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DIFFERENCES IN THE SURFACE TEXTURE OF AGGREGATE PARTICLES DETERMINED BY 3D MODEL DERIVED FROM OPTIC MICROSCOPE MEASUREMENTS

Jozef Komačka^{1,*}, Zuzana Florková¹, Juraj Mužík²

- ¹ Department of Highway Engineering, Faculty of Civil Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic
- ² Department of Geotechnics, Faculty of Civil Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic

*corresponding author: tel. +421415135949, e-mail: komacka@fstav.utc.sk

Resume

The surface texture of aggregate particles was investigated based on the 3D model of surface generated from the measurements by optic microscope. New software MicroSYS was developed to determine the wrapping plane of 3D model of aggregate using the function called "Thin plate spline". New parameter for evaluation of surface texture of aggregate particle was proposed as the volumetric difference between two planes (wrapping plane and aggregate surface).

Applicability of this parameter was tested on two aggregate fractions (4/8 and 8/11) coming form 11 quarries in Slovakia. The tested aggregates differed from petrography point of view and ranged from soft to hard. The difference among the quarries and also between fractions of aggregate was found out. The better surface texture was observed for the finer fraction of aggregate. Simultaneously, the better results were determined in the case of aggregate produced from the igneous intrusive or extrusive rocks comparing to the sedimentary carbonate rocks aggregate.

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1. Introduction

The texture of pavement surface relates to a friction on a tyre/road interface and subsequently influences traffic safety. The positive or negative influence of surface texture ranges (micro-, macro- and megatexture) in relation to a tyre/road friction is defined in [1]. The significance of the individual ranges of texture on the total level of the friction is described in [2]. It is known the micro- and macrotexture are very important from traffic safety point of view. Taking into account their wavelength [1], the size, shape and surface texture of aggregate particles forming the aggregate gradations of various of asphalts predetermine types the level

of micro- and macrotexture of pavement surface. Therefore, the methods detecting mentioned parameters (especially the surface texture) are necessary.

The method using the angularity of aggregate particle is described in [3] and [4]. It has been concluded the more shaped surface of the aggregate, firmer and also sharper material of surface means that better and more lasting friction can be expected. The possibility to measure the surface texture in the range of micro- and macrotexture on pavements in service was tested in [5]. The contactless method using laser scanning with the sensors frequency of 62.5 kHz and 1 kHz was used. Problems with optical illusion

were identified and the authors concluded the more suitable approach is to use the contactless digital image analysis methods (DIAM). Various approaches scanner, (laser photogrammetry, photos and microscope) can be used to obtain a digital image of surface texture that is obviously transferred into 3D. The use of a laser scanner for 3D image of aggregate particle and shape properties evaluation is presented in [6]. High-resolution photos of surface were used in [7] for determination of 3D model of pavement surface. The computer program developed to evaluate the texture showed good correlation with the laser scanning and the pendulum test results. A video or camera is used to take photos for 3D image generation the complex systems developed in for evaluation of aggregate surface texture [8 -12]. Although 3D surface models of aggregate particle are available the texture evaluation is mostly based on the shape of aggregate particle [4, 13 - 15] or an analysis of 2D profiles [11, 16 - 19].

Despite the fact that 2D profiles can be used to determine 3D (volumetric) parameters, the use of 3D model of surface texture increases representativeness of results larger reference area reduce and a an uncertainty due to the random choice of the profile. Information regarding the evaluation of aggregate surface texture using volumetric characteristic derived from the 3D model of aggregate surface could be found rarely. The example is the evaluation presented in [20] where the 3D model of aggregate particle resulting from the photogrammetry method was used. Only top parts of aggregate particles were included evaluation of into the the texture. The parameter Vmp (Peak Material Volume) determined profiles was from based the Abbott-Firestone curve. Lack on of knowledge has been impulse an for the research focused on this topic with the aim to find a way how to distinguish

the quality levels of surface texture of aggregate particle using the volumetric parameter determined from the 3D model of surface texture.

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2. Experimental

2.1 Generation of 3D model of surface texture

The optic microscope NIKON AZ 100 Elements and the software NIS used Documentation were record to the surface of aggregate. The measurements performed with were the optical magnification of 2 and the lens magnification of 0.5 that resulted in the total magnification of 12.5. The aggregate particle was placed on the pad of the microscope illuminated by the light of microscope and centred in the visual field of microscope. The magnification and quantity of illumination was set up (balance of white colour was always used in this phase). Focusing on the top and bottom of aggregate particle (the pad of microscope was moved up and down) determined the scan range was divided into 400 steps. Thereafter, scanning was run and the recorded data was used to generate the 3D model of aggregate that was exported into the wrml and jpg formats.

2.2 Determination of volumetric parameter for evaluation of texture

The surface texture of aggregate particles was assessed using the software MicroSYS that has been developed especially for this purpose. The basic input is a 3D model of aggregate particle as the output of measurement by microscope (Fig. 1, top). The surface of aggregate is expressed in the analytical form and for the evaluation purpose is replaced by a wrapping plane that is a convex approximation of the analytical function determining the surface of aggregate. It is an iterative process where only the concave parts of analytical function are chosen and replaced. The radial

base function called "Thin plate spline (TPS)" used in the approximation process. is Thereafter, the area of interest of assessed aggregate particle is divided into local areas with the concave course of analytical function. The values of wrapping function are calculated for all local concave areas. Finally, these are connected into the final approximation function that covers the assessed surface of aggregate. The stiffness of TPS function is optimized using null difference between the values of analytical function of aggregate surface and wrapping function at the borderlines of the local concave areas. The result of this process is a wrapping plane of aggregate surface chosen for evaluation (Fig. 1, bottom).



