TEXTURE MEASUREMENTS

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ABSTRACT

Avinor which owns and operate 44 airfields in Norway has for the past seven years worked continuously with problem issues related to runway surface characteristics. This paper presents result from this work and special two workshops held at Avinors Test Track for Surface Characteristics Oslo in 2002 and 2003. Based on the work that has been done and the fact the harmonized FAR Part 25 and JAR 25 use texture as a variable for predicting the maximum tire-to-ground wet runway braking coefficient, resulted in new method for describing surface characteristics on Norwegian airports. Hence, Avinor does not declare wet friction values for their runways. After studies of the JAR and FAR regulations and related background material Avinor decided instead to measure texture and declare these values in the Aeronautical Information Publication (AIP) for each airport.

At the workshop in 2002 macro-texture were measured by 7 laser vans from The Norwegian Road Administration and the Asphalt Institute of Technology in addition to manual glass-patch method. The workshop in 2003 included micro-texture measurement (CT Meter, BP tester) and different laser devices.

This paper will present the results from these two workshops and also how this method is used by airlines and Norwegian Airports to describe the surface characteristics.

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Avinor, qui possède et gère 44 aérodromes en Norvège, a, ces sept dernières années, concentré ses efforts sur la problématique des caractéristiques de surface des pistes. Cette communication présente les résultats de ses travaux, et plus spécialement de ceux de deux ateliers tenus sur la piste de tests des caractéristiques de surface d'Avinor à Oslo en 2002 et 2003. Les travaux effectués et le fait que le FAR, partie 25, et le JAR 25 en harmonisation utilisent la texture comme paramètre pour la prévision du coefficient maximum de freinage pneu/sol sur piste mouillée, ont abouti à de nouvelles méthodes de description des caractéristiques de surface pour les aéroports norvégiens.

De ce fait, Avinor ne déclare pas les valeurs d’adhérence à l'état mouillé pour ses pistes. Après étude des règlements du JAR et du FAR et des documents de base relatifs, Avinor a décidé de mesurer la texture et d'en déclarer les valeurs dans la Publication d'information aéronautique (AIP) pour chaque aéroport.

Lors de l'atelier tenu en 2002, la macro-texture a été mesurée par 7 véhicules à laser de l'Administration norvégienne des routes et par l'Institut de technologie des

bitumes, en plus de la méthode manuelle "glass-patch". L'atelier 2003 comprenait des mesures de la micro-texture (CT, test BP) et différents dispositifs laser.

Cette communication présentera les résultats de ces deux ateliers, ainsi que la manière dont cette méthode est utilisée par les compagnies aériennes et les aéroports norvégiens pour décrire les caractéristiques de surface.

INTRODUCTION

Avinor has for the past seven years worked continuously with problem issues related to runway surface characteristics.

In 1997 Avinor constructed the Ottar K. Kollerud Test Track located at the new Oslo Airport as a field laboratory site for runway surface tests. The test track, also known as the OKK test track in short, has ten different asphalt pavements. Eight of these pavements are used to harmonize devices measuring surface characteristics.

Description of the Ottar K.Kollerud Test Track

The texture measurements were conducted during the course of one day at the OKK test track.

The OKK test track is situated on the airside of the Oslo Airport, Gardermoen, alongside the northern end of the west runway.

The test track consists of 8 different, serially laid out asphalt surfaces of equal length 100 meters and equal width 10 meters. The eight surfaces were designed to have different characteristics and are labeled by digits 1 through 8.

The surfaces are equally divided across their width into 5 segments labeled A-E. See Figure 1.

All segments of equal letter labels constitute a test run course that is 800 meters long and 2 meters wide. A single surface segment is labeled as a surface number and a segment letter. To facilitate intuitive locations for test a driver, the notation is by letter first, as the letter signifies a driving lane. For example, B8 is segment B of surface 8.

