COMPARISON BETWEEN TWO DIFFERENT VOLUMETRIC METHODS FOR MEASUREMENT OF PAVEMENT SURFACE MACROTEXTURE

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ABSTRACT

The volumetric methods are the most used to determinate the Mean Profile Depth of road pavements. In Italy, the sand patch method, normalised by C.N.R. Official Bulletin n.94/83, has been used for a long time but lately the Volumetric Patch Method (EN 13036-1/2001) has been introduced.

The two test methods are almost similar and enable the evaluation of the macrotexture of a road pavement respectively as HS (height of sand) and MTD (Mean Texture Depth). They differ in two elements: (i) the material used for the test (standardized sand in the HS method and standardized glass micro-spheres in the Volumetric Patch Method) (ii) the measurement technique of the circular patch diameter.

The aim of this paper is to verify if these different elements can determine differences in the results obtained by the two test methods. Therefore, a sample of road pavements has been carefully selected in order to obtain reliable results. Then a significant number of homogenous sections, with different texture level, have been defined and the experimental measures have been carried out.

The statistical elaboration of the obtained values has lead interesting results; the most important is that the MTD value is often greater than HS value. This suggests a revision of technical standards in order to evaluate the pavement macrotexture correctly regarding the chosen test method. A correlation between MTD and HS, useful in the practice, has been carried out based on the experimental measures.

Keywords: pavement, macrotexture, specifications

1. INTRODUCTION

The skid resistance is the most important property of a pavement surface and it is related to two characteristics namely microtexture and macrotexture.

Microtexture depend mainly on aggregate shape characteristics and mineralogy, while macrotexture is a function of mix properties, compaction method and aggregate gradation.

There are many methods for measuring pavement macrotexture. Modern equipment (such as the laser profilometer) is based on the surface profiling techniques and allows reliable survey and electronic data processing of the measurements. However, the traditional Volumetric Patch Method is the most widely used although it has some limits. In fact, this traditional measurement system depends upon the operator ability. It needs survey surfaces which are partly or fully closed to traffic and so it is not practical for use in network tests of the roads. Despite these limits, the Volumetric Patch Method is the most commonly used for macrotexture specifications for the highway agencies and for the paving contractors.

The main objective of this study is to compare the Volumetric Patch Method normalized in Italy and that one normalized by a European Norm Standard in order to provide recommendations for implementing the new specification.

For such aim a sample of road pavements, with different texture levels, has been carefully selected and experimental measurements have been carried out.

2. THE VOLUMETRIC PATCH METHOD

The Volumetric Patch Method is the well known and world-wide used traditional system for measurement of pavement surface macrotexture.

In Italy the Sand Patch Method, normalised by C.N.R. Official Bulletin n.94/83, has been used for long time but recently a Volumetric Patch Method has been normalised by EN 13036-1/2001 Standard that draws large inspiration from the norm ASTM E 965-87.

These methodologies are similar and permit the evaluation of the macrotexture of a road pavement respectively as HS (height of sand) and MTD (Mean Texture Depth).

They differ only for the material used in the test and for the measurement technique of the circular patch diameter. In fact, standardized sand is used and two diameters of circular patch are measured in the Italian Sand Patch Method. In the European Volumetric Patch Method instead standardized glass micro-spheres (with diameter included between 0.18 and 0.25 mm) are used and four diameters of circular patch are measured.

These methodologies can give only punctual indications of the roadway macrotexture with a geometric three-dimensional schematisation. They provides the MTD (Mean Texture Depth) of a pavement by measuring of the diameter of a circular patch distributed on the surface, spreading a known volume ($V = 25.000\ mm^3$) of glass micro-spheres or normalized sand.

The MTD or HS [mm] related to the considered point of road surface can be evaluated by using the well known equation:

$$MTD/HS = \frac{4 \cdot V}{\pi \cdot D^2}$$

The average diameter D of the circular patch will be calculated using 4 measurements in the Volumetric Patch Method and 2 measurements in the Sand Patch Method.

