CIVIL ENGINEERING

Geotechnical Engineering

Compressibility and Consolidation of Soil

Chapter 9

Lecture 06

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01 Computation of Settlement

Q. Identical surcharges are placed at ground surface at sites X and Y, with soil conditions shown alongside and water table at ground surface. The silty clay layers at X and Y are identical. The thin sand layer at Y is continuous and free-draining with a very large discharge capacity. If primary consolidation at X is estimated to complete in 36 months, what would be the corresponding time for completion of primary consolidation at Y? [GATE : 2011]

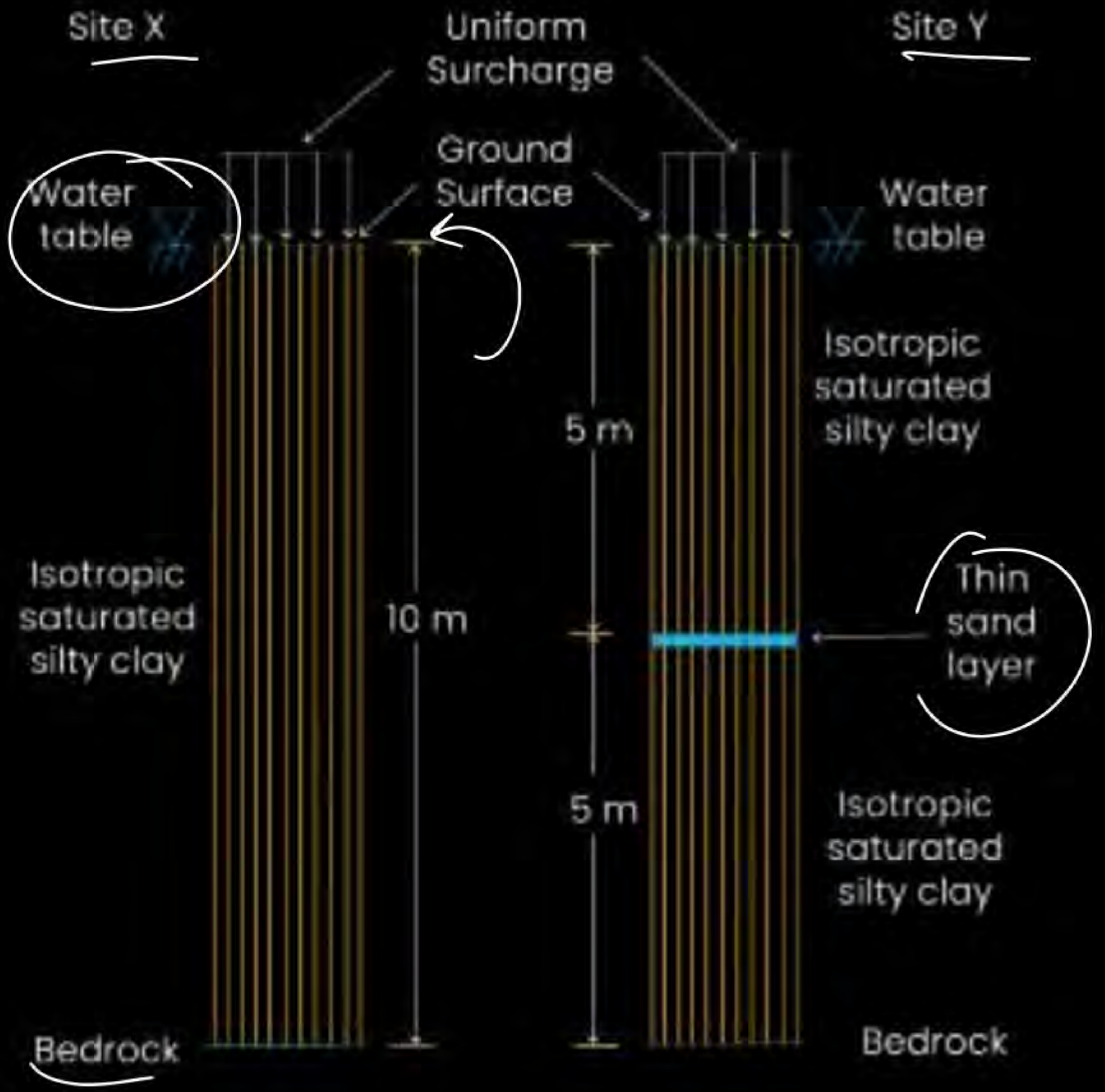
(a) 2.25 months

(b) 4.5 months

(c) 9 months

(d) 36 months

C



$t_x = 36$ months

$H_x = 10m$

$H_y = \underline{5m}$, $t_y = ?$

$t \propto H^2$

$$\frac{t_y}{t_x} = \left(\frac{H_y}{H_x}\right)^2$$

$$\Rightarrow t_y = \left(\frac{5}{10}\right)^2 \times 36 = \boxed{9 \text{ months}}$$

Q. The time taken to construct a building was from April 1992 to September 1993. In September 1996, the average settlement was found to be 5.16 cm. If the ultimate settlement is estimated to be 25 cm, then the settlement in January 1997 would have been ___ cm

Jan - 1993 → mid of construction period

