THE ASSESSMENT OF SOIL GRAIN SHAPES AND THEIR IMPACT ON THE COMPACTION OF COHESIONLESS SOILS

SUMMARY

The thesis concerns assessing the impact of cohesionless soil grain shapes on the compaction of soils. It is a term significant in terms of construction, especially when executing various earthwork constructions for which the basic technological process consists in compacting. The impact of soil grain shapes constitutes a factor so far undefined in the process of compacting cohesionless soils. The biggest barrier in solving this problem consists in the quantitative assessment of soil grain shape parameters.

The objectives of the thesis were as follows: selecting the best methods for a quantitative assessment of soil grain shape parameters among many methods described in the literature, as well as assessing the impact of cohesionless soil grain shape parameters on the compaction parameters of these soils.

The grain shape constitutes a complex feature, determined with the use of thee parameters. These are: sphericity, angularity, and the grains surface micro-texture. The sphericity, angularity, and micro-texture of the grains' surface constitute geometrically independent parameters, although a natural correlation between them may occur. Up to this day general, descriptive terms are used to define the shape of the grains in a visual manner, for example round, angular, abrasive, or flat. The most often used methods for assessing the sphericity or angularity base on using diagrams and graphic models. It is possible to find many definitions of grain shape parameters in literature, especially concerning sphericity and angularity. The micro-texture of the surface constitutes a parameter which is most often overlooked in terms of describing the shape of the grains due to the fact that it is difficult to examine it.

The issue of soil grain shape is extremely rarely taken into consideration when characterizing the parameters of soil compacting although it is often indicated as a decisive factor in terms of compaction capabilities, meaning the capability of a given soil to achieve proper compaction. The soil compaction parameters are: optimum moisture content w_{opt} and the maximum dry density ρ_{dmax} (in Poland, marked with a symbol ρ_{ds}), but also often: minimal porosity index e_{min} or dry density ρ_d at $w \approx 0$.

For the purposes of the thesis a computer program has been developed, in accordance with the idea and at the participation of the author, thanks to which it was possible to quickly calculate soil grain shape parameters of two aggregate types: crushed and natural. The two aggregates were macroscopically significantly different in terms of soil grain shapes: the crushed aggregate included

angular and abrasive grains, white the natural – spherical and smoothed. Calculations have been made on the base of 350 grain photos made with the use of a scanning or optical microscope. The sphericity has been determined on the base of twelve definitions known from literature, angularity with the use of twenty one methods, and surface micro-texture using six methods. Then a detailed analysis has been made in terms of assessing the methods of calculating the values of specific shape parameters in order to select the best method. The criterion for selecting the best method for calculating shape parameters has been determined as such a method which separates the grains of researched aggregates the most from each other and the models (which consisted in a circle and rectangle), taking into consideration grain size.

It has been determined that the best method for assessing the sphericity consists in a method developed by Cox in 1926 who defined sphericity as the relation of the grain's area to its perimeter. The best method for assessing the angularity parameter has been determined as the method developed by Lees (1964) which concerned the number of grain corners, their sharpness, and distance from the larges circle inscribed in the grain. The best method for assessing the surface micro-texture parameter has been determined as Fourier's descriptors which determine the levels of variability concerning the analyzed surfaces in terms of a given frequency. Then a general shape indicator has been determined as the arithmetic mean of three shape parameters determined with the use of the above mentioned methods (Parylak, 2000a).

In order to test the impact of grain shape on the compaction parameters, three different crushed aggregate mixtures and three different natural aggregate mixtures have been prepared. The granulation of specific crushed aggregate mixtures was identical as in the case of natural aggregate mixtures. The values of soil mixture grain shape parameters were calculated as weighted arithmetic means, taking into consideration the value of grain shape parameters of specific sizes and their percentile content in the mixtures. In total, the crushed aggregate mixtures were less spherical than the natural aggregate mixtures and more angular, with the surface micro-texture of crushed aggregate mixtures more complex than the surfaces of grains in natural aggregate mixtures. The general shape indicator of the crushed aggregate mixtures was higher than the indicator of natural aggregate mixtures.

Soil compaction tests have been carried out with the use of two methods: Proctor's method, and with a vibration table. It has been determined that there are correlations between the shape parameters and compaction parameters. Empirical dependencies have been developed concerning the compaction parameters of mixtures in relation to shape parameters for two compaction methods.

Basing on the conducted tests and analyses it has been determined that there is the possibility to select the best method for assessing shape parameters: sphericity, angularity, and soil grain surface micro-texture, and it was also determined that grain shape parameters have a significant impact on soil compaction parameters.

Key words: cohesionless soils, grain shape parameters, study of grain shape parameters, compaction parameters, the influence of shape parameters on the compactability parameters.