CCL 2/9/99
2/4/01

1.322 Part B

A. Material Initially Distributed

1) "Simple Clay" Notes = CCL (1964) Res. Report R64-17

2) 1st set of HO Notes = Cover Sheet + p1-8 (attached)

3) Home Problem No. 1 & Solution (self graded)

B Approximate Class Schedule*

Class No.	Coverage & Remarks
B 1	• NC Simple Clay via class discussion (p 1-4b), including use of Principle II to predict $w_c = f(K_c)$ & CAUC ESP (Fig II-12, 13); prediction of UUC test from 1 CIOC test (also see 1.361 II 2-3.7)
B 2	• You need to study Chap I & II of SC Notes & do most of HP #1
B 3	• OC Simple Clay via class discussion (p 5-8), including Hvorslev parameters → State Boundary Surface (not in SC Notes) and triaxial extension. • You need to study Chap III - VI
B 4	• Distribute MCC Notes & HP #2 (due to class #5)
B 5	• Cover MCC Notes, mostly via "lectures"
B 6	• Distribute HP #3 • Distribute C-I Notes • Comments on MIT-E3 (no HO notes)
B 7	• Either complete Part B or start Part C

* 1st Class = 1st or 2nd hr, Tues. 2/20/01 (Mon. class → Tues due to Monday holiday)

Handout on Basic Strength Principles & "Simple Clay"

BASIC STRENGTH PRINCIPLES & STRESS-STRAIN-STRENGTH BEHAVIOR OF "SIMPLE CLAY"

INTRODUCTION

1.1 Types of Shear Tests (Restricted now to TC & TE)

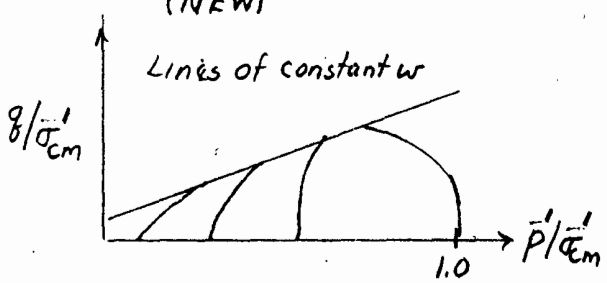
- CD
- CU
- UU

} CI, CK_0 .... D/U C/E L/U

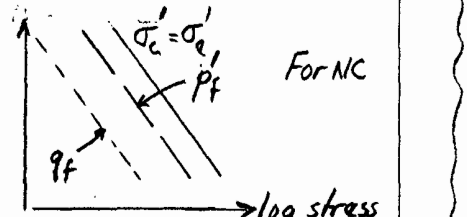
1.2 3 Basic Principles (For given b & δ, i.e. treat TC & TE separately)

Principle	Limitation	Independent Of
I Unique Failure Envelope eg. $q_f = \bar{a}' + \bar{p}_f' (\tan\alpha' = \sin\phi')$	NC vs OC	Drainage (CD, CU, CU) TSP = L vs U
II Unique $w - q - \bar{p}'$ $(q = 0 \rightarrow q_f)$	NC vs OC $\Delta q \geq 0$	Same as above
III Unique $w_f - q_f - \bar{p}_f'$ à la Hvorslev Parameters (NEW)	None	Same as above PLUS both NC & OC!

(NEW)



Corollary (1.361) → unique w_f-log stress



Note: Will lead to concept of "State Boundary Surface" (p7)

1.3 Why Study These 3 Strength Principles?

1) Reasonable approximation for many insensitive clays

2) Frequently assumed/used in practice

3) Framework for more complex behavior

4) Background for discussion of "generalized Soil Model" à la MCC = Modified Cam-Clay

1.4 Simple Clay

1) Developed as teaching aid for home problems with clay having perfect "normalized behavior"

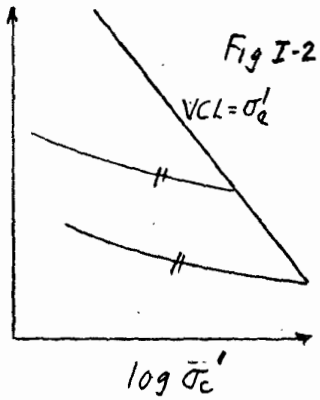


Fig I-2

2) Behavior reasonably typical of insensitive plastic clays (for K_c=1 consolidation)

3) Not intended for direct use in practice)

1.5 Variables Considered by Simple Clay

1) Drainage (CD → CU → UU)

