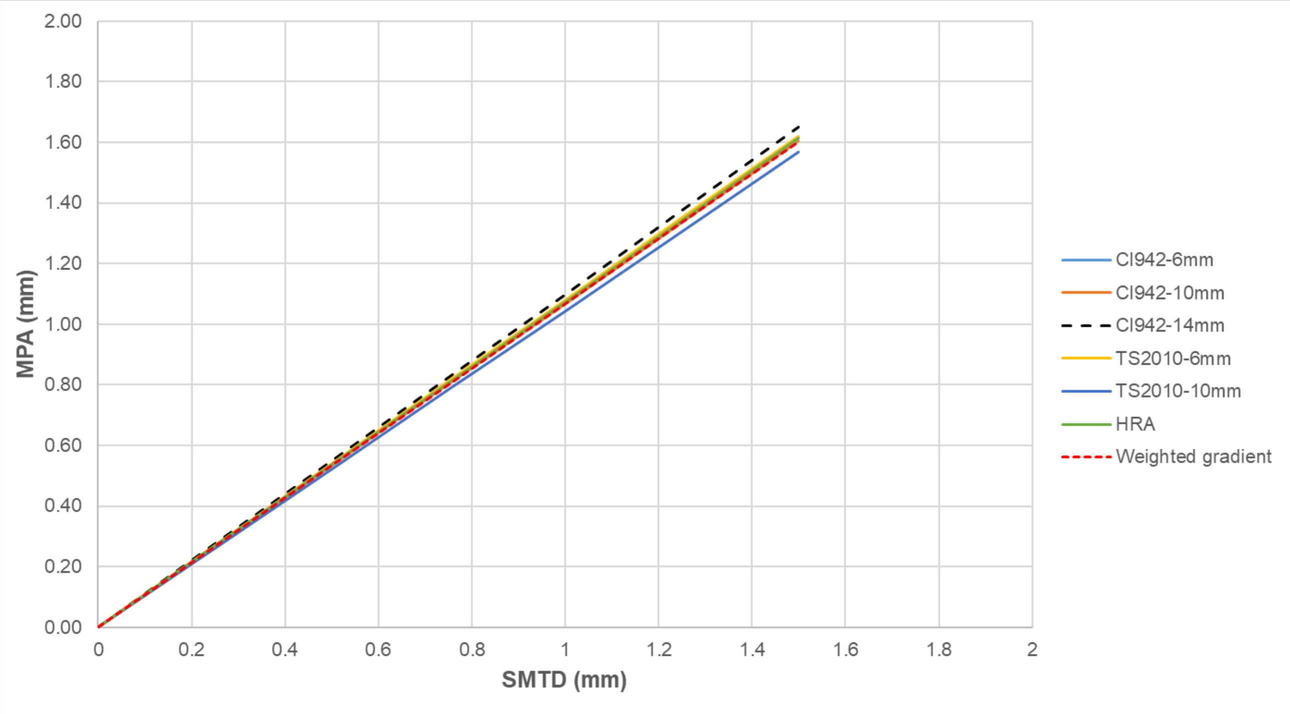



**Figure 3-6 - Gradients for material types for SMTD less than 1.5mm**

Table 3-3 summarises the revised relationships obtained from the different surfacing types when only SMTD < 1.5mm was used, i.e. the lengths exclude any 100m section that contains SMTD ≥ 1.5mm. The weighted average gradient of 1.068 is also shown on Figure 3-6.

**Table 3-3 - Summary of relationships for different surface types (SMTD < 1.5mm)**

| Surface Designation | Length (Km) | Dataset proportion | Gradient | Text type |
|---|---|---|---|---|
| Surface Course Clause 942 – 6 mm | 70.29 | 2 | 1.077 | -ve |
| Surface Course Clause 942 – 10 mm | 1261.93 | 30 | 1.056 | -ve |
| Surface Course Clause 942 – 14 mm | 1282.61 | 30 | 1.100 | -ve |
| Surface Course TS2010 – 6 mm | 80.68 | 2 | 1.081 | -ve |
| Surface Course TS2010 – 10 mm | 1293.73 | 30 | 1.045 | -ve |
| HRA | 251.43 | 6 | 1.075 | +ve |
| Average gradient | | | 1.072 | |
| Weighted average gradient | | | 1.068 | |

## 3.3. IMPACT ON MAINTENANCE ASSESSMENT

Transport Scotland use SCANNER texture depths (SMTD) for maintenance assessment reasons to define the condition of surfaces on the network. Table 3-4 shows the current criteria for surfaces, excluding high friction surfaces, and is based on the SNAA of CS 230[6].

**Table 3-4 – Condition categories for SCANNER texture measurements**

| Condition category | Definition | Texture depth (mm) |
|---|---|---|
| **Green** | Sound – negligible deterioration | >0.7mm |
| **Amber** | Some to moderate deterioration | 0.4mm< [SMTD] ≤0.7mm |
| **Red** | Moderate to severe deterioration | ≤0.4mm |

The two weighted average gradients for SMTD and MPD have been used to assess the impact of adopting MPD in preference to SMTD. It would be preferable if one of these single relationships could be used, rather than by surface type. Table 3-5 presents the proposed thresholds for MPD using the two weighted average gradients, i.e.: 1) all data; and 2) less than 1.5mm. This essentially means that the SMTD criteria (0.7mm & 0.4mm) have been multiplied by 1.09 and 1.068, respectively, and rounded to two decimal places.

**Table 3-5 – Proposed thresholds for MPD**

| Condition category | SMTD (mm) | MPD1 (mm) | MPD2 (mm) |
|---|---|---|---|
| **Green** | >0.7mm | >0.76mm | >0.75 mm |
| **Amber** | 0.4mm< [SMTD] ≤0.7mm | 0.44mm< [MPD] ≤0.76mm | 0.43mm< [MPD] ≤0.75mm |
| **Red** | ≤0.4mm | ≤0.44mm | ≤0.43mm |

### 3.3.1. Comparison Matrix

Comparison matrices can be used to assess the effect of adopting MPD rather than SMTD for the two different relationships observed. Table 3-6 has been created as an example of a comparison matrix and how it can be used.

**Table 3-6 – Example of comparison matrix**

| | | SMTD | | |
|---|---|---|---|---|
| | Category | Green | Amber | Red |
| MPD | Green | **80%** | 5% | 5% |
| | Amber | 20% | **90%** | 15% |
| | Red | 0% | 5% | **80%** |

The example matrix shown in Table 3-6 shows the proportion of 100m average lengths reported in each category if the MPD thresholds were used rather than the SMTD values. For example, the first column titled Green, the 80%, 20%, 0% scores mean the following:

- 80% - Using MPD values and the MPD thresholds, only 80% of the 100m average lengths identified by SMTD would be classified as being in the Green condition category.
- 20% - Using MPD values and MPD thresholds, 20% of the 100m average lengths identified by SMTD as being in the Green category were classified Amber using MPD.
- 0% - neither SMTD nor MPD would have classified any 100m average length as being in the Red condition category using the thresholds for Green.

To obtain the data for the comparison matrix, three calculations were undertaken:

- Firstly, the SMTD and MPD 100 m average lengths were placed in columns and arranged by chainage.
- Secondly, each length was categorised into Green, Amber and Red using the current SMTD and the new proposed MPD thresholds shown in Table 3-5.
- Finally, the respective condition categories were directly compared to see whether they matched or were different and the proportions were calculated and reported.