3. SELECTION OF THE TEST SECTIONS

In order to compare the HS and the MTD volumetric methods, some experimental measurements have been carried out. The test pavements over which to perform the surveys have been selected carefully to have enough homogeneous sections at different surface macrotexture levels. This allows coverage of as much as possible the variability field of this parameter. Therefore twenty homogeneous road sections, belonging to Italian rural road network, have been selected. Each section is 100 meter long and has different traffic and texture characteristics. In order to obtain a representative sample, the twenty tested sections have been selected as follows:

- The sections where the maintenance treatments were realized in different periods have been located;
- Visual inspections to identify the pavement conditions with respect to the different levels of macrotexture have been carried out;
- The sections with different geometric characteristics have been selected.

All the selected sections have traditional bituminous pavements with macrotexture values varying between 0.31 mm and 1.71 mm.

In order to obtain a bigger sample, for each section the measurements have been carried out on three different longitudinal alignments: wheel path, shoulder and axis of the lane.

4. EXPERIMENTAL MEASUREMENTS

On the sections previously described, the measurements with both volumetric patch methods, HS (Italian Official Bulletin C.N.R n. 94/83) and MTD (EN 13036-1/2001 Standard), have been performed. For each longitudinal alignment (100 meter long) 11 measurements of HS and MTD have been executed with a step of 10 m. Therefore, for each tested section, 66 mean texture depth values have been obtained: 22 values for every longitudinal alignment and 33 values for every measurement method considered.

For all alignments the average and the standard deviation of the measured values have been calculated. In table 1 a summary of the test results has been reported.

Table 1 Summary of the test results

Summary of Test Results HS - MTD

IDENTIFICATION OF ROAD SECTION (LENGHT: 100 M)	LONGITUDINAL ALIGNMENT		HS		MTD	
			AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION
SECTION 1	1.1	WHEEL PATH	0,88	0,10	0,96	0,01
	1.2	LANE AXIS	1,04	0,18	1,10	0,13
	1.3	SHOULDER	1,13	0,25	1,29	0,02
SECTION 2	2.1	WHEEL PATH	0,42	0,05	0,46	0,04
	2.2	LANE AXIS	0,48	0,03	0,55	0,04
	2.3	SHOULDER	0,53	0,05	0,54	0,06
SECTION 3	3.1	WHEEL PATH	0,34	0,03	0,36	0,04
	3.2	LANE AXIS	0,37	0,06	0,40	0,05
SECTION 4	4.1	WHEEL PATH	0,58	0,09	0,58	0,10
	4.2	LANE AXIS	0,68	0,16	0,73	0,15
	4.3	SHOULDER	0,65	0,15	0,54	0,09
SECTION 5	5.1	WHEEL PATH	0,44	0,03	0,50	0,03
	5.2	LANE AXIS	0,57	0,03	0,62	0,07
	5.3	SHOULDER	0,86	0,11	1,03	0,09
SECTION 6	6.1	WHEEL PATH	0,69	0,05	0,76	0,05
	6.2	LANE AXIS	1,05	0,05	1,10	0,06
	6.3	SHOULDER	0,74	0,05	0,80	0,04
SECTION 7	7.1	WHEEL PATH	1,09	0,07	1,03	0,08
	7.2	LANE AXIS	1,23	0,14	1,35	0,15
	7.3	SHOULDER	1,68	0,18	1,67	0,14
SECTION 8	8.1	WHEEL PATH	0,91	0,06	0,94	0,07
	8.2	LANE AXIS	0,89	0,06	0,96	0,08
	8.3	SHOULDER	0,85	0,07	0,97	0,13
SECTION 9	9.1	WHEEL PATH	1,24	0,17	1,38	0,08
	9.2	LANE AXIS	1,30	0,17	1,50	0,12
	9.3	SHOULDER	1,52	0,16	1,55	0,13
SECTION 10	10.1	WHEEL PATH	0,80	0,06	0,92	0,05
	10.2	LANE AXIS	1,28	0,16	1,14	0,13
	10.3	SHOULDER	0,79	0,05	0,85	0,06
SECTION 11	11.1	WHEEL PATH	0,39	0,03	0,43	0,02
	11.2	LANE AXIS	0,50	0,04	0,54	0,04
	11.3	SHOULDER	0,48	0,03	0,48	0,04
SECTION 12	12.1	WHEEL PATH	0,31	0,03	0,33	0,02
	12.2	LANE AXIS	0,52	0,05	0,52	0,04
	12.3	SHOULDER	0,64	0,02	0,76	0,09
SECTION 13	13.1	WHEEL PATH	0,46	0,04	0,49	0,05
	13.2	LANE AXIS	0,55	0,06	0,60	0,04
SECTION 14	14.1	WHEEL PATH	0,67	0,05	0,73	0,09
	14.2	LANE AXIS	0,85	0,08	1,04	0,16
SECTION 15	15.1	WHEEL PATH	0,86	0,09	0,97	0,10
	15.2	LANE AXIS	1,00	0,10	1,05	0,10
	15.3	SHOULDER	1,00	0,15	1,11	0,14
SECTION 16	16.1	WHEEL PATH	1,71	0,03	1,73	0,03
SECTION 17	17.1	WHEEL PATH	0,36	0,01	0,38	0,03
	17.2	LANE AXIS	0,42	0,02	0,47	0,03
	17.3	SHOULDER	0,54	0,06	0,57	0,07
SECTION 18	18.1	WHEEL PATH	0,42	0,05	0,47	0,03
	18.2	LANE AXIS	0,51	0,05	0,57	0,04
	18.3	SHOULDER	0,53	0,04	0,58	0,04
SECTION 19	19.1	WHEEL PATH	0,59	0,06	0,64	0,05
	19.2	LANE AXIS	0,63	0,06	0,71	0,09
	19.3	SHOULDER	0,80	0,08	0,89	0,08
SECTION 20	20.1	WHEEL PATH	0,77	0,07	0,88	0,09
	20.2	LANE AXIS	1,17	0,08	1,27	0,12
	20.3	SHOULDER	1,26	0,06	1,42	0,08