2) OCR

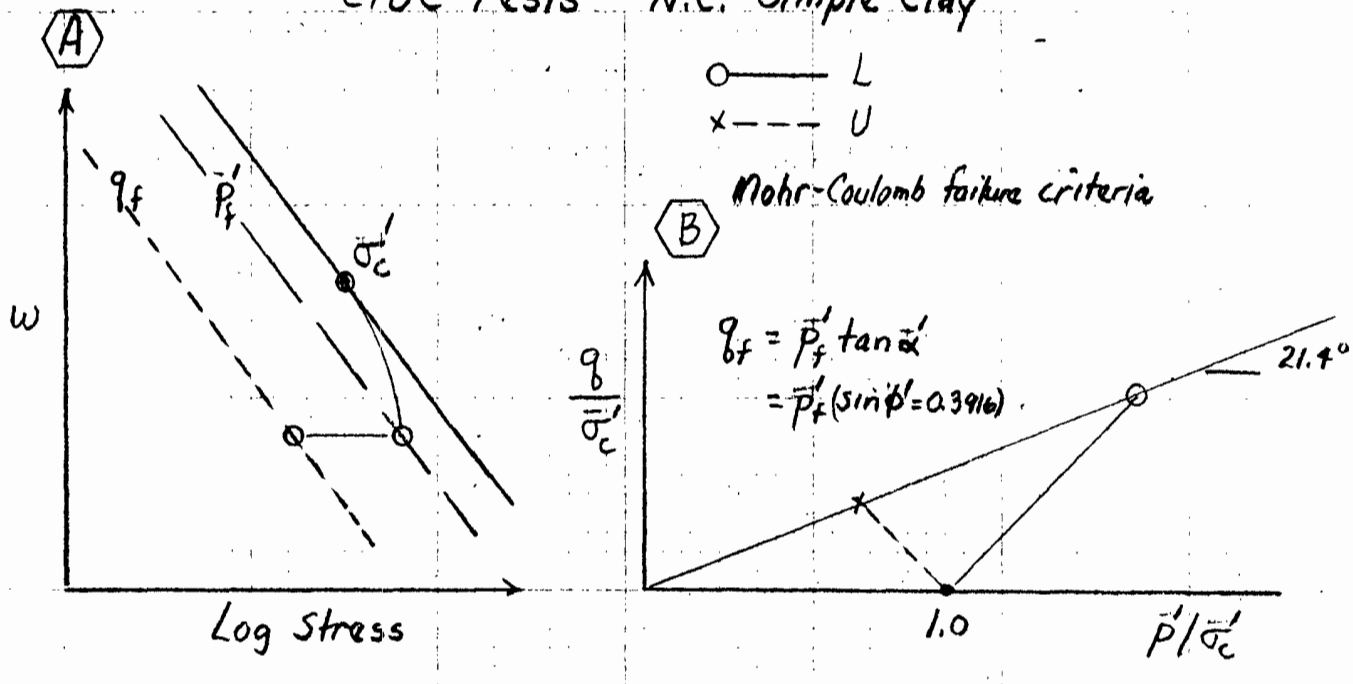
3) TSP, e.g. L vs U

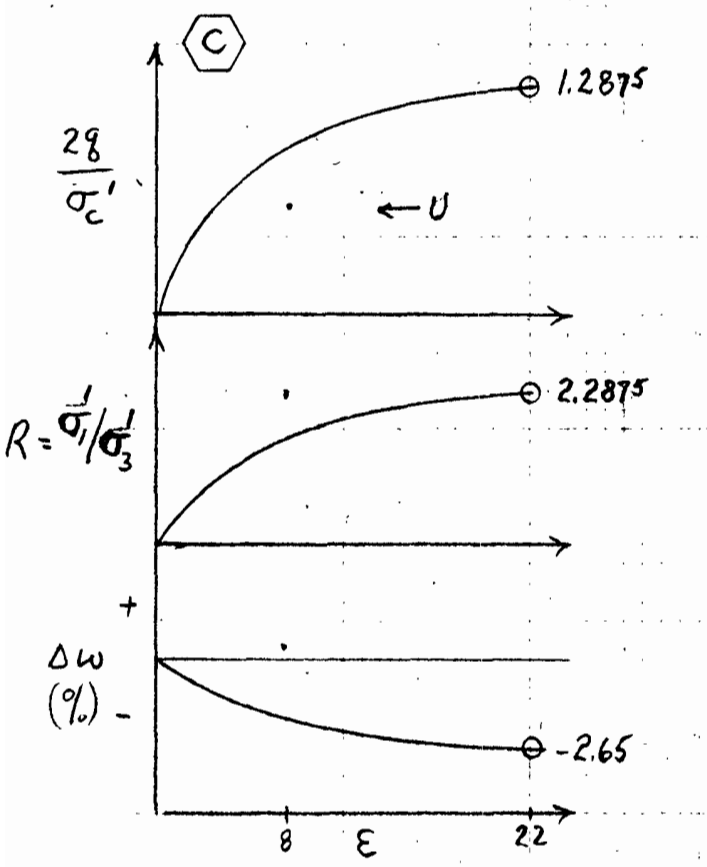
4) $K_c = \bar{\sigma}_{hc}'/\bar{\sigma}_{vc}'$

5) σ_2, e.g. TC vs TE

NOTE: Sheets 3 & 4 = start of OCR=1 Simple Clay behavior

CIOC Tests N.C. Simple Clay





- Perfect Normalized Behavior
- Why different σ-ε for U?

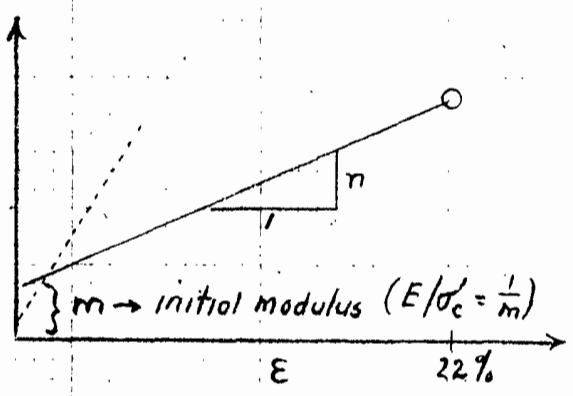
L $+\Delta q \rightarrow$

$+\Delta p' \rightarrow$

U $+\Delta q \rightarrow$

$-\Delta p' \rightarrow$

$$\frac{2q}{\bar{\sigma}_c'} = \frac{\varepsilon}{m + n\varepsilon} \text{ (Hyperbolic)}$$



1.322 Part B

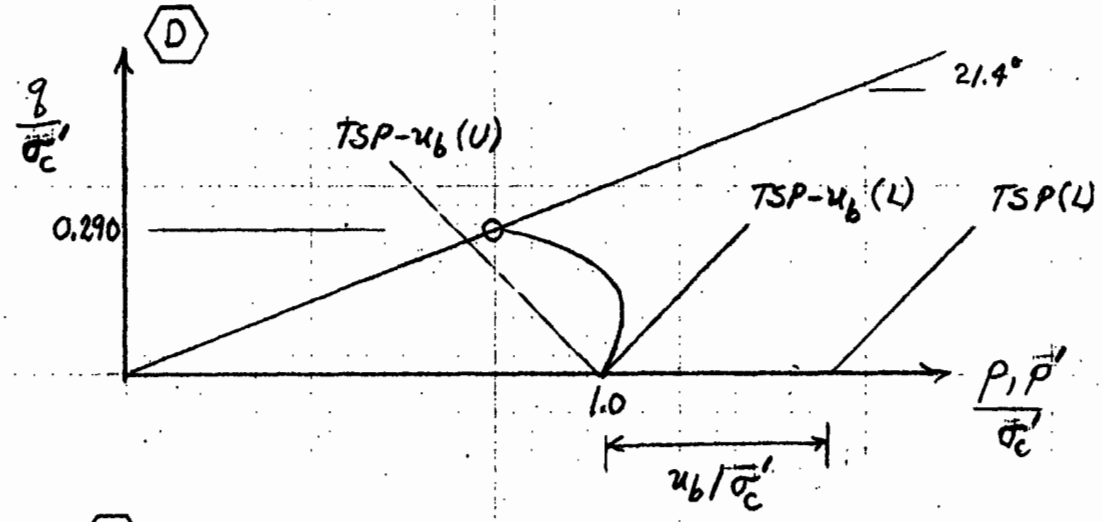
4/13

CIUC Tests N.C. Simple Clay

See (A) for w-log stress

○—— L { S=100% B=1.00 }
×--- U

(D)



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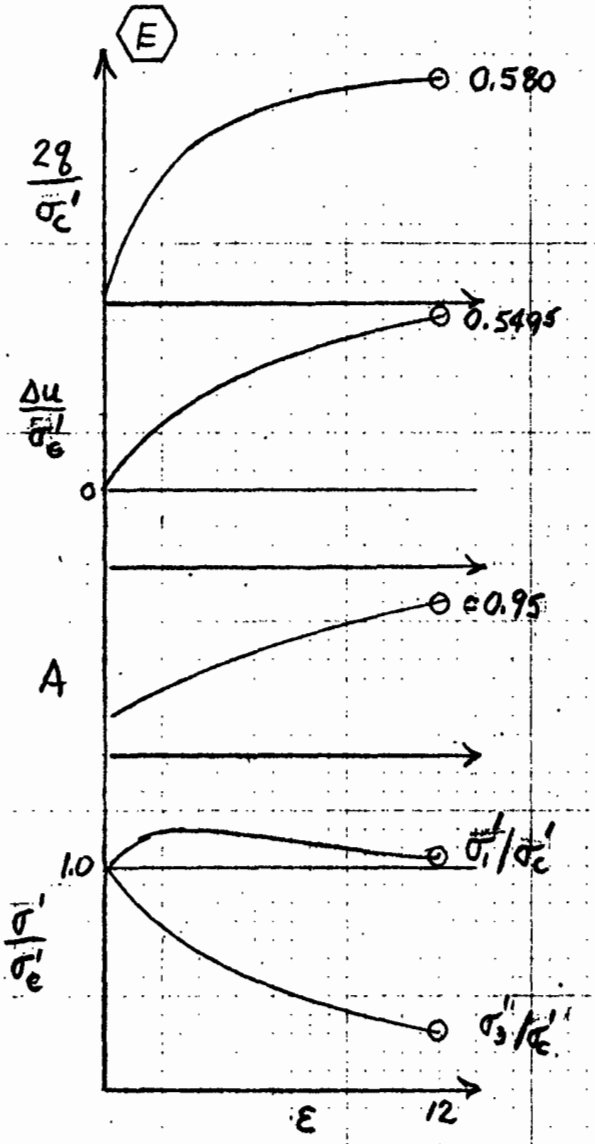
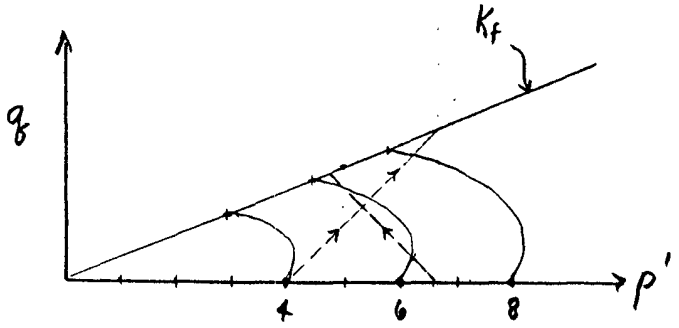


• What changes for U ?

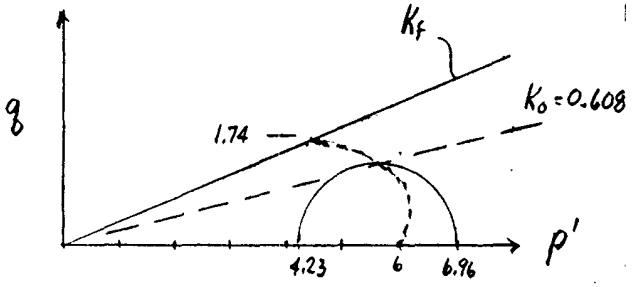
Principle II : Unique $w - q - p'$ for $\Delta q > 0$

Defined by _____ for NC SC

a) Fig II-12 : Prediction of Δw for CIOC (L) & (U) tests



b) Fig II-13 : Prediction of ESP, q_f/σ'_{vc}, etc. for CK_oUC test



- $\sigma'_{vc} / \underset{\sigma'_e}{\text{Equiv. } \sigma'_c} = \frac{6.96}{6.00} = 1.16$
- $q_f/\sigma'_{vc} = \frac{0.29}{1.16} = \frac{1.74}{6.96} = 0.25$
- $A_f =$

c) Prediction of Parameters from CIUC Stress-Strain Data Given σ'_{vc} & σ'_{hc} ($K_c < 1$)

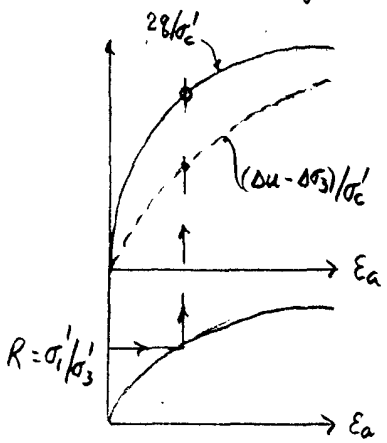
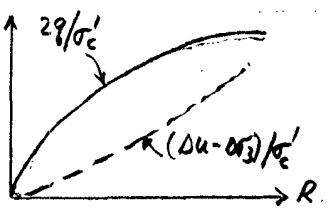


Fig II-8a (HP #1)



1) Compute $R = \sigma'_v/\sigma'_h = 1/K_c$ & $2q_c = (\sigma'_{vc} - \sigma'_{hc})$

2) Scale $2q/\sigma'_c$ at R

3) Equivalent $\sigma'_c = \sigma'_e = \frac{2q_c}{(2q/\sigma'_c)}$ → value of w_c

4) For CAUC, $q_f = (0.29)(\sigma'_e)$ → q_f/σ'_{vc}

5) " " , also can get $\Delta u_f/\sigma'_c$ → A_f, etc.

Three Factors Controlling $s_u = q_f$

1)

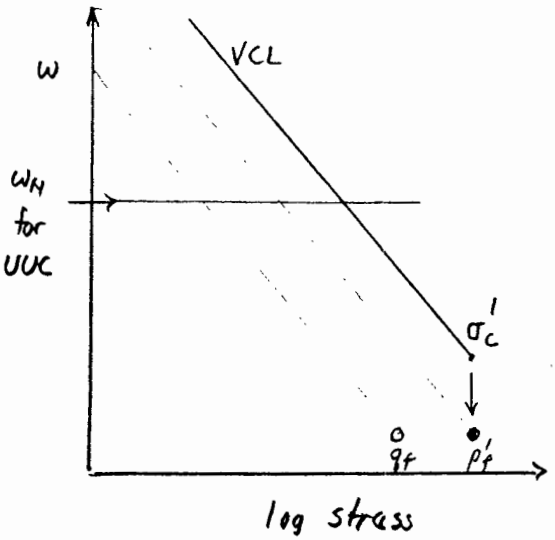
2)

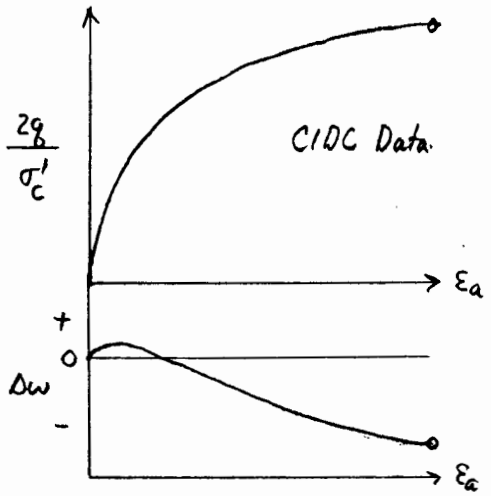
3)

CAUC : $K_c = \sigma'_{hc}/\sigma'_{vc} \geq 1$

$$\frac{q_f}{\sigma'_{vc}} = \frac{(c'\cos\phi')/\sigma'_{vc} + [K_c + (1-K_c)A_f]\sin\phi'}{1 + (2A_f - 1)\sin\phi'}$$

Prediction of UUC Test from CIDC ($p' = \sigma'_c$) Data on NC Clay ($K_c = 1$, no disturbance)

