Hydro-Mechanical Characterisation of Colloidal Silica Grout

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Distinctive Annual Meeting
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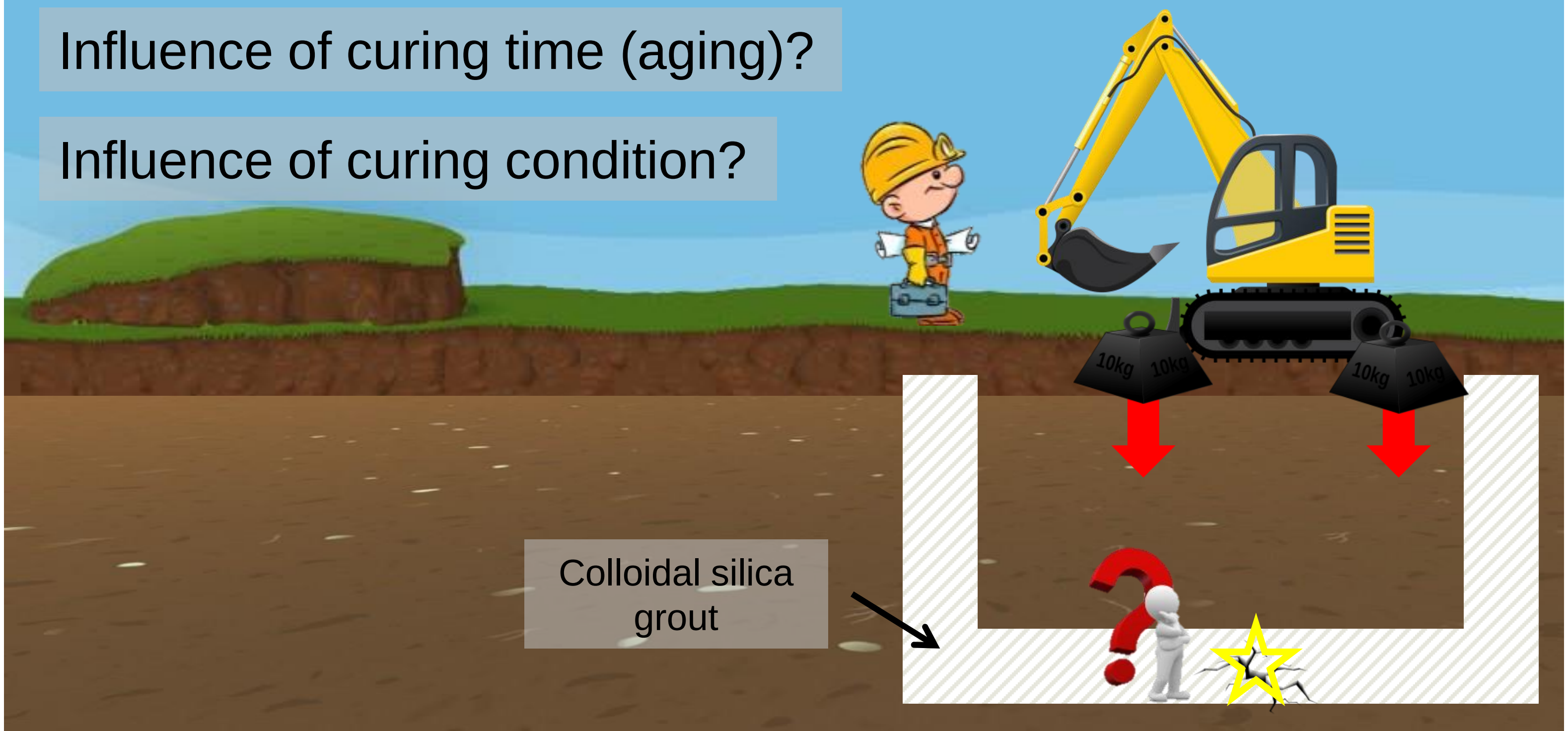
Bristol

Motivation

How does the colloidal silica grout perform?

Influence of curing time (aging)?

Influence of curing condition?



Application of testing methods used within the field of geotechnical engineering to investigate colloidal silica grout performance.

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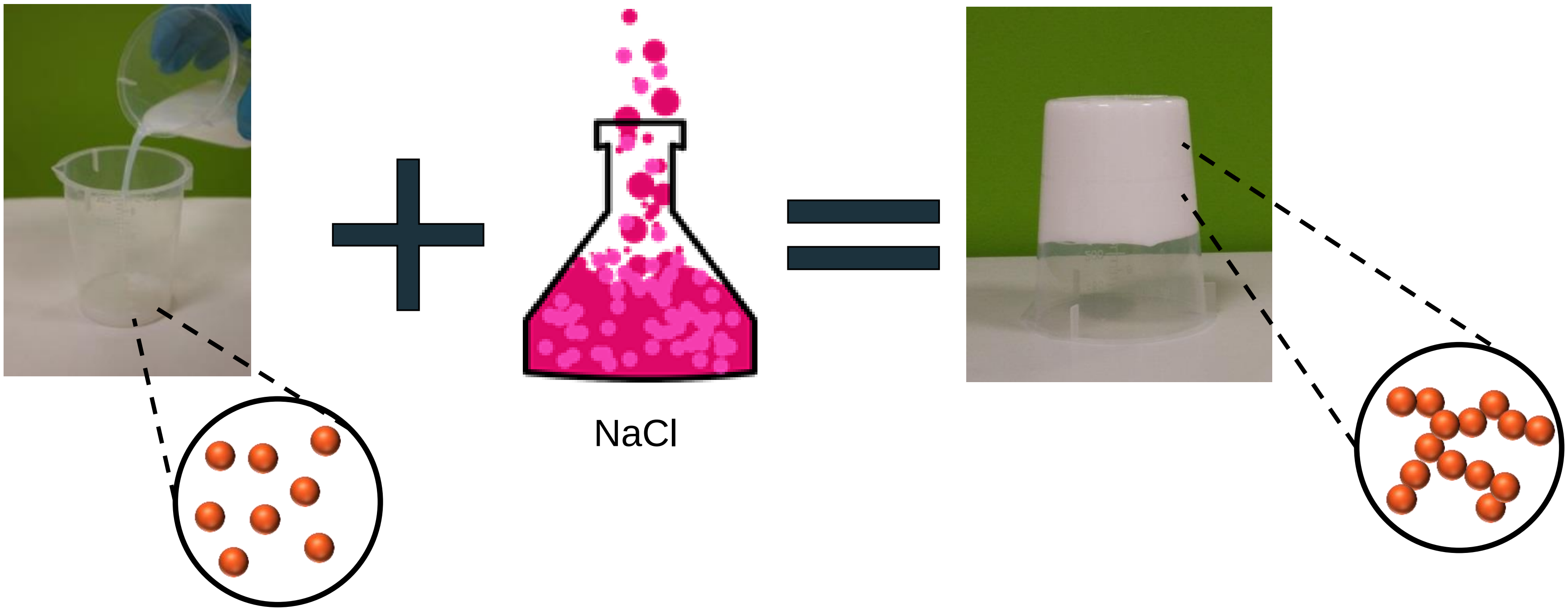
Colloidal Silica Grout

COLLOIDAL SILICA | **ACCELERATOR** | **SILICA GEL**



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Hydro-Mechanical Characterisation

What are the relevant geotechnical behaviours to investigate?

1. Soil-Water Retention

2. Consolidation/Compression Behaviour

3. Shear Strength

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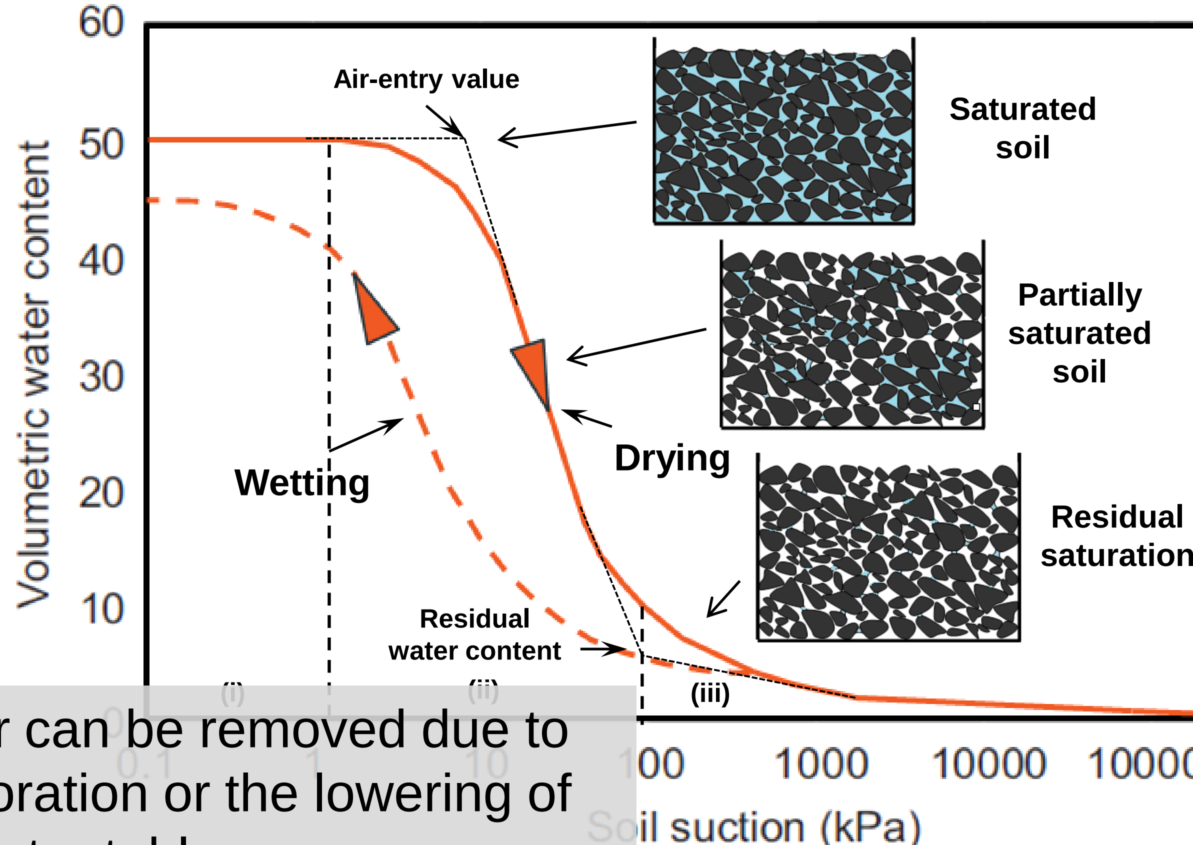
Soil Water Retention Curve

The soil-water retention curve defines the relationship between water content and soil suction (i.e. negative pore water pressure).



Wet soil

Dry soil

Water can be removed due to evaporation or the lowering of the water table.

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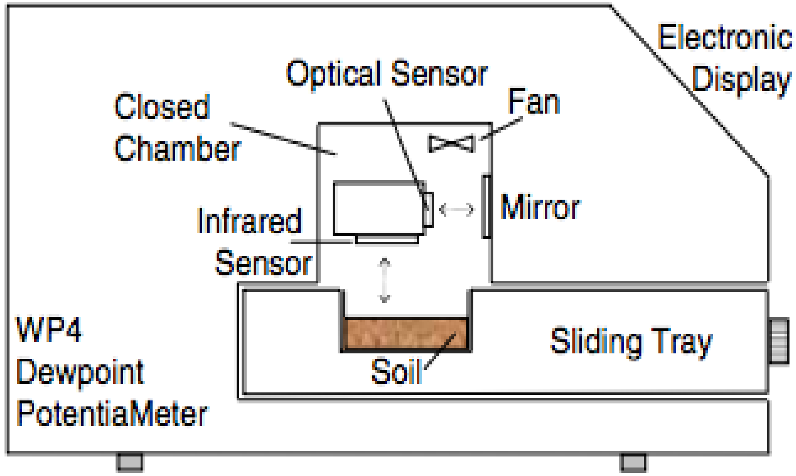
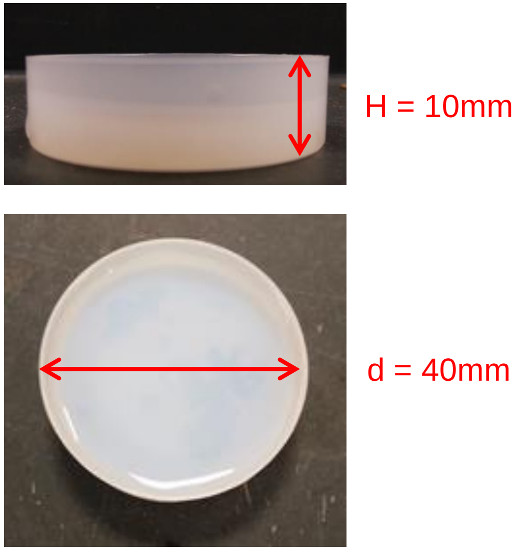
Soil Water Retention Curve - WP4 Test

- WP4 Potentiometer – Dew point Method
- Total suction inferred from relative humidity.
- Equilibrium of soil water and vapour in the sealed chamber.
- Chilled mirror dew point technique.

WP4 Potentiometer



Schematic of WP4



Test specimen

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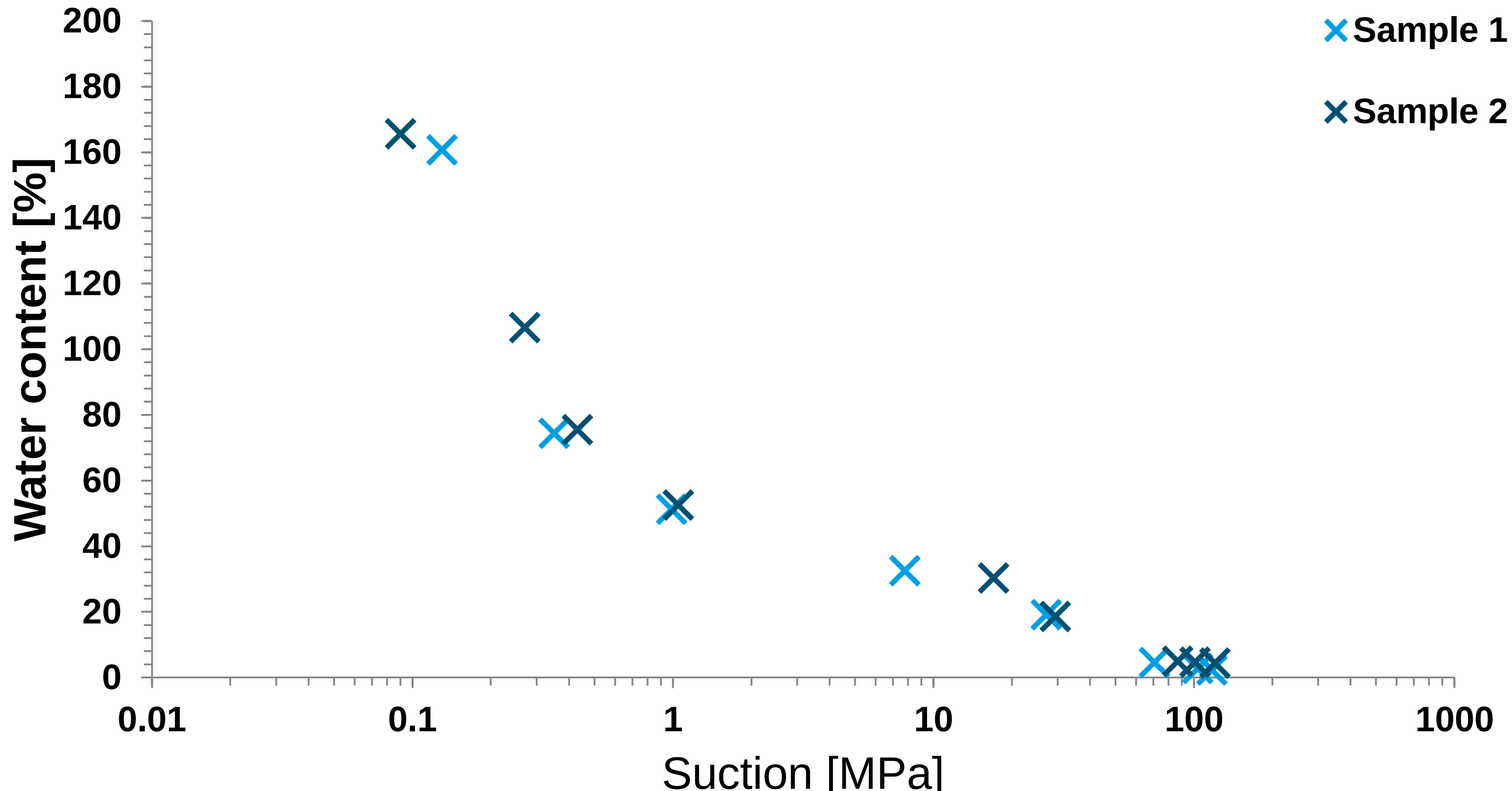
Soil Water Retention Curve - Results

Two samples of 0.28M NaCl colloidal silica grouts cured for 1 week in H_2O compared with Kaolin clay.



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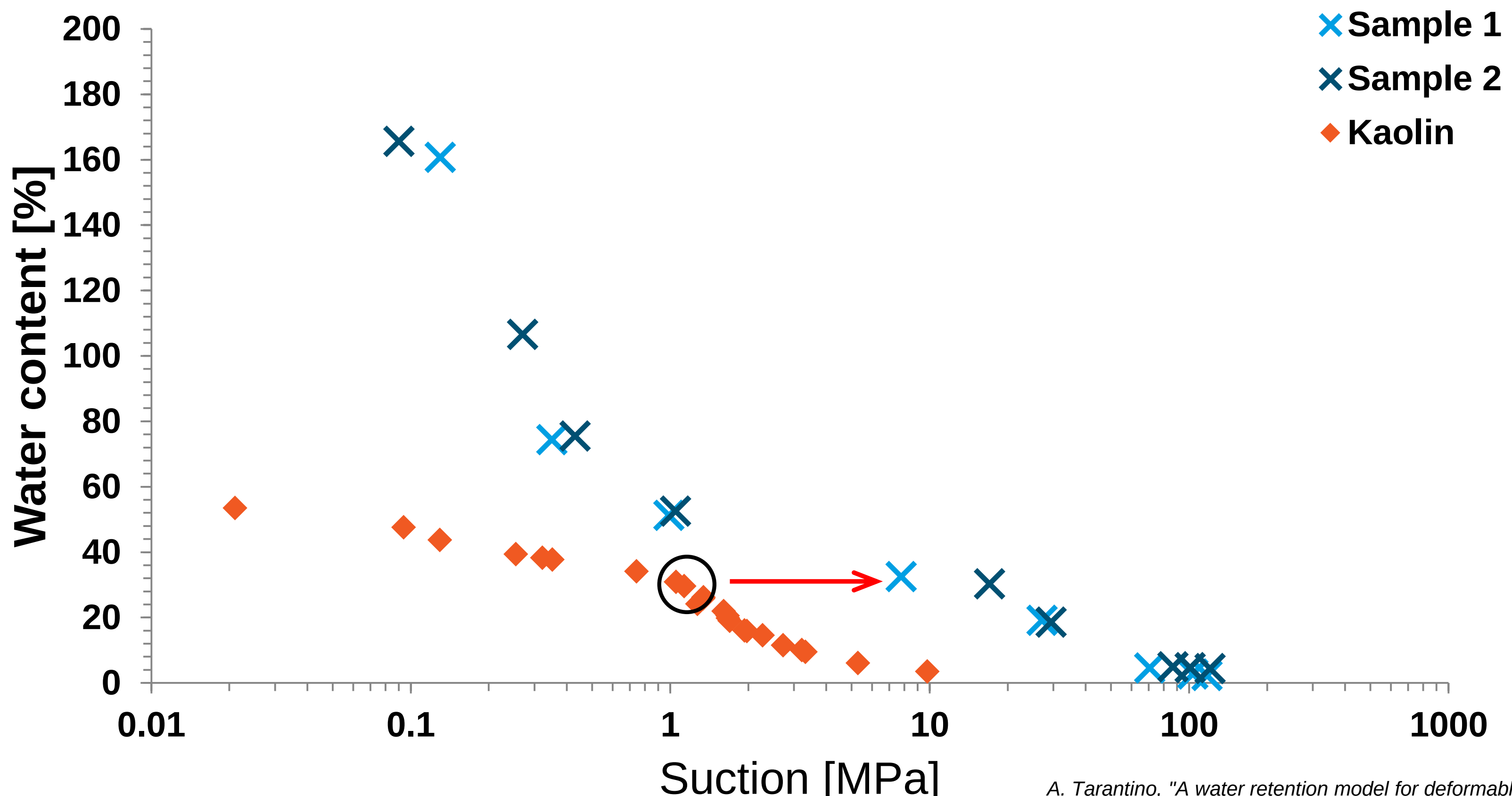
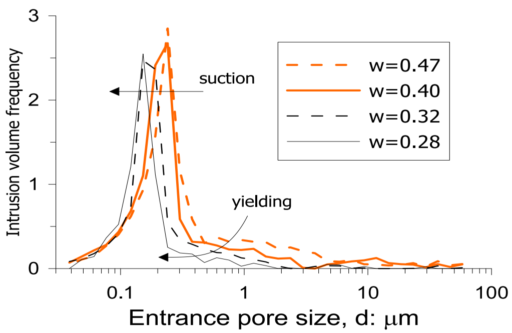


A. Tarantino, "A water retention model for deformable soils," Geotechnique, 2009.

Pore Size Distribution

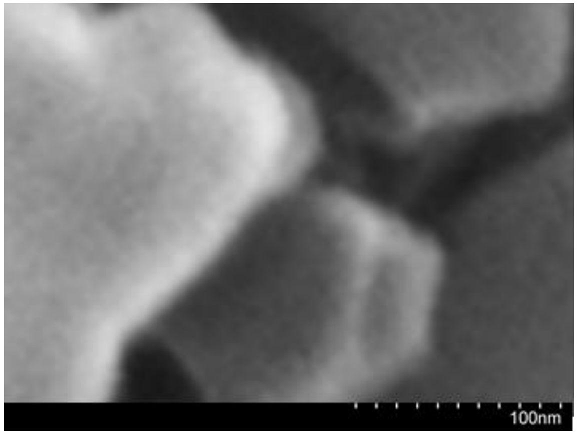
Currently colloidal silica grout is unable to survive to vacuum freeze drying process required to dehydrate the sample.

Pore size distribution results from mercury intrusion porosimetry testing.

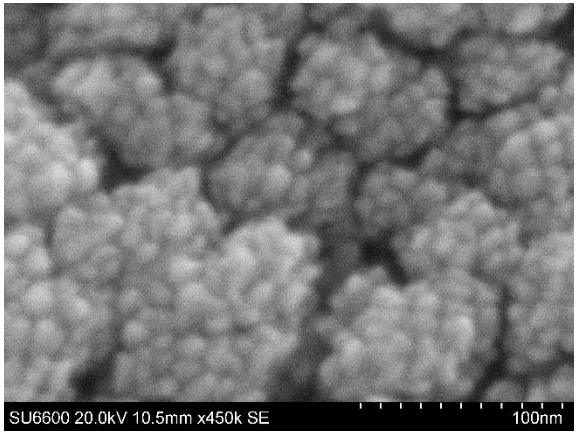


Pore size distribution of kaolin *(Pedrotti, 2016)*

Destroyed colloidal silica sample



Kaolin pores *(Yanik, 2011)*



Colloidal silica pores

Yanik, G. 2011. Mineralogical, crystallographic and technological characteristics of Yaylayolu kaolin (Kütahya, Turkey)

Pedrotti, M. 2016. An experimental investigation on the micromechanics of non-active clays in saturated and partially saturated states. PhD thesis.

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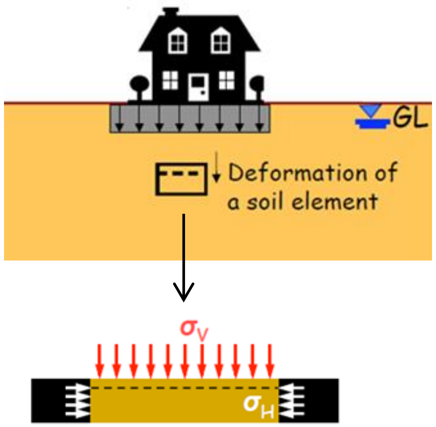
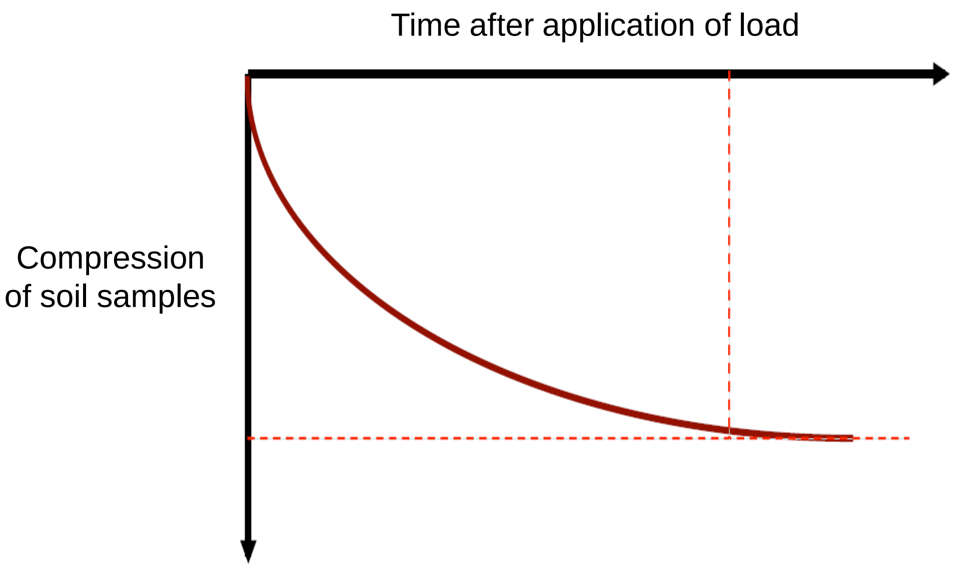
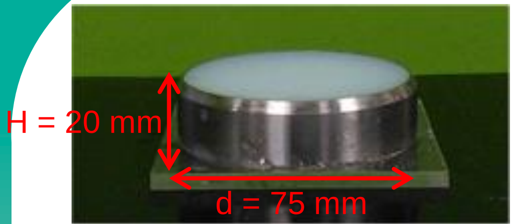
Consolidation Behaviour

- Low permeability or clay materials
- Settlement displacement occurs over a period of time
- The rate of compression varies for different soil compositions

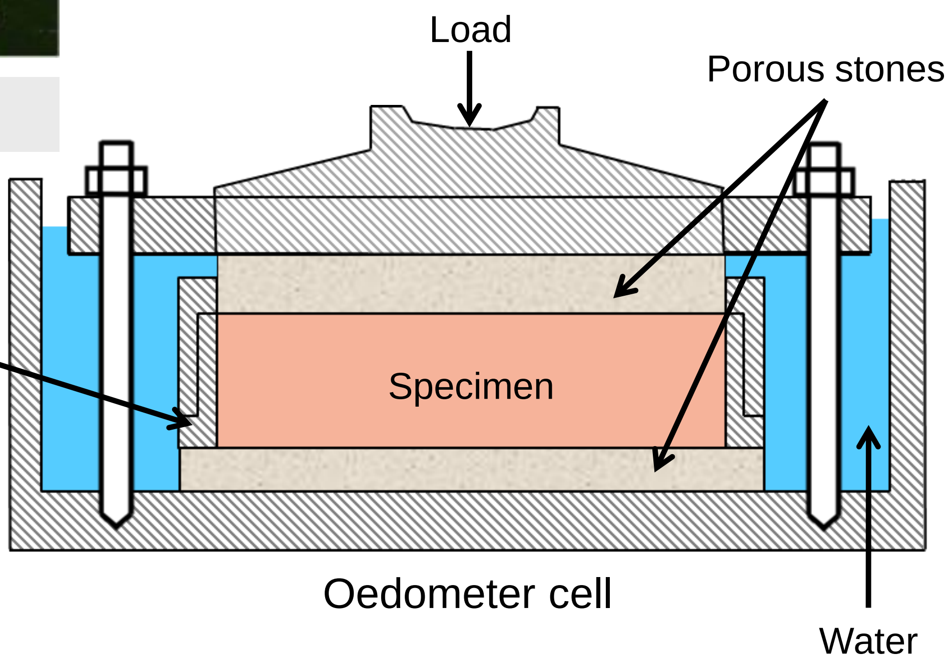




Consolidation Behaviour – Oedometer Test



Test specimen



Oedometer cell

Loading frame

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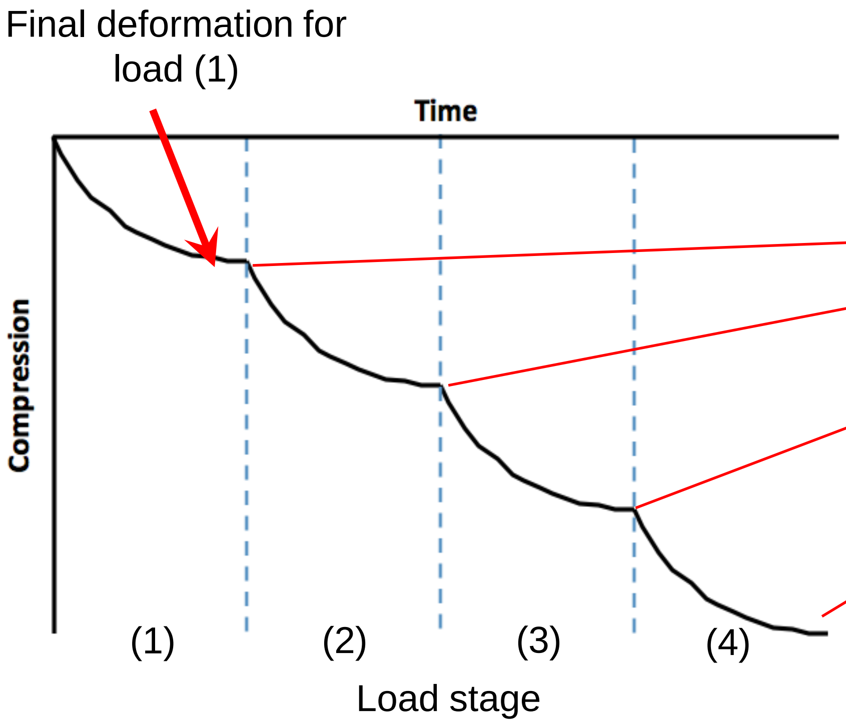
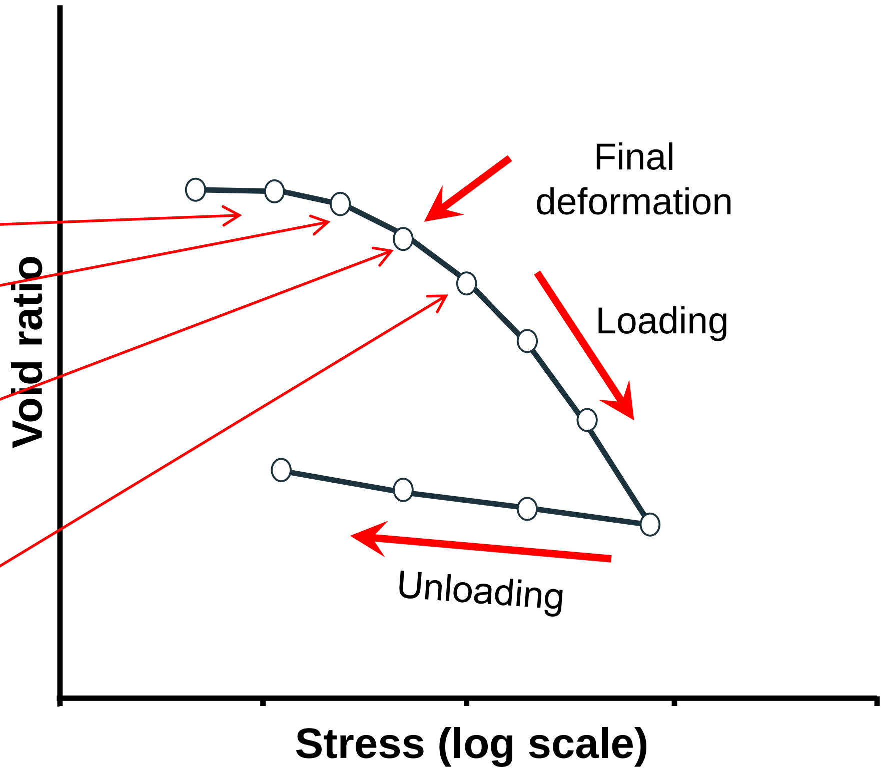
Consolidation Behavior – Oedometer Measurements

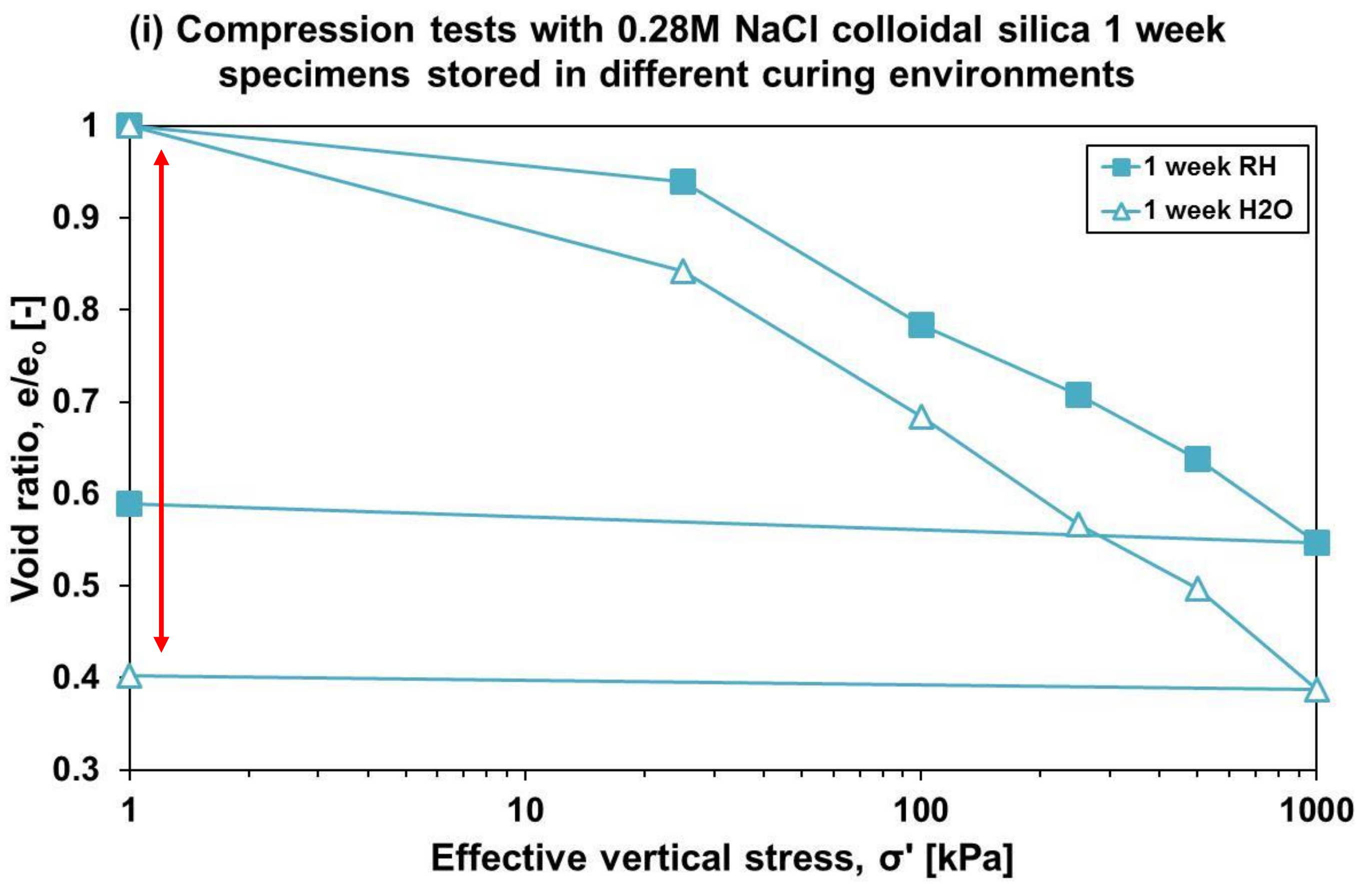


Typical test results for all load stages



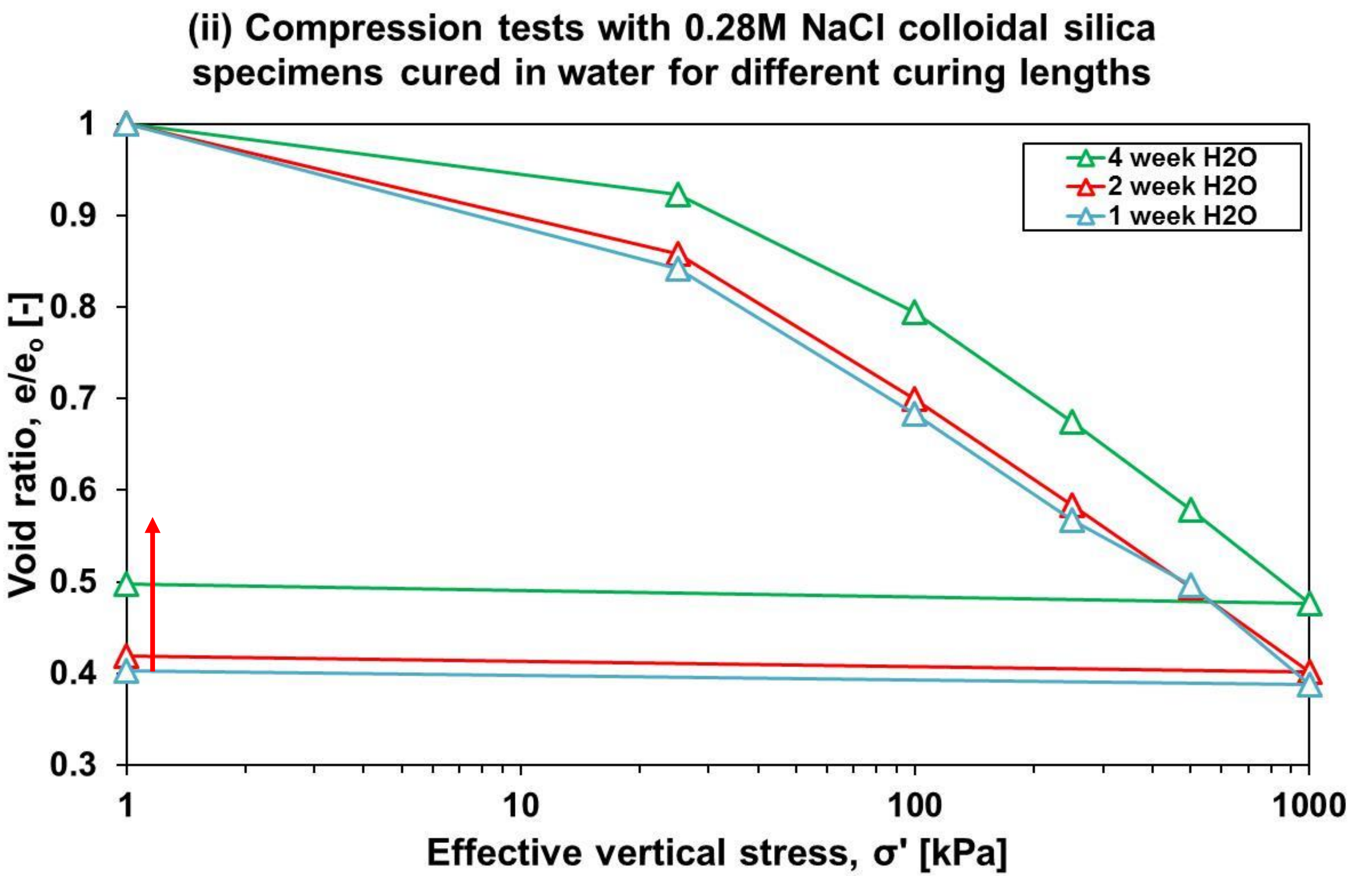
Typical effective stress void ratio response

Consolidation Behavior – Influence of curing condition



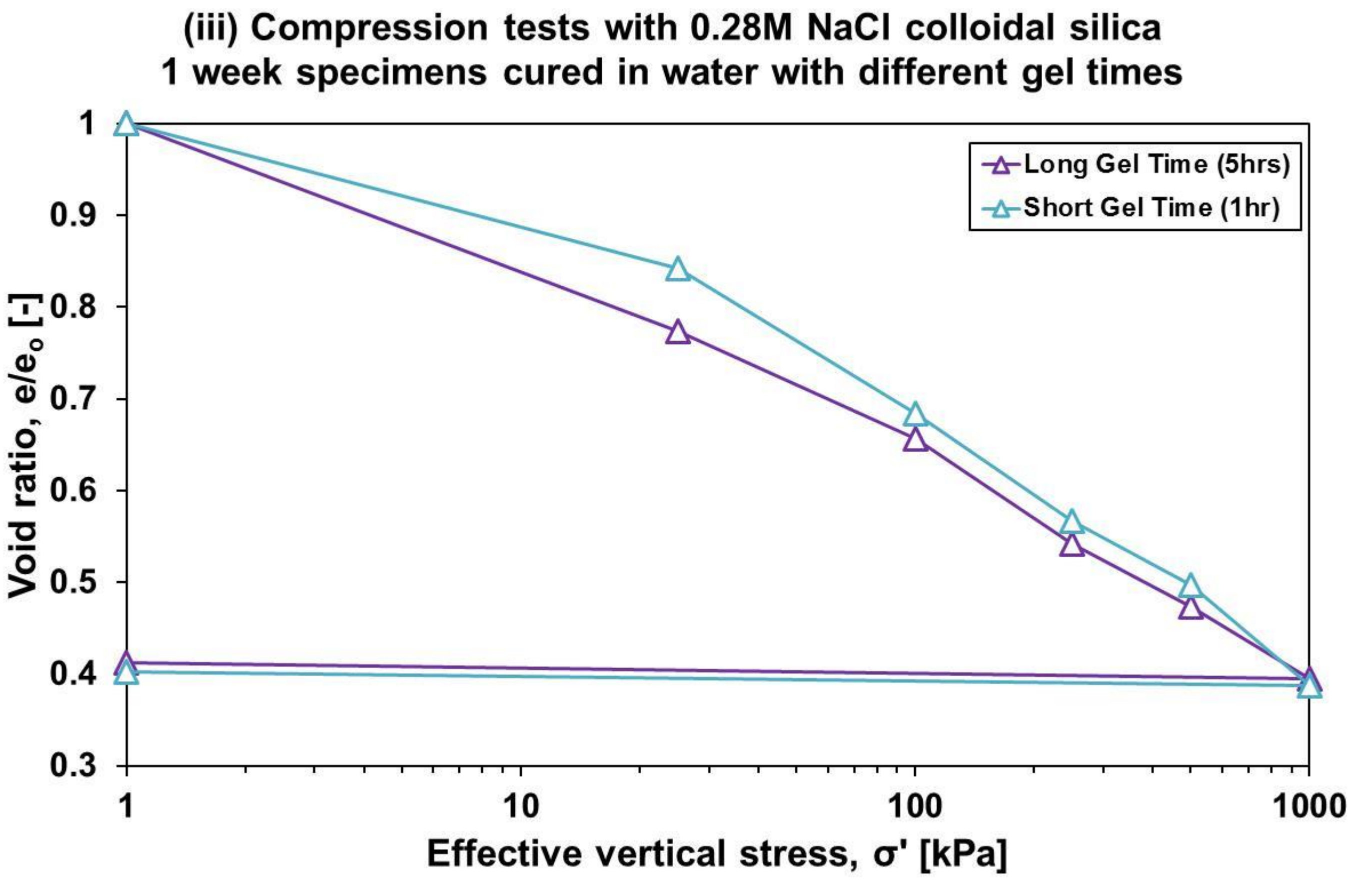
The specimen cured in H2O is more compressible that then RH.

Consolidation Behavior – Influence of curing (aging) time



Results show an increased stiffening effect for specimens of longer curing time.

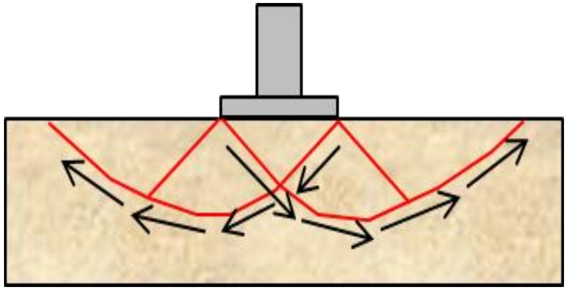
Consolidation Behavior – Influence of gel time



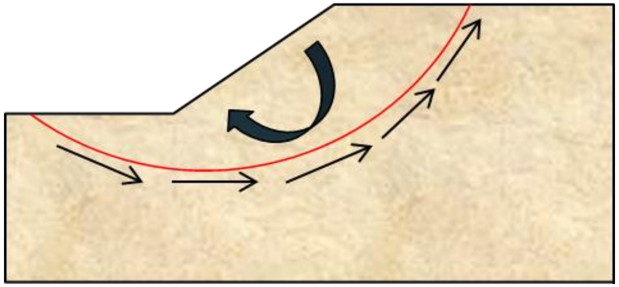
The different gel times of the specimens would appear to have a negligible influence on the overall compression

Shear Strength

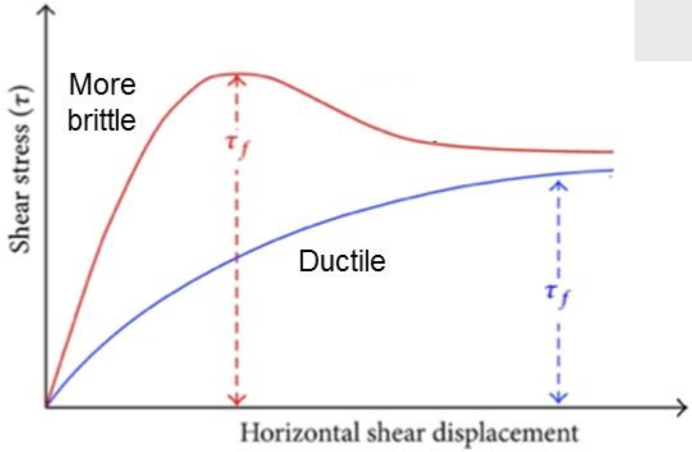
The shear strength of soils (τ_f) is the maximum shear stress that a soil can resist without failure occurring.



Footing load



Embankment



Typical stress-strain curve show brittle and ductile behaviour

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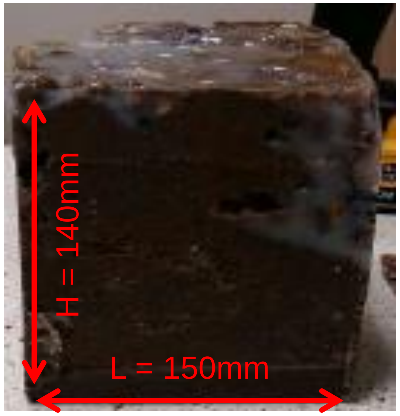
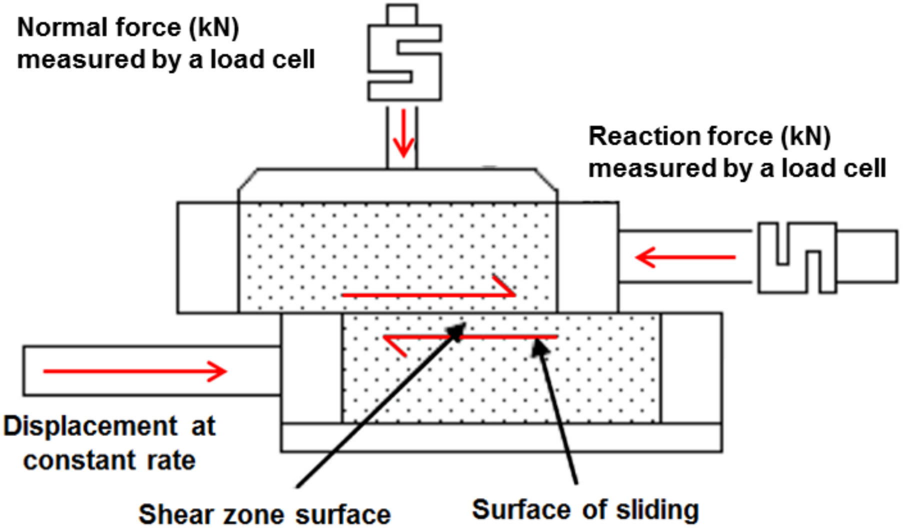
Shear Strength – Direct Shear Test



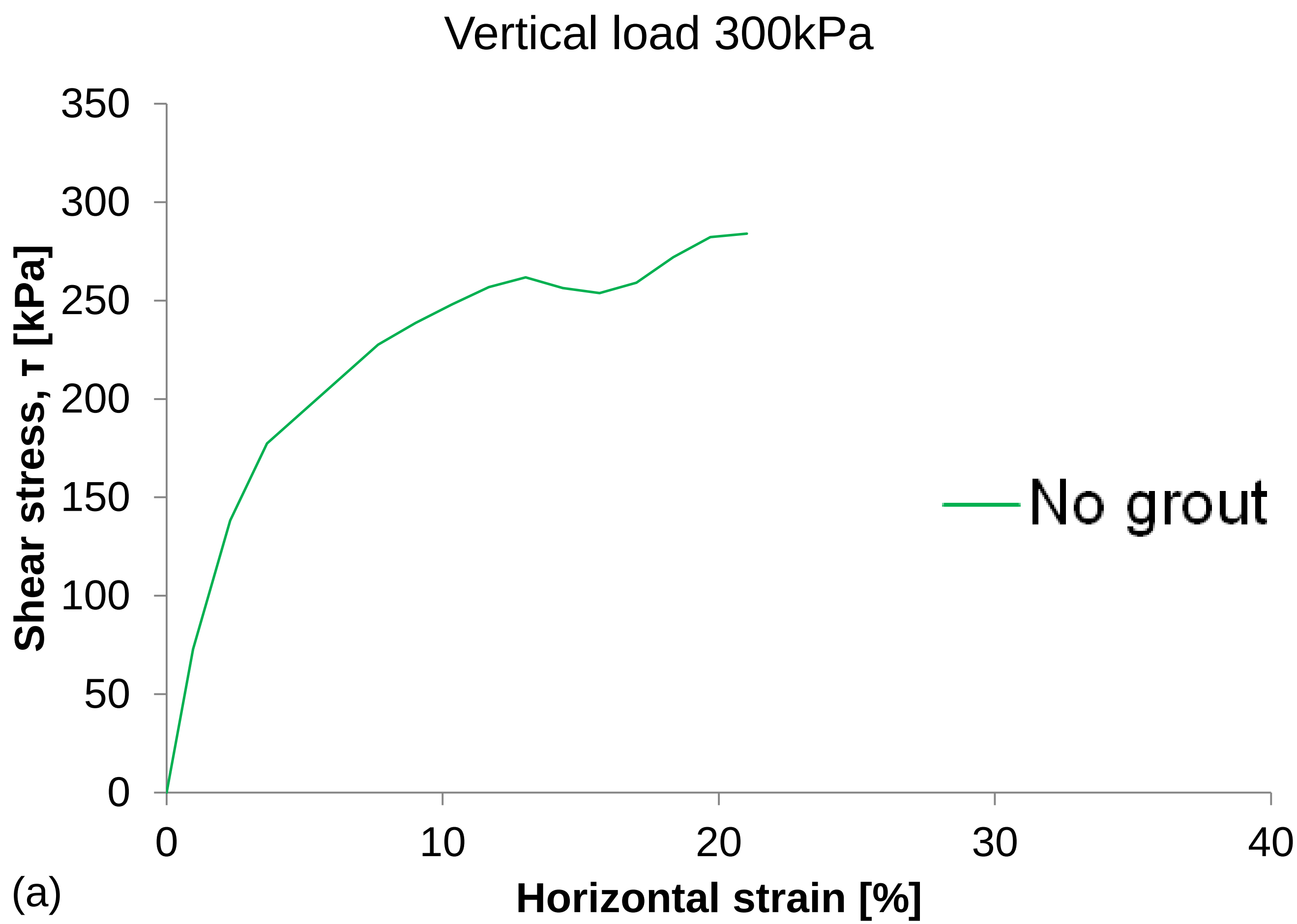
Test specimen

Soil composition of washed building sand (50%), pea gravel (30%), and Scottish beach pebble (20%).



Large shear box

Shear Strength – Influence of curing (aging) time



Shearing behaviour of distilled water-cured specimens: (a) Shear stress compared with ungrouted specimens.

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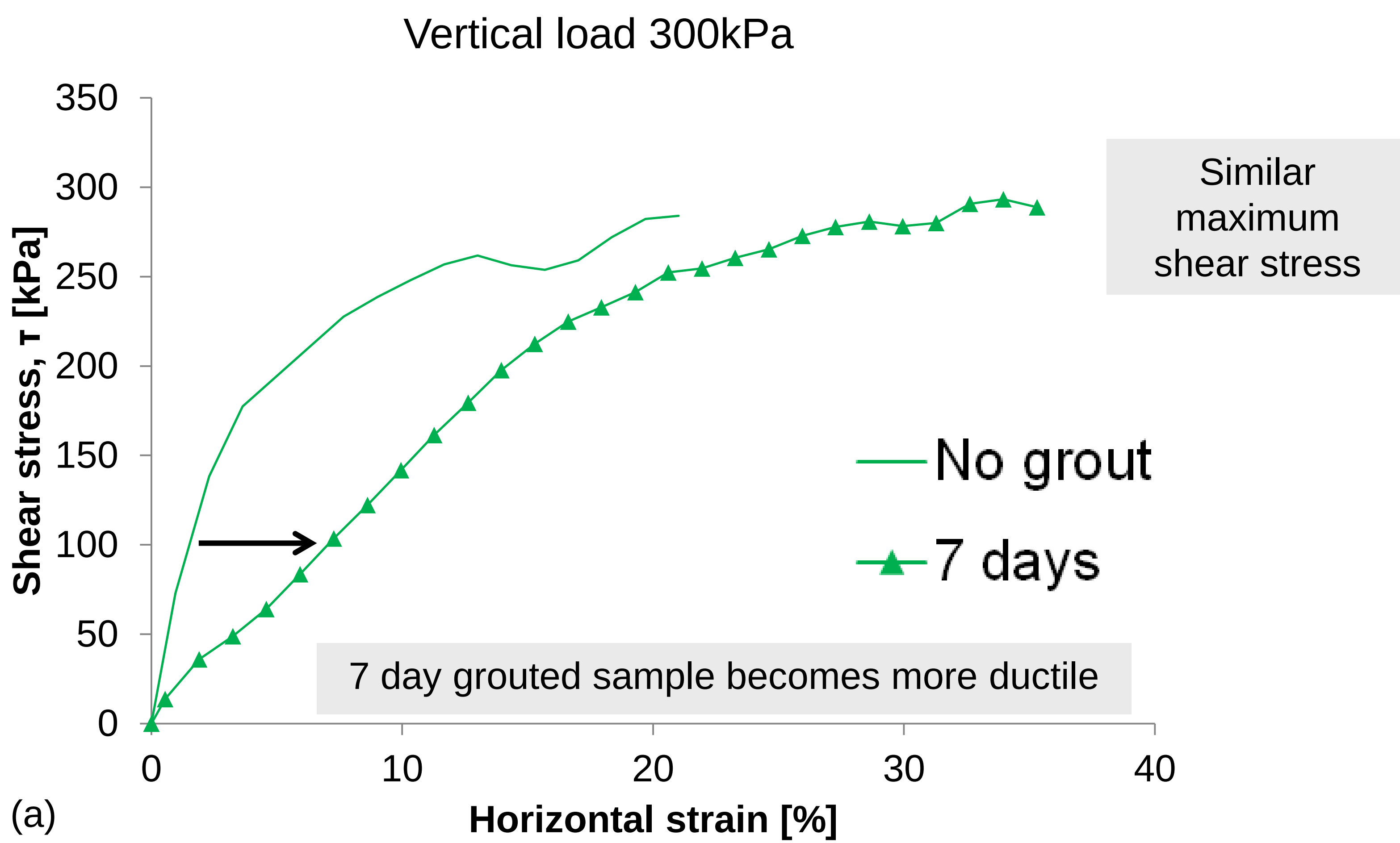
Shear Strength – Influence of curing (aging) time



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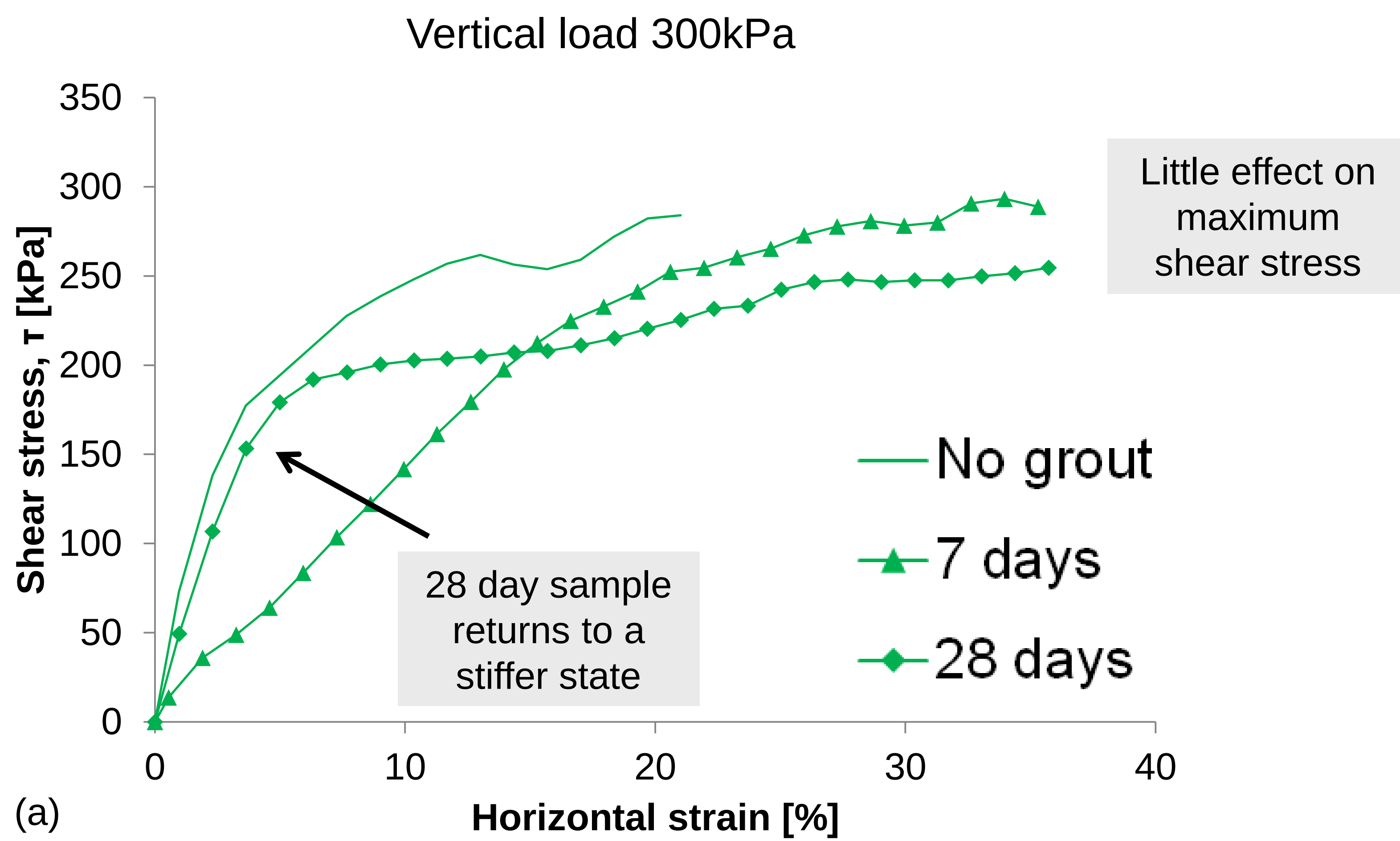

Shearing behaviour of distilled water-cured specimens: (a) Shear stress compared with ungrouted specimens.

Future Work

Soil Water Retention Curve

Colloidal silica smaller pore sizes than kaolin clay

Influence of drying on grout microstructure (pore size distribution measurements, N2 adsorption?)

Consolidation Behaviour

Investigate longer curing duration, curing conditions

Shear Testing

Investigate curing conditions

Permeability Testing

Incorporation of clay, silt and sand fractions

Write up

Thank You