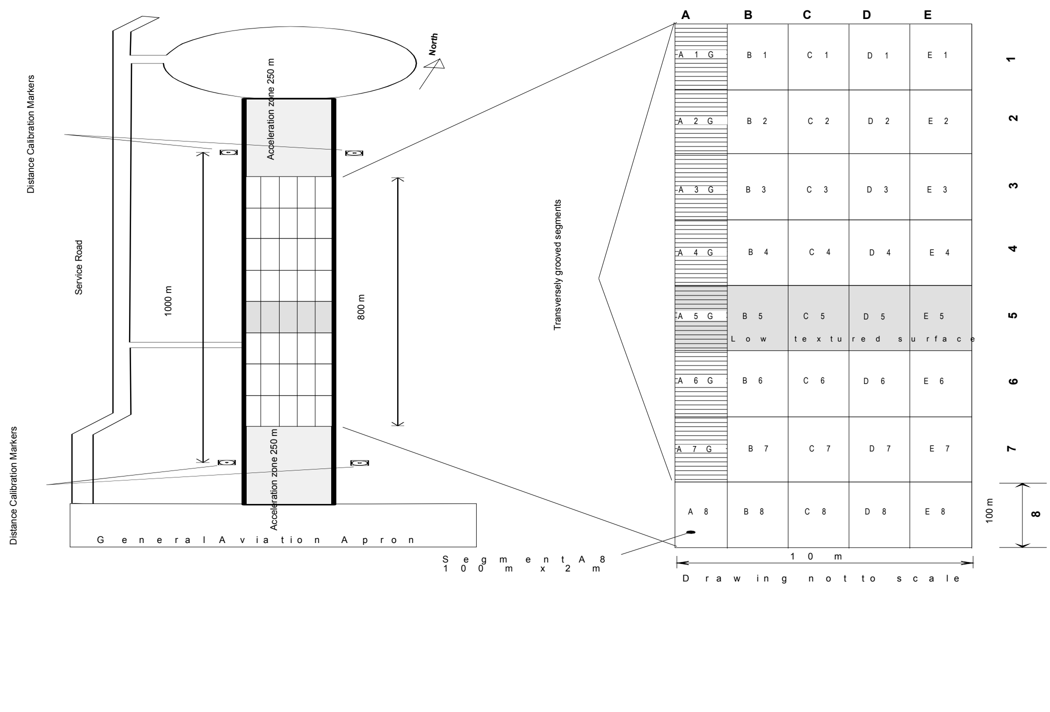

Figure 1 - Schematic drawing of the test track

Asphalt Pavement Mixes

Through April 1999 all segments within the same production mix were considered transversely uniform. After this time, transverse grooving was cut in segments A1 through A7, leaving segment letters B-E only to signify transversely uniform surfaces.

The notation for the grooved surfaces was kept as originally defined, but with a suffix G.

The groove geometry is a lace of 6 x 6 mm cross-sections cut 120 mm apart over the full 2 meter width of the A-segments. The open-graded asphalt of A8 is not grooved.

During production, each mix was laid out in half the width of the track, i.e. five meters. Thus, A and B and the first half of C segments are consistently from the same batch and the second half of C and D and E segments are from the same batch.

Surfaces 1 through 3 are the same asphalt pavement type with Asphalt Concrete 11 mm, but surface 2 and 3 were compacted more to produce less texture.

Earlier findings

Since the commissioning of the test track in 1997 a number of test programs have been performed and reported by Avinor

A good illustration of the revelations of important facts from test programs at the OKK test track is the following summary line chart in Figure 2. The friction data shown was collected in 1998.

Each line represents the average friction values reported by each of 26 GripTesters and 18 BV11's in self-wet mode for each surface at 65 km/h measuring speed. Each average is calculated from six repeated measurements.

On the line chart, the ICAO Design Objective Level (DOL) and Minimum Friction Level (MFL) for each device type are superimposed as horizontal lines.

Among other observations, it is also clear that the scatter in performance of these friction devices prohibit their use for go/no-go decisions for aircraft.

One notes that the GripTester devices, represented by the series of low lines with a valley for surface 5, observe the low-textured surface as slippery, while the BV11 devices do not.

A history of texture values are presented in the bar chart of Figure 3. For each of the eight test surfaces, a collection of bars indicate the texture values for each year since 1997, except for 2000, when no measurements were made.

The five leftmost surfaces in this chart are constructed with incremental less texture of the same pavement material. This is a unique feature the OKK test track.

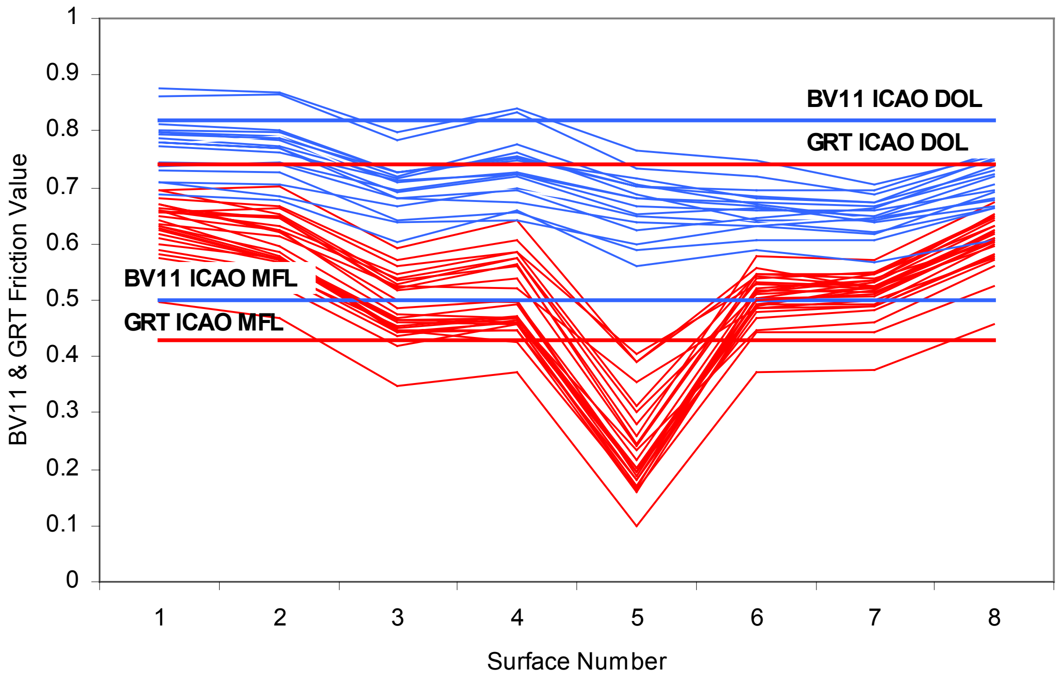

Figure 2 - Summary results from reproducibility study in 1998 of Avinor operated BV11 and GripTester units.

