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TEXTURE DEPTH DETERMINATION FOR STONE MASTIC ASPHALT (SMA)

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ABSTRACT

The primary road surface characteristics that affect users are safety, noise and riding quality. Safety particularly relates to surface texture (macro texture), which influences water dispersal and ability of a tire to contact the road surface. This paper deals mainly with texture depth contribution to tire pavement contact. A slab mould was designed and built specifically of SMA to conduct skid and texture depth tests to simulate the actual field behavior. A stepwise regression analysis was used, to indicate the separate and distinct effect of several aggregate factors such as angularity, type of aggregate, percent of asphalt voids in the mix, density, Polished Stone Value, Particle Index, Surface area, on the skid resistance of the experimental surface mixtures. At 95% confidence limit, a total of five dependent variables were found to be significantly influence texture depth of StoneMasticAsphalt (SMA). Those variables were angularity, coarse aggregate, percent of asphalt, voids in the mixture and density. It may therefore be concluded that the texture depth of SMA has the potential to optimize the contact area between tires and road surface under dry and wet conditions.

Keywords:Texture depth, skid resistance SMA, macrotexture and microtexture

1. INTRODUCTION

Road surface requirement has been changing significantly over the last thirty years. In the fifties, surface evenness maintenance work was confined to remedying potholes, and assessment of wet weather skid resistance was at an early stage. Since then, in response to rapid growth, most countries have been concerned with road traffic surface evenness OECD, [1] The skid resistance of highway pavements, particularly when wet, is a serious problem, as traffic speeds and densities continue to rise. The chances of skidding accidents, as well as their consequences, are both growing at an alarming rate over the years.

There are great numbers of road factors influencing the tire road interaction in a variety ways. These factors are related to road design (curve, grade, tangent, crown, superelvation, land location, etc). , Road surface factors (type of binder, aggregate texture, roughness, micro-topography) Ludema and Gujrati, [2]. The three primary factors influencing the skid resistance performance of bituminous roadways are pavement distress, macro texture and micro texture. Macrotexture is the result of the size, shape, and arrangement of aggregate particles in the mix. The influence of particle shape characteristics and gradation of aggregates on the skid resistance of asphalt surface mixtures has been subject of numerous field and laboratory studies. Aggregate size is controlled by the gradation requirement. Gradation is

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most important property of an aggregate, it affects almost all important properties of HMA, including stiffness, stability, durability, permeability, workability, fatigue resistance, skid resistance, and resistance to moisture damage. The aggregate properties that have direct influence on skid resistance are the type, size (gradation), shape, wear state, and the resistance to polishing wear. (Geol et al, [3] indicated that the co-efficient of friction is significantly affected by the grading of aggregates used in the preparation of bituminous mixtures. Stephens and Geotz, [4], indicated that angularity of coarse aggregates concert's contribute to tire pavement friction in the case of asphalt concrete and screening (aggregate) seal coats by establishing points contacts, that protrude the above the water level, with the tire rubber. Angularity is mostly readily attained by rock crushing operation. However, aggregates of different mineral composition with the same angularity may wear-polish at very different rates ,At the present time, no suitable standard test method is available for accelerated polishing and testing the frictional properties of compacted asphalt paving mixtures intended for wearing course. Most agencies use the bare coarse aggregate only for measuring and evaluating the polish and frictional properties. The main goal of this paper is to analyze the influence of road surface texture on skid resistance.

