Synthetic Water Repellent Soils and Slope Engineering

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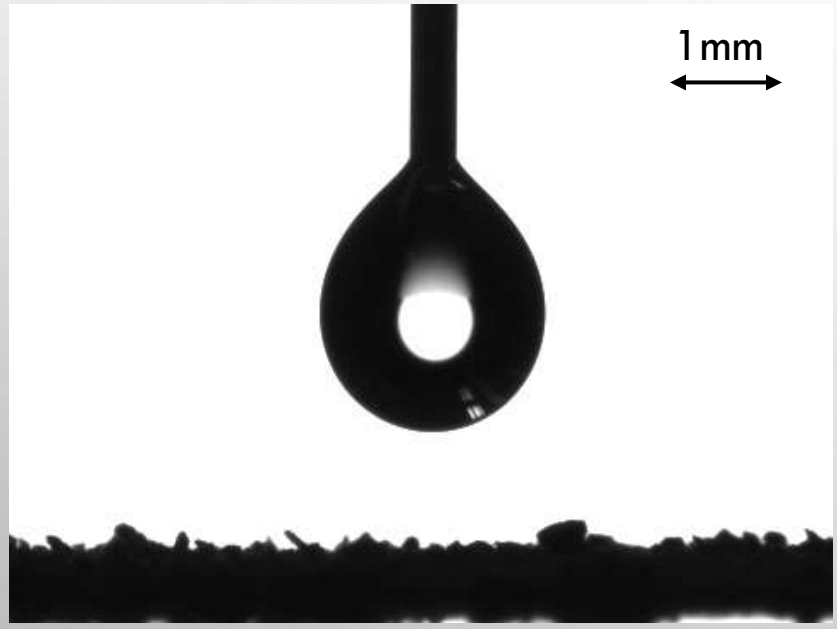
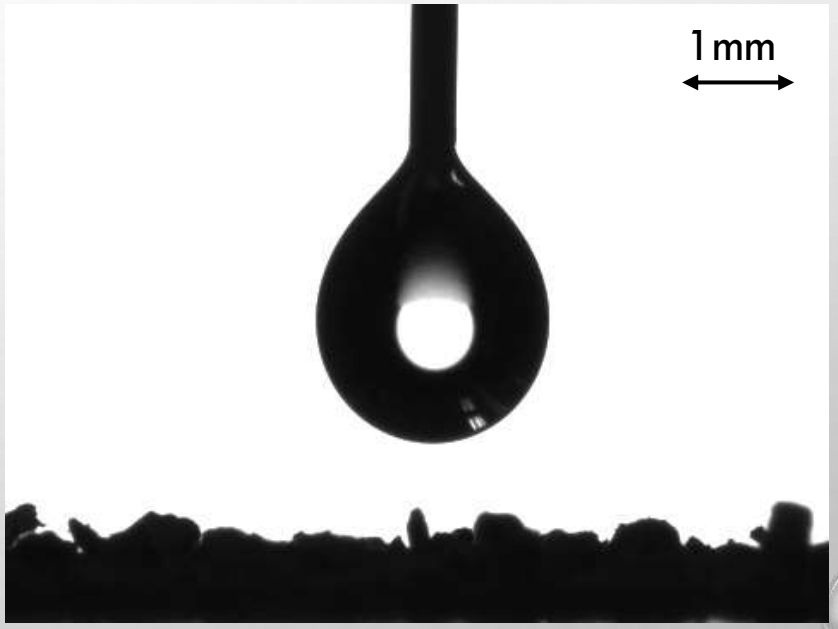
What is water repellent soil?

