A two-surface viscoplastic model for saturated clays

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Study description

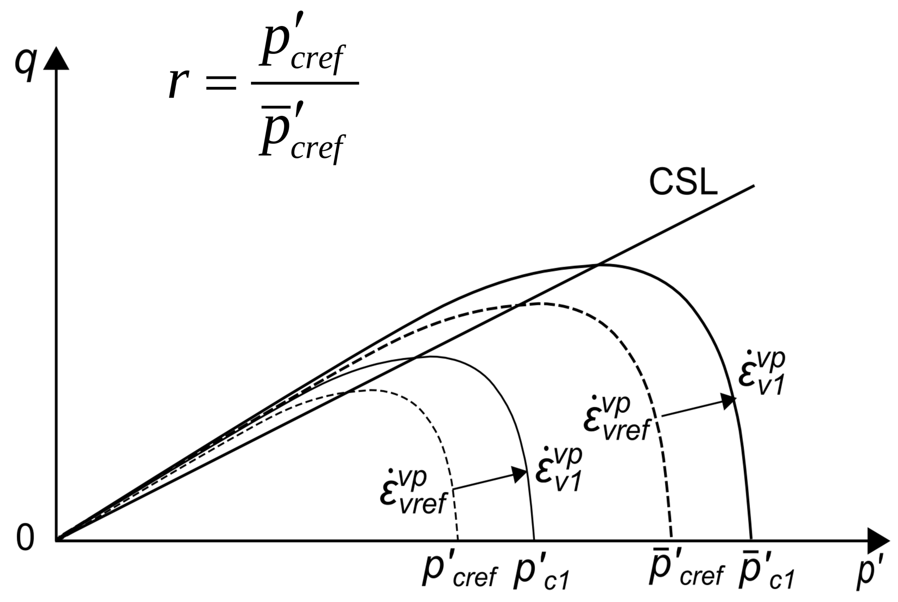
Experimental tests show that time dependent behavior is significant in Boom Clay [1]. An appropriate model of viscoplasticity is developed for Boom Clay to assess its impact on the long term evolution of the disposal facility.

Constitutive models

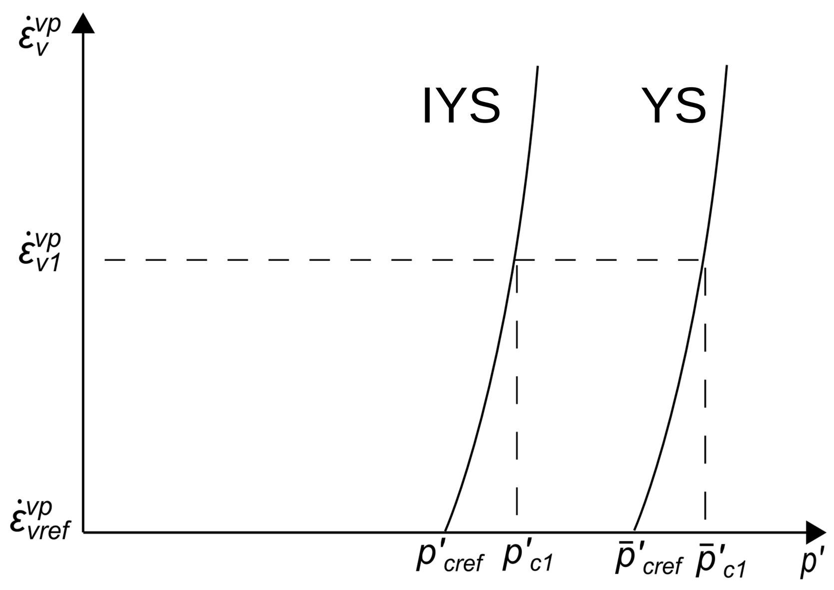
Yield surfaces :

