Introduction

This report describes tests performed to measure densities and friction angles for standard aggregate gradations 21b and #57 (VDOT 2002 and ASTM C33-02a). These and similar materials are available from most commercial quarries, and are widely used where high-quality granular materials are needed for construction. Because these materials contain particles as large as one inch, triaxial test specimens at least six inches in diameter are required. As a result, friction angles for these materials usually estimated rather than measured. The tests described here were performed to measure friction angles that can be used with confidence in design studies.

This study was undertaken at the request of members of the Center for Geotechnical Practice and Research (CGPR), and was supported by the CGPR. The tests were performed at the W.C. English Geotechnical Research Laboratory at Virginia Tech.

The friction angles measured in these tests were found to be considerably higher than usually estimated for these materials based on commonly used correlations. The measured values ranged from about 40 degrees to 56 degrees, depending on density and confining pressure.

Materials tested

Mineralogy

The materials tested are shown in Figure 1. The limestone aggregate was obtained from the Acco Stone Quarry in Blacksburg, Virginia. The granite and phyllite aggregates were obtained from the Luck Stone crushed aggregate plants in Rockville and Charlottesville, Virginia.

Grain size

Grain size distribution curves for the materials are shown in Figures 2 and 3. The sieve analyses were performed in accordance with ASTM D422.

All four of the gradations shown in Figures 2 and 3 fall within the allowable range of grain sizes specified by VDOT 2002 and ASTM C33-02a.

The 21b materials are well-graded, with maximum particle size of 1 inch and about 10% passing the #200 sieve. The coefficient of uniformity, $c_u = D_{60}/D_{10}$, was found to be 64 for the granite, and 95 for the limestone.

The #57 materials are very narrowly graded, with particle sizes from 3/8 inch to 1 inch, and a coefficient of uniformity, c_u, equal to 1.7. The gradations of the limestone and phyllite aggregates are virtually identical.