Fig. 1. 3D model of aggregate particle in the software MicroSYS without (top) and with (bottom) the wrap plane.

The volumetric difference between two planes (wrapping plane and aggregate surface) can be used as a parameter for evaluation of surface texture of aggregate particles. The value of difference in volume relates to number of local concave areas and difference in height inside these ones. Lower values express a less propitious texture (small difference between the minimal value at a local area and the value at the borderline of a local area) and vice versa.

2.3 Tested aggregate

The procedures described above were used to difference determine the in volumes for the aggregate coming from 11 quarries in Slovakia. The chosen quarries produce the highest quality aggregate that fulfil all quality criteria required from road construction point of view. The aggregates differed from petrography point of view and ranged from soft (dolomite) to hard (andesite). The overview is done in Table 1. Two fractions (sizes) of aggregate particles, 4/8 and 8/11, taken from each quarry were used in investigation. These fractions are the most important to assure the sufficient level of microtexture of pavement wearing course. It was supposed the different nature of aggregate in the individual quarries (and various portion of hard and soft minerals in these rocks) in combination with equipment used for aggregate production could influence number, shape and evenness of fracture Rightness of this assumption can planes. be observed on the pictures in Table 1. It is evident that the aggregate particles from some localities have their surface rougher when compared to others (e.g. No. 6 and/or 7 compared to No. 8). Likewise, the borderlines of aggregate particle volume are slightly different. Some of them are relatively even others are more bumpy. These entire predispositions resulting from different petrology and production should lead to difference in micro- and macrotexture and the goal of the investigation was whether the volumetric parameter determined according the method described above could be used to reveal it.

		Table 1
Aggregate used in testing.		
Quarry	Petrographic	Aggregate
No.	type	picture
1	granodiorite	
2	melaphyre	
3	paleobasalt	
4	siliceous limestone	
5	andesite	
6	andesite	
7	paleobasalt	
8	dolomite	
9	andesite	
10	andesite	
11	dolomitic limestone	

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2.4 Results and discussion

The volumetric difference between two planes was determined for each tested aggregate particle using the procedure mentioned above. Five aggregate particles were used in each group representing by a quarry and of aggregate. The determined fraction differences in volumes were transformed to differences in percentage of volume. The approximately same volume of investigated aggregate was chosen for all aggregate particles to have comparable results. It was ensured by position of the base plane (Fig. 1, bottom) that can be positioned at any level in the vertical direction.

The average values were calculated and used for next comparison. As it can be seen in Fig. 2, the volume differences of aggregate are not the same and therefore a difference in surface texture can be supposed. Two basic distinctions be observed. There can is a difference among the quarries and also between fractions of aggregate. The former was expected, reasons mentioned the are in the Chapter 2.3. However, when two fractions are compared, a production equipment should not play any role (obviously the same is used for production both fractions) and a texture of surface should only depend on properties of rock. Nevertheless, it is evident in Fig. 2 the higher value of difference in volume were determined in the case of finer fraction (4/8). According to the used evaluation method, the higher difference in volume means the surface is rougher and aggregate particle has the better texture (microand macro). A reason for it can be that more fracture planes are generated during crushing the aggregate to finer fractions, they overlap into each other and increase an angularity of aggregate. Finally, it could influence evaluation of surface texture based on the volumetric parameter (i.e. difference in volume).

To asses importance of a production equipment comparing to aggregate nature the variability of volume difference was checked using the minimum, maximum and average values (Fig. 3). Based on this it seems the nature of aggregate is more important since the differences in volumes among quarries are a little bit higher than it is in the case of fractions.

Therefore, ranking from the best to the worst was made using the highest value of difference in volume (higher value means better surface texture) for a quarry (regardless fraction of aggregate) to look into the type of rock mined in the individual carries (Fig. 4). It is evident the best values (i.e. the highest values of difference in volume) have the aggregate produced from the igneous intrusive or extrusive rocks (basalt, andesite, melaphyre, diorite). The differences in this group for the same rock (e.g. the quarries No. 5, 6, 9 and 10) relate probably to geologic era and the same type of rock from petrography point various mineralogical of view can have compositions that could influence the brittleness of rock and subsequently the surface texture of aggregate. The worst results (i.e. the lowest values of difference in volume) were found out for the sedimentary carbonate rocks where the silicious and dolomitic limestone were comparable and the dolomite form the quarry No. 8 had absolutely the lowest value of volume difference.



Fig. 2. Volume differences among fractions and quarries.



Fig. 3. Range of differences between the volumes of fractions and quarries.



Fig. 4. Ranking in relation to petrography of aggregate.

3. Conclusions

The surface texture of aggregate particles was investigated based on the 3D model of surface generated from the measurements by optic microscope. New software MicroSYS was developed to determine the wrapping plane of 3D model of aggregate using the function called "Thin plate spline". New parameter for evaluation of surface texture of aggregate particle was proposed as the difference in volume between two planes (wrapping plane and aggregate surface).

Applicability of this parameter was tested on two aggregate fractions (4/8 and 8/11)coming form 11 quarries in Slovakia. The tested aggregates differed from petrography point of view and ranged from soft to hard. The difference among the quarries and also between fractions of aggregate was found out. The better surface texture (i.e. the higher values of difference in volume) was observed for the finer fraction of aggregate. Simultaneously, the better results from surface texture point of view (higher values of difference in volume) were determined in the case of aggregate produced from the igneous intrusive or extrusive rocks comparing to the sedimentary carbonate rocks aggregate.

Based on the results obtained so far, it seems the new approach based on the volumetric difference between two planes of 3D model of aggregate has a potential to distinguish a surface texture of aggregate. Moreover, some relation between this parameter and aggregate nature was observed. To confirm these findings next test have to be carried out to extend the current database of results.

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and air pollution

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project

material

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