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Značilnosti cestnih in vzletnih površin – Preskusne metode – 5. del: Določanje indeksov vzdolžnih neravnin

Road and airfield surface characteristics - Test methods - Part 5: Determination of longitudinal unevenness indices

Oberflächeneigenschaften von Straßen und Flugplätzen - Prüfverfahren - Teil 5: Bestimmung der Längsunebenheitsindizes

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Caractéristiques de surface des routes et aérodromes - Méthodes d'essais - Partie 5: Détermination des indices d'uni longitudinal

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ICS:

17.040.20	Lastnosti površin	Properties of surfaces
93.080.10	Gradnja cest	Road construction
93.120	Gradnja letališč	Construction of airports

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ICS

English Version

Road and airfield surface characteristics - Test methods - Part 5: Determination of longitudinal unevenness indices

Oberflächeneigenschaften von Straßen und Flugplätzen - Prüfverfahren - Teil 5: Bestimmung der Längsunebenheitsindizes

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 227.

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Foreword

This document (prEN 13036-5:2006) has been prepared by Technical Committee CEN/TC 227 “Road materials”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

Introduction

The road profile unevenness through road/vehicle dynamic interaction and vehicle vibration affects safety (tyre contact forces), ride comfort, energy consumption and vehicle wear. The road profile unevenness is consequently a key information for road maintenance management systems.

The measurement of road unevenness has been a subject of numerous researches for more than 70 years. Methods developed can be classified into two types:

— those based on response type devices and

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— those based on profiling devices or profilometers.

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Assessing the condition of a road using a profilometer usually involve to record its profile, then computing a limited set of numbers or indices characterising the unevenness, and eventually comparing these indexes to a reference scale. Only profilometers able to digitise and record under a digital format a road profile from which different indices can be computed are considered in this prEN 13036-6.

The purpose of this document is to standardise various possible characterisations of the road profile unevenness such as the International Roughness Index (IRI) computation procedure, wave bands analyses as well as Power Spectral Density (PSD) analyses. The objective of the document is not to impose a single specific procedure but to insure that when applying one of the possible procedure exactly the same steps are carried out with the aim of facilitating the comparison of unevenness measurements carried out with different profiling instruments in European countries.

It is beyond the scope of this document to provide reference values for these indices, or to provide detailed information about the characteristics of profilometers.

1 Scope

This document defines different possible methods for processing digitised road profiles:

— Computation of the International Roughness Index (IRI); based on the Golden car characteristics,

— Spectral analyses: Wave band analysis and Spectrum analysis, based on the Power Spectral Density (PSD)

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2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

prEN 13036-6, *Road and airfield surface characteristics — Test methods — Part 6: Measurement of transverse and longitudinal profiles in the unevenness and megatexture wavelength ranges*.

ISO 2041, *Vibration and shock — Vocabulary*.

ISO 8608, *Mechanical vibrations — Road surface profiles — Reporting of measured data*.

ANSI – S1. 11-2004-07-27, *Specification for octave band and fractional octave band, analog and digital filters*.

IEC 61260, *Octave-band and fractional-octave-band filters*.

ISO TS 13473-4, *Characterisation of pavement texture by use of surface profiles*. (in preparation)

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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3.1
profile
is the intersection between the surface of the pavement and the plane which contains both the vertical of the measured pavement and the line of travel of the measuring instrument; when the measuring instrument travels in a curve the line of travel is the tangent to that curve, when travelling in a straight line it is this line. In this plane, a point of the profile can be adequately described by its coordinates x (abscissa) and z (elevation), in any orthonormal reference system (X, Z), where Z is parallel to the aforementioned vertical

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3.2
spatial sampling interval
is the absolute value of the difference of abscissa between two adjacent points of the digitised longitudinal profile line. This definition assumes that the distance measured by the profilometer, which is usually related to the curvilinear abscissa, is close enough to the abscissa in the mathematical sense

3.3
longitudinal road profile
is one of the profiles obtained when the measuring instrument travels in the same direction as the usual traffic. Usually one of the profiles measured in the wheel tracks is used

NOTE Strictly speaking the digitised profile given by a profilometer, is a distorted image of the real profile, usually referred as a pseudo-profile ; in order to make the remaining part of this standard more easy to read the word profile is used to denote this image.

