The dependency of creep in peat on the organic content and its implications for decomposing soils

How different 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, 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). Viscous compression is primarily affecting clay and peat soils. Two important aspects of viscous compression are that 1) it occurs under constant effective stress (stress at grain interfaces) and 2) the relation between viscous compression and time is logarithmic[1]. The driving processes of viscous compression of clay have been studied in detail[2], whereas for peat studies are less numerous. This is the case even though viscous behaviour can contribute in the order of 5-30% of total land subsidence in areas with clay and peat subsurfaces. Peat is generally more compressible than clay. However, it is largely unknown how changing composition of peat-clay mixtures affects compressibility.

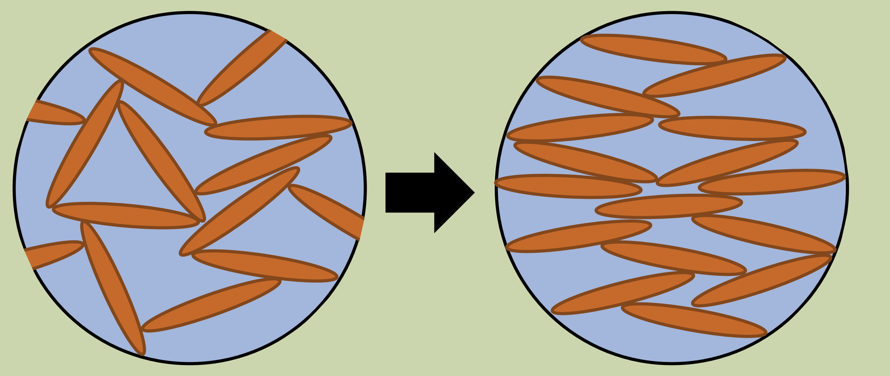

Fig. 1: Schematic view of soil particles reorientating towards a more horizontal position.

How does geotechnical compression behaviour and especially viscous compression behaviour differ between clay and peat, and can we use this to predict compressibility with changing organic matter content?

Methods

A database containing oedometer test results has been used to link viscous compression to different lithological classes. This database contains 349 peat samples and 63 clay samples collected throughout the Netherlands (Fig. 2). With the test results, the compression ratio (CR, representing mostly inelastic consolidation), recompression ratio (RR, representing the elastic compression) and the secondary compression coefficient (C_α, representing the viscous compression) have been analyzed. The relative wet unit weight was used to try and indicate sample composition. By masking the data iteratively to gain new trendlines (Fig. 3), insight in grouping of clay and peat within the data is acquired without a bias based on the lithology determined in the field.

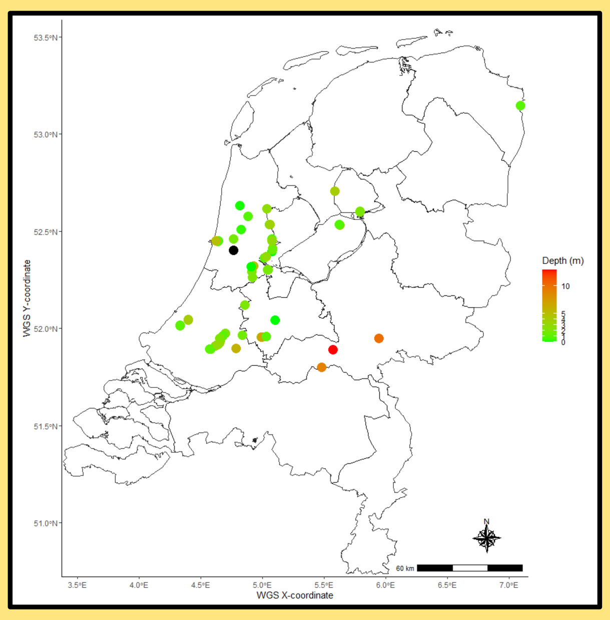

Fig. 2: Oedometer sample locations originate from the Rhine-Meuse Delta plain and the peat bog area in the west of the Netherlands.

