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EVALUATION OF PAVEMENT FRICTION ACCORDING TO EUROPEAN STANDARDS

Pavement friction was measured in Slovakia by SKIDDOMETER BV 11. An evaluation of skid resistance by Mu index value for use in the Slovak Pavement Management System (PMS) is based on one parameter of friction, only. The tendency to adapt the Slovak PMS to European standards involves creation of criteria for the skid resistance evaluation by International Friction Index IFI. The Slovak SKIDDOMETER BV11 did not participate in the PIARC harmonisation experiment for pavement friction measurement. Therefore the new approach for IFI calculation was required. The PIARC experiment and concerned equipment were analysed in detail. The British Portable Tester TRL was chosen as subsidiary equipment depending on Canadian experiences. The new methodology for IFI calculation by the Slovak SKIDDOMETER was suggested depending on comparison measurements and experiences analyses. On the base of new methodology criteria for pavement skid resistance evaluation were created.

1. Introduction

Pavement skid resistance is an important factor of pavement serviceability and traffic safety. The factor indicates wet pavement friction and describes an interaction between a tire and road surface by a friction coefficient. The friction coefficient is frequently determined according to one type of the road surface texture - microtexture or macrotexture, only. Obtained value can be misleading whereas the friction parameters depend on both characteristics. Thus, the same value of the friction measurement obtained from two pavements can indicate very different friction properties.

In 1992, the World Road Association PIARC carried out extensive test with pavement friction and texture measurement devices. The proposal of criteria for evaluation of the pavement skid resistance by International Friction Index (IFI) was a result of the test [1]. IFI describes the skid resistance properties like a result of the simultaneous measurements of the friction and macrotexture. The IFI contains two parameters: a speed constant derived from the macrotexture measurement indicating the speed dependence of the friction, and a friction number that is a harmonized level of friction for a slip speed 60 km/h.

2 International Friction Index IFI

The determination of the IFI consists of two basic steps:
1. Evaluation of the macrotexture (TX).
2. Evaluation of the friction.

2.1 The macrotexture evaluation

Several methods for pavement surface macrotexture determination are used at present. The determination of the surface texture depth by the sand patch test is the most widely used method. The Mean Texture Depth (MTD) is a resulting value.

The PIARC experiment confirmed Mean Profile Depth (*MPD*) as the best parameter for describing of the macrotexture subject to statistical evaluation. Very subjective sand patch test used for determination of *MPD* is the source of inaccuracy so the laser method is contemplated in future The surface macrotexture is described by the coefficient S_p (speed constant) determined by equation (1) [8].

$$S_p = a + b * TX. \qquad (1)$$

In equation *a*, *b* are regression coefficients determined for each type of macrotexture measurement, *TX* is parameter characterised the macrotexture (*MPD*, *MTD*, *ETD*).

The best results in the IFI calculation are achieved using the Mean Profile Depth method. The sand patch test also provides good results despite of the subject effect. The essential formulas are described in (2) and (3).

$$S_p = 89.7 * MPD + 14.2 \qquad (2)$$

$$S_p = 113.6 * MTD + 11.6 \qquad (3)$$

In equations *MPD* and *MTD* are expressed in mm and S_p in km/h.

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By combination of (2) and (3) formulas we can determine the relation between *MTD* and *MPD* (4):

$$MTD = 0.79 * MPD + 0.23\,. \tag{4}$$

Using (4) the Estimated Texture Depth (*ETD*) is determined and the value S_p is calculated by equation (5).

$$S_p = 93.0 * ETD + 17.63 \tag{5}$$

2.2 Friction evaluation

The friction coefficient is a basic value determined by all measuring equipment. For general use and comparison with different equipment the recalculation to the conventional slip speed (*S*) 60 km/h is needed. The slip speed value is dependent on equipment type and measuring speed (*V*).

a) In case of a locked wheel $S = V$.
b) In case of a slipped wheel $S = V * slip$. Relation $S = 0.17 * V$ is valid for 17% slip.
c) In case of a wheel with a slip angle $S = V * \sin(Q)$, where Q is the slip angle.

The friction coefficient *FRS* obtained from measuring equipment with current slip speed *S* is recalculated to the unified speed 60 km/h by (6):

$$FR60 = FRS * \exp\lfloor (S - 60)/S_p \rfloor. \tag{6}$$

In the equation FR60 is adapted friction coefficient for 60 km/h equivalent of the slip speed; FRS is the friction coefficient for current slip speed S; and Sp is a speed constant according to (1).

The value FR60 is used for IFI determination by relations (7) and (8).

$$F60 = IFI = A + B * FR60 + C * TX \tag{7}$$

$$F60 = IFI = A + B * FRS + \\ + \exp[(S - 60)/(a + b * TX)] + C * TX \tag{8}$$

where *A*, *B*, *C* are calibration constants for each equipment [8]; and *C* is zero for the smooth tyre.

2.3 The methodology for IFI calculation by SKIDDOMETER BV11

The Slovak Road Administration uses SKIDDOMETER BV11 [2] for friction measurement. Unfortunately, the equipment did not participate in the International PIARC Experiment to Compare and Harmonize Texture and Skid Resistance Measurements [1]. Therefore, the two steps were required. An implementation of the coefficients related to SKIDDOMETER BV11, and realization of the comparison measurements for IFI estimating. The three equipment were chosen as a reference – Canadian SKIDDOMETER BV11, side force device *SCRIM* and analysis of friction measurements by British Portable Pendulum Tester (*BPT*). The results from PIARC experiment [1], Cenek [3] and Canadian [4] experiences were used.