3.4
Longitudinal unevenness
is the deviation of the longitudinal profile from a straight reference line in a wavelength range of 0,5 m to 50 m. The reference line, is usually the intersection of the profile plane and the horizontal plane.

The range from 0,5 m to 50 m is the common range for roads. This limit can be extended to 100 m for runways. Higher values don't deal with unevenness but depend on road geometry

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3.5
raw profile
is the profile given by a profilometer when measuring a longitudinal road profile. Characteristics of raw profile, depend on the profilometer used

3.6
pre-processed profile (re-sampled and filtered profile)
is obtained by applying the re-sampling and filtering procedure described in clause 6. The pre-processing procedure aims to harmonize the profile provided by various devices

3.7
wavelengths
in most cases the profile can be adequately described as a sum of sine functions, when this is possible one such sine function is

$$A\sin\left(\frac{2\pi}{\Lambda}(x - x_0)\right)$$

Where

Λ is the wavelength of the sine in metres (m);

A is the amplitude of the sine in metres (m);

x is the abscissa of the current point, in metres (m);

x_0 is the phase of the sine, in metres (m).

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3.8
spatial frequency
is the reciprocal of a wavelength in cycles per metre. The spatial frequency N defines the number of waves, of wavelength Λ, per metre:

$$N = \frac{1}{\Lambda}$$

3.9
spatial sampling interval
is the horizontal distance between two adjacent points of the digitised longitudinal profile line

3.10
standard reference sampling interval
is the spatial sampling interval which must be used when computing the indices defined in this standard, its value is 0,05 m

3.11
measuring track
is the intersection of the envelope of the profile plane and the horizontal plane

3.12
profile measurement length
is the length of an uninterrupted profile measurement. It is the length over which the profilometer continuously and accurately digitises and records the profile (from point B to C in Figure 1). Most profilometers need to run for some minimum distance before and after the very profile they are to measure, these starting (from point A to B in Figure 1) and ending phases (from point C to D in Figure 1) should not be included in the profile measurement length

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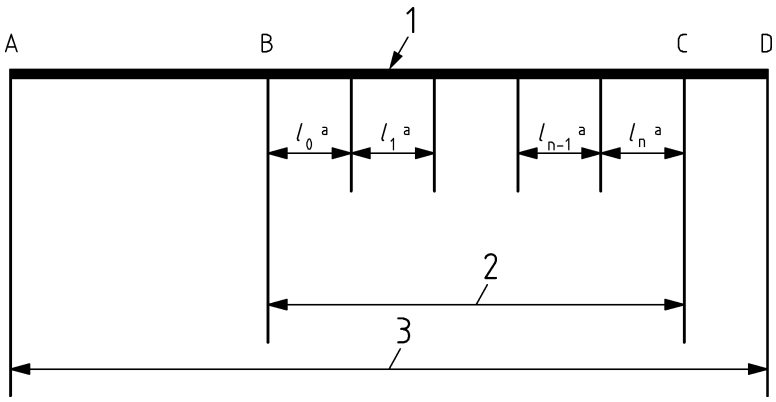

Key

1 road

2 $l_0 \ldots l_n$ sample reporting length

3 profile measurement length

4 overall profilometre route

Figure 1 — Profile lengths definitions

3.13
evaluation or reporting length
are the measurements made over the profile measurement length which are often analysed using shorter parts or samples (l_0 to l_n in Figure 1) to allow for a more precise description of the measured profile. The evaluation or reporting length is the length of such a sample

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NOTE In the case of consecutive samples such as l_0 and l_1 in Figure 1, over the profile measurement length, the word “segment” is used.

