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Thermal strain response of saturated clays in 1D condition

Qi-yin ZHU, Tian-yu ZHAO, Pei-zhi ZHUANG

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Thermo-elastoplastic modelling

Total strain increment

$$\mathrm{d}\varepsilon=\mathrm{d}\varepsilon^{\mathrm{me}}+\mathrm{d}\varepsilon^{\mathrm{mp}}+\mathrm{d}\varepsilon^{\mathrm{Te}}+\mathrm{d}\varepsilon^{\mathrm{Tp}}$$

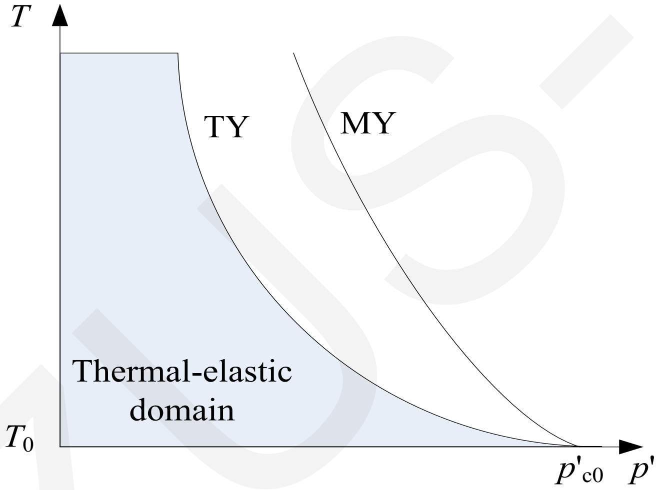
Elastic behavior

$$\mathrm{d}\varepsilon^{\mathrm{e}}=\mathrm{d}\varepsilon^{\mathrm{me}}+\mathrm{d}\varepsilon^{\mathrm{Te}}$$

$$\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{e}}=\frac{\kappa}{1+e}\frac{\mathrm{d}p}{p}-\alpha\mathrm{d}T$$

$$\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{e}}=\frac{2(1+\mu)}{9(1-2\mu)}\frac{\kappa}{1+e}\frac{\mathrm{d}q}{p}$$

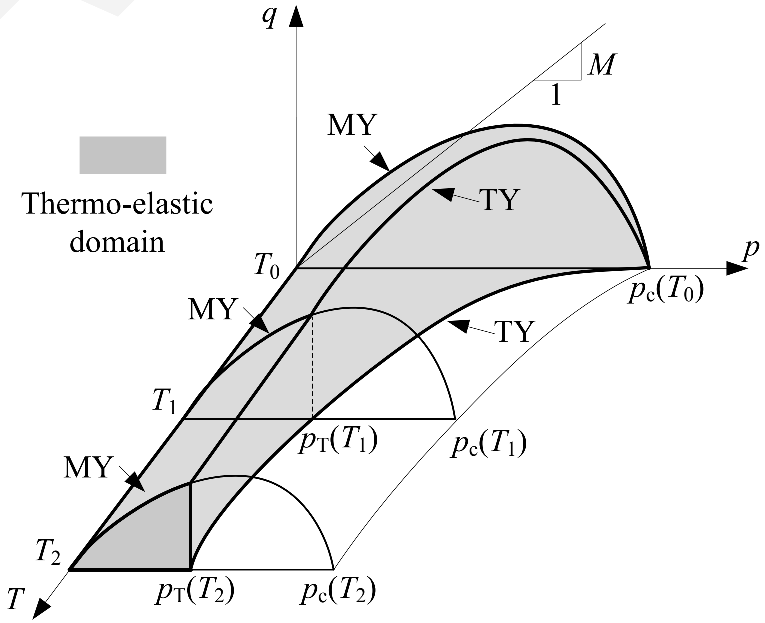
T-p plane



TY

$$\frac{p_{\mathrm{c(T_0)}}}{p_{\mathrm{T(T)}}}=\beta\sqrt{\ln\frac{T}{T_0}}+1$$

T-p-q plane



MY

$$\left(\frac{q}{Mp}\right)^n=-\frac{\ln(p/p_{\mathrm{c(T)}})}{\ln r_{\mathrm{(T)}}}$$

Thermo-elastoplastic modelling

Thermal plastic strain increments

$$\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{tp}} = \omega\left(T - T_0\right)\left(\frac{p}{p_{\mathrm{c}(T_0)}}\right)^2 \mathrm{d}T$$

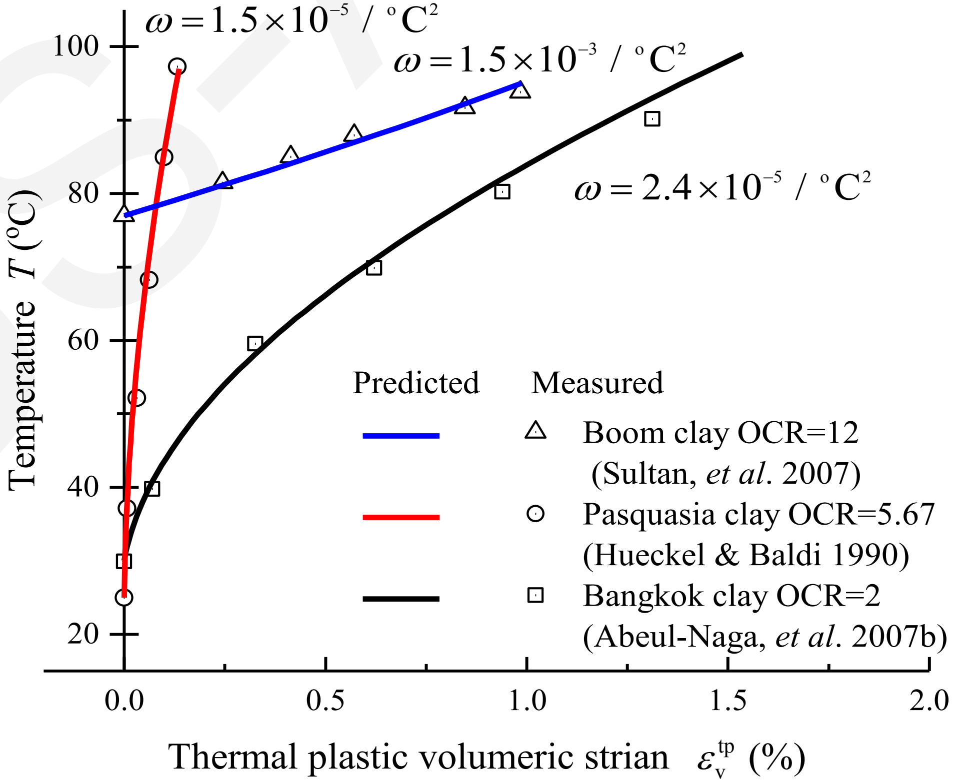
Mechanical plastic strain increments

$$\mathrm{d}\varepsilon_{v}^{\mathrm{mp}} = \mathrm{d}\lambda_{\mathrm{m}} \frac{\partial g^{\mathrm{MY}}}{\partial p}$$

$$\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{mp}} = \mathrm{d}\lambda_{\mathrm{m}} \frac{\partial g^{\mathrm{MY}}}{\partial q}$$

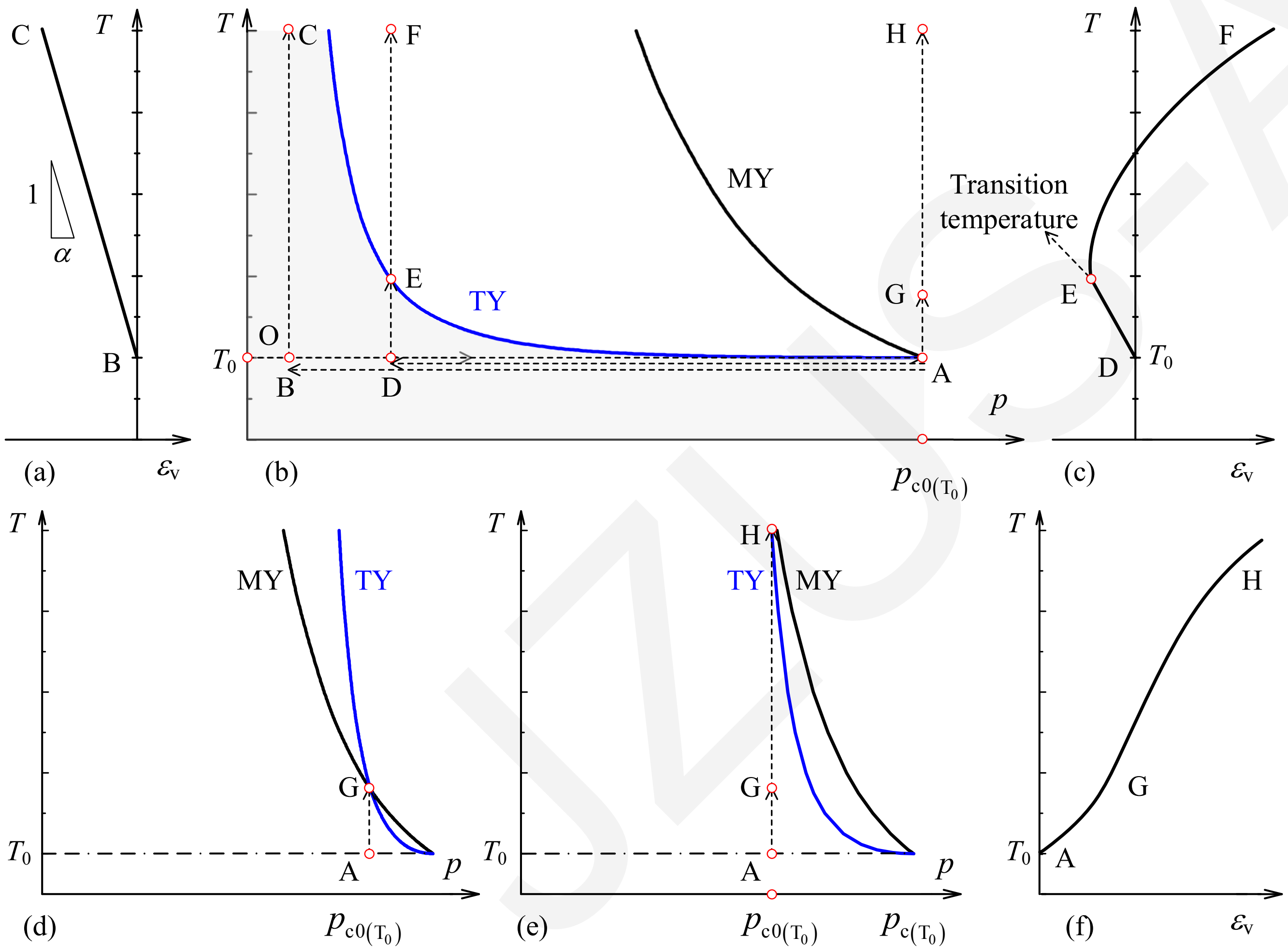
$$g^{\mathrm{MY}} = k\ln\left[1+(k-1)\left(\frac{\eta}{M}\right)^2\right] + 2(k-1)\ln\left(\frac{p}{C}\right)$$

