CRUSHING OF GRANULAR BASES: FRACTAL AND LABORATORY ANALYSES

Luis E. Vallejo
Associate Professor
Department of Civil and Environmental Engineering
University of Pittsburgh, USA
E-Mail: vallejo@civ.pitt.edu

ABSTRACT

Granular materials forming part of the base of flexible pavements experience crushing as a result of static and dynamic loads. Very little research has been conducted to date on how to evaluate crushing and what effect varying levels of crushing have on the engineering properties of these granular materials (for example, shear strength and hydraulic conductivity).

In this study crushing of granular materials is evaluated using fractals. Crushing of a particle can be the result of either its abrasion or its total fragmentation. Abrasion takes place when the sharp corners of the particle are removed as a result of shear, compression or both. Thus, as a result of abrasion, the particle changes in shape. In this study, the fractal dimension of the particle profile evaluates the changes in shape of a particle before and after abrasion. It was determined that the rougher a particle profile is; the higher is the fractal dimension. Thus, the fractal dimension concept is an excellent tool to measure abrasion in particles.

When crushing is the result of fragmentation of a particle, the structure of the particle changes from a single solid element to a mixture of many small particles of varying sizes. When a granular base experience fragmentation, the resulting granular mass will be composed of a granular mixture that has a fractal distribution in particle sizes (large, medium and small). In this study, crushing as a result of fragmentation was evaluated using the fragmentation fractal dimension of the size distribution of the particles before and after crushing.

This study presents the results of a ring shear tests on sand. This study was conducted to evaluate the crushing experienced by the sand using fractals. The effect of crushing on the shear strength and the hydraulic conductivity of the sand as a result of a sustained application of normal and shear stresses were also evaluated. The hydraulic conductivity, K, of the sand was calculated using a relationship developed by Hansen. This relationship relates K to the D_{10} obtained from the grain size distribution curve. The hydraulic conductivity of the sand was found to decrease with an increase in its level of crushing.

The friction angle measured in the ring shear tests was found to decrease with an increase in the fractal dimension values. High values of fractal dimension are associated with high normal and shear stresses in the ring shear test. These high normal and shear stresses cause the grains to change from rough to smooth with the resulting decrease in shear strength These changes in the roughness of the sand grains seem to be the controlling factor for the decrease in shear strength measured in the ring shear tests.