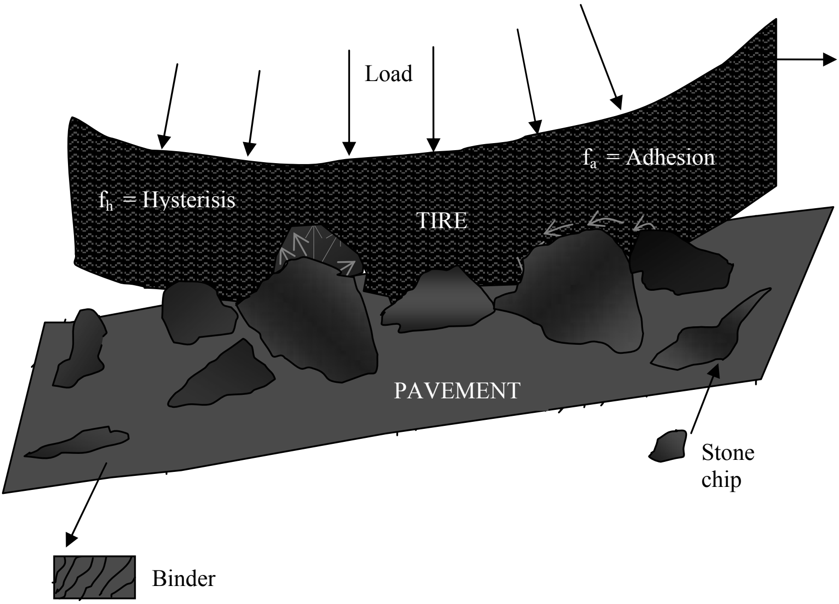

Figure 1 : Components of Friction [5]

The tread rubber is a material capable of large, almost totally recoverable deformations. The pavement surface is considered as completely rigid and unyielding. Pavement surface micro asperities distort tire-rubber; this is the first component of tire pavement friction-deformation (Hysterisis) component. Any individual rubber surface particle goes through a deformation cycle as it passes over pavement asperity. The second component of tire pavement friction is the adhesion developed between the rubber and the aggregate. Clapp,[6] says that the adhesion component is attributed to bonding (probably electrostatic attraction) of exposed rubber molecules and aggregates. The significance of this relationship as shown in Figure 1 is paramount in the understanding of the factoring that influence field measurements. It has been shown that adhesive component of friction is speed dependent, whereas the hystresis component is relatively independent of speed except at high speeds where it decreases as the tire gains heat.

2. MATERIALS AND METHODS

2.1 Aggregates

Granite was selected for use in the test program from the Negri Road Stone physical properties for the aggregate are shown in Table 1.

Property	Results
LAAV	22.1
Aggregate Crushing value	19.8%
Particle Shape Index (PI)	12.9
Polished Stone Value (PSV)	52.10
Angularity Number (AN)	9.00
Soundness	5.28

Table 1 : Physical Properties of Aggregate

2.2 Asphalt

A type of rubberized bitumen supplied by Petronas was used in this investigation.. The physical properties are shown in Table 2.

Property	Results
Penetration	63
Softening Point	54^{o}C

Table 2: Physical Properties of Asphalt

In the laboratory, the Sand Patch Method was used to determine the texture depth of 0.43 x 0.43 m pavement slabs. A typical example of the slab is shown in Figure 2. The sizes was dictated by practical considerations but calculated to be long enough to conduct sand-patch and skid resistance testing.

Sufficient aggregate for the slab of Stone Mastic Asphalt (SMA14), (SMA12.5) and ACW14 dense graded asphalt, were proportioned and heated at 175°C. The rubberized bitumen also heated to 163°C, was then added to the heated aggregate in a mixer. Mixing continued until all aggregate particles were thoroughly coated with the binder and the material was then placed in the molds. Compaction at 140°C was accomplished using the roller compactor. The roller was applied uniformly up to 10 passes in three layers. The slabs were then allowed to cool down before removal from the molds. Beforehand, trial runs were conducted to determine the number of passes required to attain the desired mix density. All slabs were tested for surface texture by using sand-patch and the values ranged from 0.38 mm to 1.74 mm

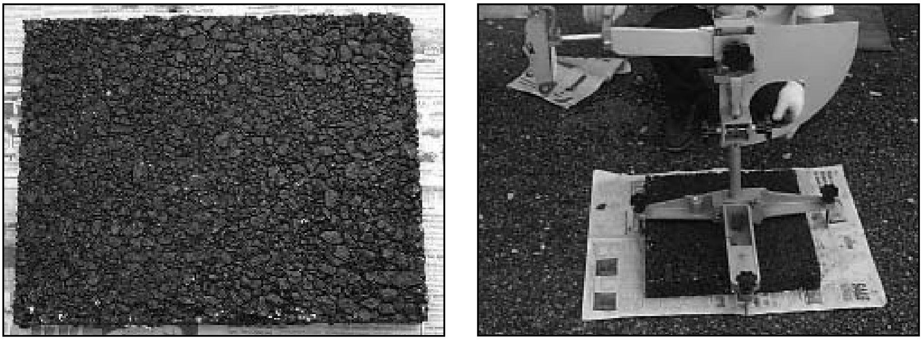

Figure2 : SMA 14 Aggregate Sizes Slab and Portable Friction Tester

3. DISCUSSION AND ANALYSIS OF THE RESULTS

To indicate the separate and distinct effect of the several aggregate factors on the skid resistance of the experimental asphalt surface mixtures, the particle and composition effect were analyzed statistically in association with the texture depth (TD) obtained from various gradations, in addition of aggregate factors, the percentage of asphalt and air voids, were also included as independent variables for possible association with the TD. The analysis was facilitated by the use of stepwise regression equation in stepwise manner using the SPSS statistical software.

