Physical characterisation of pit latrine sludge

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FSM2 Conference 31st October 2012
Sanitation: a global challenge

Photo: Maxine Von Eye
Emptying existing urban pits

Photo: Kookync, Google Earth

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What happens when the latrine is full?

Photo: Partners in Development
Manual pit emptying

Photo: Partners in Development

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Pit emptying technologies

Photos: M.Coffey, PID, S.Sugden, M.O'Riordan
Subjective assessments
Previous studies: IRCWD, Botswana, 1985

Pit latrine sludge strengths

Viscometer scale reading @ speed 4

Density (kg/m³)

25 = Vacuum system limit
Portable penetrometer: Design criteria

- Test sludge in-situ to 2.5m depth
- Simple to use
- Man-portable
- Human or battery powered
- $1000 target cost
- Rugged – mishandling, dusty environment
Laboratory mini-ball penetrometer
Design and manufacture

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Laboratory calibration

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Field testing: septic tanks
Field investigation: Kampala, Uganda
Field investigation: Kampala, Uganda
Field investigation: Kampala, Uganda
Shear strength profiles
Shear strength: comparison with literature
Shear strength: pits -vs- vaults

Shear strength, τ (Pa)

Unlined pits, Kampala study

Lined vaults, Kampala study

Pit number
Shear strength: sensitivity

Effect of physical remoulding on sludge shear strength

$S = 3.3 + 0.0005 \tau$

$p_A = 0.01$

$p_B = 0.63$
Density: testing samples
Density: comparison with literature

AIT (2012)  1092-1159 kg/m³
Conclusions

- Pit latrine sludge 4x stronger than previously reported, >2kPa
- Pit contents highly variable – within and between pits
- Strong surface crust is common
- Strong sub-surface layers also encountered
- Remoulding reduces strength by a factor of >3
- Density in range 1000 – 1200kg/m$^3$ for 'pure' faecal sludge
Future work

- Portable penetrometer: multi-city baseline study
- Chart performance of different pit emptying technologies
Performance benchmarking

Photos: M.Coffey, PID, S.Sugden, M.O'Riordan

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Future work: sludge classification
Future work

- Portable penetrometer: multi-city baseline study
- Chart performance of different pit emptying technologies
- Factors affecting pit function: longitudinal studies
Future work: factors affecting pit function
Future work

- Portable penetrometer: multi-city baseline study
- Chart performance of different pit emptying technologies
- Factors affecting pit function: longitudinal studies
- Fluidisation: Overconsolidated simulant, full-scale tests
Sludge fluidisation: proof of concept

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Sludge fluidisation: dilution

Synthetic sludges overlaid on IRCWD shear strength classes

- Uniform sludge pre-dilution
- 23.5% increase in WC
- Uniform sludge post-dilution

Shear strength, $\tau$ (Pa)

Shear rate, $\gamma$ (1/s)
Sludge fluidisation: remoulding

Synthetic sludges overlaid on IRCWD shear strength classes

- Consolidated sludge
- Air-blown remoulding
- Remoulded sludge
- High +
- High
- Med +
- Low

Shear strength, $\tau$ (Pa)

Shear rate, $\gamma$ (1/s)
Future work: full scale fluidisation
Future work

- Portable penetrometer: multi-city baseline study
- Chart performance of different pit emptying technologies
- Factors affecting pit function: longitudinal studies
- Fluidisation: Overconsolidated simulant, full-scale tests
- Synthetic sludge: Higher strength, extraneous matter
Future work: synthetic sludge

- Kaolin clay
- Topsoil
- Water
- 'Extraneous matter'
  - Sand, gravel
  - Newsprint
  - Plastics
  - Textiles
Synthetic sludge: higher strength
Future work

- Portable penetrometer: multi-city baseline study
- Chart performance of different pit emptying technologies
- Factors affecting pit function: longitudinal studies
- Fluidisation: Overconsolidated simulant, full-scale tests
- Synthetic sludge: Higher strength, extraneous matter
- Low cost sludge characterisation tools
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