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A laboratory miniature full-flow penetrometer system for peat

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Uncertainties and difficulties surrounding laboratory strength testing of peat have caused the increasing reliance on in situ testing methods, which include T-bar and ball penetrometers, to determine the undrained strength of peat for design purposes. This paper presents the results of miniature full-flow penetrometer (T-bar and ball) tests on decomposed peat samples to provide a better understanding of the interpretation of the strength parameters in this material. The tests were conducted in a pressure chamber, in which miniature T-bar and ball penetrometer tests can be performed on peat samples consolidated under specific vertical effective stresses. Penetrometer bearing factors were derived experimentally using the monotonic penetration resistance and the undrained shear strength estimated from triaxial tests. The bearing factors, expressed as the penetration resistances normalised by the undrained shear strength data (obtained from triaxial tests) compare well with those derived from plasticity solutions. In addition, the remoulded strength parameters derived from penetrometer cyclic tests are comparable with those obtained from fall cone tests. The findings reported in this paper illustrate the capability of full-flow penetrometer tests to measure the undrained strength of peat.

Notation

A_p	projected area of a penetrometer
A_R	penetrometer area ratio
A_s	area of the shaft
c_v	coefficient of consolidation
d	penetrometer diameter
d_m	miniature penetrometer diameter
d_s	standard penetrometer diameter
N	bearing factor
N_E	empirical bearing factor
N_{Eball}	empirical bearing factor for ball penetrometer
$N_{ET\text{-}bar}$	empirical bearing factor for T-bar penetrometer
N_{TBall}	theoretical bearing factor for ball penetrometer
$N_{TT\text{-}bar}$	theoretical bearing factor for T-bar penetrometer
q	penetration resistance
q_{ball}	ball resistance
q_{ini}	first penetration resistance
q_{rem}	final penetration resistance
q_t	deviatoric stress
$q_{T\text{-}bar}$	T-bar resistance
S_t	sensitivity
s_u	undrained shear strength
s_u/σ'_v	undrained shear strength ratio
$s_{u\text{-}CIUC}$	undrained shear strength from consolidated undrained compression (CIUC) triaxial test
$s_{u\text{-}CIUE}$	undrained shear strength from consolidated undrained extension (CIUE) triaxial test
$s_{u\text{-}DSS}$	undrained shear strength from direct simple shear (DSS) test
$s_{u\text{-}DSS}/\sigma'_v$	DSS undrained shear strength ratio
$s_{u\text{-}FC}$	undrained shear strength from fall cone test
V	non-dimensional velocity
v	penetration rate
v_m	miniature penetrometer penetration rate
v_s	standard penetration rate
w_c	moisture content
ΔH	vertical displacement
σ'_v	vertical effective stress

1. Introduction

The difficulties in determining peat strength accurately using conventional laboratory equipment have led to the increasing reliance on in situ test methods. In situ tests, such as vane shear (VST), piezocone (CPTu) and full-flow penetrometers (T-bar and ball), that are normally used for characterising inorganic soils can be performed on peat and other organic soils (Boylan and Long, 2006). Of these tests, the VST has been shown to be problematic in peat on account of its failure mechanism. Peat fails by tearing rather than shearing during VST tests (Long, 2005). Furthermore, water may drain behind the vane blade during tests, thereby inducing artificially high undrained strength measurements (Landva and Pheeney, 1980). In contrast, the CPTu, T-bar and ball penetrometer can provide continuous