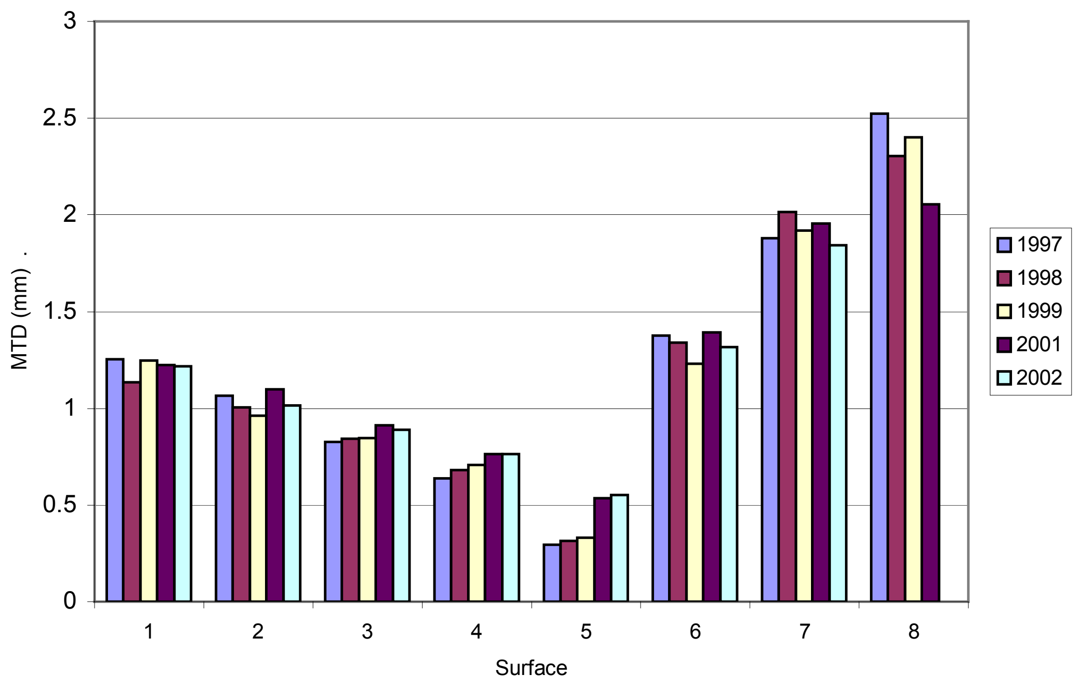

Figure 3 - Mean texture depth for OKK surfaces 1997 – 2002

Use of Texture Information

Avinor does not declare wet friction values for their runways. After studies of the JAR and FAR regulations and related background material, Avinor decided instead to measure texture and declare these values in the AIP.

The harmonized FAR Part 25 and JAR 25 use texture as a variable for predicting the maximum tire-to-ground wet runway braking coefficient.

A practice is now established to measure the mean texture depth, when performing the annual runway inspection, and publish this value in the AIP AD 2.12. "Runway physical characteristics"

As member of the Institute of Asphalt Technology (IAT), Avinor has access to their instrumented van that has the capabilities to perform measurements of transverse profiles, rut depth and texture in terms of mean profile depth.

A good correlation between mean texture depth and mean profile depth was found from measurements by a single laser based texture measurement system at the OKK test track in 2001.

Texture Workshop 2002

Avinor invited The Norwegian Road Administration which has a fleet of 11 vans similarly instrumented as the IAT van. Six of these were able to join in a calibration and reproducibility measurement workshop at the OKK test track on April 19, 2002.

The results from this workshop are reported in this paper, and these plus combine findings from earlier measuring events at the OKK test track are report in ISBN 82-91156-26-3, by Avinor.

In June 2003, Avinor hosted an international workshop regarding Comparison of Texture Measurements Systems were 14 laser vans, and 9 manual devices attended. Results from this workshop are to be presented at the PIARC Airfield Pavement Seminar in Durban 2003.

Description of the Test Program

Laser Instrumented Vans

The laser heads were mounted on a transverse beam at the front of the vehicles, as shown on the photo in Figure 4. A schematic drawing of the laser head mounting geometry is shown in Figure 5.

The systems used a Selcom[1] OPTOCATOR laser sensor type 2008-180/390-A. This type of sensor has a measurement range of 180 mm when mounted at a 467 mm stand-off. Its scale factor is 0.045 mm/LSB. The sampling frequency was 32 kHz with a frequency response bandwidth of 10 kHz. The laser uses near-visible infrared light at 785 nm.The laser beam of this sensor type was down to 0.2 mm in diameter.

The MPD values reported by these systems conform to ASTM International ASTM E-1845 [2] and/or ISO 13473-1.

An additional software filter to remove the effects of grooves was applied. The purpose of this filter is to normalize the data to a non-grooved surface type for comparisons with non-grooved surface types and to enable evaluations of roughness and longitudinal evenness from the same database.

The vans were labeled by a number representing the district name of their home bases.