- Wettable soil

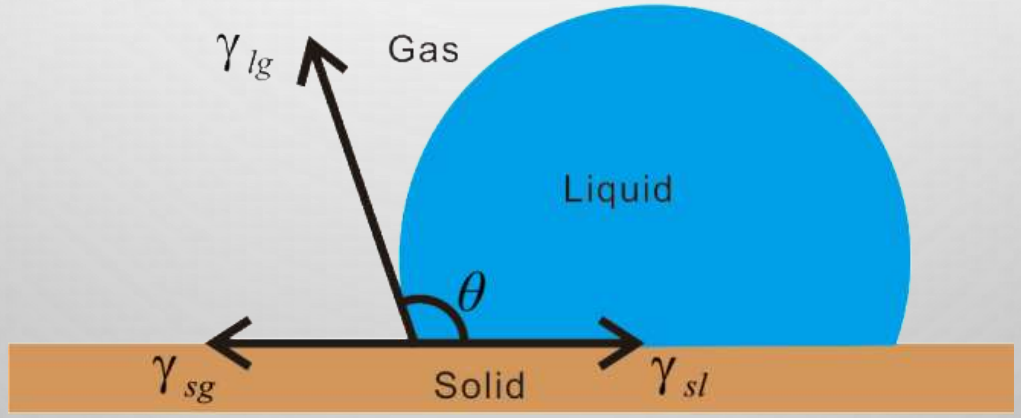


- Water repellent soil



Contact angle

- Young's equation (Shaw, 1992)
  - $cos\,\theta = \frac{\gamma_{sg} - \gamma_{sl}}{\gamma_{lg}}$
  - where θ denotes contact angle, γ denotes interfacial surface tensions



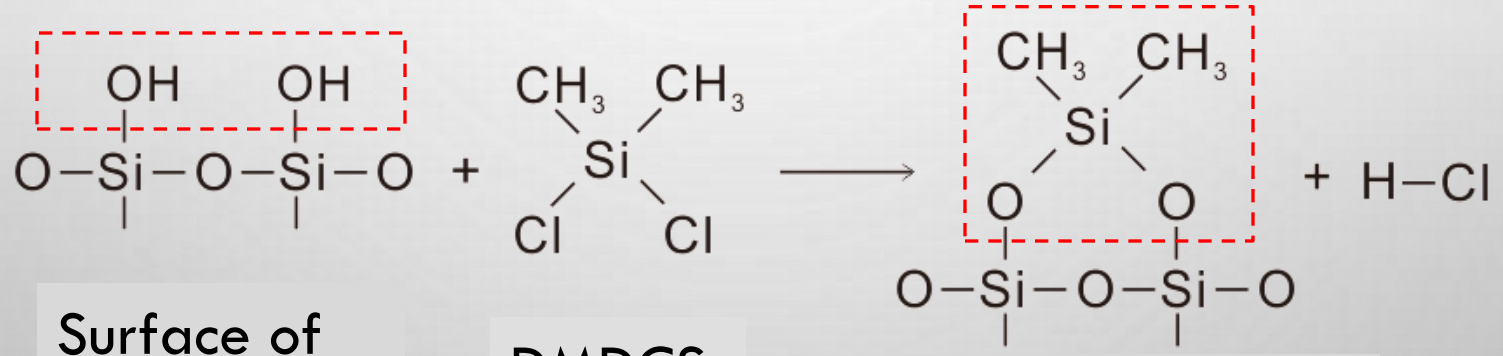
Origins of soil water repellency

- Natural water repellent soils (DeBano, 2000)
  - Plant oil & wax
  - Fungi species
  - Decomposed organic matter
  - Wildfire heating
- Influenced by environment
  - Temperature & Relative humidity
- Losses in agriculture

(www.permacultured.us)

Origins of soil water repellency

- Synthetic water repellent soils
  - Hydrophobizing agents (e.g. Silane compounds)
  - Simple sample preparation
  - Persistent water repellency



Surface of wettable soil

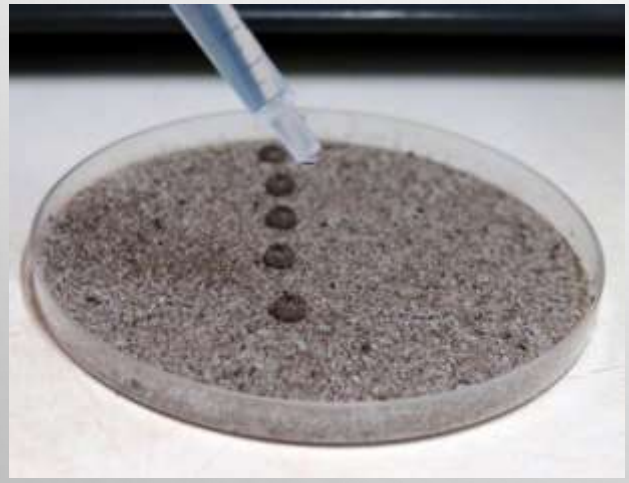
DMDCS

Surface of water repellent soil

(Ng and Lourenço, 2016)

Quantification of water repellency

- Water drop penetration time (WDPT)
  - Index test
  - Simple operation



(www.bgpa.wa.gov.au)

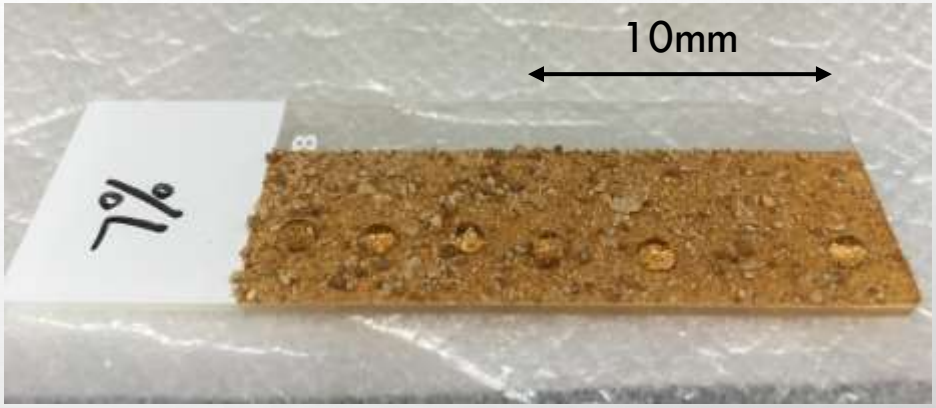
Water repellency level	WDPT (s)
Wettable	≤5 s
Slightly repellent	5-60 s
Strongly repellent	60-600 s
Severely repellent	600-3600 s
Extremely repellent	≥3600 s

(Doerr, 1998)

Quantification of water repellency

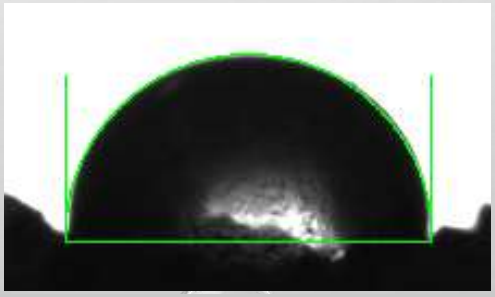
- Sessile drop method (SDM)
  - Direct measurement
  - Reproducible result

  (Bachmann et al., 2000)

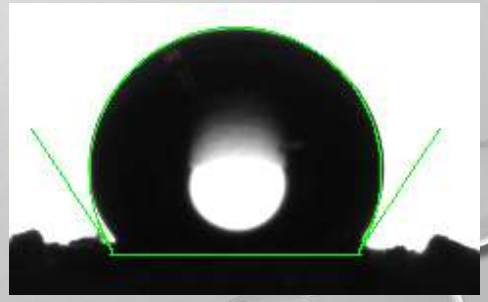


Soil sample for SDM

CA=70°



CA=90°, threshold



CA=120°

Rainfall-induced landslides

Sau Mau Ping Landslide, 1972

Po Shan Road Landslide, 1972

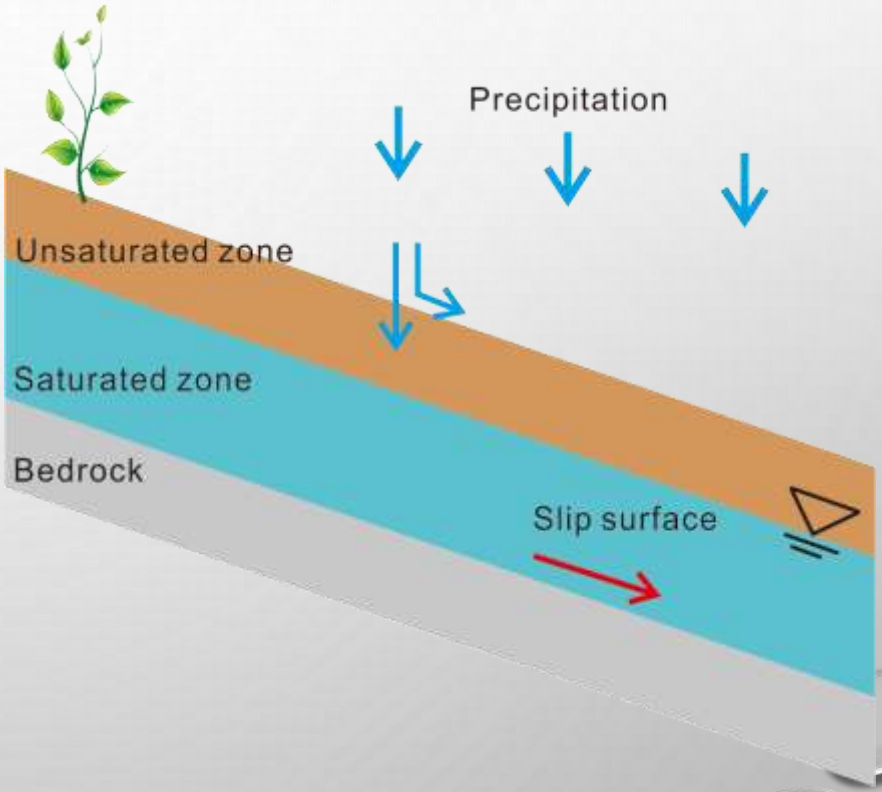
(hkss.cedd.gov.hk)

- "The slope failure was the result of infiltration during intense rainfall, in end-tipped, loose fill, followed by loss of strength…"

-GEO Report No. 86

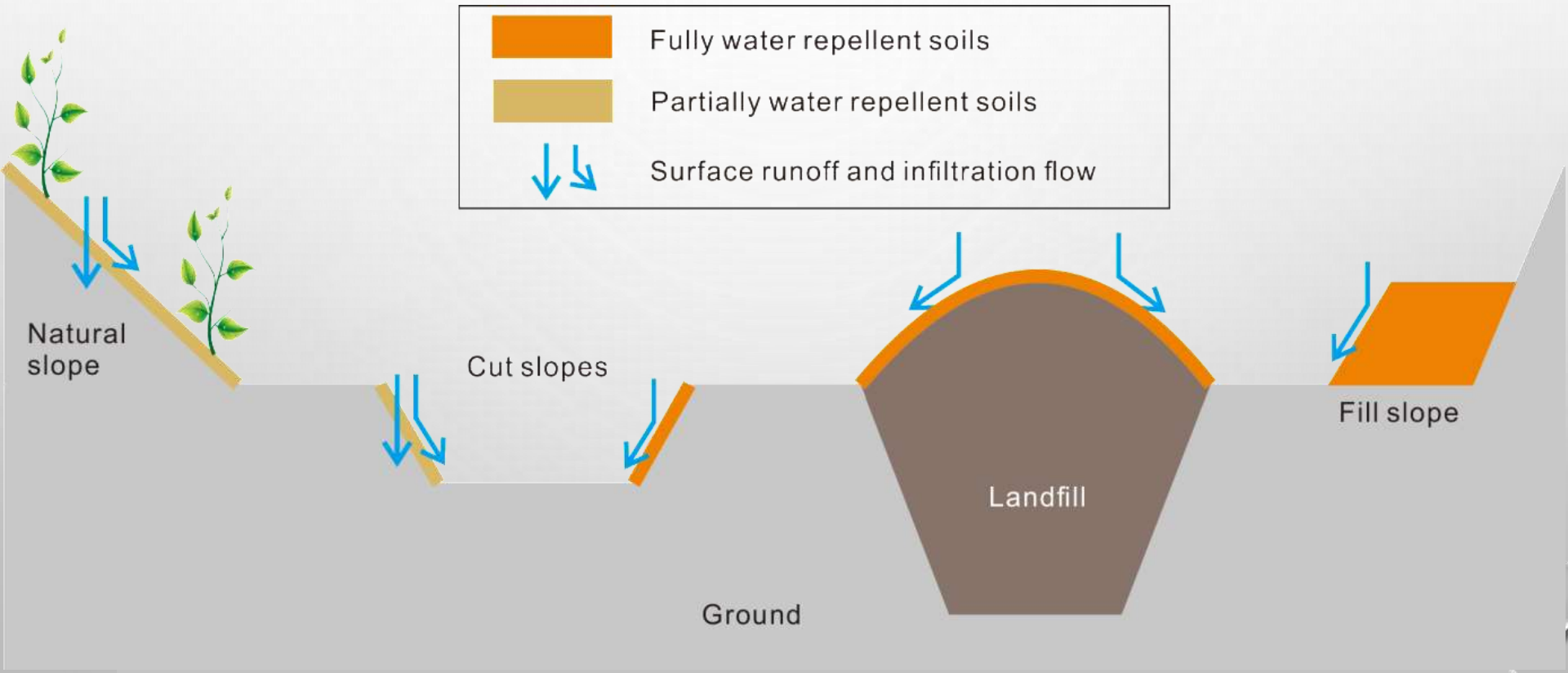
Rainfall-induced landslides

- Failure mechanism (Eckersley, 1986)
  - Wettable soils
  - Infiltration
  - Excess pore pressure
  - Decreased strength
- Stabilizing method
  - Reinforcement element
  - Prevention of infiltration



Potential applications

- Slope engineering



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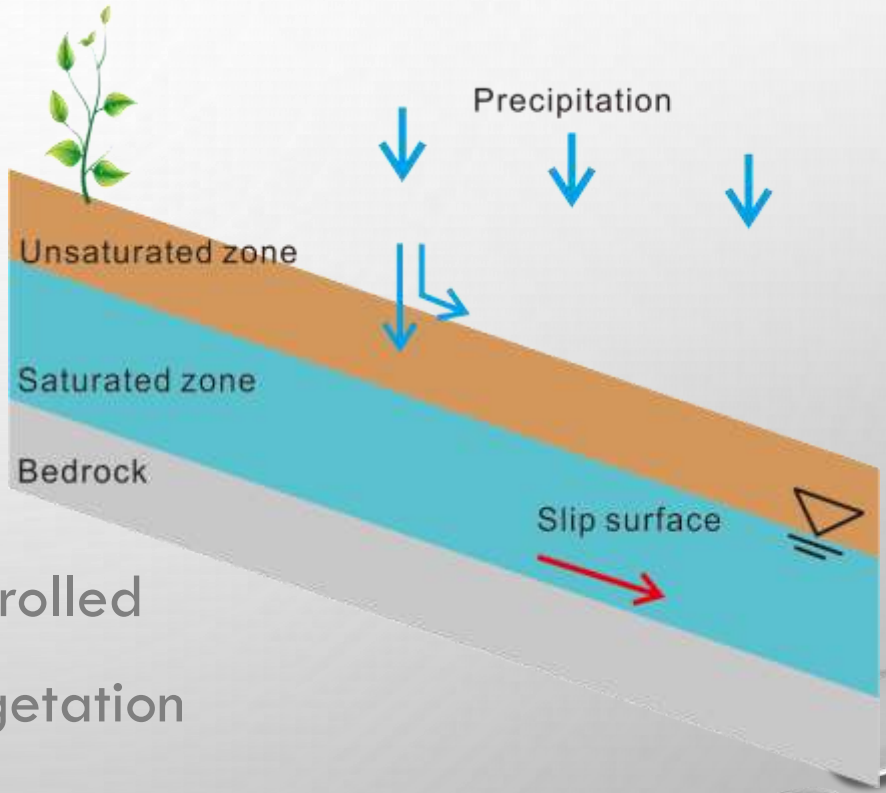
Slope stabilization

- Natural and man-made slopes
  - Water repellent soils as impermeable barrier
  - Infiltration is delayed and reduced
- Advantages
  - Infiltration rate can be controlled
  - Can be integrated with vegetation



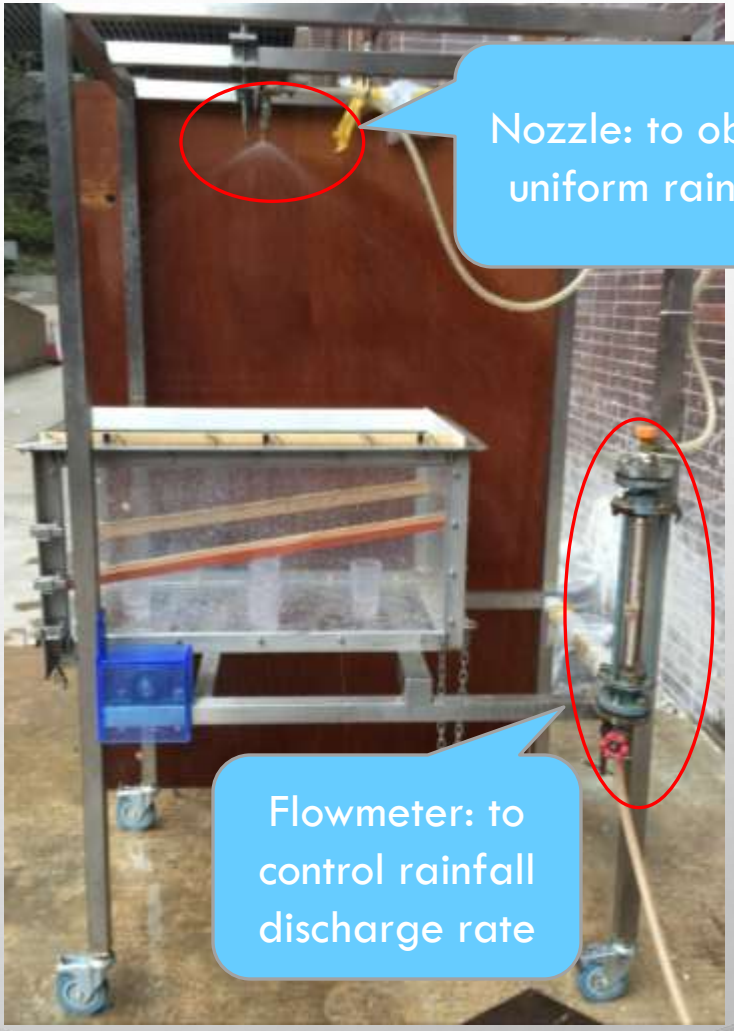
Aim & Objectives

- To model slopes under rainfall condition, and identify the optimum condition for water repellent soils in sloping ground

- Objectives
  - To establish the relation between infiltration/surface runoff discharge and soil water repellency
  - To investigate how the effectiveness of water repellent soil is influenced by various factors (e.g. slope angle, relative compaction and rainfall intensity)

