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Analysis of 1D large strain consolidation of structured marine soft clays

Key words: Structured soft clays; Large strain consolidation; Structural yield stress; Finite difference method

Compressibility and permeability of structured clays

- The compression curves in the $e-\log\sigma'$ coordinates determined by oedometer tests can be divided into a pre-yield regime and a post-yield regime according to the yield stress. (Fig.1)

- The void ratio decreases with increasing the effective stress, along with the decrease of permeability. Some studies show that the variation of permeability of structured clays reasonably follows the relationship of $e-\log k_v$.

- The permeability of natural structured clays during the consolidation process can be expressed as:

$$k_v = k_{v1}\left(\frac{\sigma'_1}{\sigma'_y}\right)^{\frac{C_{cr}}{C_k}}\left(\frac{\sigma'_y}{\sigma'}\right)^{\frac{C_{cn}}{C_k}}, \sigma'_y > \sigma' \geq \sigma'_0$$

$$k_v = k_{v1}\left(\frac{\sigma'_1}{\sigma'}\right)^{\frac{C_{cr}}{C_k}}, \sigma' \geq \sigma'_y$$

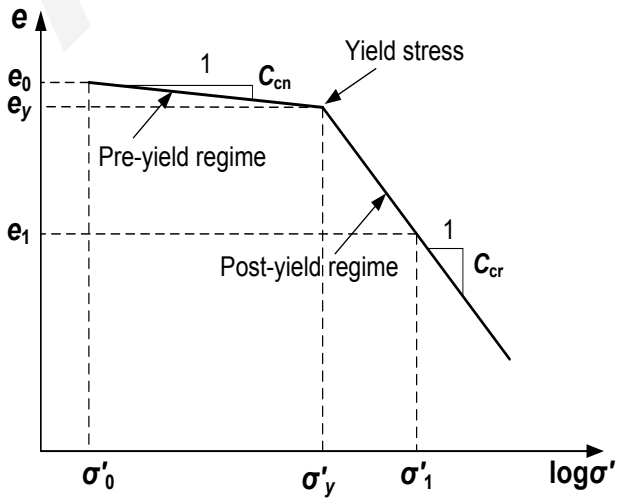

Fig.1. Simplified compression model of structured clays

Large-strain consolidation model of structured clays

- The small strain assumption has been adopted in the all existing consolidation theories which incorporate the influences of the natural structure on the variation of compressibility and permeability. Furthermore, previous studies on large strain consolidation ignored the effect of the natural structure of clays on consolidation behavior.
- The consolidation model of one-dimensional large strain consolidation of natural structured clays is developed in Lagrangian coordinate (Fig.2) by considering the variation of structural yield stress with depth and using different calculation methods for initial effective stress of structured clay deposits.
- The corresponding solution is derived by the finite difference method. To evaluate the effectiveness of the above finite difference solution, two types of analyses were performed.
- Finally, the influences of the natural structure of soft clays and different geometric assumptions on consolidation behavior were investigated.

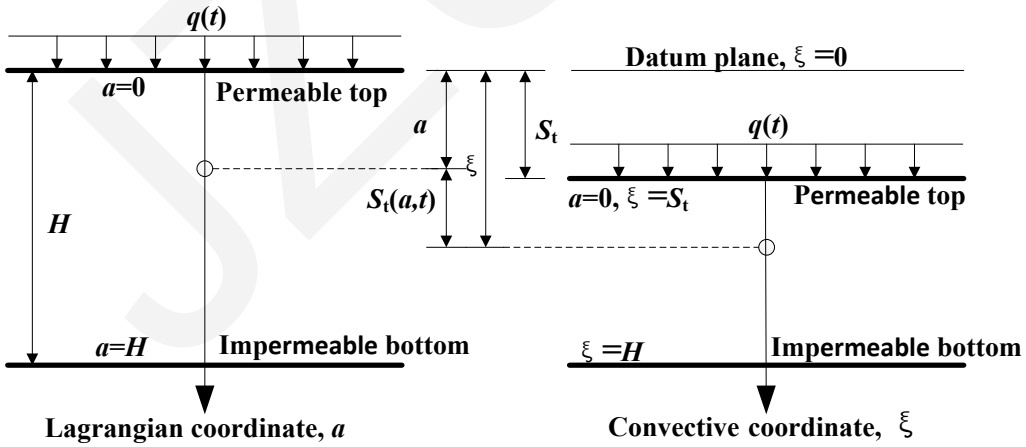

Fig.2. Lagrangian and convective coordinates

Conclusions

- This investigation proposes a novel one-dimensional consolidation model which can take into account the correlation between the mobilized effective stress and the yield stress for structured marine soft clays under the large strain assumption.
- The dissipation rate of excess pore water pressure of structured clays under the large strain assumption is expected to be faster than that under the small strain assumption, and the difference in consolidation behavior between the two assumptions increases with the strain level of natural structured clays. If the strain level in the clay layer is more than 15%, the difference in consolidation behavior between the large and small strain assumptions must be considered. However, the final settlement of natural structured clays under the large strain assumption is the same as that under the small strain assumption when the calculation method for the initial effective stress is the same.
- The yield stress of natural structured clays has a great influence on the dissipation rate of excess pore water pressure. The greater the yield stress, the smaller the strain in the clay layer, and the smaller the difference in the dissipation rate of excess pore water pressure between the large and small strain assumptions.
- Under the same geometric assumption, the method for determining the initial effective stress has no influence on the dissipation rate of excess pore water pressure, whereas the settlement of the natural structured clay layer is different.
- If the method for determining the initial effective stress is the same, the dissipation rate of excess pore water pressure under the large strain assumption is faster than that under the small strain assumption, whereas the final settlement of natural structured clays is the same.