It should be noted that the sum of each column adds up to 100% and the diagonal values, highlighted in red, are important as they report the largest value for each condition category. In an ideal scenario, where SMTD and MPD classified all the 100m lengths in the same condition category, each of these values would be 100%.

### 3.3.2. MPD performance using threshold based on all SMTD data

Table 3-7 shows the results if the MPD values were used with the threshold that was derived using the weighted average gradient of the total dataset; the latter produced MPD thresholds of 0.76mm and 0.44mm. In addition to using percentages, Table 3-7 also shows the lengths reported in each category. The latter has been used to highlight that although the performance can appear poor, the length classified is also important. For example, the 73.3% reported in the Red category only relates to 2.2km. The lengths reported in the table add up to the total dataset of 4,563km.

**Table 3-7 – MPD performance using threshold based on all SMTD data**

| | | SMTD (%) | | | | SMTD (km) | | |
|---|---|---|---|---|---|---|---|---|
| | Category | Green | Amber | Red | | Green | Amber | Red |
| MPD (% or km) | Green | **91.7%** | 7.1% | 0% | | **3,659.5** | 40.4 | 0 |
| | Amber | 8.3% | **92.9%** | 26.7% | | 330.6 | **529.7** | 0.8 |
| | Red | 0% | 0% | **73.3%** | | 0 | 0 | **2.2** |

### 3.3.3. MPD performance using threshold based on SMTD data less than 1.5mm

Table 3-8 shows the results if the MPD values were used with the threshold that was derived using the weighted average gradient of SMTD data less than 1.5mm; the latter produced MPD thresholds of 0.75mm and 0.43mm. Table 3-8 also shows the lengths reported in each category.

**Table 3-8 – MPD performance using threshold based on SMTD data less than 1.5mm**

| | | SMTD (%) | | | SMTD (km) | | |
|---|---|---|---|---|---|---|---|
| | Category | Green | Amber | Red | Green | Amber | Red |
| MPD (% or km) | Green | **93.2%** | 8.9% | 0% | **3,718.5** | 50.9 | 0 |
| | Amber | 6.8% | **91.1%** | 43.3% | 271.6 | **519.2** | 1.3 |
| | Red | 0% | 0% | **56.7%** | 0 | 0 | **1.7** |

# 4

# DISCUSSION

# 4. DISCUSSION

## 4.1. LINEAR RELATIONSHIP

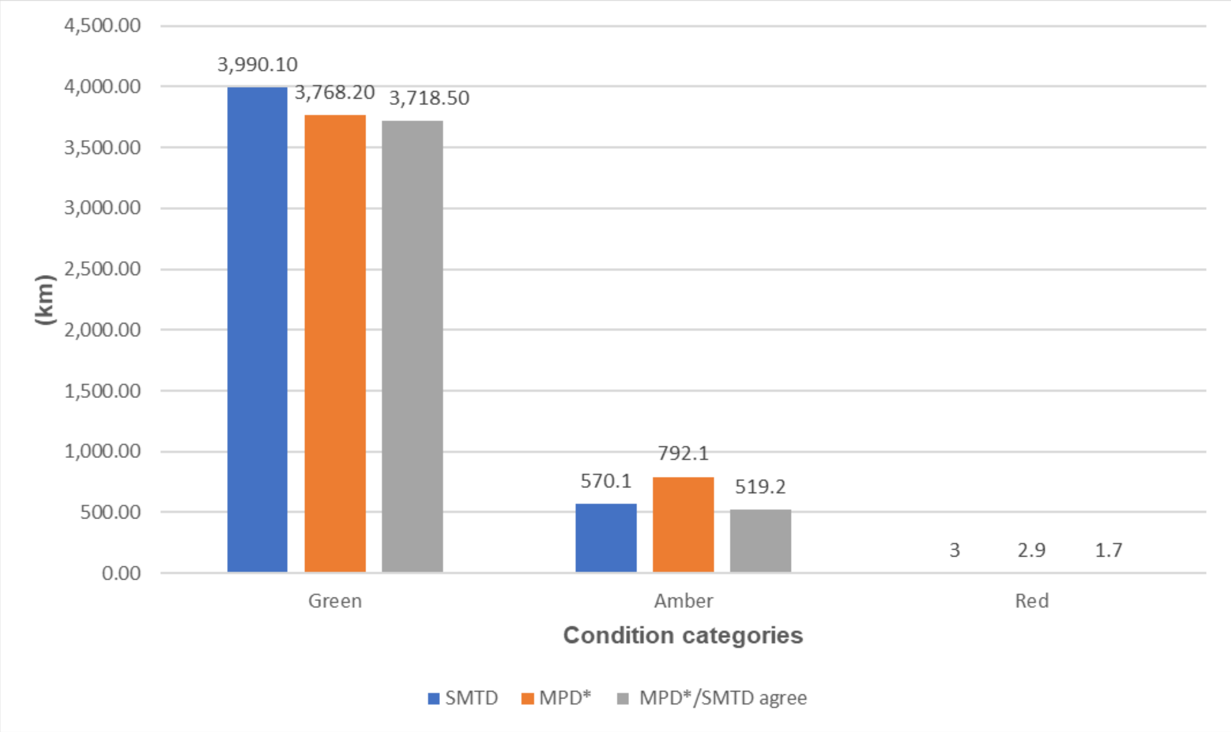
A general linear relationship appears to be present when comparing SMTD and MPD for all the material types, particularly at a texture range between 0 and 1.5mm. A visual inspection of the relationship for individual surface type suggests that the data points cease to be linear at higher SMTD texture depths and they appear to curve upwards from around 1.0 to 1.5mm. Detailed analysis of the data shows there are subtle variations dependent on surface type but the relationship exists for both negative and positive textured materials.

The cumulative distribution chart in Figure 3-3 highlights that 93.2% of all the SMTD values measured on the network are less than 1.5mm. The latter explains why some of the trendlines for graphs presented in Appendix A and Appendix B appear to be flatter than the data would indicate. The reason for this is mainly due to the density of data points between 0 and 1.5mm, i.e. data points will be stacked on top of each other. The latter has an influence on how the trendline is calculated and explains why the linear trendlines look slightly flat compared to if trendlines were estimated using the human eye, i.e., the latter would be placed at a steeper angle.

Linear relationships were determined using the individual material data sets using all the data and values less than 1.5mm. A weighted average gradient was adopted to reflect the proportions of different material that exist on the Scottish network. The two weighted average gradients were then used to convert the current SMTD condition category criteria for use with MPD. Dependent on the relationship used new thresholds for MPD were calculated. Using the data from the entire data set the existing (SMTD) threshold changed from 0.7mm to 0.76mm and from 0.4mm to 0.44mm. The dataset containing SMTD that was less than 1.5mm produced new MPA thresholds of 0.75mm and 0.43mm. Based on the analyses undertaken these increases appear sensible and reflect the general observation that, although SMTD and MPD estimate texture depth in a different way, MPD values generally produce higher estimates of texture. It also seems sensible to adopt the latter thresholds, based on less than 1.5mm SMTD, as the relationship is strongly linear in this range, particularly between 0mm and 1mm.

