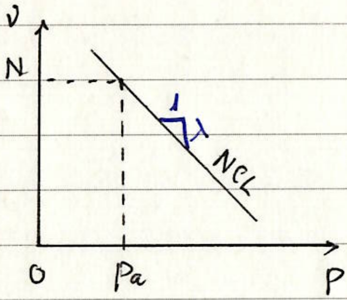
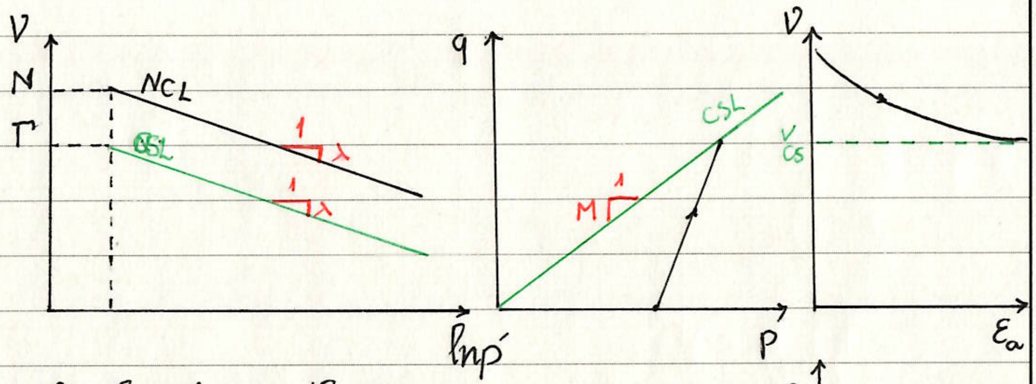
CAM CLAY MODEL : NC SOIL

① First we need to accept the evidence that the state of NC soil in isotropic consolidation locates on this NCL line

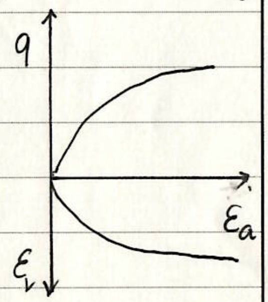


② If we shear the soil, its final fairlure state



will locate on the CSL

• $\Gamma < N$



③. Equation to describe the behavior of isotropic compression $(q/p = 0)$

$$v = 1 + e = N - \lambda \ln \frac{p'}{p_a}$$

. At critical state : $(q/p = M)$

$$v = 1 + e = \Gamma - \lambda \ln \frac{p'}{p_a}$$

. What is the equation of v for soil at $0 < \frac{q}{p} < M$

$$v = N + (\Gamma - N)\, J(\eta) - \lambda \ln \frac{p'}{p_a}$$

(If we get stress state, we get the volume)

+ Original Cam Clay: $J(\eta) = \dfrac{q}{Mp}$

+ Modified Cam Clay: $J(\eta) = \dfrac{\ln\left\{1 + \left(\frac{q}{Mp}\right)^2\right\}}{\ln 2}$

ORIGINAL CAM CLAY MODEL

- Suppose clay changes from:
  - State 1: e_0, $p' = p'_0$; $q_0 = 0$ to
  - State 2: e, p', q

$$1 + e_0 = N - \lambda \ln(p/p_a)$$

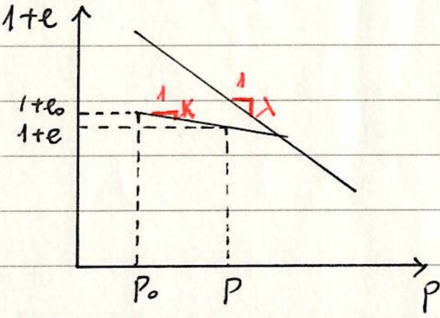
$$1 + e = N + \frac{\Gamma - N}{M}\frac{q}{p} - \lambda \ln(p/p_a)$$

- volumetric strain resulting from this change of state

$$\varepsilon_v = - \frac{de}{1+e_0} = - \frac{v - v_0}{v}$$

$$\varepsilon_v = \frac{(1+e_0) - (1+e)}{1+e_0} = \frac{1}{v_0}\left[\frac{N-\Gamma}{M}\frac{q}{p} + \lambda \ln\frac{p}{p_0}\right]$$

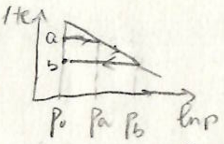
- Elastic component in volumetric strain:



- $K = \Delta e / \Delta \ln p'$

$$\Rightarrow \Delta e = K \Delta \ln p' = K \ln\frac{p}{p_0}$$

$\Delta \varepsilon_v^e = 0$ if $\Delta p = 0$



From a→b: $\Delta \varepsilon_v^e = 0$

- $$\varepsilon_v^e = - \frac{v - v_0}{v_0} = \frac{(1+e) - (1+e_0)}{1+e_0} = \frac{\Delta e}{1+e_0}$$

$$\Rightarrow \varepsilon_v^e = \frac{K}{1+e_0} \ln\frac{p}{p_0}$$

- Plastic component in volumetric strain:

$$\varepsilon_v^p = \varepsilon_v - \varepsilon_v^e = \frac{1}{v_0}\left[\frac{N-\Gamma}{M}\frac{q}{p} + (\lambda - K)\ln\frac{p}{p_0}\right]$$

ε_v^p can be stopped, increased, but not ↓ in this equation

Note: ε_v^p $\begin{cases} \notin \text{loading path;} \\ \in \text{initial \& final stress state} \end{cases}$

Notice:

- During loading process, $(q/p \uparrow ; p \uparrow)$: $\begin{cases} \varepsilon_v^e \uparrow \\ \varepsilon_v^p \uparrow \end{cases}$
- During unloading process: $(q/p \downarrow ; p \downarrow)$: $\begin{cases} d\varepsilon_v^p = 0 \\ \varepsilon_v^e \downarrow \end{cases}$

⇒ Yield function:

$$f = \frac{\Gamma + N}{v_0}\frac{q}{Mp} + \frac{\lambda - K}{v_0}\ln\frac{p}{p_0} - \varepsilon_v^p$$