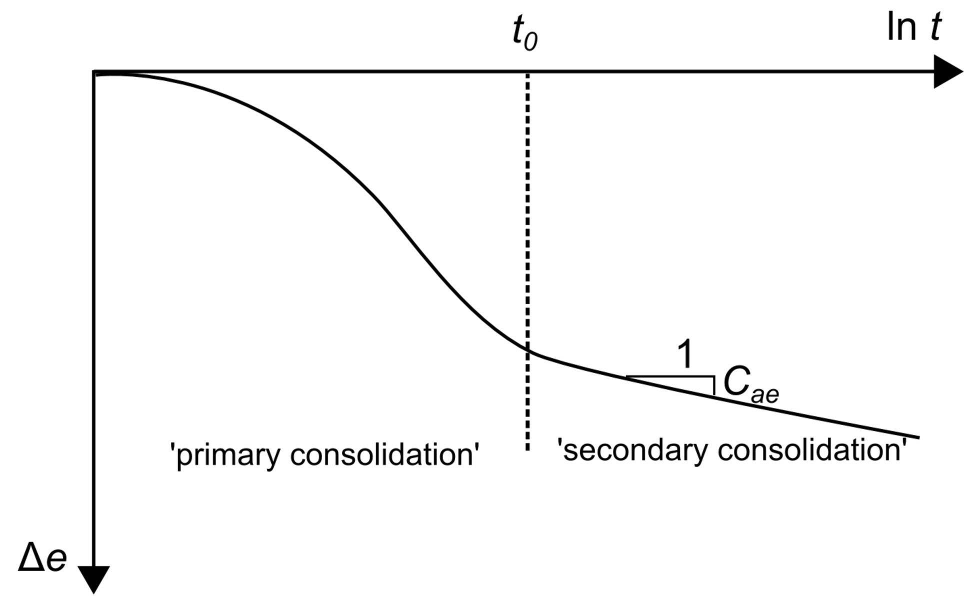
$$f_{IYS} \equiv q^2 + \frac{M_f^{\,2}}{1-k_f}\left(\frac{p'}{r\bar{p}'_c}\right)^{2/k_f}\left(r\bar{p}'_c\right)^2 - \frac{M_f^{\,2}\,p'^2}{1-k_f} = 0 \quad \text{with:}$$

(p'- q) plane:



$p' - \dot{\varepsilon}^p_v$ plane





Hardening law:

$$\begin{cases} d\bar{p}'_{cref} = \dfrac{v_0}{\lambda-\kappa}\,\bar{p}'_{cref}\,d\varepsilon^{vp}_v \\[2ex] dr = \dfrac{v_0}{\lambda-\kappa}\,s(1-r)\,d\varepsilon^{vp}_v \end{cases}$$

Dilation ratio:

$$d = \frac{d\varepsilon^{vp}_v}{d\varepsilon^{vp}_s} = \frac{M_g^{\,2} - \eta^2}{k_g\eta}$$

Viscoplastic strain rate:

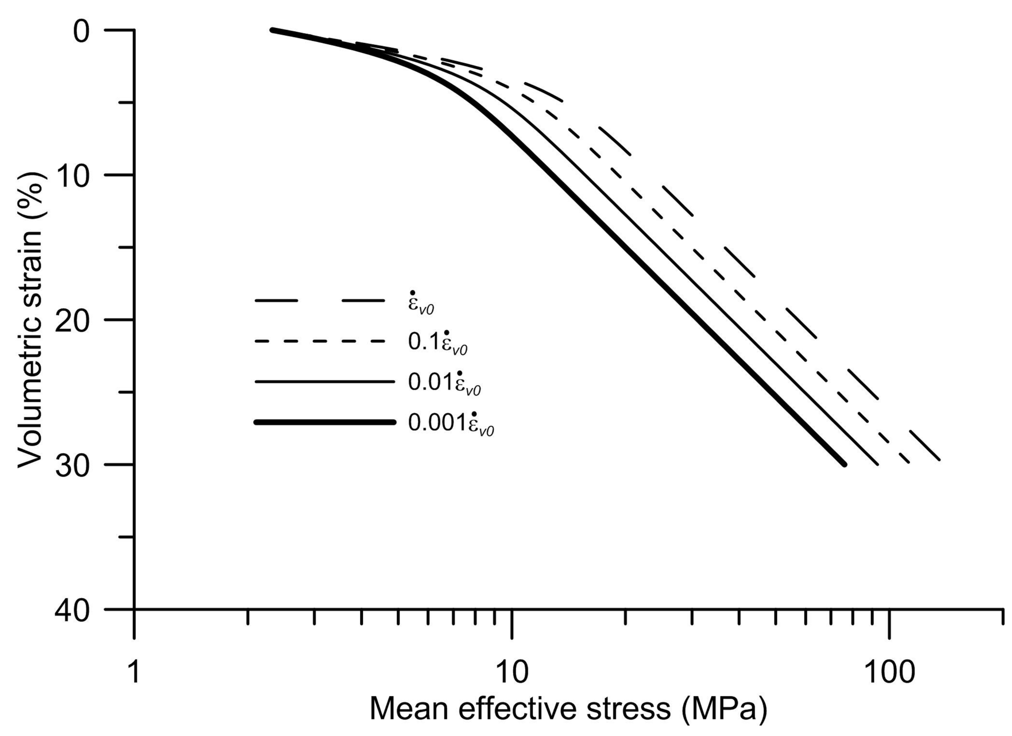
$$\dot{\varepsilon}^{vp}_v = \dot{\lambda}\left.\frac{\partial g_{IYS}}{\partial p'}\right|_{\substack{p'=p'_{cref}\\ q=0}}$$

