ABSTRACT

Alvarado C., Maria G. M.S.C.E., Purdue University, August 2016. Laboratory Characterization of Ohio Gold Frac sand. Major Professor: Monica Prezzi.

The mechanical response of sand depends on state variables (such as density, stress state and fabric) and intrinsic variables (such as particle size distribution and particle shape). The mechanical response of sand is also a function of sand crushability. Recent research studying the cone penetration process in a unique digital image correlation (DIC) chamber is underway at Purdue University. The test sand is Ohio Gold Frac sand, which meets criteria regarding particle size and gradation related to elimination of chamber boundary and scale effects.

The mechanical behavior of this sand can be simulated by a suitable constitutive model, such as the Purdue Sand Model (PSM). In order to calibrate the constitutive model, a number of laboratory tests are required. This thesis describes some of these tests, which include determination of index properties, particle mineralogy and morphology, one-dimensional compression tests, direct shear and ring shear tests.

Ohio Gold Frac sand is classified as a clean, poorly-graded silica sand (99% of silica content). Additionally, the minimum and maximum void ratios are equal to 0.59 and 0.81, respectively. The critical-state direct shear friction angle is 35º, while the critical-state ring shear friction angle is 33º.

Particle crushing was observed in one-dimensional compression tests, ring shear tests as well as in cone penetration tests. In order to understand the degree of particle crushing and the process by which it happens, the evolution of particle gradation and morphology of Ohio Gold Frac sand was

assessed both before and after one-dimensional compression and ring shear tests. One-dimensional compression tests were performed to a maximum load of 74kN (24MPa); the onset of crushing for loose and dense samples of Ohio Gold Frac sand occurred at normal stresses of 9 MPa and 10MPa, respectively.

Ring shear tests were performed on Ohio Gold Frac sand with normal stresses of 100 kPa, 200 kPa, 300 kPa and 400 kPa and shear displacements ranging from 1 to 20 m. Cycles of compression and dilation followed by stages of stabilization due to particle crushing were observed in all the tests. The results indicated that particle damage within the shear band (with a thickness of about 6 mm) increased with increasing normal stresses and shear displacements. The fines content of the sand in the shear band increased to 5% after the ring shear test performed with a normal stress of 400 kPa and 7 m of shear displacement.

The main particle damage mechanisms that affected the gradation of Ohio Gold Frac sand after loading were abrasion and shearing off of asperities of large particles and splitting of the small particles, which produced an increment of the fines content of the sand, without affecting the maximum particle size.