## 4.2. MAINTENANCE COMPARISON MATRICES

Comparison matrices were used to assess the impact of using MPD rather than SMTD. The main purpose of this exercise was to determine how MPD would categorise the condition of the network in terms of maintenance requirements when compared to SMTD. The performance of MPD compared to SMTD is examined in Table 3-7 and Table 3-8. Figure 4-1 summarises the lengths of surfacing identified as being in the Green, Amber and Red categories by SMTD, MPD and the lengths where they both agreed. It shows that currently SMTD places more lengths (3,990km) than MPD (3,768km) in the Green category. In contrast, the MPD places more lengths (792km) that SMTD (570km) in the Amber category. The lengths placed in the Red category by SMTD (3km) and MPD are both very small (2.9km).




**KEY**: *MPD performance using threshold based on SMTD data less than 1.5mm

**Figure 4-1 - Summary of identification of condition categories**

It can be seen that MPD classified 3,718.5km of surfacing as being in the same Green category as SMTD, i.e. 93.2% agreement. The remaining portion, 271.6km or 6.8%, was classified as Amber. In accordance with CS 230[6] this category is defined as having *some to moderate deterioration*. These sections would be added to Transport Scotland's site ranking score[11] and be considered along with friction (SCRIM) and accident data to determine whether any corrective action would be required.

The Red category which is defined in CS 230 as *moderate to severe deterioration*, is very small irrespective of the texture estimate used. The current SMTD method classifies 3km of surfacing in this category, whereas MPD classifies 2.2km and 0.8km in the higher Amber category.

## 4.3. COMPARISONS WITH OTHER COUNTRIES

The Office of Rail and Road (ORR) commissioned a study[12] to benchmark the condition of the National Highways (NH) network against Transport Scotland (TS), the Welsh Assembly (WA) and the Netherlands. The measurements of road surface condition included texture depth. For the UK networks, NH, TS and WA, texture depth was estimated using SMTD. In the Netherlands SMTD is not used and texture depth is reported as MPD. In order to compare texture depth with the Netherlands, a relationship based on SMTD and MPD measurements collected on surfacing in England was used. The data collected on the NH network produced a weighted gradient of 1.21 and was based on the relationship between SMTD and MPD on different surface types for SMTD values less than 1.5mm. Although the approach is similar to that adopted for this study, it should be noted

[11] Transport Scotland Interim Amendment 51/22 - Skidding Resistance [TSIA 51/22]
[12] Benchmarking the condition of highway networks [CPR4016]

that the NH sample was around five times larger (23,500km) and contained 16 different types of material, albeit Clause 942 and HRA were the dominant types.

The weighted gradient used to convert SMTD threshold values to MPD values in this study was 1.068, which is around 13% smaller than that used in the ORR study. One possible explanation for the difference in calculated gradients relates to the standard used to calculate MPD. The NH relationship utilised data that was processed in accordance with the 2019 ISO standard for the calculation of MPD[3], and it was noted that this produces different estimates of texture compared to the previous 2004 ISO standard. Work carried out by WSP in New Zealand[13] indicates that the difference between $MPD_{2004}$ and $MPD_{2019}$ is not linear, i.e. the difference is greater at low textures than high textures. A check was undertaken to establish what standard the Scottish SCANNER data was processed to and it was confirmed that the MPD values were calculated using the same standard as NH, i.e. ISO, 13473-2019.

A second plausible reason for the difference in relationships could be due to Scottish materials producing lower texture levels owing to their material components and configurations. It is recognised that certain materials, such as TS2010, are denser and produce different surface characteristics from some of the materials used on the NH network. The ORR report also contains some visible differences in histogram distributions for the UK networks. Nonetheless, it would be expected that texture levels for individual material types such as HRA would provide a similar relationship. For example, the average weighted gradient for HRA on the NH network was 1.24 and this compares to 1.08 for HRA on the Scottish network, which is 15% smaller. However, on closer examination of material specifications, it became evident that the HRAs were produced to different requirements. The HRA used on the NH network relates to Clause 943[14], and the HRA on the Scottish network relates to Clause 911TS[15]. The former relates to a mixture that contains a PmB to produce an enhanced resistance to deformation. Other factors that could influence the texture between the two HRAs include levels of trafficking, which are significantly higher on the NH network.

## 4.4. SKID POLICY

Texture depth forms part of Transport Scotland's skid policy and any decision to transition to MPD requires to be considered carefully. Accident studies show that the contribution of texture depth is complex and appears to be an important factor in some circumstances but not in others[10]. As such, it is recommended that texture depth should not be used in isolation as a surrogate for risk of skidding accidents. However, as a general rule, it is widely acknowledged that maintaining adequate levels of texture is essential where the measured skid resistance is low. The current study has not considered in detail how the application of MPD could affect the use of texture within the current skid policy. Yet, early indications suggest that the adoption of MPD may be more conservative as it categorised more of the network as Amber when compared to SMTD.

[13] Internal correspondence
[14] MCHW, 0900 Series (Cl. 943)
[15] MCHW, 0900 Series (Cl. 911TS)

# 5

# CONCLUSIONS

# 5. CONCLUSIONS

An examination of SCANNER data collected on the Scottish Trunk Road network was carried out to consider the implications of transitioning from SMTD to MPD. Based on various analyses, the following conclusions can be drawn:

- A general linear relationship exists between SMTD and MPD for all the material types, particularly in the SMTD texture range of 0 to 1.5mm.
- The relationship is dependent on surface type.
- A single relationship, weighted to the proportion of each surface type present, could be used to move to the use of MPD.
- An exercise to assess the impact of moving from SMTD to MPD as a measure of texture indicates that the transition could be relatively smooth.
- The study suggests that the adoption of MPD may be more conservative in categorising texture for maintenance intervention compared to SMTD.
- A comparison with similar data collected by NH showed that the relationship between SMTD and MPD was similar but that the ratio or slope of the line was found to be greater in the NH study.
- As the relationship is seen to be dependent on surface type, the most plausible explanation is that Scottish materials produce different surface characteristics. Higher trafficking levels experienced in England could also be a contributing factor.
- It is recommended that prior to adopting MPD, its use should be assessed within current skid policy. Initial indications suggest that the use on MPD may result in a more conservative approach to assessing the risk of skidding accidents.