Table 1 - Labels of participating vans

Van Code	**Home Base (County)**
02	Akershus
09	Aust-Agder
10	Vest-Agder
14	Sogn og Fjordane
15	Møre og Romsdal
16	Sør-Trøndelag
99	Asfalt Teknisk Institutt (IAT)

Figure 4 – Front mounted hosting beam for multiple measurement systems; mean profile depth, evenness and transverse profile.

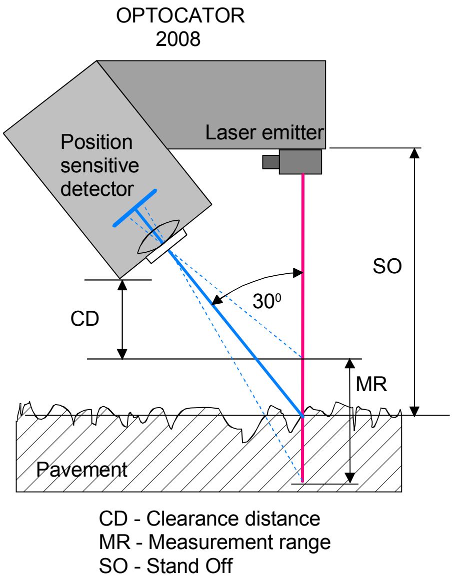

Figure 5 – Schematic of laser head of the texture measurement system.

Test Procedures

The group of seven laser instrumented vans ran three distance calibration runs in lane A and then 6 repeated test runs for each of three sets of surface segments. The sequence followed was: 1) 6 runs of lane B, 2) 6 runs of lane A and 3) 6 runs of lane D.

After the laser instrumented vans completed their measurements, volumetric texture measurements were taken of lanes B and D.

Data Collection and Processing

Reported Mean Profile Depth
All data was processed by IAT as averages of 20 meters distances.

The data collection was achieved over a longer distance than the 800 meters designated test surfaces and the 1000 meter calibration distance. All vans initiated measuring at the same marker line, but ended at the discretion of the driver beyond the south distance calibration marker. The central data processing harmonized the data series by cutting the data series for all runs and all vans at 1060 meters.

It can be verified that each 100 meter distance is made up of five data points, except for the last 60 meter distance that has three points. The total number of data points in each run was 53.

The design intent of the test track surfaces was to have a stepped texture profile with 0.1 mm MTD as the step size for the first five surfaces.

Comparison Parameters

Since no fundamental calibration reference for texture measures exists, the units of measurement are unique for a device.

A deviation from a calibration reference is also called bias. With no calibration reference available, the bias cannot be established for texture devices.

The ability of a measurement device to produce the same measured value of the same surface object, when measurement runs are repeated under the same conditions, is called the repeatability of the device. This ability is also known as precision.

The ability of several different devices of the same brand, type and configuration to report the same texture value for the same surface object under the same conditions is called reproducibility.

Methods of comparing devices with respect to their different units of measurements are called harmonization methods.

Harmonization can be used as a means of adjusting reported values to a common unit of measurement. The common measure is taken as the units of a particular selected device or an average of several devices participating in the same comparison trials.

As measures of repeatability, a group of common descriptive statistics have been employed. A brief overview of these statistical terms is given in the following sections.

Measurement units of texture reported by continuous non-contact methods, such as the van mounted laser systems, are called mean profile depth, abbreviated MPD, and expressed in mm units of length.

Standard Deviation
The standard deviation expresses how much the repeated friction values deviate from the arithmetical mean, or average, of all the measurements. The unit of measure is the texture unit of the measurement device. It is designated as StdDev in this report. The absolute standard deviation value may be a function of the average

value. The average value and standard deviation are often given as companion values and are the basis for the calculations of the coefficient of variation and the standard error.

Coefficient of Variation

The coefficient of variation (CV) is the standard deviation divided by the average measured value. It is a measure of variability per measurement unit, a normalized measure of variability. Therefore, it depends on the average texture value or texture level. The CV value per friction unit is multiplied by 100 to express it as a percentage. It is designated CV % in figures of this report.

Standard Error of Measurements

The standard error is the standard deviation divided by the square root of the number of measurements. It is a measure of texture variability per number of repeated measurements. With the square root function, however, the effect of the number of runs is disproportionate and diminishes with increasing number of repeated measurements. It is designated as StdErr in figures of this report.

Range of Variability

The difference between the maximum and minimum measured values is called the range of variation. It is expressed in the device units of texture.

This is reported in detailed in ISBN-82-91156-26-3 and are not included in this paper. The report is available from the authors.

Volumetric Texture Measurements

Measurement Procedure

With the method of ASTM International Standard E-965, a pre-measured volume of 25 000 cubic mm of glass spheres is used. The glass spheres were manufactured to have 90 percent roundness and graded in accordance with ASTM International Standard D-1155.

Each pre-measured volume of glass spheres were emptied from a cup on a randomly selected spot of the pavement. The pile of glass spheres were made into an even, circular layer, filling voids in the pavement by applying a light pressure from an ice hockey puck using rotary motion by hand.

The average diameter of the circular layer was measured and the corresponding circular area was calculated. The average, or mean, texture depth, MTD, with units of mm, was calculated by dividing the pre-measured volume by the calculated area.

Five spots were measured in each segment 1 – 7 of lane B and lane D. Surface 8 was open-graded and the volumetric method was therefore invalid for this type of surface and not used. The B segments and the D segments were measured by two different persons.