Set-up of flume

An ongoing flume test

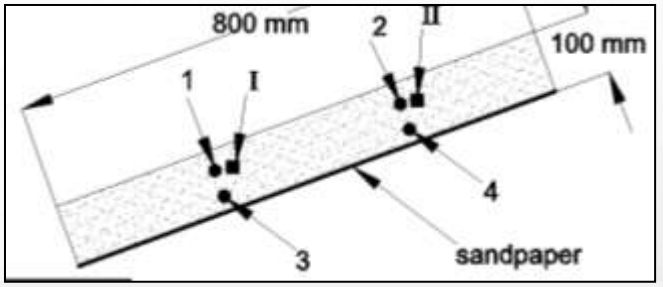


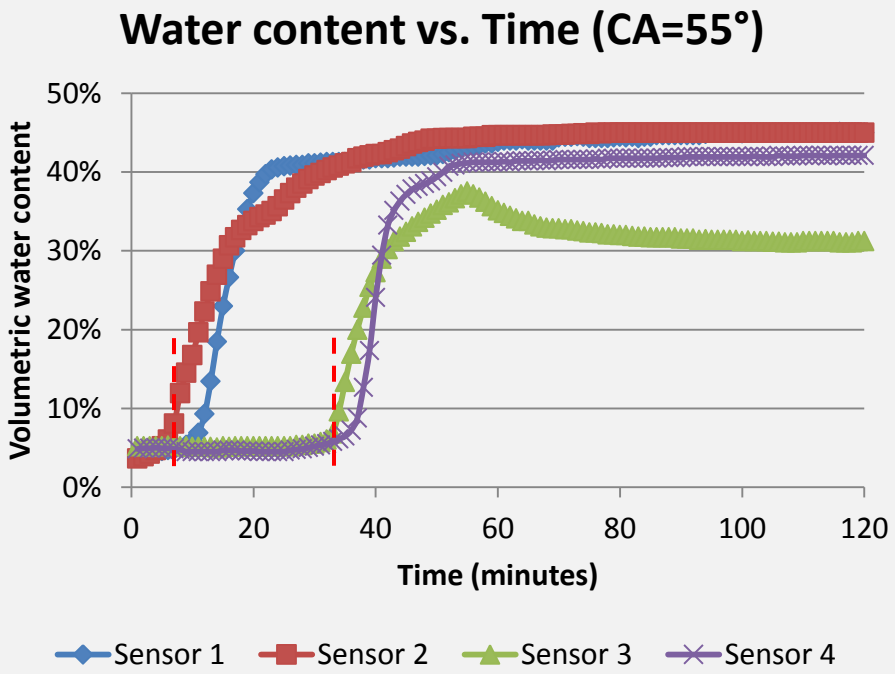
Rainfall simulator calibration

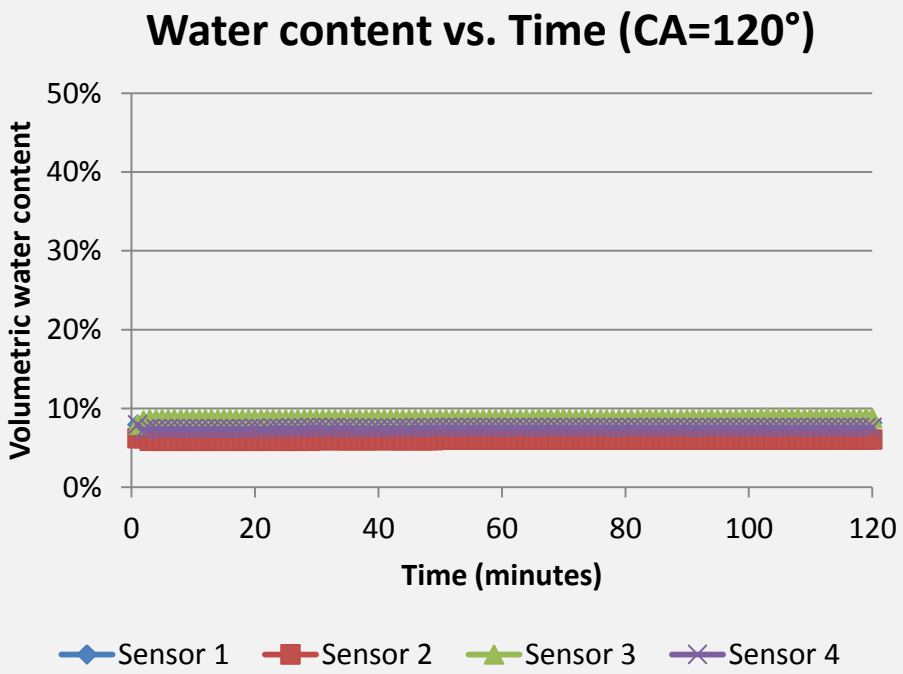
Effect of soil water repellency

- Contact angle

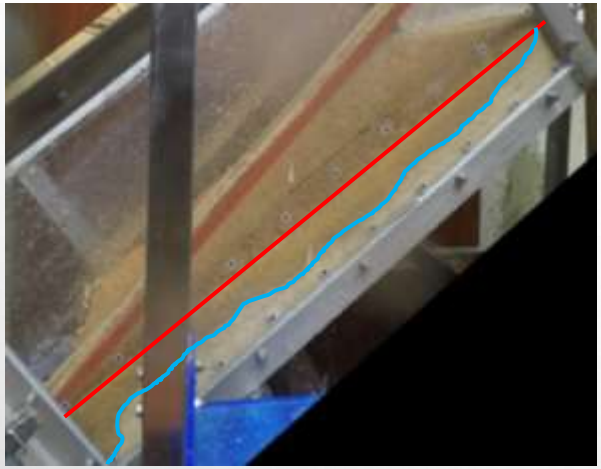
  55°, 120°





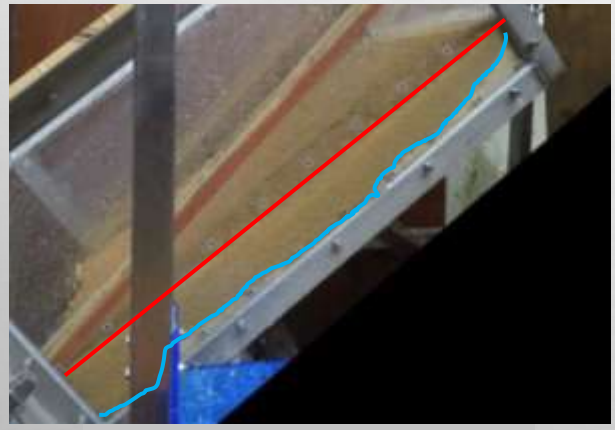


- Effect on infiltration pattern
  - Advancing of wetting front



CA=55°, 10 minutes

CA=120°, 10 minutes



CA=55°, 20 minutes

CA=120°, 120 minutes

Conclusions

- Increase in soil water repellency leads to a reduction of infiltration rate, which can be further controlled by manipulating the level of water repellency (contact angle).

- Increase in soil water repellency leads to a reduction of amount of water retained in the slope.

- Water repellent soils are promising materials for slope stabilization, improve slope safety by reducing both the infiltration and generation rate of surface runoff.

THANK YOU!

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