Gradation	Texture Depth (mm)
SMA14-G1	1.74
SMA14-G2	1.32
SMA12.5-G3	1.28
SMA12.5-G4	0.98
Control-G5	0.42
Control-G5	0.38

Table 3 : Texture Depth of Pavement Slabs Tested

As shown in Table 1. It was also noted that the skid resistance and texture depth data of SMA14 and SMA 12.5 indicate a wide spread of values ranging 0.38 to 1.74 mm , regardless of composition of the mixture.

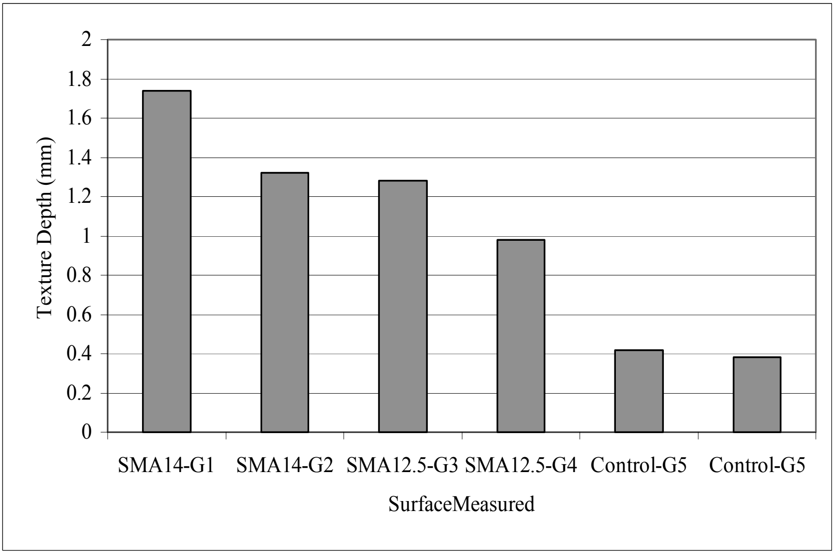

Figure 3 : Comparison of Texture Depth of SMA and ACW14 Mixtures

The macrotexture and microtexture describe the characteristics of a road surface, the average depth, which is the average depth of the surface below the highest point. The texture depth used on this study was that measured by a sand patch method, the resulted were correlated with the skid resistance, the relation is plotted in Figure 4, and is seen to be linear with a correlation coefficient 0.88.

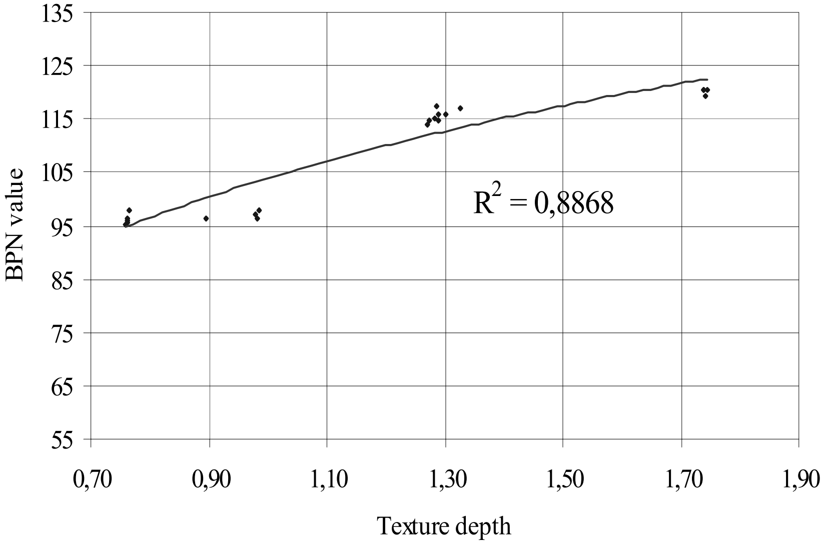

Figure 4 : Effect of Texture Depth on Skid Resistance

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3.1 Statistical Analysis of the Results

