Desiccation of Tailings in an Instrumented Column Under Laboratory and Atmospheric Conditions

Professor David Williams
Director Geotechnical Engineering Centre
Sebastian Quintero, Chenming Zhang & X
The University of Queensland, Brisbane, Australia
Email: D.Williams@uq.edu.au
Scope

• Description of instrumented column for testing settling, self-weight consolidation and desiccation of tailings from a slurry state:
  – Column
  – Sensors and data logging
  – Test methodology – calibration, sample preparation and data logging

• Column testing of Samarco sand tailings and slimes:
  – Laboratory simulation
  – Rooftop exposure

• Summary of results
• Conclusions
Instrumented Tailings Column

Purpose-built settling, consolidation and desiccation column for use in laboratory and field (with a weather station):

• Diameter 200 mm (available off-the-shelf)
• Height 1.4 m (in sections for ease of preparation)
• Instrumented with inexpensive, robust and calibrated moisture, suction, salinity and temperature sensors developed at UQ
• Water balance monitored
• Tested from a slurry placed in layers
• UQ data logger downloading to a website

Calibrated from laboratory to field to full-scale

For optimising deposition layer thickness and cycle time, and hence TSF footprint for a given tailings production, given that desiccation drops off exponentially with depth
Moisture, Suction & Temperature, and Salinity Sensors and Load Cells

- Dielectric moisture
- Salinity (humidity)
- Dielectric suction
- Thermal suction & temp.
- Load cell for water balance
Weather Station

• Measurements:
  – Rainfall
  – Temperature
  – Humidity
  – Atmospheric pressure
  – Wind direction
  – Wind intensity
  – Solar heat intensity
  – Real time image of all columns (every 4 hours)
Open-Source Data Loggers, Downloading to Web
Sensor Calibration in Tailings Under Test Conditions
Laboratory and Rooftop Instrumented Columns

Rooftop column:
- Slurry tailings added in layers and allowed to settle
- Exposed to weather monitored by weather station

Laboratory column:
- Slurry tailings added in layers and allowed to settle
- Desiccation simulated using heat lamp
- Flooding to simulate re-wetting by rainfall
Rooftop Column – Samarco Sand

Diagram showing:
- Time (days) vs. Temperature (°Celsius)
- Degree of Saturation for different depths:
  - 5mm
  - 20mm
  - 60mm
  - 110mm
  - 200mm
  - 850mm
- Rainfall from weather station (mm/day)

CRICOS Provider No 00025B
Rooftop Column – Samarco Slimes

(A) EVAPORATION RATE FROM WEATHER STATION (mm/day)

(B) DEGREE OF SATURATION

(C) SUCTION (kPa)

(D) TEMPERATURE (Celsius)

CRICOS Provider No 00025B
Samarco Sand Tailings in Laboratory Simulated Drying

- Evaporation Rate (mm/day)
- Temperature (°C)
- Saturation
- Degree of Saturation

CRICOS Provider No 00025B

Geotechnical Engineering Centre
Samarco Slimes in Laboratory Simulated Drying

Graphs showing the evolution of evaporation rate, temperature, and saturation over time in different depths and conditions.
Samarco Sand Tailings in Rooftop Drying Column

**Geotechnical Engineering Centre**

**CRICOS Provider No 00025B**
Samarco Slimes in Rooftop Drying Column
Instrumented Column Test Results

• All column test results suggested flow in two directions:
  – Upwards flow, driven by evaporation, which diminished with time and depth, and ceased due to sealing by surface crust that formed
  – Downwards flow below a certain depth, driven by gravity drainage towards sealed base of column, which also diminished with time and depth

• Simulated desaturation in laboratory using a heat lamp was complete after ~70 days for both sand tailings and slimes

• Desaturation under prevailing dry (Brisbane) weather conditions was complete after ~30 days for sand tailings and ~25 days for slimes, indicating that natural drying in this climate is over twice as intense as simulated drying
Instrumented Column Test Results

- Desaturation dropped off approximately exponentially with depth, and reached depths of approximately:
  - 70 cm for sand tailings in laboratory column test, causing surface settlement of ~9.5 cm
  - 60 cm for slimes in laboratory column test, causing surface settlement of ~15 cm
  - Only 6 cm for sand tailings in rooftop column test, causing surface settlement of only 2.75 cm
  - 60 cm for slimes in rooftop column test (same depth as in laboratory column), causing surface settlement of ~14 cm – This result was similar to that obtained in laboratory, except that it occurred in less than half time
Instrumented Column Test Results

- For sand tailings, results of rooftop instrumented column test suggest that there is little to be gained from atmospheric drying.
- For slimes, an optimal layer thickness for desaturation of ~60 cm is suggested, requiring about a month to achieve under atmospheric conditions prevailing at time of test.
- Amphirolling would increase effective depth and extent of desiccation achieved in fine-grained tailings.
Conclusions

- Instrumented column test results for sand tailings and slimes demonstrate:
  - More extreme (over twice as fast, and less deep in the case of sand tailings) desiccation on exposure to Brisbane weather than can be simulated using heat lamps
  - Capability for instrumented column testing to inform design and optimisation of tailings slurry deposition and rehabilitation