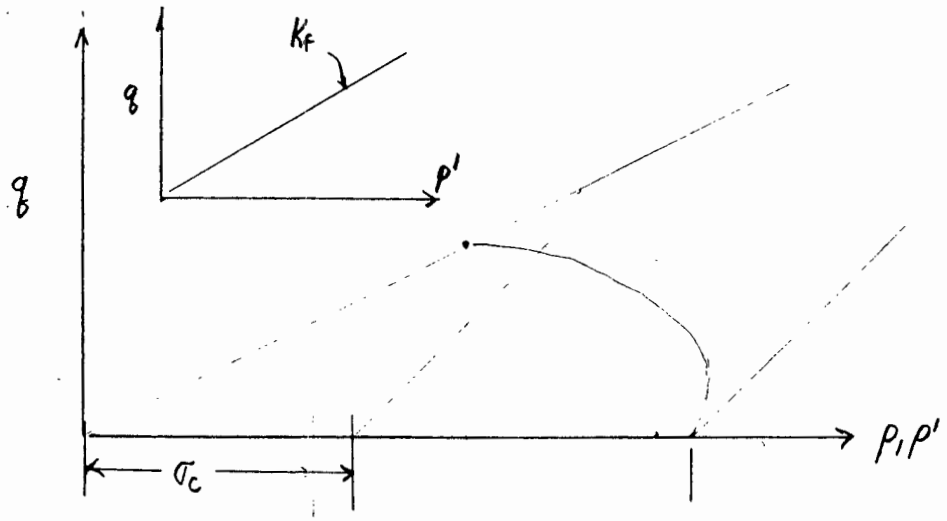




1) σ'_o & u_o 2) $s_u = q_f$ & p'_f 3) u_f 4) Δu_f 5) A_f

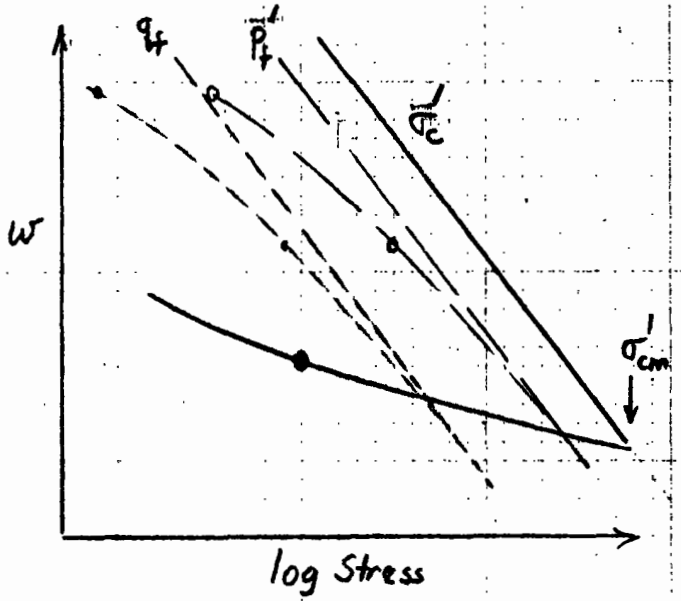
6) ESP

7) q vs ε_a

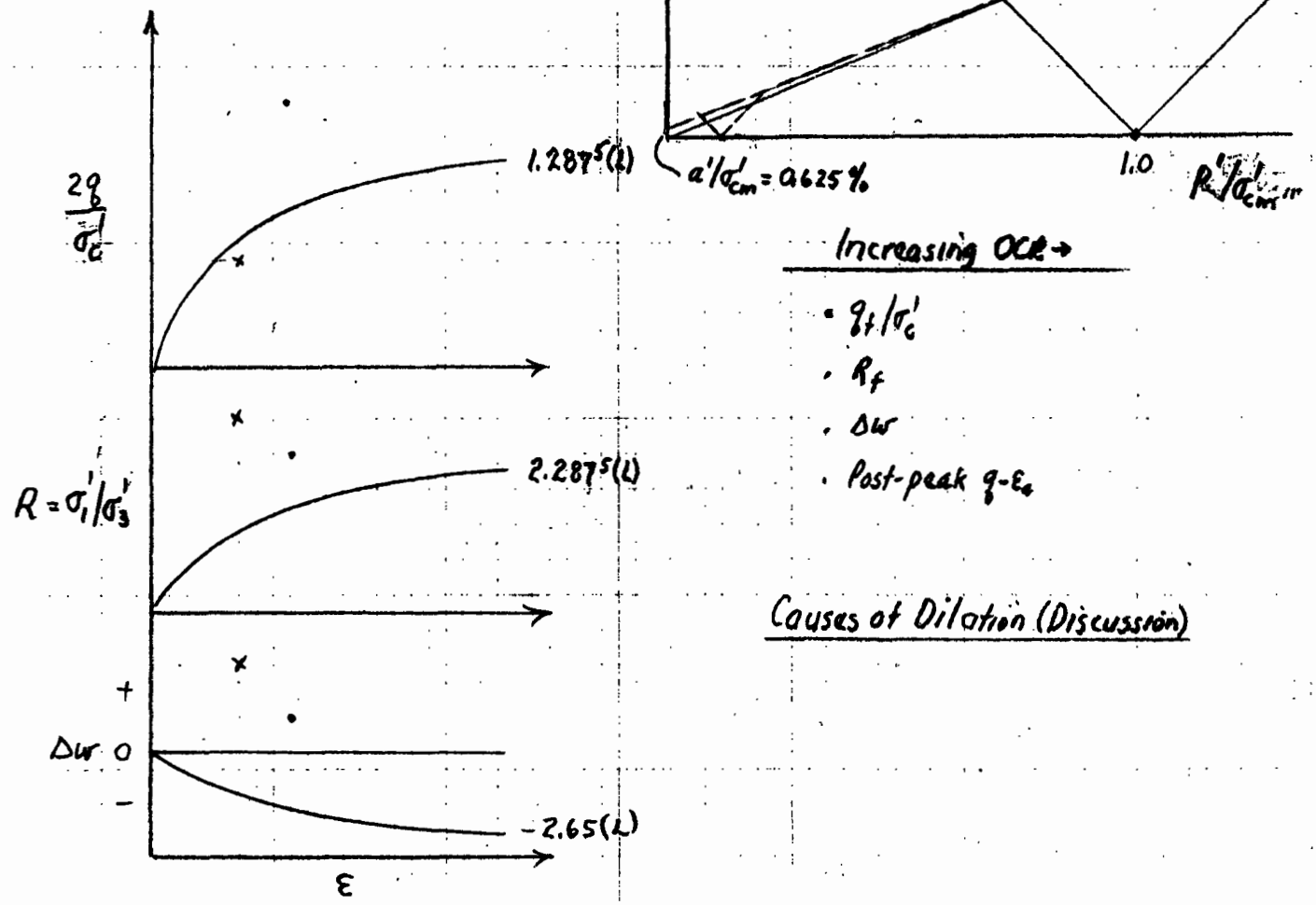


CIDC Tests - Effect of OCR

(Fig. III-5)