# Appendix A

## - SMTD V MPD PLOTS

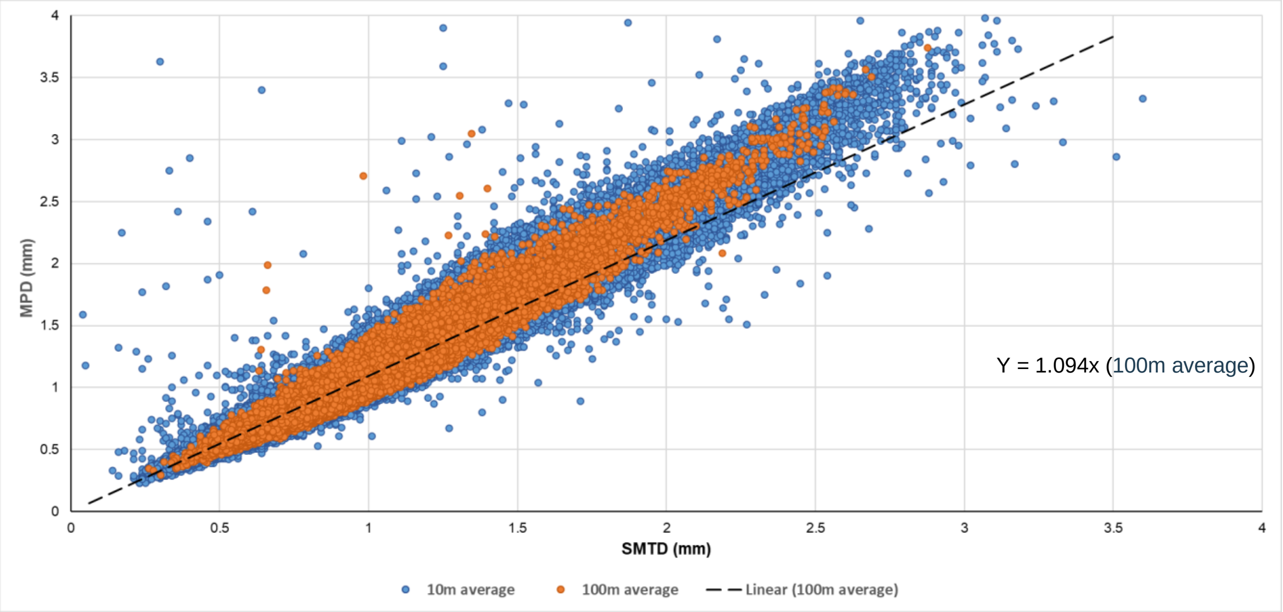



**Figure A-1 - All data**

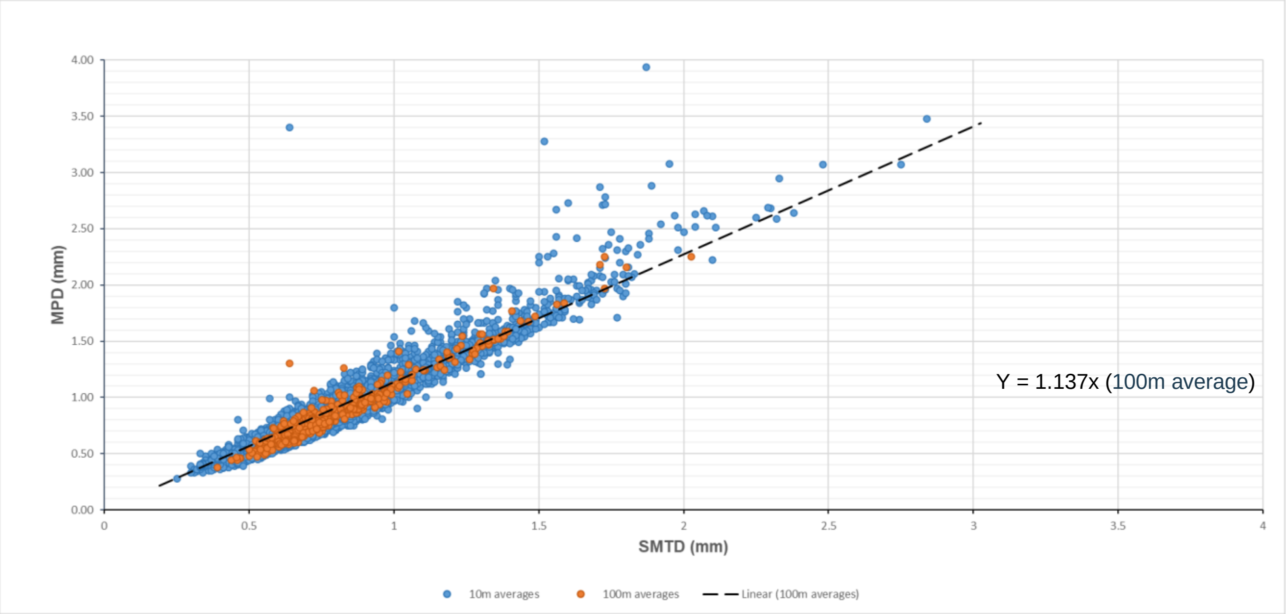



**Figure A-2 - Cl942 - 6mm**

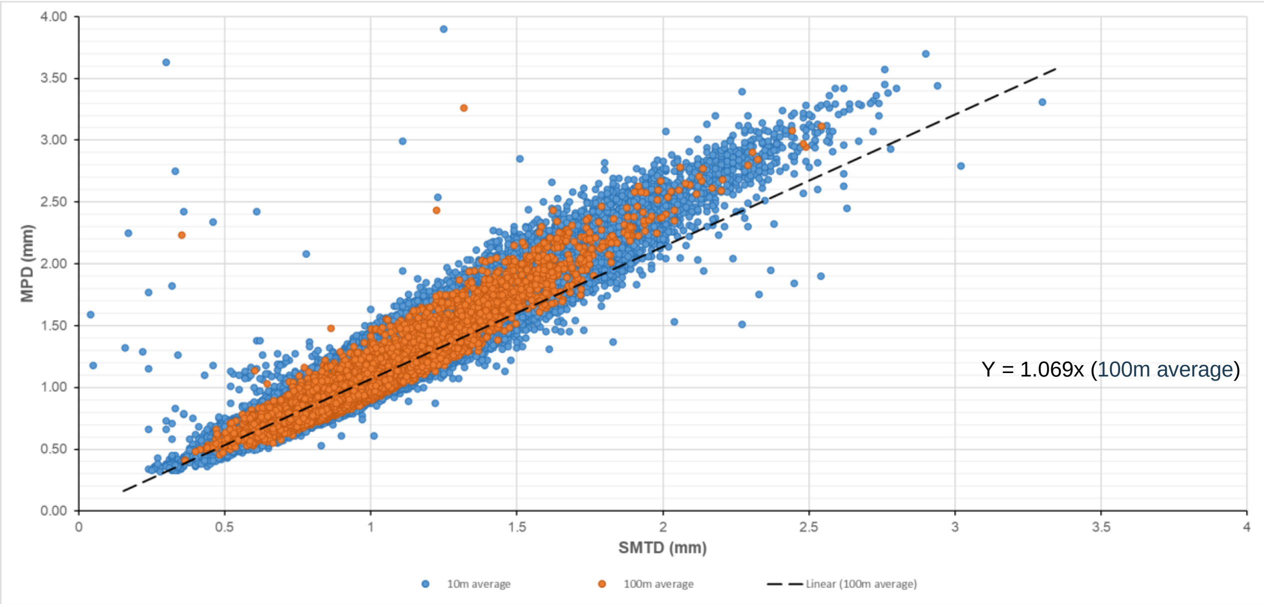