Results

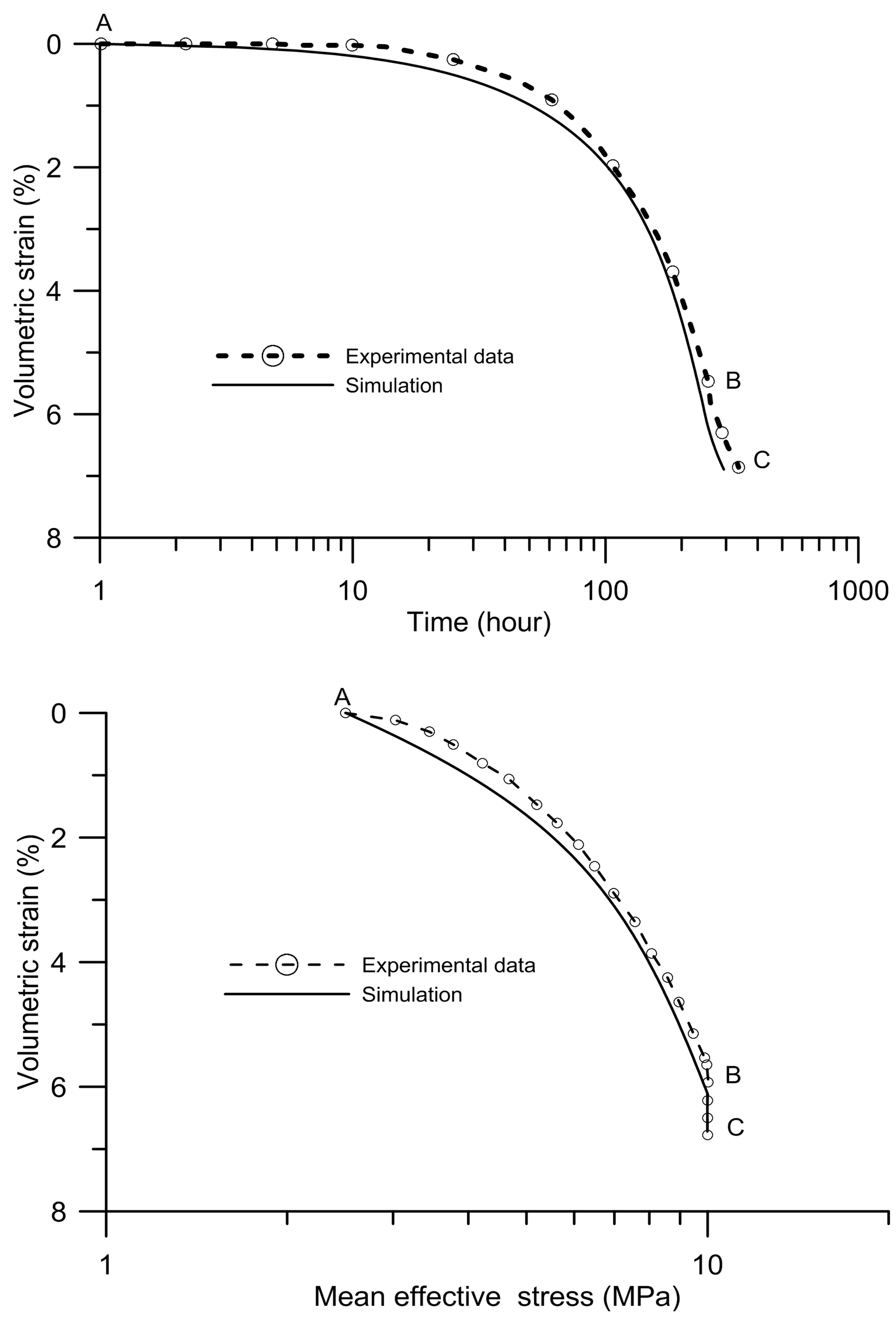
-The model can describe the time effects on the mechanical behavior (viscosity);

-The model can also describe some important features of natural clays evidenced experimentally such as the limited elastic zone, the smooth transition from elastic to viscoplastic behavior.