(Fig. III-2)



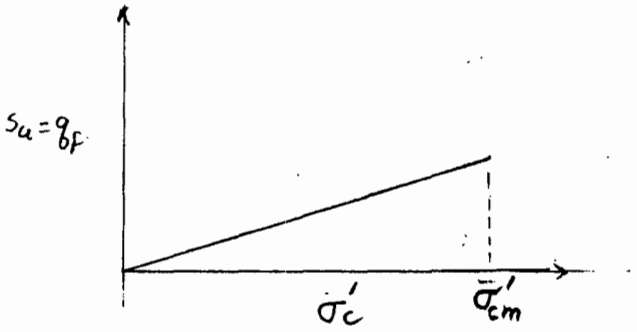
Increasing OCR →

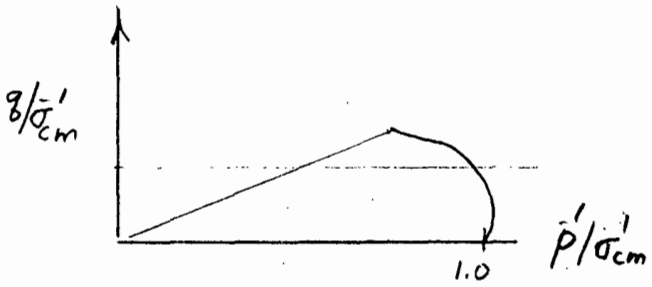
- $q_f/\bar{\sigma}_c'$
- R_f
- Δw
- Post-peak q-ε_a

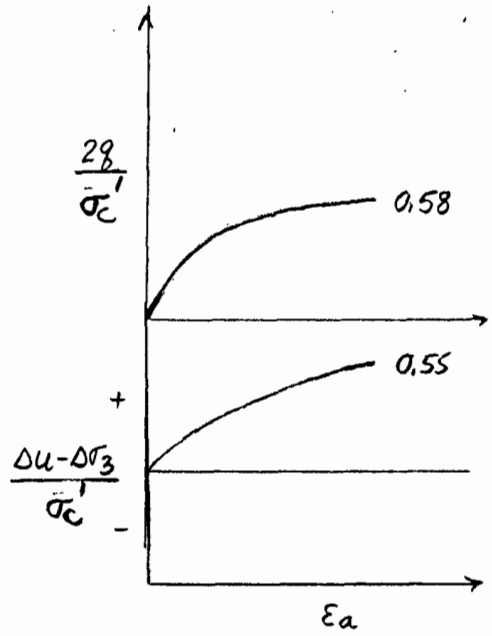
Causes of Dilation (Discussion)

CIUC Tests - Effects of OCR

— OCR=1
--- OCR>1





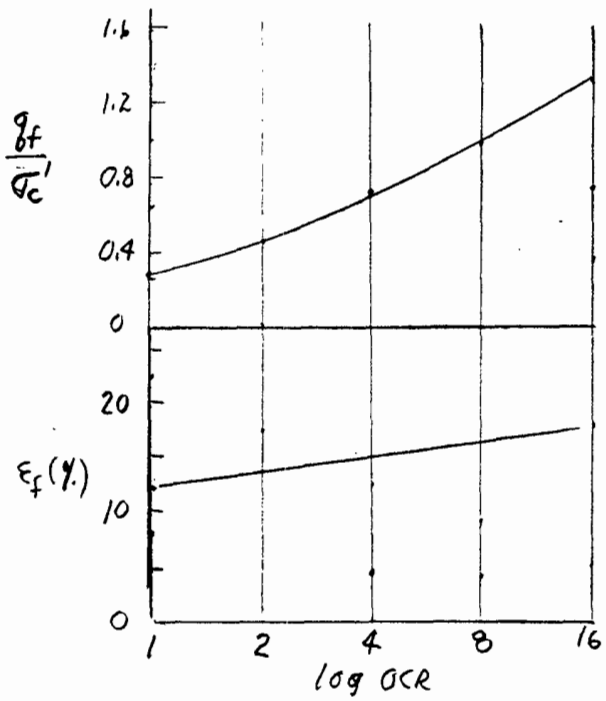


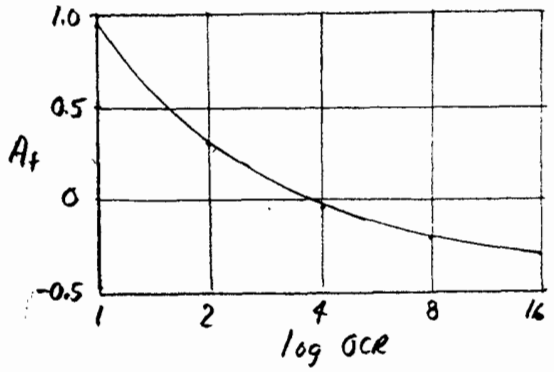
Effect of inc. OCR on:
- $s_u/\bar{\sigma}_c'$
- ε_f
- R_f

What is main reason for OCR → incr. $s_u/\bar{\sigma}_c'$?

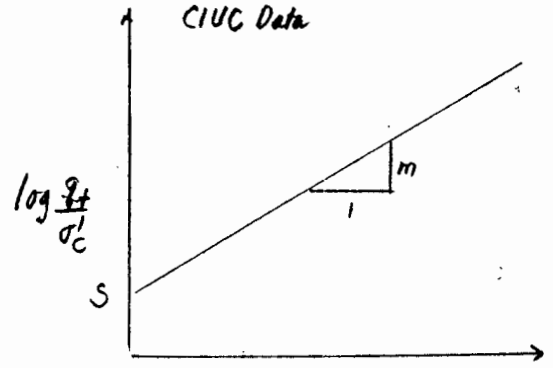
Summary (Fig III-17, 18, 19)

— CIUC
--- CIOC(L)
····· CIOC(U)





SHANSEP Eq. $q_f/\sigma'_c = S(OCR)^m$



—— SHANSEP Eq → S=0.31 & m=0.54 (LR OCR=1 → 16)

- - - - Simple Clay "data"
S=0.29, m≈0.7 → 0.55 with increasing OCR

$\therefore \left(m = \frac{\log(q_f/\sigma'_c/0.29)}{\log OCR}\right)$

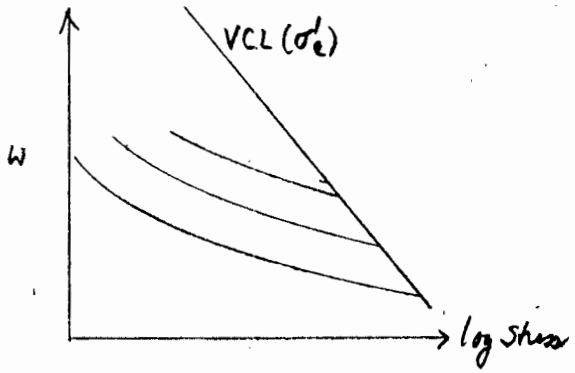
∴ Should revise SC data → constant m

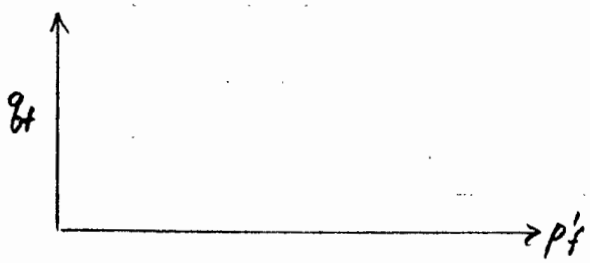
Hvorslev Parameters

1) Hvorslev's contributions → $\tau_{ff} = K\sigma'_e + \sigma'_{ff}\tan\phi'_e$

2) Golden Rule

3) Revised determination/presentation for CIUC/CIOC data
$q_f = \beta\sigma'_e + p'_f$ ($\tan\alpha'_e = \sin\phi'_e$) where $\beta\sigma'_e = a'_e$ (ω_f)





