

● Initial modulus, E for large strain. ($> 10^{-1} \%$)

- Can be important for soft clays (E_u).
- Is evaluated from static laboratory tests (Triaxial tests).

i) Consolidation stress.

$$E_u = f(\sigma_c')$$

$$\rightarrow \frac{E_u}{\sigma_c'} \text{ (or } \frac{E_u}{s_u} \text{)} = \text{constant.}$$

$$\rightarrow \text{Janbu, } E = KP_a \left(\frac{\sigma_3}{P_a} \right)^n, \quad (n \approx 0.5 \text{ for sands.})$$

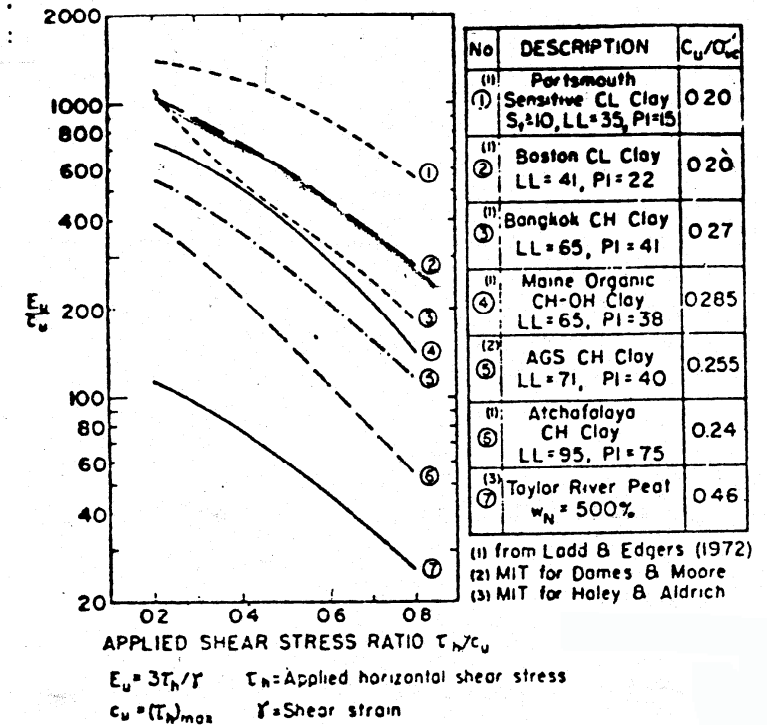


Fig. 19 Normalized Young's modulus vs stress level from CK₀U direct simple shear tests on seven normally consolidated soils.

*See Mitchell (1976) for a review of methods of fabric measurement and typical results.

ii) Sample disturbance.

Disturbance $\rightarrow$ underestimates E_u ($E_{\text{field}} = (2 \sim 10)E_{\text{lab}}$).

a) use a modulus during a second cycle of loading.

b) use the undisturbed block sample.

c) SHANSEP.

iii) Rate of loading. (or strain rate.)

$E_{\text{fast}} > E_{\text{slow}}$.

($E_{\text{dynamic}} \approx (1.5 \sim 2.0) E_{\text{static}}$).

iv) Load cycle.

$$E_{\text{initial loading}} < E_{\text{subsequent cycle}}$$

v) Initial stress condition.

→ Initial shear stress (depending on OCR).

→ Isotropic consolidation vs. K_0 consolidation.

vi) Stress path for loading.

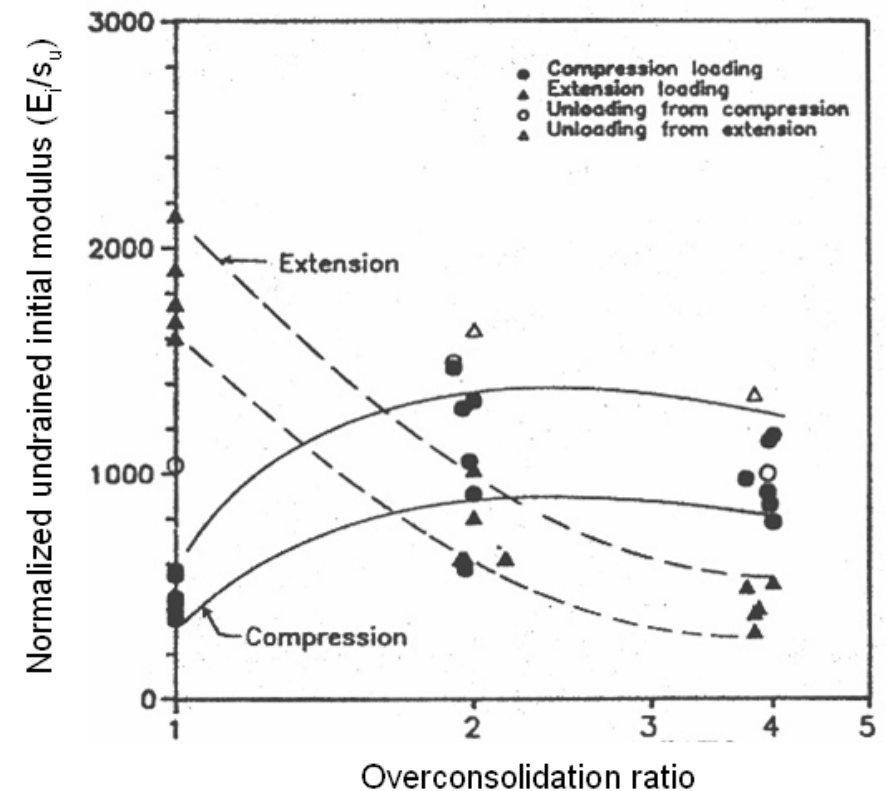


Figure 4-8 Normalized Undrained Moduli
(estimated at 0.1% axial strain)

vii) Aging.

Aging → increase density → increase E.

Recommendation for testing

→ Allow at least 1(log t) cycle of creep at σ_c' prior to starting the shearing phase of the test.

viii) Strain (or stress) level.

- Ways to estimate E_u .

1. Correlations, $E_u = (200 \sim 2000)S_u$.

2. Run CIU/CKoU triaxial tests based on recompression approach, obtain E_u from σ - ε plot and multiply result by (2 to 5).

3. To reduce sample disturbance effect, run triaxial test based on SHANSEP.

4. Stress path method. (same as 2 or 3, but run test according to stress path method principles.)