Sol April 1992 → Sep. 1993

To estimate the settlement during the construction period the total will be assumed to be applied at the mid of construction period

Sep 1996 → $\Delta h_1 = 5.16$ cm

Jan 1997 → $\Delta h_2 = ?$

Jan 1993 $\rightarrow$ Sep 1996 $\Rightarrow$ 3 years 9 months = 3.75 years = t_1

$$3 + \frac{9}{12} = 3.75$$

Jan 1993 $\rightarrow$ Jan 1997 $\Rightarrow$ 4 years = t_2

$\Delta H = 25\text{cm}$,

$$U_1 = \frac{\Delta h_1}{\Delta H} = \frac{5.16}{25} \times 100\% = 20.64\%$$

$$\boxed{T_v = \frac{C_v t}{H^2} = \pi/4\, U^2} \quad \text{for } U \leq 60\%$$

$$\Rightarrow t \propto U^2$$

$$\Rightarrow \frac{t_2}{t_1} = \left(\frac{U_2}{U_1}\right)^2$$

$$\Rightarrow U_2 = \sqrt{\frac{4}{3.75} \times 20.64^2} = 21.317\%$$

$U_2 \leq 60\%$ ok ✓

$$\Delta h_2 = U_2 \times \Delta H$$

$$= \frac{21.317}{100} \times 25 = \boxed{5.329\,\text{mm}}$$

Q. A 6 m thick fine silt stratum ($C_v = 7.2 \times 10^{-3}$ cm^2/sec) underlies a coarse sand deposit and overlies a 0.15 cm thick fine sand layer under which there is a clay stratum 3 m thick ($C_v = 9 \times 10^{-5}$ cm^2/sec). A pervious stratum lies below the clay layer. When the clay layer reaches a degree of consolidation of 20%, what would be the degree of consolidation of the silt layer?

Given :