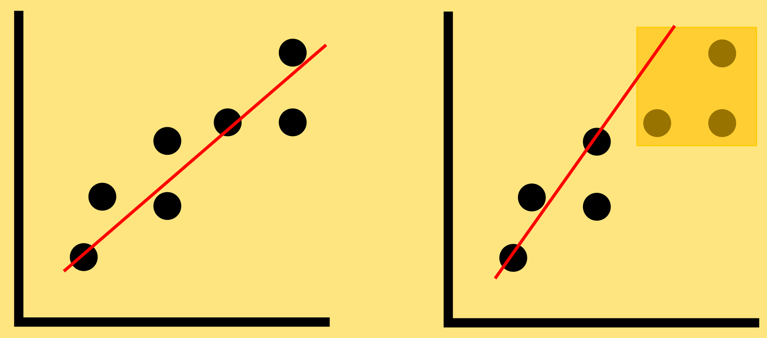

Fig. 3: Conceptual visualization of partial masking of data leading to changing trendlines.

Results: Trends and evolutions for different geotechnical compression parameters

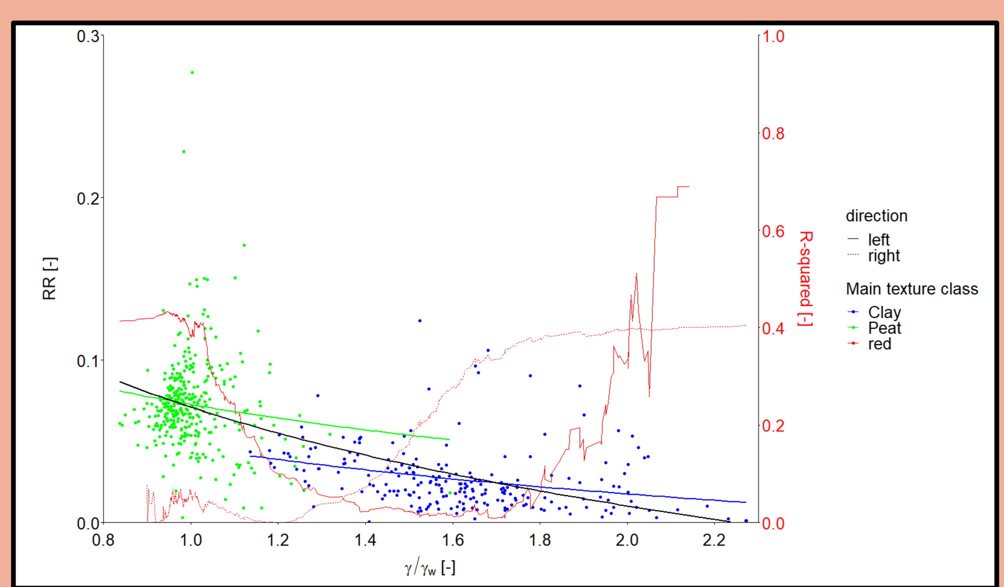

Fig. 4: Recompression ratio (RR) for varying relative weight of the soil sample (γ/γ_w). The data has been grouped based on the reported main lithological class.