**Figure A-3 - Cl942 - 10mm**

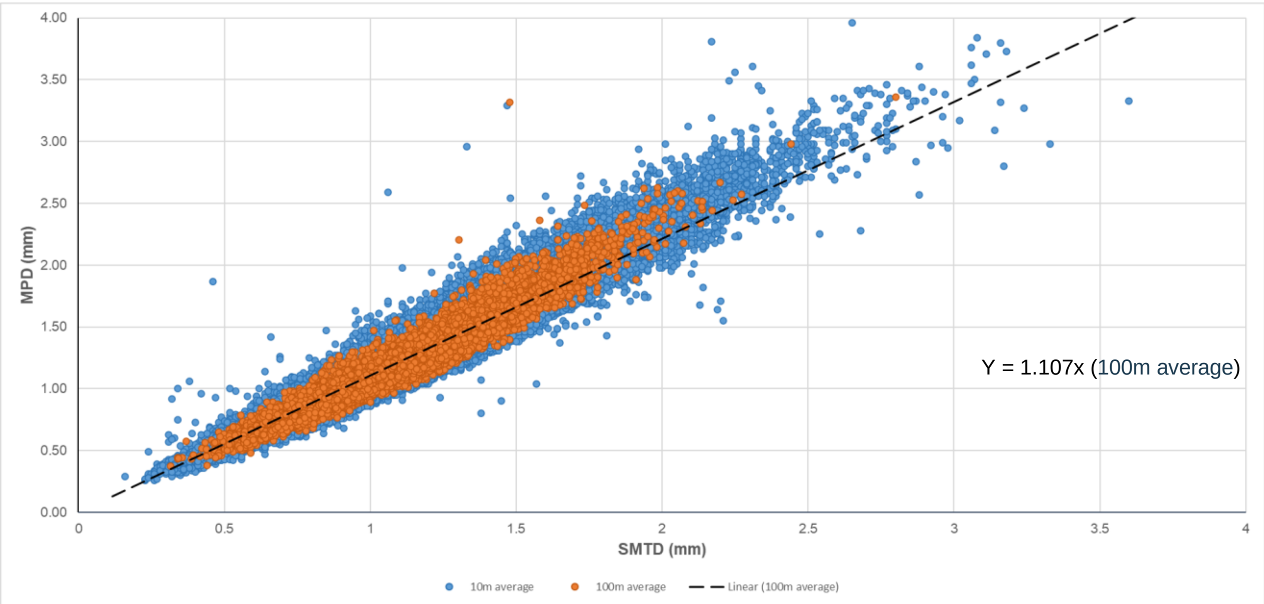



**Figure A-4 - Cl. 942 - 14mm**

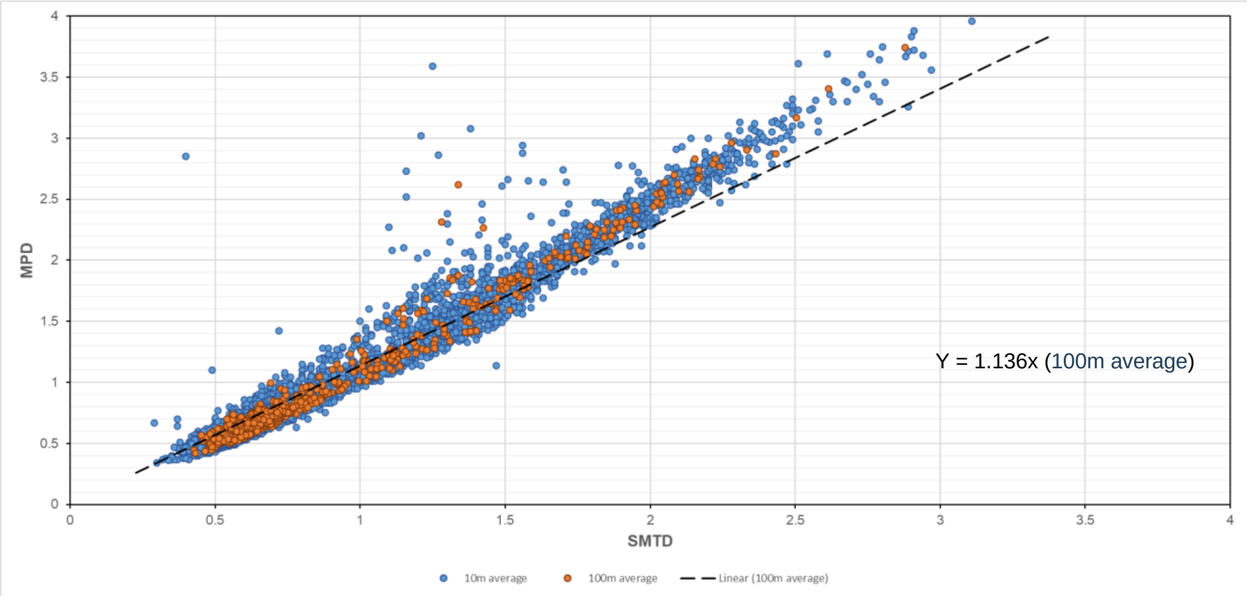



**Figure A-5 - TS2010 - 6mm**

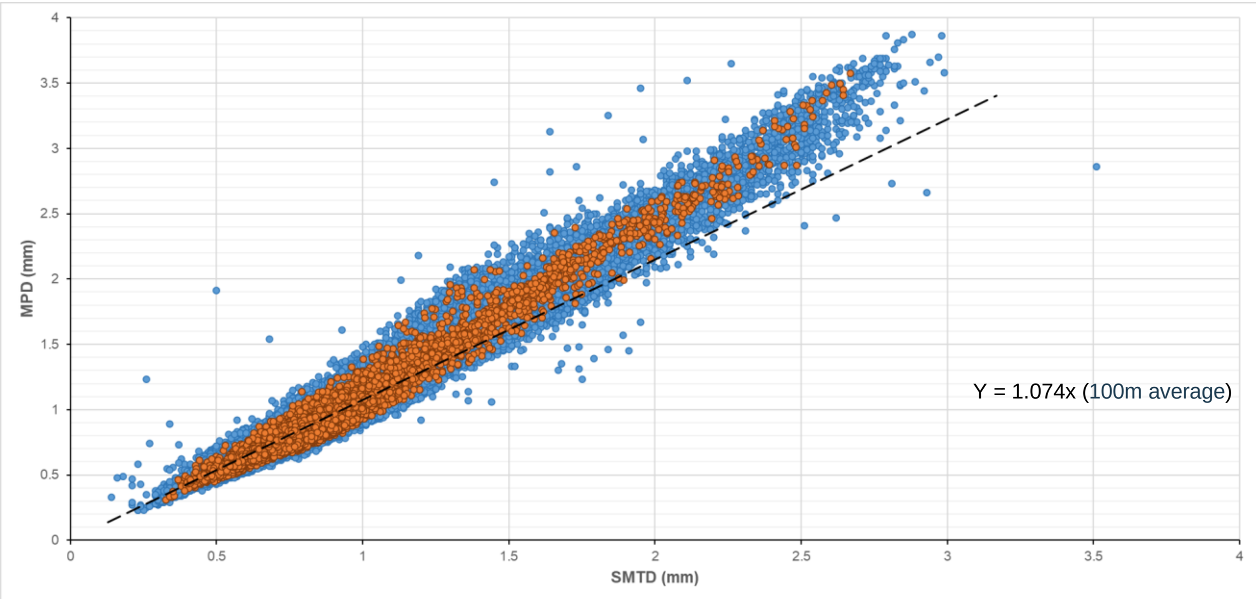



**Figure A-6 - TS2010 - 10mm**

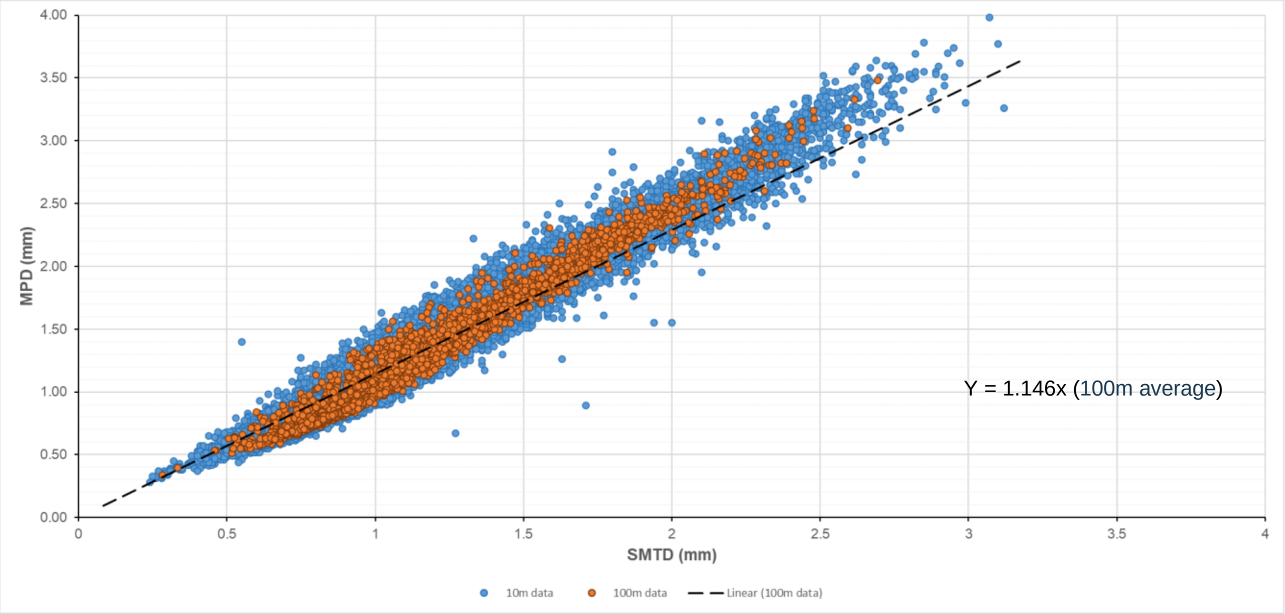



**Figure A-7 - HRA**

# Appendix B

## - SMTD V MPD < 1.5MM

Confidential

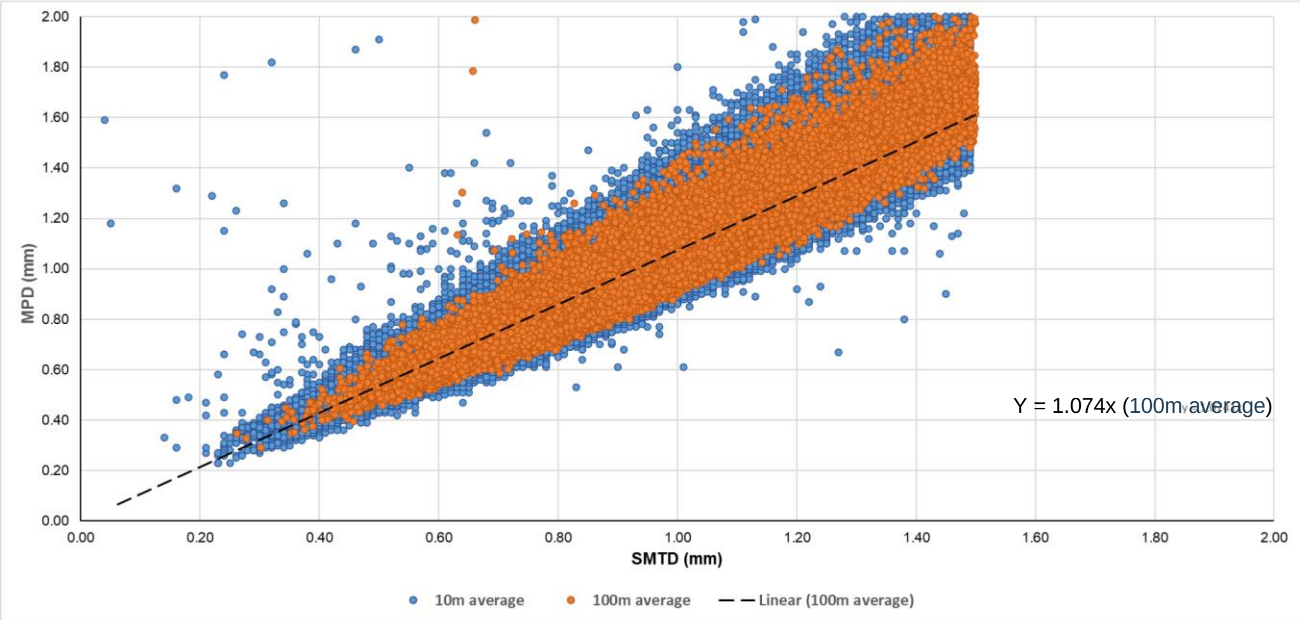



**Figure B-1 – All data less than 1.5mm**

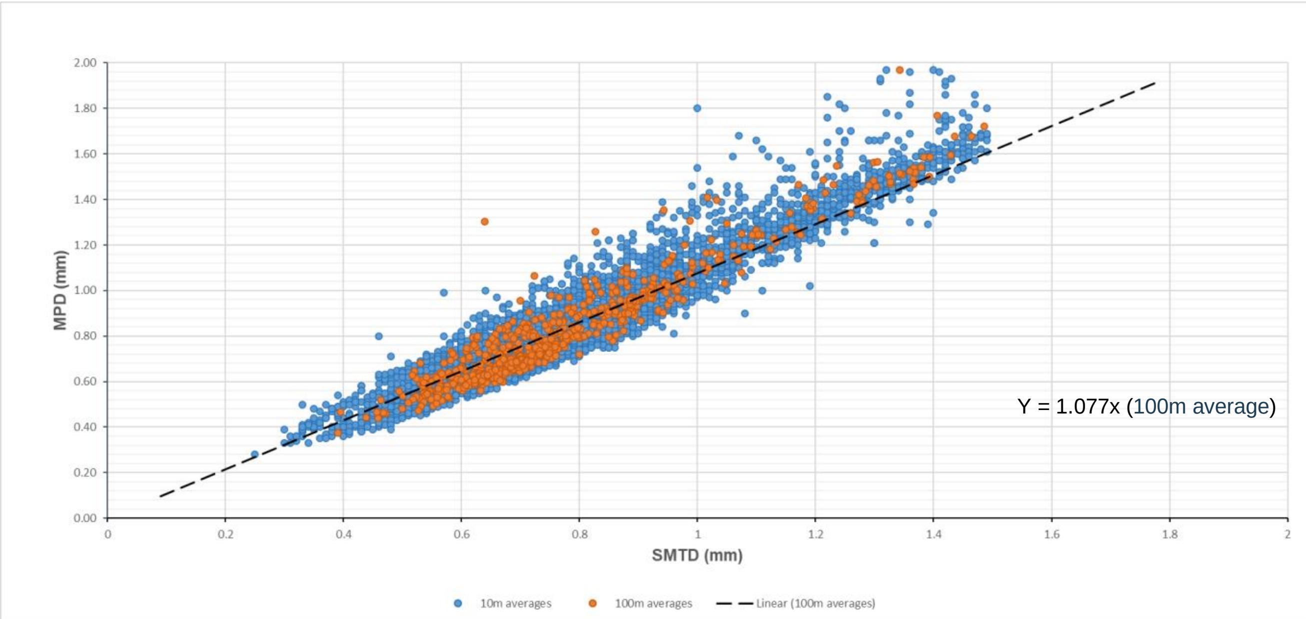



**Figure B-2 - Cl942 - 6mm less than 1.5mm**

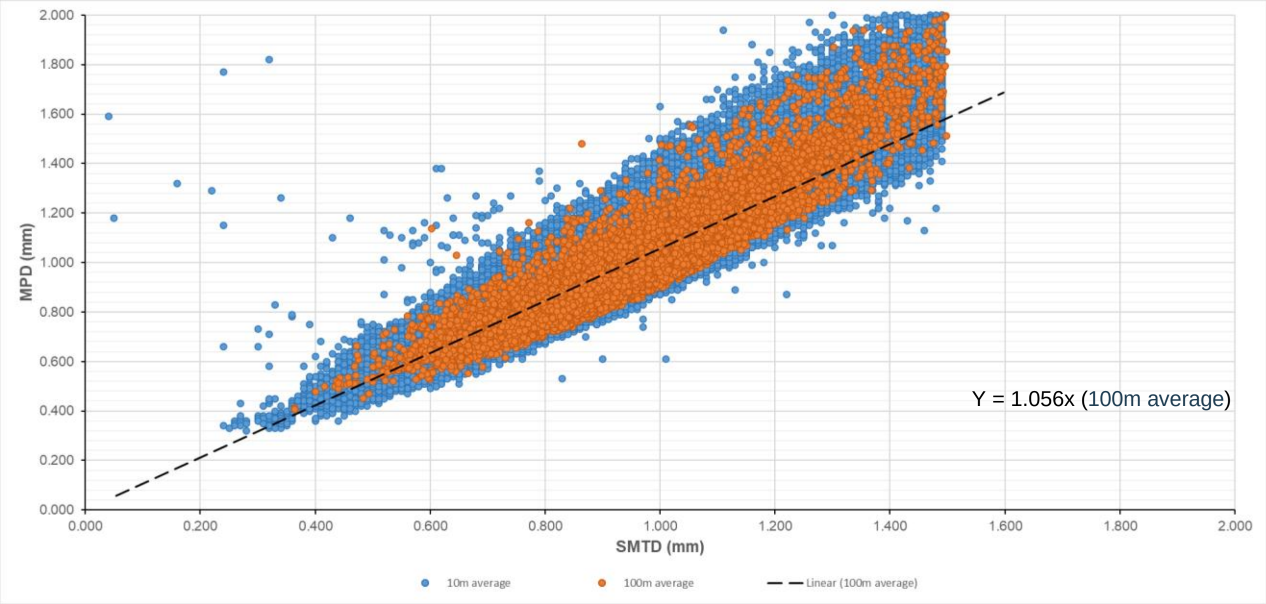



**Figure B-3 - Cl942 - 10mm less than 1.5mm**

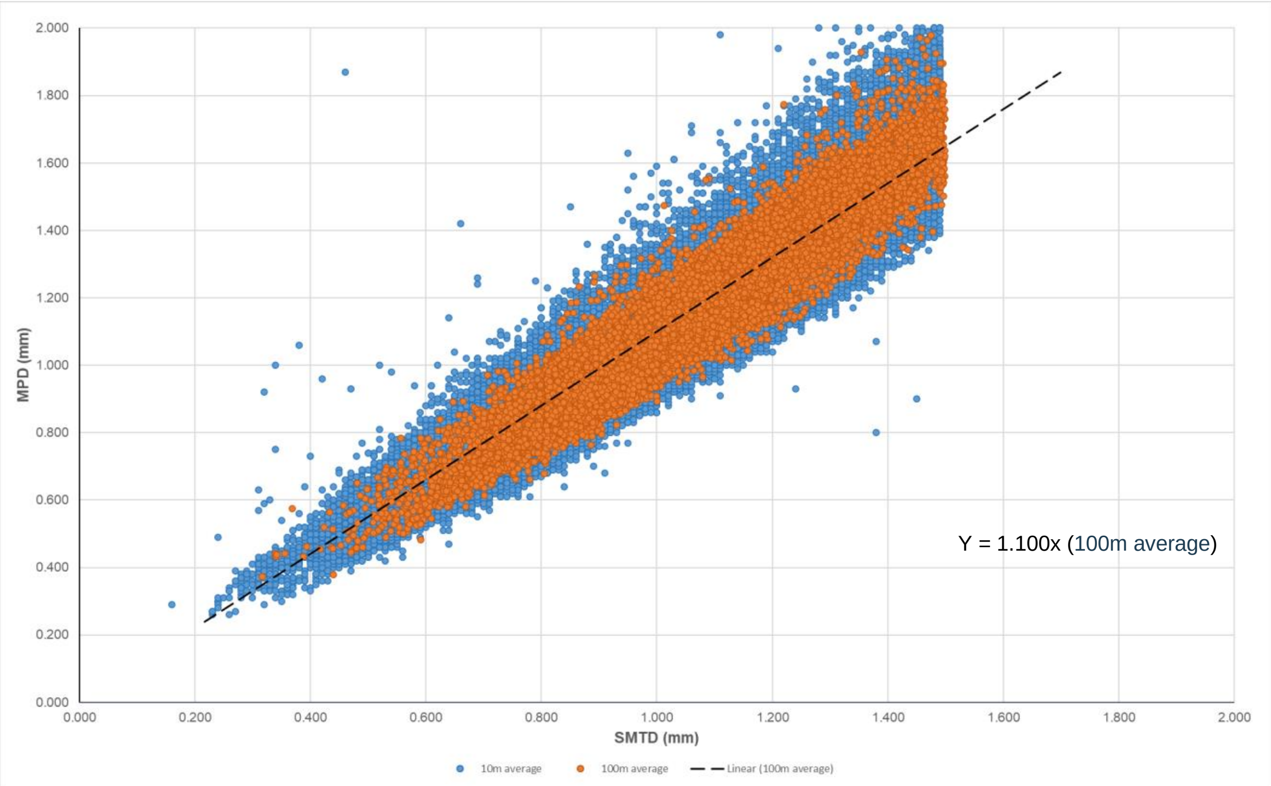



**Figure B-4 - Cl942 - 14mm less than 1.5mm**

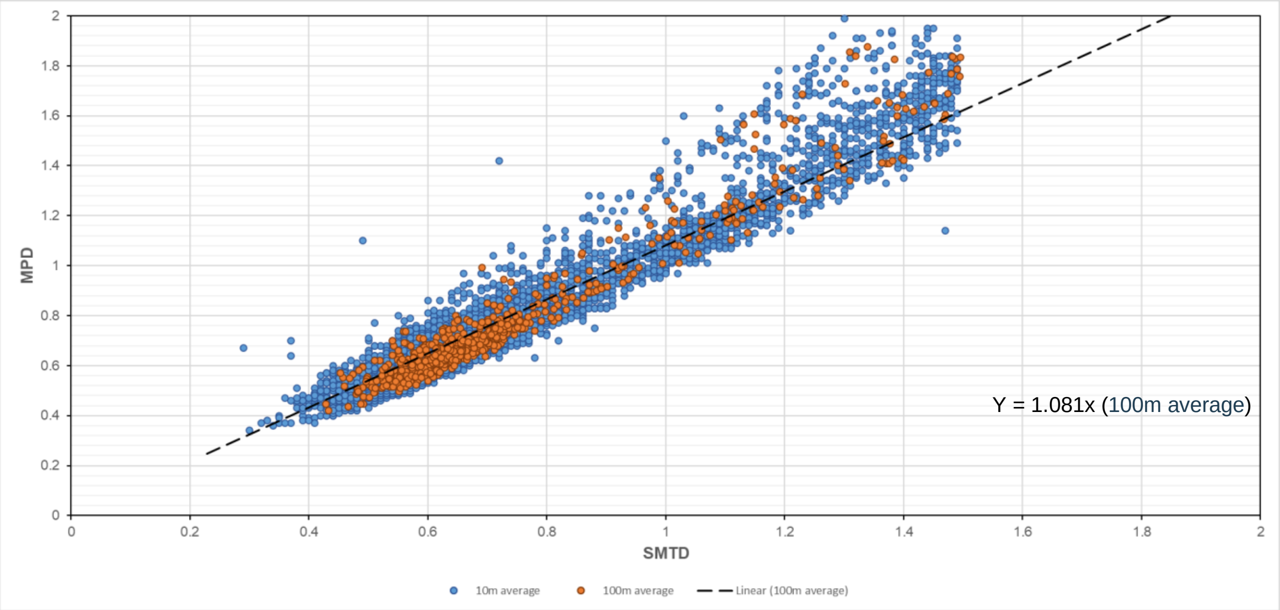