The data were analyzed statistically for association with the BPN and TD units obtained from various gradations. In addition of aggregate factors the percentage of air voids, density were also included as independent variables for possible association with the BPN and TD. In each case, the various independent variables were inserted one at a time until the most significant parameter was obtained. The order of insertion was determined by using the partial correlation coefficient as a measure of relative importance of the variables not yet in the equation, as variables was entered in the regression, the P-value for each variable in the regression at any stage of the calculation were evaluated and compared pre selected percentage point of P-value. To indicate the separate and distinct effects of aggregate factors on the skid resistance and texture depth of the experimental asphalt mixtures, cross tabulations on variables of interrelation were also made to identify the relation ship among variables relevant to skid resistance and texture depth of SMA and Contribution of particle and composition indexes of paving mixture. All the variables (Polished Stone value (PSV), Particle Shape Index (PI), Voids in the Total Mix (VTM), Distribution of Coarse Aggregate (DOC), Angularity Number, VMA, and Density indicated above were considered initially. The α value for each independent was systematically checked at a confidence level of 95 percent, any variable which is not significant were left out, and analysis were carried out considering only the significant variables.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression Residual Total	0.553 0.000 0.553	4 0 4	0.138		a
2	Regression Residual Total	0.553 4.012E-04 0.553	3 1 4	0.184 4.012E-04	459.246	0.034[a]
2	Regression Residual Total	0.552 8.099E-04 0.553	2 2 4	0.276 4.050E-04	681.909	0.001[b]

a. Predictors (Constant). VTM, ASHAL, AN, DOC
b. Predictors (Constant). ASPHAL, AN, DOC
c. Predictors (Constant). DOC, ASPHAL
d. Dependent Variable. TD

Table 4 : Analysis of Variance of all Parameters Considered Initially

The order of insertion was determined by using partial correlation coefficient as a measure of the relative importance of the variables not yet in the equation, and the one most highly correlated with dependent variables entered the regression first. As the variables entered into the regression, the p-value for each variable in the regression at any stage of calculation was evaluated and compared with $\alpha = 0.05$. Any non-significant variable was removed from the model. The stepwise method is well explained in textbooks on regression analysis, and is not described in detail here.

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a. Predictors (Constant). DOC
b. Predictors (Constant). DOC, ASPHAL
c. Dependent Variable. TD

Table 5 : Analysis of Variance of all Parameters

The results indicated that as shown in Table 5, coarse aggregate, and percentage of asphalt significantly affects the texture depth of Stone Mastic Asphalt (SMA) tested in this investigation. From the statistical analysis shown in Table 6, the reason for the relatively small effect of the angularity number on texture depth property in this study lies in the fact that the aggregate particles were coated completely by the asphalt, which prevented effective interaction between the aggregate and the slider. This result is the similar to a study conducted by Texas Transportation Institute (TTI) which investigated the relationship between SN and combined texture parameters by multiple regression analysis. Skid number was related to independent variables consisting micro textures, macro textures, and aggregates size factors. A correlation co-efficient of 0.867 was obtained by relating skid numbers to combined independent variables [7].

Model	R	R Square	Adjusted R Square	Std Error of the Estimate
1	1.000[a]	1.000	1.00	.
2	1.000[b]	0.999	0.997	2.013E-02
3	0.999[c]	0.999	0.997	2.012E-02

a. Predictors (Constant). VTM, ASHAL, AN, DOC
b. Predictors (Constant). ASPHAL, AN, DOC
c. Predictors (Constant). DOC, ASPHAL

Table 6 : Summary of the Results

4. CONCLUSIONS

Material characteristics that influence surface characteristics include aggregate surface texture, size and roughness apart from binder content. The combined effects of these factors have been the subject of numerous field and laboratory studies. The results of this investigation showed that SMA exhibits superior surface characteristics compared to conventional dense mix. The proportion of aggregate size and asphalt content are the two factors that governs the texture depth hence the effectiveness of tire-contact area at the tire-pavement interface.

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