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3.14
PSD (Power Spectral Density)
Is the limiting mean-square value of a signal spectrum per unit bandwidth, i.e. the limit of the mean-square value in a rectangular bandwidth divided by the bandwidth, as the bandwidth approaches zero. In the unevenness measurement field, the signal used is usually the road profile. In practice the PSD spectrum is characterised by fitted straight regression line[s] and expressed by indices related to the location of these line[s]

4 Symbols and abbreviations

Symbols, which are used in equation are written using normal characters, abbreviations are written using bold characters.

B is the base used for IRI computation in metre (m). It is the length over which the IRI computation is performed (or reporting length using the terminology of this document).

$G(x)$ is the displacement PSD value for the spatial frequency x;

L denotes the measurement length, in metres (m), provided the conversion factor (1 km = 10^3 m) is given, kilometres can be used as an alternative;

N is the spatial frequency, in cycles per metre (m): $N = \frac{1}{\Lambda}$; N is usually called a wave number;

X_i is the abscissa of the sampled point i, in metre (m).

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z_i is the elevation of the profile determined at the sampling point i, in metre (m), provided the conversion factor (1 mm = 10^{-3} m) is given, millimetres can be used as an alternative;

δ_x is the spatial sampling interval for the digitisation of the profile, in metre (m), provided the conversion factor (1 mm = 10^{-3} m) is given, millimetres can be used as an alternative;

Λ is the wavelength, in metre (m);

Ω is the spatial frequency, in radian per metre (rad/m) $\Omega = \frac{2\pi}{\Lambda}$;

$G(\Omega_0)$ is the unevenness index; where Ω_0 = 1 rad/m;

IRI is the International Roughness Index;

PSD is the Power Spectrum Density of a signal spectrum;

WB is the wave band index calculated by using root mean square analysis applied to the pre-processed profile elevations for the wave band W, in metre (m), provided the conversion factor (1 mm = 10^{-3} m) is given, millimetres can be used as an alternative;

SW is the Root Mean Square value of the short waves band;

MW is the Root Mean Square value of the medium waves band;

LW is the Root Mean Square value of the long waves band;

w is the waviness of the signal spectrum

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5 Computation of unevenness indices

5.1 General overview of the computation

The computation of unevenness indices, involves three steps:

— the measurement and pre-processing of the profile, the output of which is a filtered and re-sampled (or pre-processed) profile,

— the computation of one or more index(es),

— the creation of a report (see Figure 2).

