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# SOIL SUCTION IN MINE TAILINGS

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A thesis submitted in partial fulfillment of the requirements for the degree of

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# THESIS SUMMARY

# SOIL SUCTION IN MINE TAILINGS

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The failure of the tailings dam at Merriespruit highlighted the uncertainties concerning the strength and stability of such dams. Owing to the theory, a tailings dam would remain stable at a slope equal to the material's internal angle of friction and is thus designed accordingly. In practice however, it was found that these structures remain stable at slopes greater than this specified angle. It was also found that, irrespective of sufficient freeboard, failures often occur after prolonged rainfall. Negative pore or suction pressures present in the tailings, especially in the upper regions, increases the effective stress and hence the stability of the structure. Currently the friction properties of tailings can be measured with relative accuracy whereas the opposite is true for the suction pressures. Measurement of these pressures would result in the economical design and risk assessment of tailings dams.

The aim of the thesis is therefore to design, calibrate and test an instrument that is able to measure the suction pressures in gold mine tailings.

A literature survey was conducted to assess the advantages and disadvantages of the available suction measurement devices. Attention was paid to the specific characteristics of suction pressures in mine tailings. This study showed that the tailings environment is harsh with varying moisture contents and temperatures as well as high salinity. The instrument required for measuring the suction pressures in gold mine tailings would have to be able to operate under these conditions. The literature survey however, indicated that most of the instruments, with the exception of the Imperial College suction probe, would not comply with these criteria. Limitations such as suction range, long response time and their susceptibility to salinity and other environmental influences made them unsuitable.

A suction probe was designed and built based on the Imperial College suction probe but using a lower air entry ceramic. Laboratory desorption tests were conducted on two samples of gold mine tailing. These tests indicated some design flaws of the instrument but none the less gave an indication of the suction characteristics of the material. The instrument was however discarded after some period of time due these design flaws and a new instrument, namely the mid-plane suction probe, was designed and built. This probe incorporated a Kyowa PS-2KA pressure transducer and the overall size was reduced to the dimensions generally used for a mid-plane triaxial pore pressure sensor (hence the name). Desorption tests were carried out on the same tailings using the mid-plane suction probe. These tests were successful demonstrating that the goals set out in this thesis were met.

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| | |
|---|---|
| a, m, n | fitting parameters |
| $C_S$ | the concentration of the solute |
| $C_\psi$ | correction factor introduced by Fredlund and Xing (1994) to ensure that $\theta$ reach zero as $\psi$ reach a limiting value ($\psi_0$) equal to $10^7$ cm of water. |
| c′ | intercept of the "extended" Mohr-Coulomb failure envelope on the shear stress axis where the net normal stress and the matric suction at failure are equal to zero: it is also referred to as the "effective cohesion" |
| h | pressure head |
| $h_{oc}$ | corresponding water head which is linear to the suction |
| m | undetermined parameter with m = 1- (1/n) |
| n | porosity |
| $\pi$ | osmotic suction |
| p | slope of linear part of SWCC |
| q | intercept of linear part of SWCC |
| R | universal (molar) gas constant i.e. 8.31432J/ mol K |
| $R_S$ | radius of curvature |
| S | degree of saturation |
| T | absolute temperature i.e. T = (273.16+t°) (K) |
| $T_S$ | tensile pressure |
| t° | temperature (°C) |
| $(u_a - u_w)$ | matric suction |
| $(u_a - u_w)_f$ | matric suction on the failure plane at failure |
| $u_a$ | pore-air pressure |
| $u_{af}$ | pore-air pressure on the failure plane at failure |
| $u_{vo}$ | saturated pressure of water vapour over a flat surface of pure water at the same temperature (kPa) |
| $v_{wo}$ | specific volume of water or the inverse of the density of water i.e. 1/ρw ($m^3$/kg) |
| $\Delta u$ | $u_a$-$u_w$ |
| $\Omega$ | the molar osmotic coefficient of the solute |
| $\Psi$ | soil suction or total suction (kPa) |

| | |
|---|---|
| $\bar{u}_v$ | partial pressure of the water vapour (kPa) |
| $\alpha$ | undetermined parameter |
| $\chi$ | a parameter related to the degree of saturation of the soil |
| $\phi b$ | angle indicating the rate of increase in shear strength relative to the matric suction, $(u_a - u_w)_f$ |
| $\phi'$ | angle of internal friction associated with the net normal stress state variable, $(\sigma_f - u_a)f$ |
| $\theta$ | volumetric water content |
| $\theta_r$ | residual water content |
| $\theta_r$ | residual volumetric water content |
| $\theta_s$ | saturated volumetric water content |
| $(\sigma f - u_a)_f$ | net normal stress state on the failure plane at failure |
| $\rho_w$ | density of water i.e. 998kg/ m³ at t° = 20 °C |
| $\omega_v$ | molecular mass of water vapour i.e. 18.016 kg/kmol |
| $\psi$ | soil suction |
| $\psi_r$ | soil suction corresponding to the residual volumetric water content |