4) Table with data from CIUC and/or CIOC at varying OCR

w_f	q_f	p'_f	σ'_e	q_f/σ'_e	p'_f/σ'_e

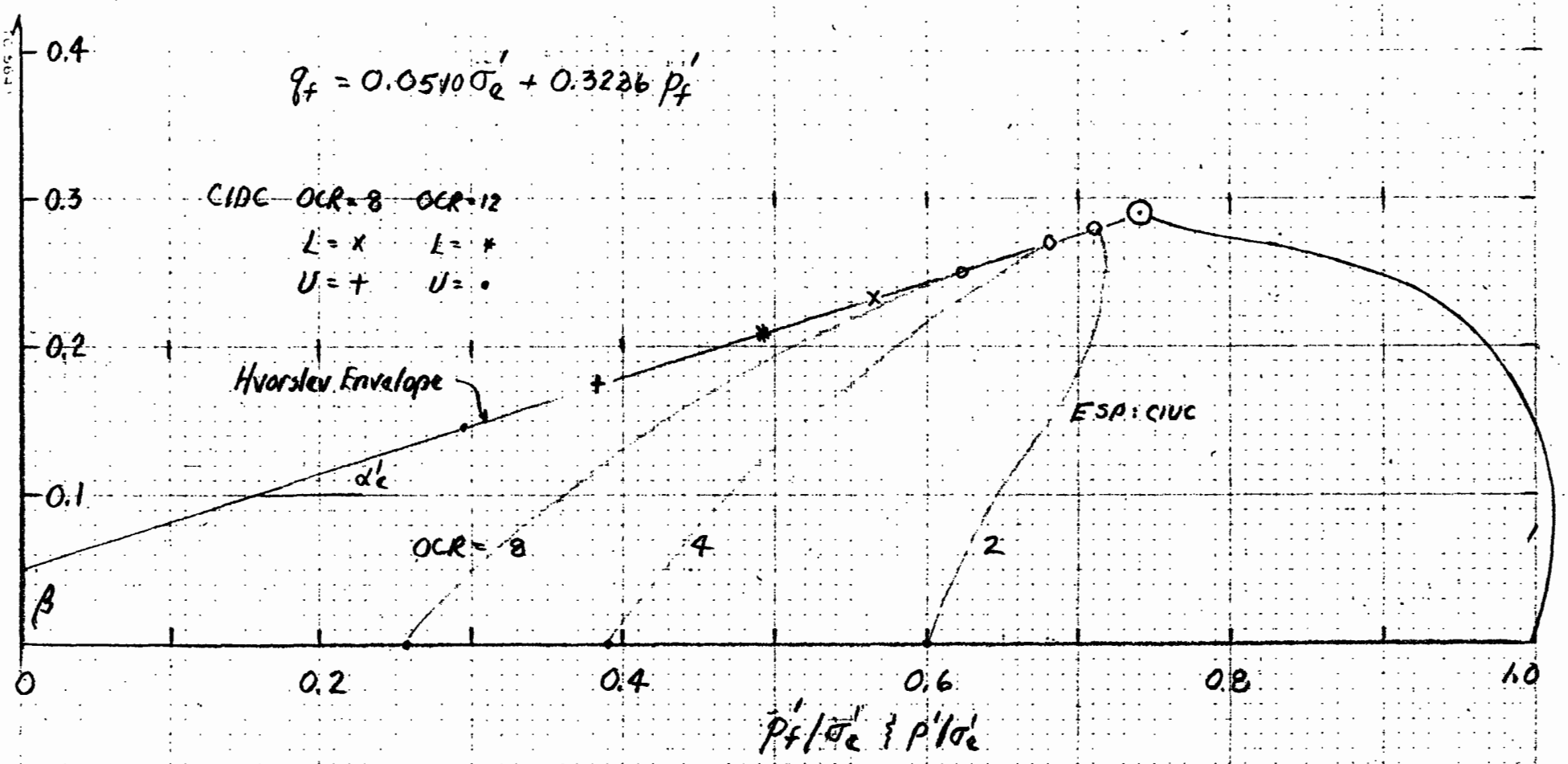
5) Hvorslev Envelope (p7)

6) State Boundary Surface (Hvorslev + Roscoe = NC CIUC ESP)

7) Discussion

1.322 Part B

CCL 2/85 2/01
2/89
2/97 2/98



State Boundary Surface for Simple Clay

78

2/97 2/01
2/98 COMMENTS ON SIMPLE CLAY TE vs TC

1) Generalized Pore Pressures - Henkel(1960) p53-54 incorrect

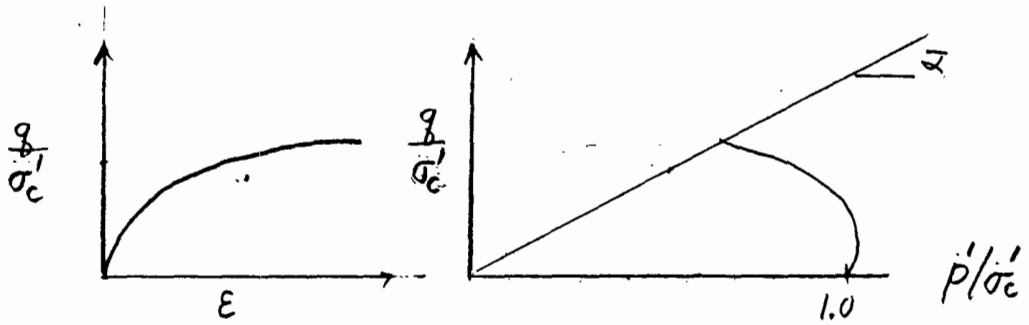
$$\Delta u = \Delta\tau_{oct} + a\,\Delta\tau_{oct} \quad , \quad \Delta\tau_{oct} = \left(\frac{1}{3}\right)\sqrt{(\Delta\sigma_1-\Delta\sigma_2)^2+(\Delta\sigma_1-\Delta\sigma_3)^2+(\Delta\sigma_2-\Delta\sigma_3)^2}$$

For $b=0 \rightarrow A = \frac{a\sqrt{2}}{3} + 1/3$

0.5 $A =$ " $+\frac{1}{2}$

1.0 $A =$ " $+2/3$

2) CIUE vs CIUC NC' — CIUC ---- CIUE



- Change in s_u/σ_c'? Why?
- Comparison MCC

3) Effect of OCR (III-19)

- $s_u(OC)/s_u(NC)$ vs OCR - How compare to CIUC?

4) What happens to Principle II relationships?

5) What happens to Hvorslev Parameters for SC? (OC ESE and)
(Actually don't know for real clays)