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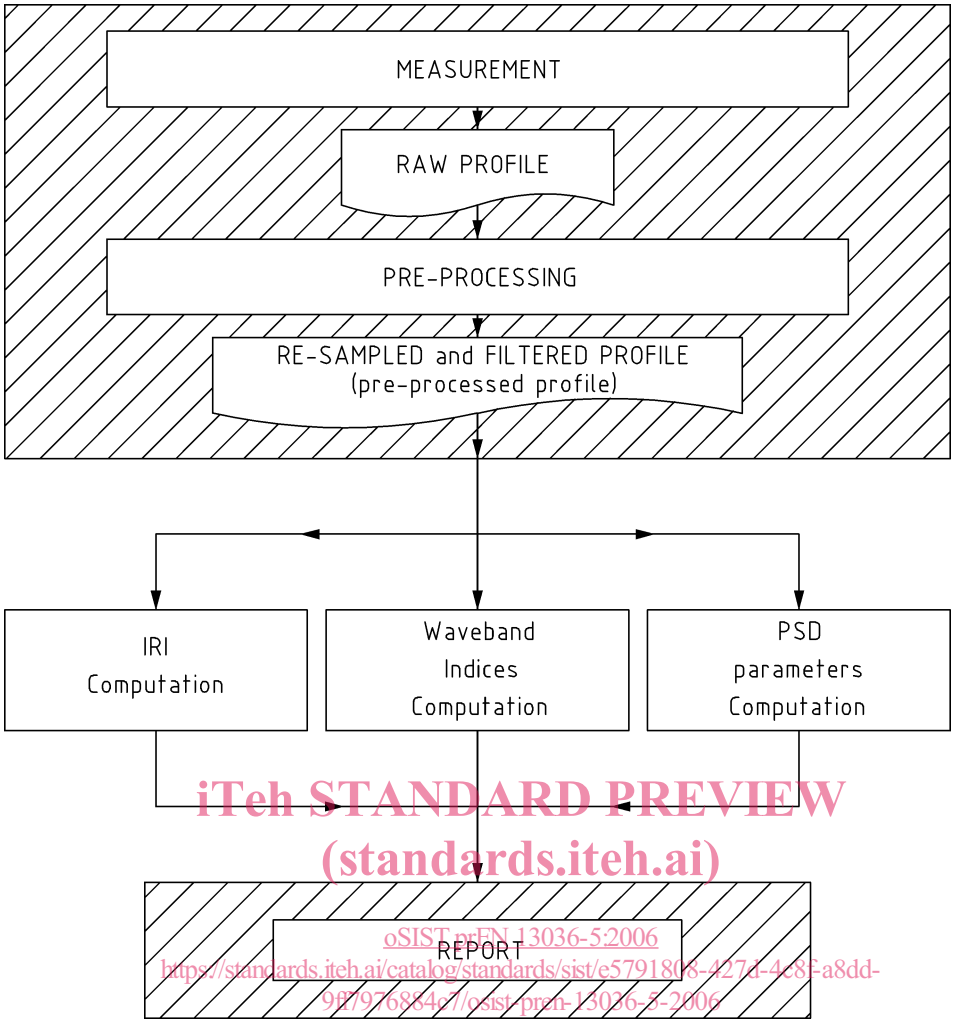

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Figure 2 — General overview of the computation

The pre-processing is essential in the case of wave band analysis is strongly recommended to homogenize the profiles and facilitate comparisons.

5.2 Pre-filtering and re-sampling

In order to allow for meaningful comparisons all the analyses described below, should be carried out using exactly the same algorithms which must be applied to signals sampled with exactly the same sampling interval.

As indicated in Figure 2, the output of a profilometer measurement is a raw profile, which makes use of a sampling interval which depends on the profilometer used.

NOTE The profilometer used should at least have a class 2 vertical definition and traveled distance accuracy, and a class 3 acquisition sampling interval, larger wavelength cutoff and reporting sampling interval as defined in the prEN 13036-6

As it is very unlikely that all profilometers will natively report results using the same sampling interval, one of the first step of the spectrum analysis must consist in re-sampling the original data to the standard reference sampling interval which is defined to be 0,05 m. This re-sampling process must be preceded by a bandpass filtering of the original signal, in order to insure that no unwanted distortion of the profile can be introduced (see Figure 3).

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The result of this procedure is the pre-processed profile, which has a sampling interval of 0,05 m, and a wavelength bandwidth limited to the 0,781 m to 50,0 m band. For certain applications the limitation of bandwidth is not applied.

Unless the used profilometer and the computations made afterward make use of a spatial sampling interval which is an integer multiple of the standard reference sampling interval, carrying out this the pre-processing is mandatory.

Profile analysis can afterward be carried out using either limited wave bands and derived associated indices or the full frequency content of the signal in which case the spectral density must be adequately estimated and described.