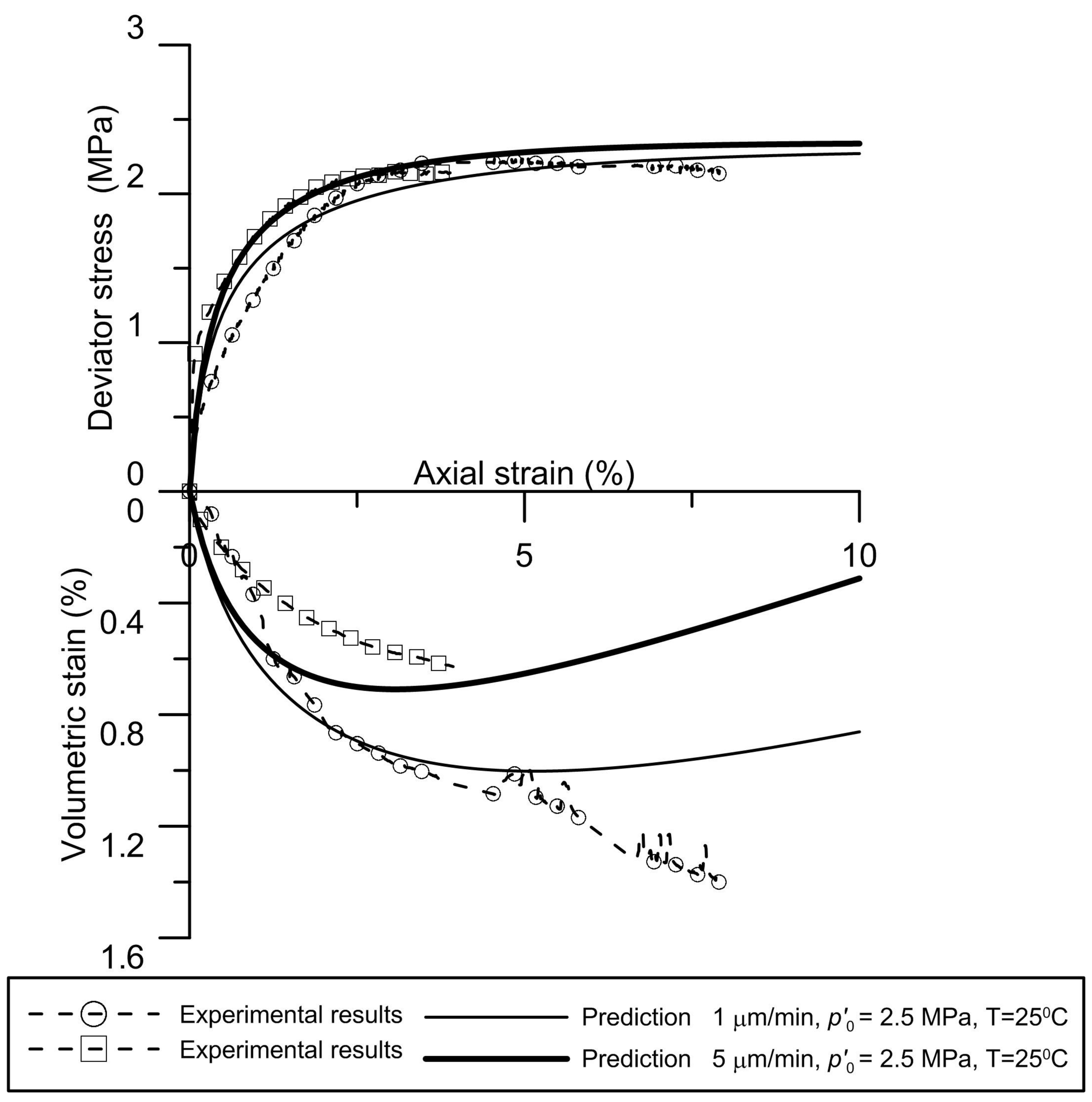
Isotropic compression tests at different strain rates:



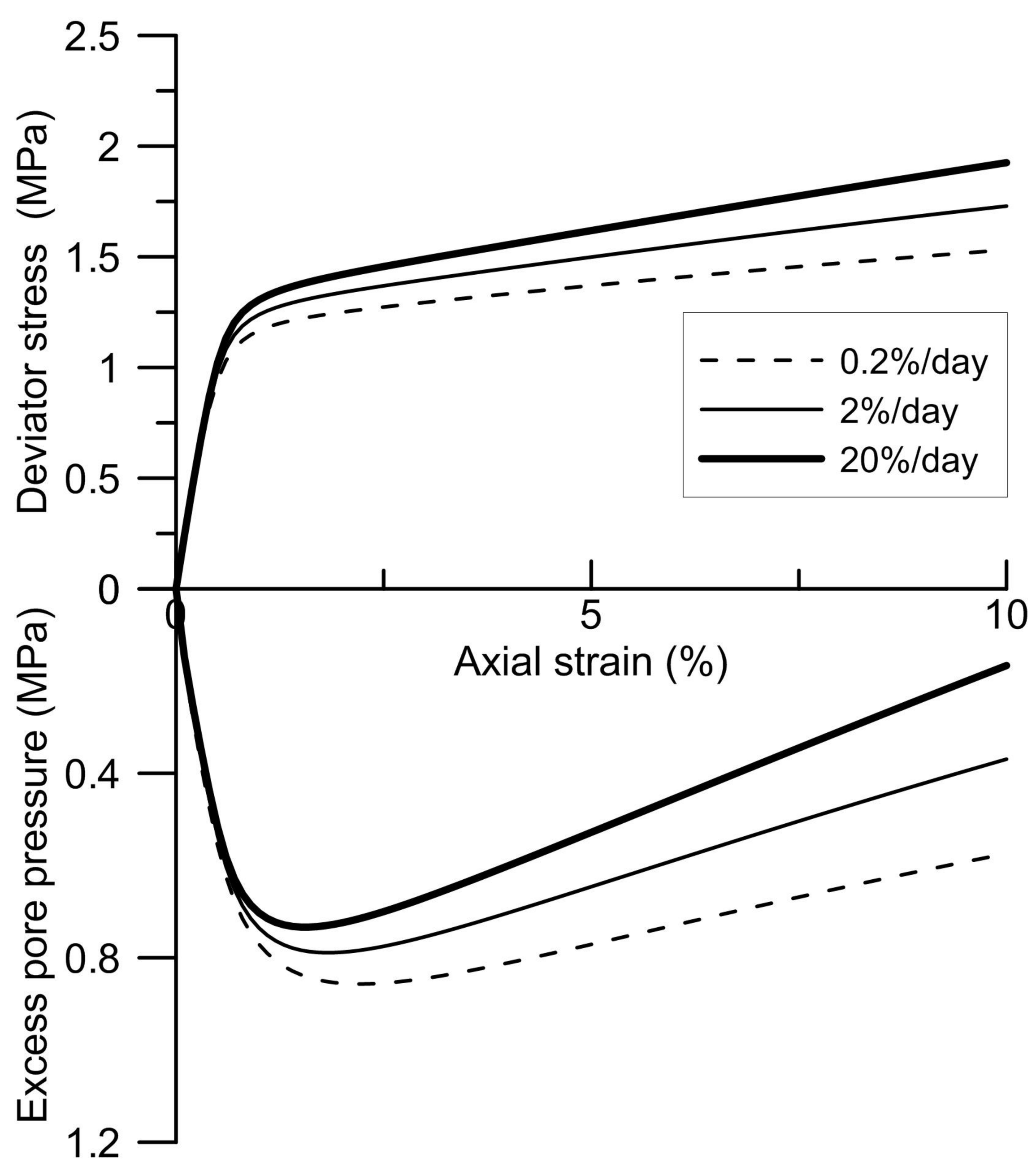
Isotropic compression test including a creep stage on Boom Clay:



Drained triaxial tests on Boom Clay:



Undrained triaxial tests on Boom Clay:



[1] Y.J. Cui, T.T. Le, A.M.Tang, P. Delage, X.L. Li. Investigating the time dependent behaviour of Boom clay under thermo-mechanical loading. Géotechnique, 59 (4): 319-329, 2009.
[2] L. Šuklje. The analysis of the consolidation process by the isotache method. In: Proc. 4th Int. Conf. on Soil Mech. and Found. Engng., London, vol. 1: 200–206,1957.

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Study realised for: