Influence of organic content on viscous compression of soft soils

How differently does peat react to loading in comparison to clay and sand?

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Introduction: What is viscous compression of soils?
When a soil shows viscous behaviour, when vertical pressure is applied, the soil starts to behave similar to a liquid. Essentially, the particles of which the soil matrix is composed start to reorientate to a more efficient, horizontal position leading to compression of the soil volume (Fig. 1).

Two important aspects of viscous compression:
1. It occurs under constant effective stress
2. The time dependency (Fig. 2)

Study aim: Examine the relation of specific weight and water content of laboratory samples to geotechnical viscous compression parameters. Why? To improve subsidence modelling by trying to make the secondary compression coefficient dependent.

Example: The case of Kansai Airport Islands, Osaka, Japan
Kansai Airport is located on artificial islands that exceed subsidence expectations.

Original situation:
- Started in 1992 by draining the original seabed level at 18–20 m below MSL
- Drilled to ~400 m depth in unconsolidated subsurface
- clay layers have a combined thickness of 290 meter
- Construction and preloading with 36.7 m sand fill
- Elevation goal to stay above minimum safety elevation of 4 m above MSL

Simplified model prediction
- Incorrect prediction

Consequences:
- Minimum safety elevation reached in 2023 for Island I (Fig. 2) and in 2036 for Island II
- In 2010, predicted total subsidence in the range of 17–25 m for both islands
- Newly calculated viscous compression of 4.60 m
- Additional costs for the construction due to subsidence of $12 billion in 2008

Hypothesized drivers of viscous compression in peat

Preliminary results: Soil strength parameters
Methodology:
- 349 peat samples and 63 clay samples collected
- Standard Incremental oedometer test or CRS test to determine i.e., the secondary compression coefficient (C₂) or abc-isochotach c parameter
- Determined additional sample characteristics: wet/dry weight, water content & void ratio

Results:
- Clay samples consistently better correlation for the different parameters and ratios
- Peat samples especially large variation in reported C₂ and c values (Fig. 3).

Outcomes:
- Continuous trend/relationship for both the clay and peat samples?
- Not likely, thus different behaviour
- Suggestions: trend up to certain boundary & link water content to loss on ignition

References
6. Reports of the University of Minnesota (2022) from otsouthernminnesota.edu/soil-management-and-health/soil-organic-matter-cropping-system

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The information has been carefully collected, but should not be interpreted differently than presented here.

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