Comparison between the Non-Contact and Volumetric Texture Measurement Techniques

The MTD values are consistently a little higher than the MPD values for lanes B and D.

The average MTD for all lane B segments 1-7 was 1.02 mm and the MPD average for the same was 0.97 mm.

For lane D the MTD average of all segments was 1.15 mm and MPD was 0.97 mm.

A Transform for MPD to MTD
A mathematical relationship between MTD and MPD can be determined with regression techniques. This relationship is also called a transform.

Determining a transform with the data from lane B offers the opportunity to check a prediction using the transform against measurements of another lane D[2].

Transform Based on Lane B only
A linear regression of lane B data yields the results shown in Figure 6.

According to this linear regression result, MTD values can be predicted from MPD values with the transform

$Tx_{MTD} = 0.9469 \cdot Tx_{MPD} + 0.1518$ (1)

where Tx_{MTD} denotes a volumetric measurement and Tx_{MPD} denotes a non-contact measurement.

Applying the mathematical equation on the measured average values of MPD for lane D, the results are as shown in **Erreur ! Source du renvoi introuvable.**. The predicted values for each segment are shown next to the actual measured average MTD values.

The prediction errors are tabulated in Table 3 below.

The prediction errors are largest for segments of surface 6 and 7.

Table 2 - MTD texture averages per D segment and predictions from B segments

Segment	**Actual MTD (D) (mm)**	**Predicted MTD (D) (mm)**	**Error Actual-Predicted (mm)**
D1	1.21	1.17	0.04
D2	1.10	1.05	0.06
D3	0.96	0.96	0.00
D4	0.80	0.84	-0.03
D5	0.54	0.53	0.01
D6	1.32	1.18	0.14
D7	2.11	1.77	0.34

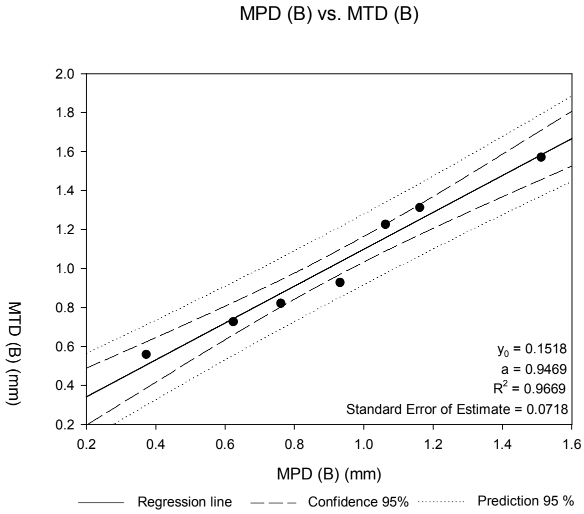

Figure 6 - Linear regression results for all device average MPD versus MTD using data of lane B first seven segments

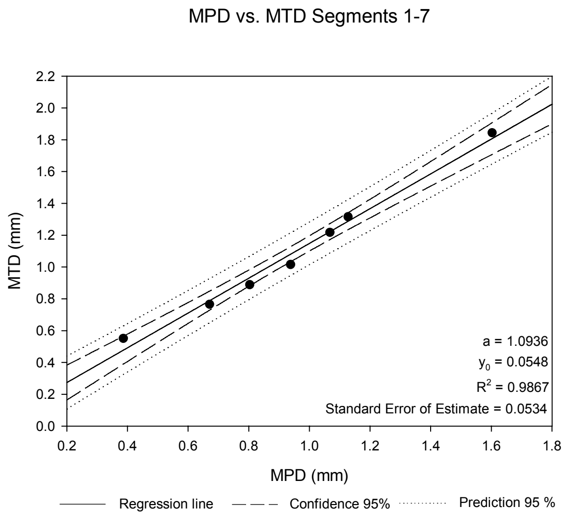

Figure 7 - Correlation MPD vs. MTD

Transform Based on Lane B and Lane D

Combining the data of lanes B and D can produce a more robust relationship. (Lane A data are not included, as no valid MTD data are available for the grooved A segments). In

Table 3 below, the measured values for both segments of the same surface are averaged per surface.

Figure 7 shows the results of the linear regression. The regression equation is

$Tx_{MTD} = 1.0936 \cdot Tx_{MPD} + 0.0548$ (2)

Using the above equation the measured MPD values can be transformed to MTD values. The transformed MPD values and the differences relative to the actual MTD values are shown in

Table 3. The difference values in this table are expressions of goodness of fit of the transform relative to the measured values.

Note: This transform is valid only for the surfaces of the OKK test track.

Table 3 –Texture averages per surface and transformation of MPD to MTD

Surface	MPD (mm)	MTD (mm)	MPD Trans-formed to MTD (mm)	Difference
1	1.07	1.22	1.22	0.00
2	0.94	1.02	1.08	-0.06
3	0.80	0.89	0.93	-0.04
4	0.67	0.77	0.79	-0.02
5	0.39	0.55	0.48	0.07
6	1.13	1.32	1.29	0.03
7	1.60	1.84	1.81	0.04

Since lane B and D are from different batches of asphalt pavement production, however, according to the same recipies, a transform based on the data from both lanes represents a variability closer to real surface production. It is, therefore, prudent to use the transform from the combined data when predicting the mean texture depth from the mean profile depth.