**Figure B-5 - TS2010 - 6mm less than 1.5mm**

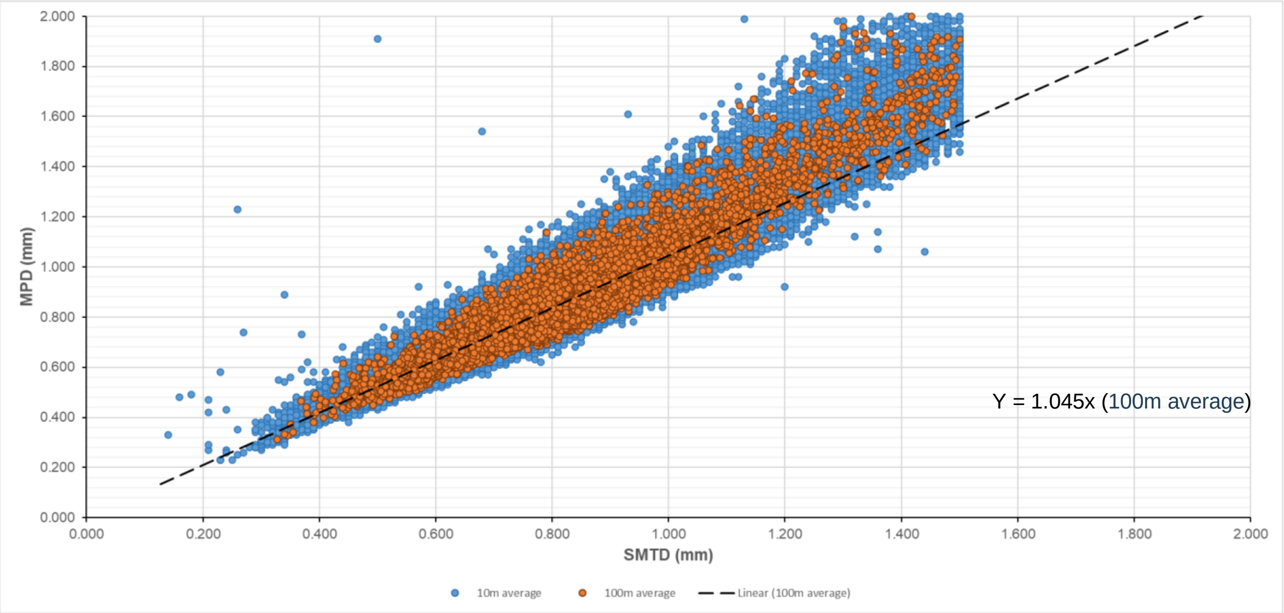



**Figure B-6 - TS2010 - 10mm less than 1.5mm**

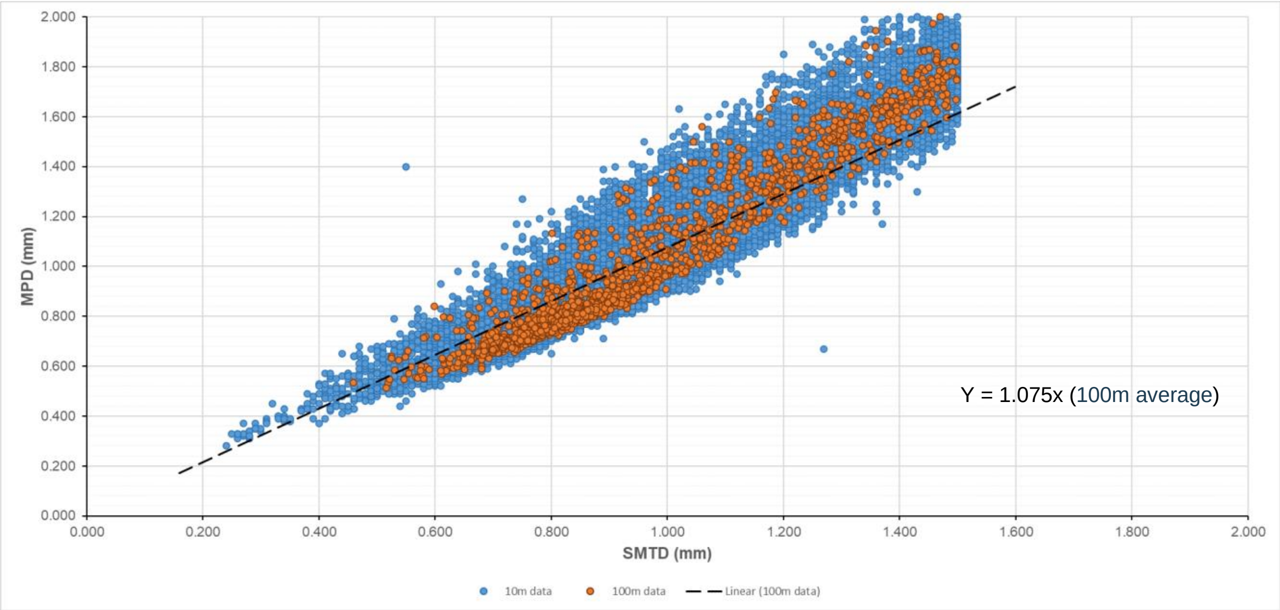



**Figure B-7 - HRA less than 1.5mm**

7 Lochside View
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