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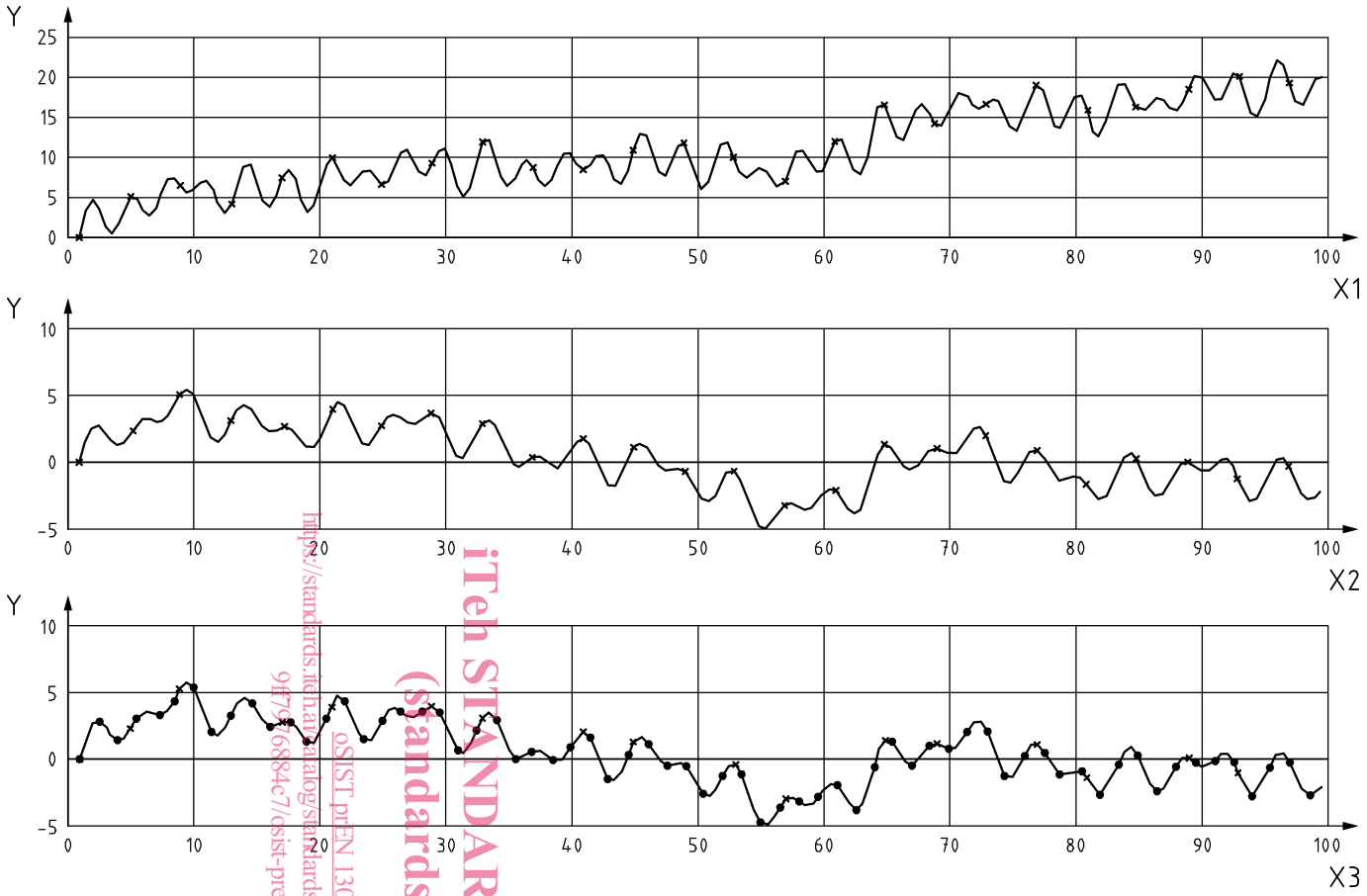

Key

1 elevations, in millimetre (mm)
2 measured originals profile (x = sampled points)
3 filtered originals profile (x = sampled points)
4 resampled profile (x = original points, • = resampled points)

Figure 3 — Filtering and Re-Sampling illustration

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