For practical predictions the transform (2) may be simplied to

$$Tx_{MTD} = 1.09 \cdot Tx_{MPD} + 0.06 \qquad (3)$$

Harmonization of the Non-Contact Texture Measurement Systems

Figure 10 indicated a potential benefit of harmonizing the texture devices. In the following harmonization demonstration, the average MPD value by all devices for each segment was taken as the harmonization reference.

Harmonization coefficients were determined from a linear regression of segment paired data for lane A and lane B, such that the average MPD value of all devices for a segment was paired with the individual device average MPD for the segment.

The regression equation was

$$MTD_{AVG} = y_0 + a \cdot MTD_{DEVICE} \qquad (4)$$

where y_0 is the intercept parameter and a is the slope parameter of the first order polynomial (straight line).

An example regression plot for one system is shown in Figure 8.

As inspection of data collecting shows, the correlations were excellent as the coefficient of determination, R^2, approached a value of one for all devices. Furthermore, the slope parameter, a, was close to one for all systems, except for system 16. The intercept parameter, y_0, was close to zero for three systems.

The effect of harmonization is demonstrated by applying the harmonization coefficients for each texture system on its data for lane D.

The largest error was found for system 02 with surface segment D8, which is open-graded asphalt. The maximum error was 0.038 mm.

The average absolute error for all devices and segments of lane D was 0.01 mm.

The effect of harmonization for each system is depicted in the report. For each system the percentage difference of actual measured values and the predicted (harmonized) values are shown relative to the actual average of all devices (reference). Before harmonization the average difference for the fleet of systems was 3.2 percent. After harmonization, the difference went down to 0.9 percent. This is an improvement of 72 percent.

Harmonization had little effect for systems 02 and 99. These systems were already having the smallest differences relative to the measured average of all systems.

Systems 09, 10, 14 and 16 improved the most with the application of harmonization.

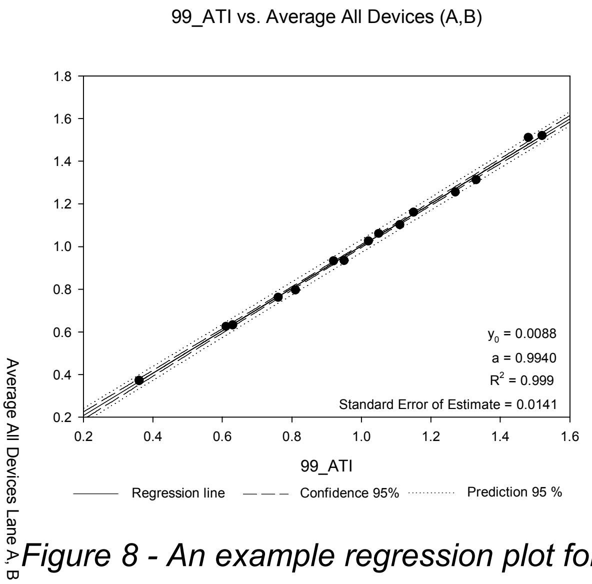

Figure 8 - An example regression plot for paired data of lane A and lane B

Summary

This summary is organized by objectives, as identified in Section 2.

Repeatability

The overall or fleet average range of variability including all test track surfaces was 3.8 percent.

The repeatability of the non-contact texture measurement systems was found to be an average coefficient of variation of 1.4 percent for all participating systems and all non-grooved surfaces.

For grooved surfaces the average coefficient of variation was 1.9 percent.

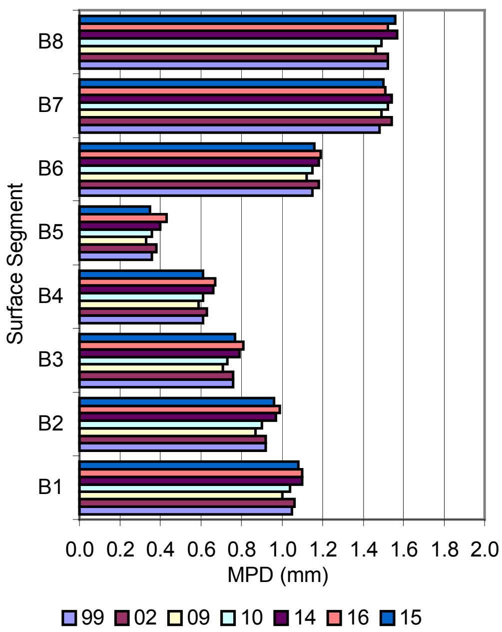

Figure 9 - Average reported texture values, MPD (mm), for six repeated runs over the surface segments in lane B

Reproducibility

The average reproducibility coefficient of variation for all devices and all segments was 4.0 percent. The variance for the low texture surface was markedly higher than for the other surfaces. Disregarding the low texture segments, the average reproducibility coefficient of variation for all remaining segments was 3.1percent.

The reproducibility range of variability was found to be between a low 0.05 mm and a high 0.12 mm in units of non-harmonized MPD, when comparing segment against segment.

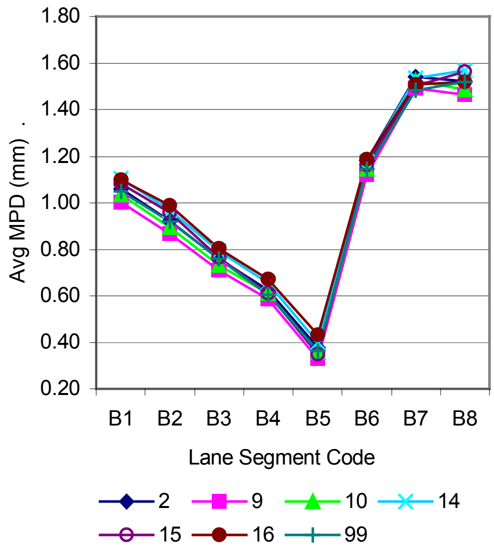

Figure 10 - The series of average MPD per segment of each device shown for lane B

Effects of surface grooves

When disregarding the open, coarse surface types, a comparison of the non-grooved vs. grooved surfaces showed no difference in average mean profile depth values for each measured lane. The system software successfully removed the effects of grooving.

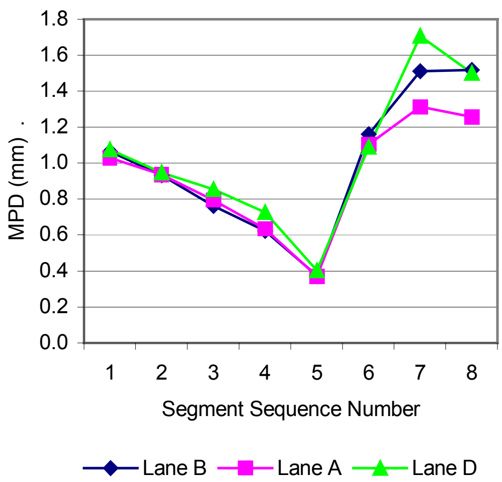

Figure 11 - MPD level for each segment in each lane

Relationship of Mean Profile Depth to Mean Texture Depth

It was found that mean texture depth (MTD) values can be predicted from mean profile depth (MPD) values with the transform

$$Tx_{MTD} = 1.09 \cdot Tx_{MPD} + 0.06$$

where Tx_{MTD} denotes an estimated volumetric measurement value (sand patch) and Tx_{MPD} denotes a non-contact measurement value, both in units of mm.

Harmonization of Non-Contact Texture Devices

Harmonization relationships were determined for each device relative to an average performance of all devices using data for lanes A and B. The relationship determined was a linear equation of the form

$$MPD_{AVG} = y_0 + a \cdot MPD_{DEVICE}$$

All correlations were excellent having coefficients of determination (R^2) approaching 1. The slope parameters were close to 1, except for one device that had a slope parameter of 1.06. The intercept values were found to be a rounded value of 0.0 in five cases and +/-0.1 mm in two cases.

Device	**y_0**	**a**	**R^2**	**StdErr**
99	0.01	0.99	0.999	0.014
02	0.00	0.99	0.999	0.010
09	0.06	0.98	0.998	0.017
10	0.04	0.98	0.999	0.012
14	-0.04	1.00	0.999	0.011
16	-0.08	1.06	0.999	0.012
15	0.01	0.99	0.996	0.024

Applied to a group of selected surfaces (lane D), the average difference by each system relative to an average of all systems went down from 3.2 percent to 0.9 percent corresponding to a 72 percent improvement in fleet precision/reproducibility.

Friction Changes over Five Years

As measured by the OSCAR machine, the friction level change of each surface has followed different patterns over time. However, for surfaces 1 through 6, the minimum friction level occurred in year 2000, three years after production date of the surfaces.

All surfaces have increased the friction level over the last two years.

Recommendations

For Non-Contact Texture Measurement Systems

1. Although reproducibility of the participating non-contact texture systems are very good, further improvement is available by applying the harmonization constants determined from the 19 April workshop in normal operations.

2. A repeat workshop is recommended ahead of the next season of measurement to collect data to study time stability of the non-contact systems.

For Validation of Constraints of Predicting Friction from Texture Values

Although methods to predict friction from texture values alone in general are meaningless, introducing additional parameters to a combination of predictive factors seems to have a potential for development of a prediction method for regional use. Such additional factors may be both quantitative and qualitative in nature aimed at categorizing surface or pavement materials.

Candidate parameters that may be looked at include aggregate stone strength, stone aspect ratio, stone hardness, polish ability, petrographic properties such as differential between the matrix and the grains and standardized stone classes.

Surfaces being similar with the OKK test track surfaces can be expected to exhibit similar frictional characteristics. Since surface numbers 1-3 and 6 represent asphalt pavement recipes constructed on several Norwegian runways, an OKK developed prediction method can be validated with data from a number of these runways.

One way to validate the findings of this report would be to measure a number runway sections with respect to OSCAR friction and mean profile depth. Using the mean profile depth data, the OSCAR friction can be predicted. The measured and predicted friction values are then compared.

Also runway surface sections being different from the OKK surfaces should be measured to obtain data that would further help to define an envelope of surface material descriptions that may or may not be eligible for use of an OKK developed prediction method.

Aircraft Tyre Harmonization

Most aircraft tires may be viewed as blank treaded tires when compared against the width of the blank friction measurement tires. One may, therefore, on the background of the described OSCAR results in this report, expect that strong correlations between such tires and the OKK surface textures can be demonstrated. That would enable a practice for calculating aircraft tire-to-ground braking slip friction with techniques similar to the IFI, i.e. harmonizing aircraft tires to friction measurement devices.