The values obtained for each longitudinal alignment (wheel path, shoulder and axis) on the same section are different as a result of the unlike wear conditions. So, the longitudinal alignments are independent sub-sections and then the experimental sample is composed of 55 alignments.

In the figure 1 all sub-sections data are reported. The shape of the curve is representative of the wide variability range of the measurements.

In fact experimental sections with macrotexture levels variable between 0.31 mm and 1.71 mm, have been chosen in order to obtain reliable results.

The figure 1 shows that often the obtained measurements of MTD are greater than the corresponding HS values.

The differences are very small in some cases but they are significant in other cases.

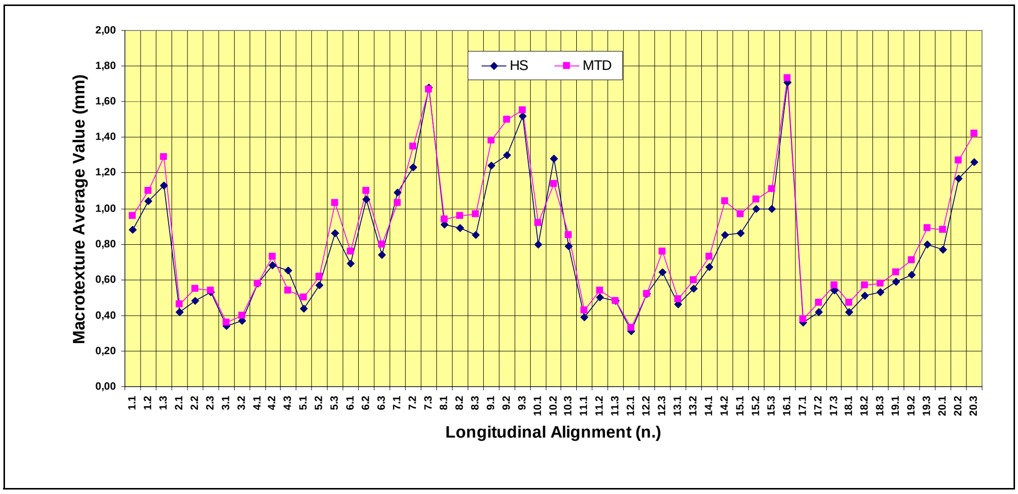

Figure 1 Comparison between HS and MTD (total data set)

This observation is very important considering that the HS or MTD values are the most commonly parameters adopted in the technical macrotexture specifications to evaluate the skid resistance of the road pavements.