Temperature effects on the volumetric strain



Thermo-elastoplastic modelling

Thermal evoluations of the MY and TY curves in the p-T plane



Explanation of model responses subjected to heating at three typical OCR values

Model Performance

Thermal volumetric deformation

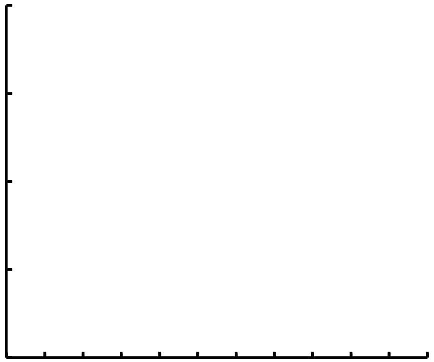


Fig. 3 Thermal volumetric deformation under multiple heating and cooling cycles
(a) OCR=1; (b) OCR=2; (c) OCR=4; (d) OCR=8

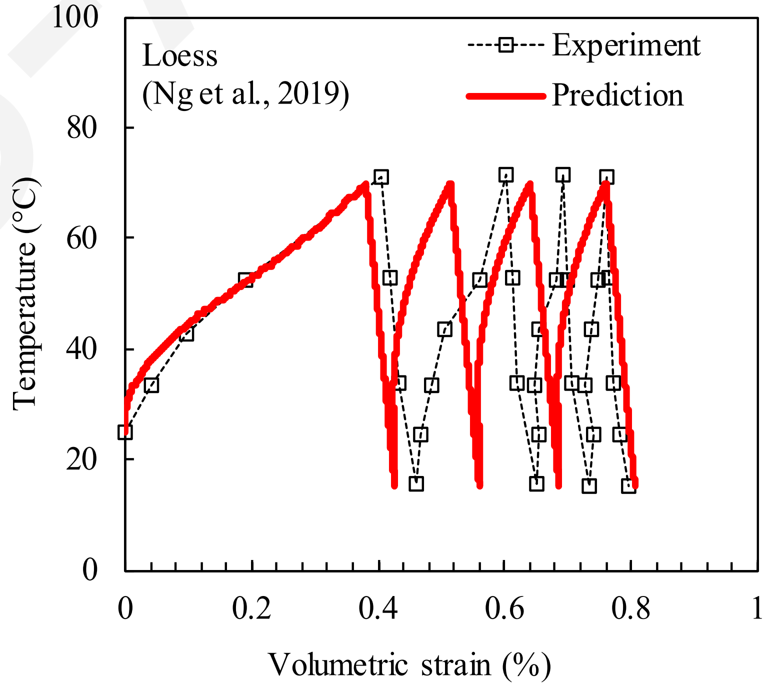


Fig. 5 Modelling the thermal strain of normally consolidated loess under multi-cycles

Conclusions

- A thermomechanical two surfaces constitutive model based on the elastoplastic theory is proposed;
- The performance of the model in reproducing the main features of clay thermomechanical volumetric behavior was studied by a set of synthetic tests examined by comparing with the selected temperature-controlled experimental results on illite clay and loess.