Mounting of a small or medium size aircraft tire on an OSCAR test wheel should be explored. If mountable, a test series of friction measurements can be used to demonstrate any relevance of the OKK findings for aircraft tires.

Current airworthiness regulations, such as FAR Part 25 or JAR 25.109 applicable for the certification of new aircraft types, define a set of mathematical functions for maximum tire-to-ground friction for aircraft tires. For wet pavement, the functions have ground speed as an independent variable and different polynomial coefficients for different tire inflation pressures.

In principle, therefore, prediction of friction is acknowledged for calculating required runway length for landing and aborted take-off.

The OKK test track is a cost-effective test bed for determining basic relationships between tire-to-ground friction and texture.

A derivative of the FAR Part 25 or JAR 25.109 is that an aircraft should not be operated on runway conditions for which it has not been certified. These regulations therefore impose requirements on operational runways.

International Test Track Activities

The OKK test track has gained recognition internationally for its findings about friction tester reproducibility.

The further documented findings related to the impact of texture on friction in addition to the demonstrated efficiency of the track layout, makes the OKK test track suitable for verifying proper functioning of friction and texture measurement devices for other organizations.

The OKK test track has established itself as a suitable site for conducting field test programs that advances the development of friction measurement technologies and for dissemination of knowledge in this field.

It is a weakness of the IFI that the harmonization relationships established in 1992 will deteriorate over time. There is a need for better control of the friction reference and choosing a real device and real surfaces may remove this weakness. The OKK test track may serve as one of a few effective collections of IFI reference surfaces.

Acknowledgements

The texture workshop was coordinated by Bjørn Holshagen, Institute of Asphalt Technology, and Torleif Haugødegaard, Norwegian Directorate of Public Roads.

The texture measurement systems of all the vans were installed by the vendor, Datainstrument AS, Bergen, Norway.

Six of the instrumented vans for texture measurement were owned by several district offices of the Norwegian Roads Administration and one unit was owned by the Institute of Asphalt Technology.

Bjørn Holshagen also performed the data reduction of the texture measurements to averages per 20 m distance.

The remaining data analysis and report material were produced by Arild Andresen, MFT Mobility Friction Technology AS.

The report has been reviewed by Dr. John J. Henry, Professor Emeritus of Pennsylvania State University.

List of Definitions and Acronyms

AIP	Aeronautical Information Publication. See also IPPC.
Avinor	Owner and operator of Norwegian airports. Previously named Norwegian Air Traffic and Airport Management, head office in Oslo, Norway. http://www.avinor.no
BV11	Bremsvagn 11 – a type of friction measurement device developed by the Swedish National Road and Transport Research Institute. http//:www.vti.se
CV	Coefficient of variation – a descriptive statistic calculated as the standard deviation divided by the mean (average) value
DOL	Design Objective Level, a device type specific threshold friction value recommended by ICAO for newly constructed runways
ESDU	Engineering Sciences Data Unit – ESDU International plc, a company in the IHS Group. Offices worldwide. Offers performance data series for aircraft/runways by subscription. http//: www.esdu.com
FAR	Federal Aviation Regulation, issued by the Federal Aviation Administration of the United States, head office in Washington, D.C., USA. http://www.faa.gov
F60	A prediction of the reference friction value (Golden Value) of the International Friction Index (GF60)
FR60	Friction value at 60 km/h that is an adjusted friction value by means of an exponential function of friction with slip speed as independent variable and a harmonized speed number for the surface texture value
GripTester	A brand of friction measuring devices manufactured by Findlay, Irvine Ltd
IAT	Institute of Asphalt Technology, Oslo, Norway. http://www.asfaltteknisk.com
ICAO	International Civil Aviation Organization, head office in Montreal, Quebec, Canada. http://www.icao.org
IFI	International Friction Index – a general use, two-parametric friction index originally defined by World Road Association, Paris, France. http://www.piarc.org
IHS	Information Handling Services Group Inc., a content provider for the engineering and energy industries with head office in Englewood, Colorado, USA. http//:www.ihsgroup.com
IPPC	Internet Pilot Planning Centre, an internet service, part of the Norwegian Aeronautical Information System. http//:www.ippc.no
ISO	International Organization for Standardization, head office 1, rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland. http//:www.iso.org
JAR	Joint Aviation Regulation,recommendations issued by the Joint Aviation Authority of Europe, head office in Hoofddorp, The Netherlands. http://www.jaa.nl
LSB	Least significant bit – the smallest digital bit in the 12 bit data stream from the Optocator. 1 LSB is equal to the scale factor.

MFL	Minimum Friction Level, a device type specific threshold friction value recommended by ICAO taking immediate action for improving runway friction
MFT	Mobility Friction Technology AS, consulting and services company in Oslo, Norway. http://www.mft.as
MTD	Mean texture depth – a unit for measurement of texture using volumetric techniques such as sand or glass beads
MPD	Mean profile depth – a unit for measurement of texture using non-contact (laser) techniques
OKK	Ottar K. Kollerud Test Track at Oslo Airport, Gardermoen, a wholly-owned subsidiary of Avinor. Named in honour of the airport manager who started friction testing at Oslo Airport, Fornebu, in 1949.
Tx	General notation for texture measurement value