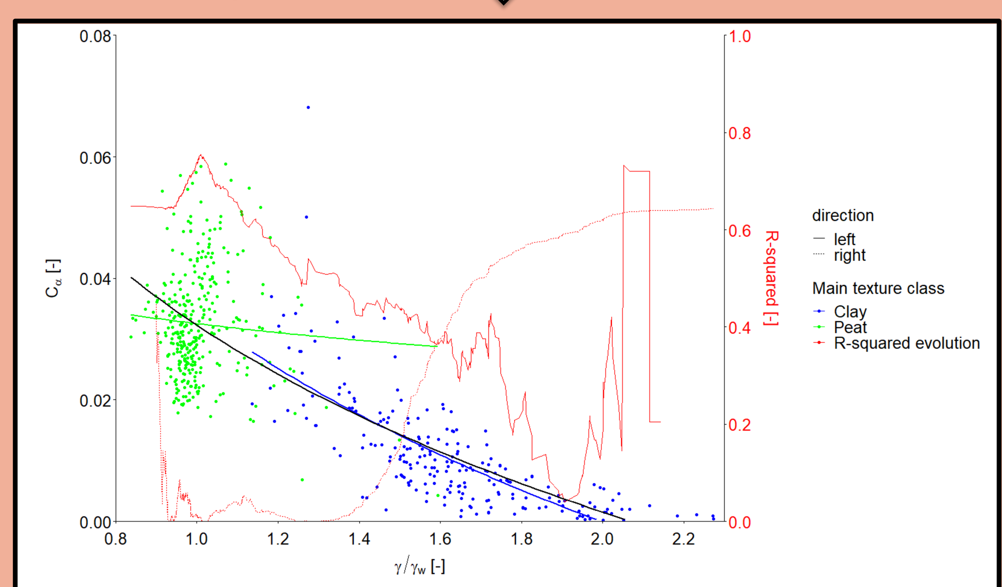

Fig. 5: Secondary compression coefficient (C_α) for varying relative weight of the soil sample (γ/γ_w). The data has been grouped based on the reported main lithological class.

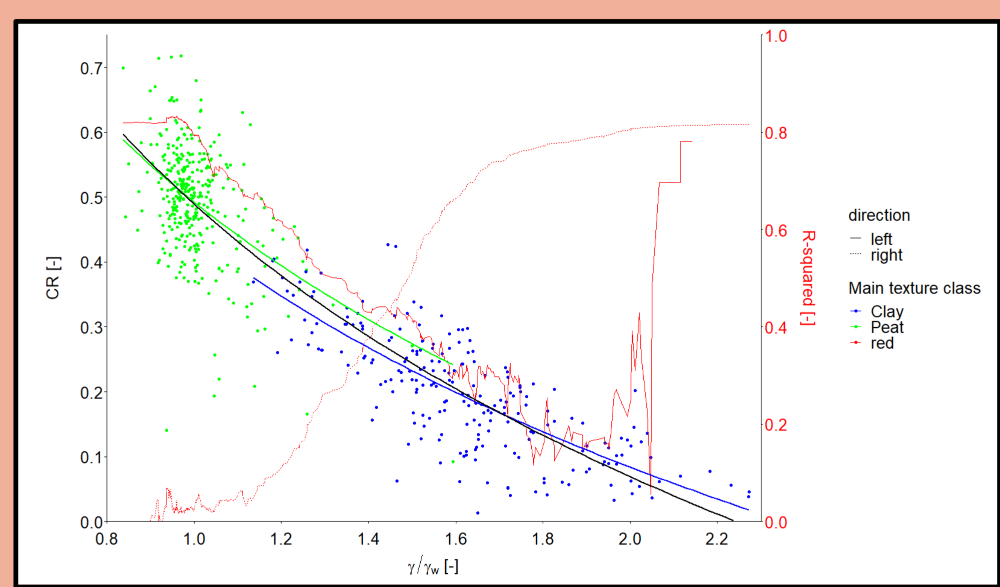

Fig. 6: Virgin compression ratio (CR) for varying relative weight of the soil sample (γ/γ_w). The data has been grouped based on the reported main lithological class.

The absolute variation in the geotechnical parameters is larger for peat than for clay. As a result, R-squared values for trendlines through the peat samples are low. The evolution of trendlines shows the best fit when the peat samples with the lowest relative weight are masked. The RR shows the lowest significance overall. The smallest and largest differences in trends between clay and peat are visible for respectively CR and C_α.

Implication and application

Absolute variation in parameter values of the peat samples can be correlated to the high heterogeneity that characterizes peat. Consequentially, trendlines through the peat samples have a low R-squared value and do not correspond well to the trendlines through the entire dataset, except for the CR. The difference in spreading between peat and clay does indicate a distinction in behaviour.

This research is an initial step towards the predictive capability of geotechnical compression parameters based on the composition of a sample. Based on these results the predictive capability is limited to clays. A transitional zone, consisting of organic clays, separates the clay domain from the peat domain. The predictive capability could be used to improve subsidence modelling for changing sample composition, for example occurring because of organic matter decomposition.

Future research can focus on supporting the geotechnical behaviour zonation in clay and peat as data on the organic content is needed. The relative weight of the sample can be influenced by compaction, which means it does not represent the composition perfectly.

References

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