Therefore, in order to not make mistakes in the macrotexture evaluation, the definition of the test methods is necessary when the recommendations are implemented.

For this aim a relationship that joins the two parameters HS and MTD can be useful.

5. COMPARISON BETWEEN “HS” AND “MTD” VALUES

The Average Value (AV) of the macrotexture indicators examined, related to each homogeneous section, have been correlated in order to obtain the comparisons of the two different inspection devices of the surface texture.

The aforesaid corresponding average values were subjected to statistical analysis by determination of the associated regression curves.

The correlation, obtained using the data measured on the 55 tested sections, is explained in figure 2. The graph shows the linear trend, calculated from the dispersion zones of the single obtained points and they disclose the associated equations of the determined regression lines plus the coefficient of correlation R^2.

The coefficient of correlation R^2 associated to the total data set is 0,9702.

The validity range of the regression curve in figure 2 is variable between 0.31 mm and 1.71 mm, that is the range of macrotexture values measured on the experimental sections.

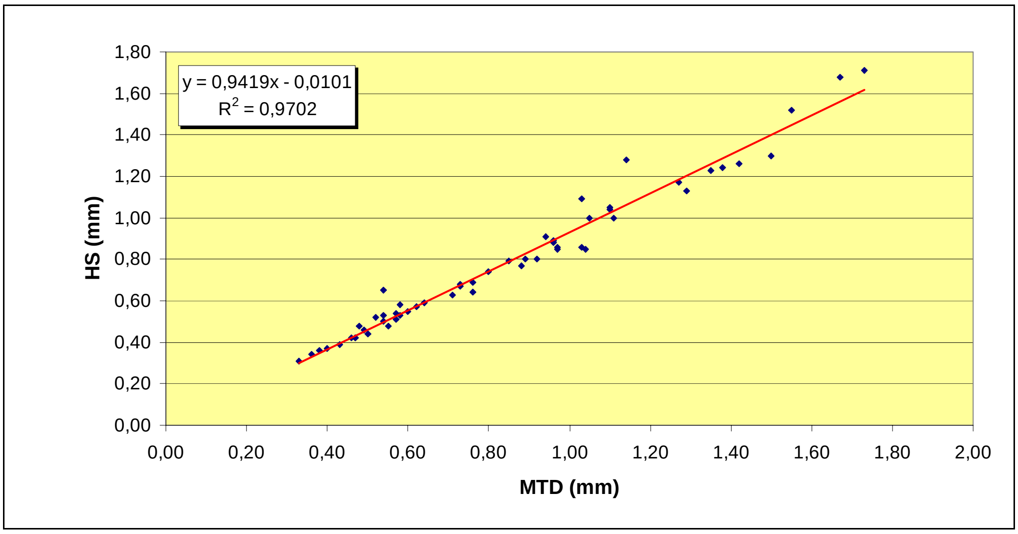

Figure 2 Correlation between MTD-HS on 55 sections (total data set)

In order to obtain a more reliable correlation between the parameters analysed, a reduced data set, obtained removing by original set the inconsistent values, has been used. Specifically the removed values are: i) the values of a section equal other sections, because irrelevant for the correlation; ii) the values concerning non homogeneous alignments, characterised by high standard deviation; iii) inconsistent values related to a same section, because of possible mistakes of the operator.

Figure 3 illustrates the comparison between HS and MTD only for the reduced data set made up of 32 sections.

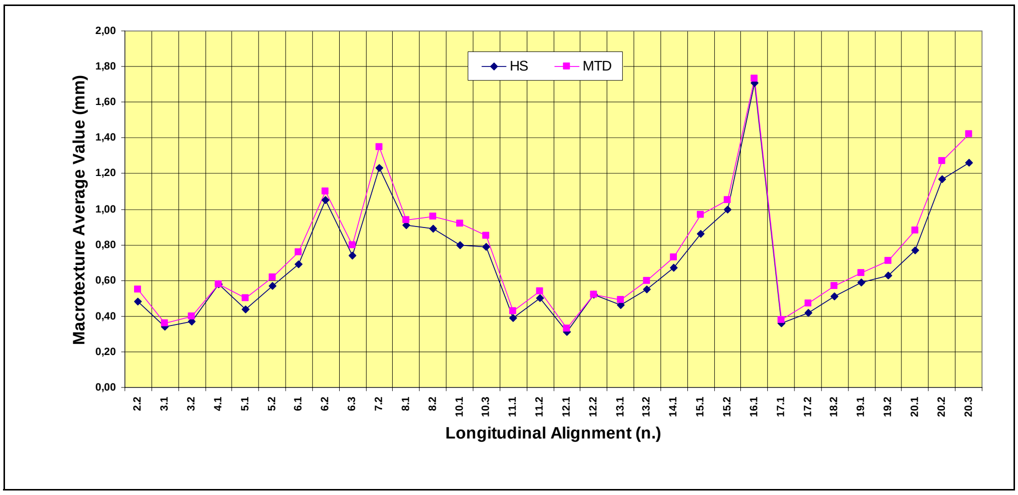

Figure 3 Comparison between HS and MTD (reduced data set)

The correlation obtained considering the 32 selected sections is shown in figure 4.

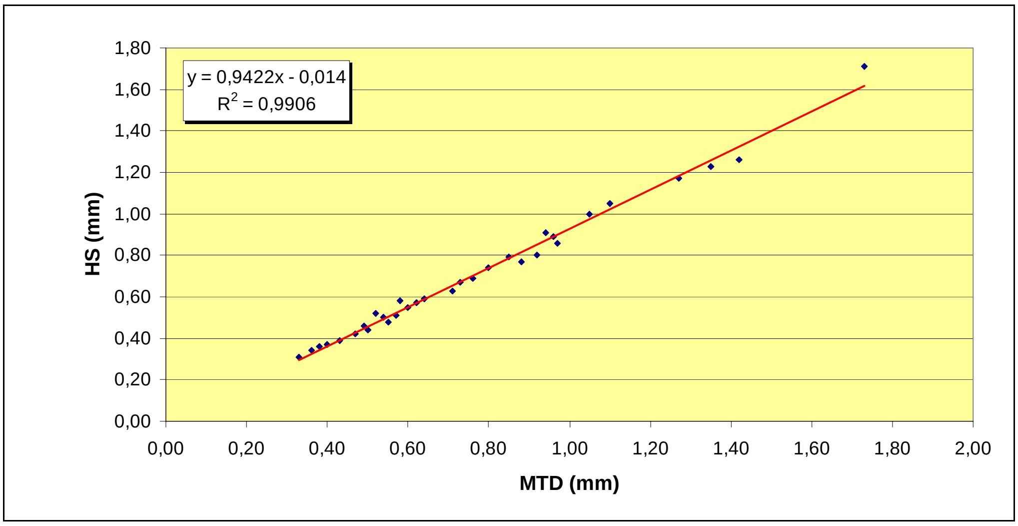

Figure 4 Correlation between MTD-HS on 32 sections (reduced data set)

The removal of the anomalous values allows a better correlation with a R^2 coefficient equal to 0,9906.

Also for this regression curve the validity range is variable between 0.31 mm and 1.71 mm

Therefore, for the pavements examined, the equation joining HS and MTD is the following:

$$HS = 0{,}94\ MTD - 0{,}01$$

The obtained correlation shows that the MTD method overestimates the available skid respect to the HS method, with possible disadvantages for the safety.

6. CONCLUSION

This paper contains analyses and comparisons between the Sand Patch Method, normalised by C.N.R. Official Bulletin n.94/83, and the Volumetric Patch Method normalised by EN 13036-1/2001, both of which are standard methods for quantifying pavement surface macrotexture. A number of experimental measures have been carried out selecting a significant sample of homogenous sections belonged to Italian rural network.

The results of the experimentation have highlighted some differences in the values obtained by two test methods. This is very important considering that the volumetric patch methods are the most used to define the technical macrotexture specifications in order to evaluate the skid resistance of the road pavements. Therefore the description of the test method is necessary when the specifications are implemented.

Based on the experimental measurements, a relationship between the parameter obtained by the sand patch method (HS) and that one obtained by volumetric patch method (MTD) has been achieved. Further measurements can be performed in order to extend the tested sample.

The results presented in this paper can be useful to define the changes in the pavement macrotexture specifications from Italian HS method to European MTD method.

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