SUCTION INDUCED SHEAR STRENGTH OF GOLD MINE TAILINGS

DELMÉ WESTRAAD

A dissertation submitted in partial fulfilment of the requirements for the degree of

MASTER OF ENGINEERING (GEOTECHNICAL ENGINEERING)

in the

FACULTY OF ENGINEERING

UNIVERSITY OF PRETORIA

February 2004

DISSERTATION SUMMARY

SUCTION INDUCED SHEAR STRENGTH OF GOLD MINE TAILINGS

DELMÉ WESTRAAD

Supervisor: Prof E Rust

Department: Civil Engineering

University: University of Pretoria

Degree: Master of Engineering (Geotechnical Engineering)

The disposal of fine-grained mining and industrial waste by formation of hydraulic-fill tailings dams is becoming a design and construction activity of increasing scale. In light of the increasing pressure on the mining industry to sustain stringent safety and environmental standards it is becoming more important to gain technical knowledge of the waste problem. The upper layers of the tailings residue dams are in the unsaturated state with the matric suction component contributing to the overall shear strength. The ability to incorporate the matric suction component in shear strength calculations is important to safe design.

This research project investigates the use of the mid-plane suction probe to measure matric suction. The results obtained from the probe is used along with various tests to construct a complete soil-water characteristic curve for Mispah gold tailings as well as to investigate suction induced shear strength of drying tailings with depth.

The tests were conducted on gold tailings from Vaal Operation's Mispah tailings dam. The laboratory tests consisted of a trough test, to determine the soil-water characteristics of the gold tailing and also a drying box test that simulated the drying and desiccation of the gold tailings in the daywall.

The project concluded that the mid-plane suction probe could be used with acceptable accuracy to determine soil suctions. The model for the prediction of the soil water characteristic curve, derived by Fredlund and Xing (1992), was used successfully to predict the complete soil water characteristics curve for Mispah gold tailings. The equation derived by Vanapalli et al. (1996) was successfully used to calculate both the normal and suction induced shear strength of gold mine tailings using either the volumetric water content from the extracted samples or from the soil water characteristic curve.

Key words: air-entry, desiccation, gold mine tailings, linear shrinkage, soil-water characteristic curve, suction, suction probe, unsaturated soils, suction induced shear strength.

ACKNOWLEDGEMENT

I whish to express my appreciation to the following organizations and persons who made this dissertation:

- The NRF for the research grant.
- Vaal Operation for the providing the tailings material.
- Professor E. Rust, my supervisor for his guidance and support.
- My family and friend for their encouragement and support during the study.
- Leon for his motivation and confidence in my abilities.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

A_{dw}	-	the total area of water at 100% saturation [mm^2]
A_{tw}	-	the total area of water corresponding to any degree of saturation [mm^2]
a	-	approximate of the air-entry value of the soil
C_r	-	is the suction value corresponding to residual water content q_r
$C(Y)$	-	a correcting function that forces the SWCC through a suction of 1 000 000 kPa and zero water content.
e	-	the void ratio
G_s	-	specific gravity [2.74]
g	-	gravitational acceleration [$9.81 m.s^{-2}$]
h_c	-	capillary height [m]
M	-	daily total mass measurement [kg]
M_{box}	-	mass of drying box [kg]
M_i	-	initial mass of sample [kg]
M_s	-	mass of solids [kg]
M_{sample}	-	mass of sample taken at every stage [kg]
M_{trough}	-	mass of trough [kg]
M_w	-	mass of water [kg]
M_{wi}	-	initial mass of water [kg]
m	-	parameter that is related to the residual q_r
n	-	parameter controlling the slope at the inflection point in the SWCC
n	-	the porosity
r	-	radius of capillary tube [m]
R_s	-	radius of curvature of the meniscus [m]
S	-	degree of saturation
S_r	-	residual degree of saturation
T_s	-	surface tension of the water [N]
u	-	pore-water pressure
u_a	-	pore-air pressure [kPa]
u_w	-	pore-water pressure [kPa]
V_{sample}	-	volume of the sample [cm^3]

V_t	-	total volume of soil specimen [m^3]
V_v	-	volume of voids in the soil specimen [m^3]
V_w	-	volume of water in the soil specimen [m^3]
a	-	contact angle [degree]
p	-	osmotic suction [kPa]
q	-	volumetric water content
q_r	-	residual volumetric water content
w	-	gravimetric water content of soil
w_0	-	initial moisture content [%]
r_d	-	dry density of soil [kg / m^3]
r_w	-	density of water [0.000981 kg / cm^3]
s	-	total stress
s'	-	effective stress
c	-	parameter related to the degree of saturation of the soil
κ	-	fitting parameter
Ψ_p	-	intercept of the tangent line on the semi-log plot and the matric suction axis.
$2R_s \, sinb$	-	projected length of membrane [m]
Du	-	change in pore pressure [kPa]
$(u_a - u_w)$	-	matric suction [kPa]
$(u_a - u_w)$	-	matric suction [kPa]
$(s_1 - u_a)$	-	vertical net normal stress
$(s_2 - u_a)$	-	horizontal normal stress
$(u_a - u_w)$	-	matric suction