

**Cite this article**

Amuda AG, Hasan A, Sahdi F and Taib SNL  
A laboratory miniature full-flow penetrometer system for peat.  
*International Journal of Physical Modelling in Geotechnics*,  
<https://doi.org/10.1680/jphmg.18.00067>

**Research Article**

**Paper 1800067**  
Received 20/09/2018;  
Accepted 23/08/2019

**Keywords:** geotechnical engineering/  
model tests/strength & testing of  
materials

ICE Publishing: All rights reserved

# A laboratory miniature full-flow penetrometer system for peat

**Akeem Gbenga Amuda** PhD

Lecturer, Department of Civil Engineering, Nile University of Nigeria (NUN), Abuja, Nigeria (Orcid:0000-0003-3268-8340)

**Alsidiq Hasan** PhD

Senior Lecturer, Department of Civil Engineering, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), Sarawak, Malaysia (corresponding author: [halsidqi@unimas.my](mailto:halsidqi@unimas.my)) (Orcid:0000-0001-7543-096X)

**Fauzan Sahdi** PhD

Senior Lecturer, Department of Civil Engineering, Universiti Malaysia Sarawak (UNIMAS), Sarawak, Malaysia; Centre for Offshore Foundation Systems, The University of Western Australia (on postdoctoral leave)

**Siti Noor Linda Taib** PhD

Associate Professor, Department of Civil Engineering, Universiti Malaysia Sarawak (UNIMAS), Sarawak, Malaysia

**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
$N_{ET-bar}$	empirical bearing factor for T-bar penetrometer
$N_{TBall}$	theoretical bearing factor for ball penetrometer
$N_{TT-bar}$	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
$q_{T-bar}$	T-bar resistance
$S_t$	sensitivity
$s_u$	undrained shear strength
$s_u/\sigma'_v$	undrained shear strength ratio
$s_{u-CIUC}$	undrained shear strength from consolidated undrained compression (CIUC) triaxial test
$s_{u-CIUE}$	undrained shear strength from consolidated undrained extension (CIUE) triaxial test

$s_{u-DSS}$	undrained shear strength from direct simple shear (DSS) test
$s_{u-DSS}/\sigma'_v$	DSS undrained shear strength ratio
$s_{u-FC}$	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
$\Delta H$	vertical displacement
$\sigma'_v$	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