The measured values from devices *BPT*, *SCRIM* and SKIDDOMETER BV11 were compared and recalculated to the IFI value by well-known formulas first. The comparison of results from devices *SCRIM* and SKIDDOMETER BV11 showed that the values obtained from devices are very similar, in spite of different principles. Following this, the results from SKIDDOMETER were used for IFI calculation by SCRIM [1], [3].

The long-time observed road sections in Slovakia were used for evaluation of the relations between *IFI* values. Computation was realized on the base of friction index by SKIDDOMETER BV11 (expressed by Mu value), macrotexture measurement by sand patch test and by *BPT* friction. Measured results were obtained from 31 random selected measurement sections.

Following the analysis the methodology for *IFI* calculation by SKIDDOMETER BV11 was created. The next values are necessary for calculation:

- Friction index from SKIDDOMETER BV11, expressed by the parameter *Mu*.
- Measuring speed of the device.
- Slip speed of the device.
- Macrotexture determined by the volumetric method hp (sand patch test), determined as the Mean Texture Depth (*MTD*).

On the basis of the described input data the friction index is calculated by equation (9), adapted for Slovak conditions.

$$IFI = 0.065' + 0.92 * Mu * exp^{\lfloor (0.17*v - 60)/S_p \rfloor} - \\ - 0.075 * h_p\,, \tag{9}$$

where: $S_p = 113.6 * h_p - 11.6$ (10)

Mu is a friction index from SKIDDOMETER BV11, v is measuring speed of the device in km/h, h_p is the macrotexture determined by sand patch test in Mean Texture Depth (*MTD*).

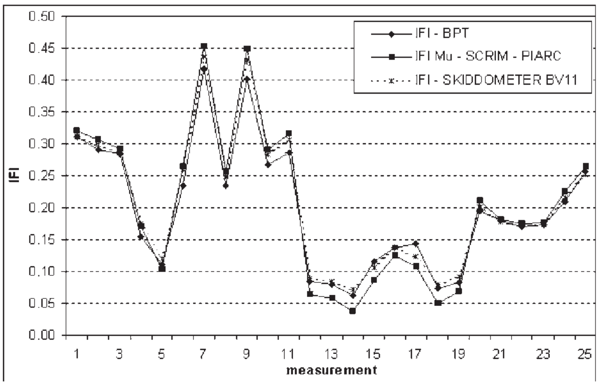

Fig. 1 Comparison of the proposal methodology of IFI calculation

The recommended equations were tested for a routine use by experimental measurements in the long-time monitoring experimental sections of the Slovak Road Administration. The obtained results are presented in the next figures. The comparison of the designed methodology with present practices valid for chosen reference devices are presented in Fig. 1. The results confirm the correctness of the created methodology for *IFI* calculation by using SKIDDOMETER BV11.

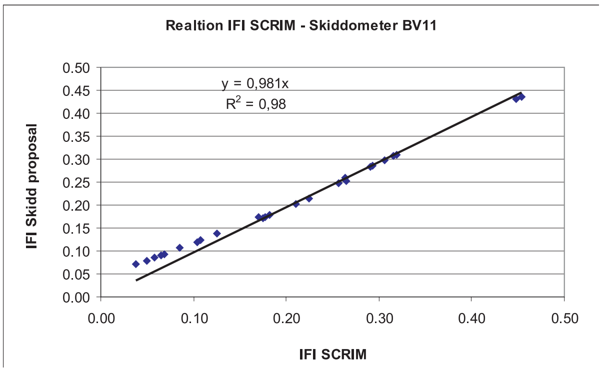

Fig. 2 Comparison of the SCRIM and SKIDDOMETER design method values

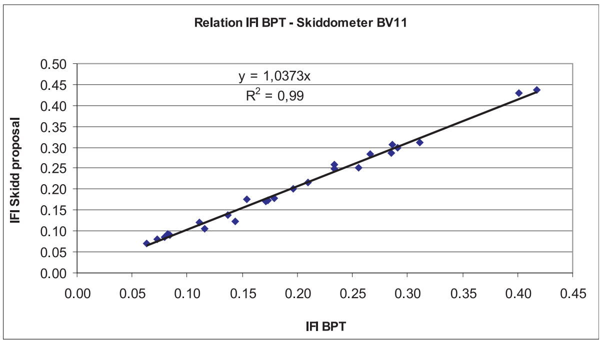

Fig. 3 Comparison of the BPT and SKIDDOMETER design method values

Fig. 2 and Fig. 3 show relations between the calculated *IFI* values by a designed formula for measurements of *Mu* factor by SKIDDOMETER BV 11 and reference devices *BPT* and SCRIM under the same edge conditions.

3 Criteria for the pavement friction evaluation by IFI

The *Mu* value only is used in the Slovak Pavement Management System for evaluation of the pavement friction characteristics at present. The proposal of new criteria by *IFI* value was created on the base of the presented analysis. The criteria are shown in Table 1.

Friction quality evaluation — Table 1

Evaluation	Type of road Design speed $v_n >= 80$ km/h		Type of road Design speed $v_n < 80$ km/h	
	by Mu	by IFI	by Mu	by IFI
Insufficient quality	$Mu < 0.53$	$IFI < 0.14$	$Mu < 0.53$	$IFI < 0.16$
Applicable quality	$0.53 < Mu \leq 0.79$	$0.14 < IFI \leq 0.31$	$0.53 < Mu \leq 0.68$	$0.16 < IFI \leq 0.33$
Good quality	$Mu > 0.79$	$IFI > 0.31$	$Mu > 0.68$	$IFI > 0.33$

4 Conclusion

The presented results are based on the measuring samples and afforded values from past experiments. The multiple comparison measurements are inevitable for verification or modification of them. Following this, the classification of the pavement friction by *IFI* will be used in the Slovak PMS.

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