$T_v = \pi/4\ (U/100)^2$ if % $U \leq 60\%$

$T_v = 1.781 - 0.9332 \log_{10}(100 - U)$ if % $U > 60\%$

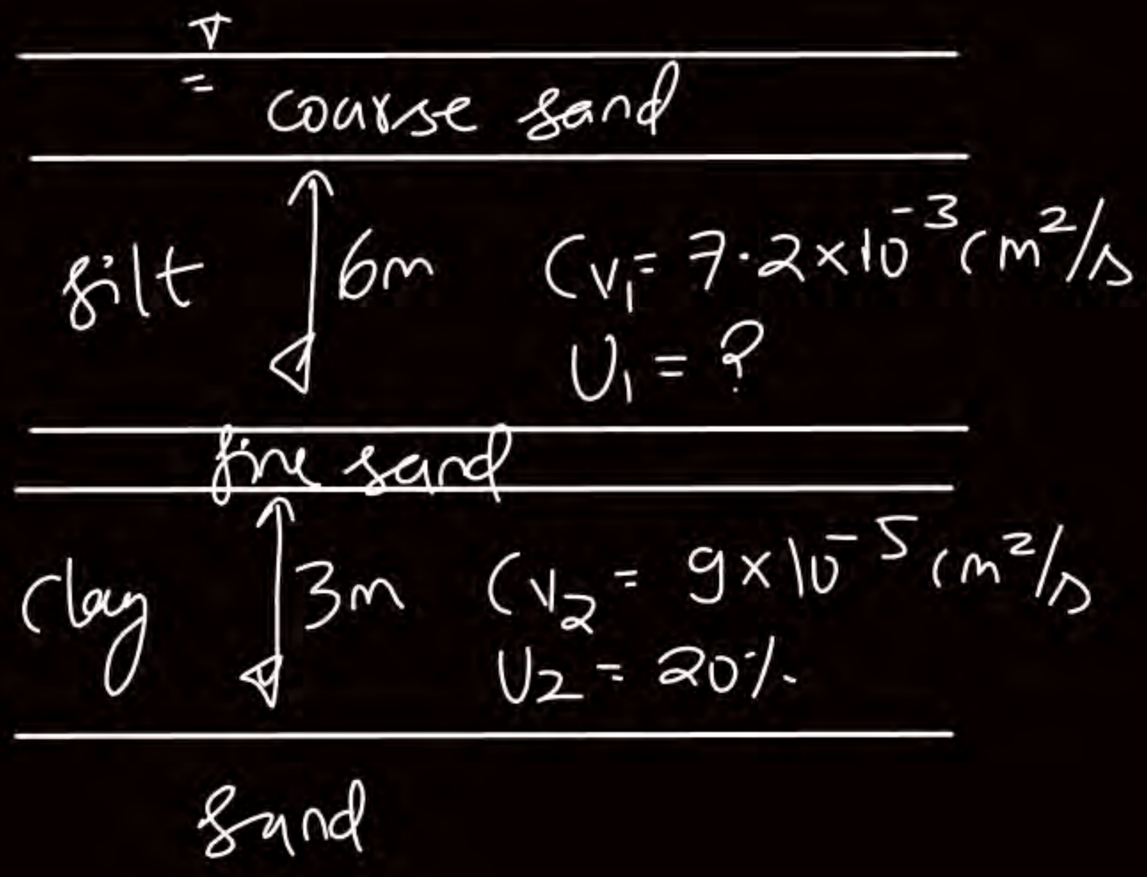
(a) 28.42%

(b) 66.60%

(c) 82.81%

(d) 90.51%

C



$$H_1 = 6/2 = 3m$$

$$H_2 = 3/2 = 1.5m$$

for clay

$$T_{v_2} = \frac{\pi}{4} U_2^2 = \frac{C_{v_2} t}{H_2^2} \quad \ldots \quad U_2 \le 60\%$$

$$\Rightarrow \frac{\pi}{4} \times 0.2^2 = \frac{9\times10^{-5}\times t}{(1.5\times10^2)^2}$$

$$\Rightarrow t = 78.5398\times10^5 \text{ secs}$$

Now for silt

$$T_{v_1} = \frac{C_{v_1} t}{H_1^2} = \frac{7.2\times10^{-3}\times78.5398\times10^5}{(3\times10^2)^2} = \underline{0.6283}$$

for $U = 60\%$, $T_{V_1} = \pi/4 \times 0.6^2 = 0.283$

if $T_{V_1} > 0.283$, $U > 60\%$

$$\Rightarrow T_{V_1} = 1.781 - 0.9332 \log(100 - U_1\%) = 0.6283$$

$$\boxed{U_1 = 82.81\%}$$

10.1 INTRODUCTION

→ In all geotechnical strength analysis we evaluate shear strength because whatever by the type of soil failure almost always occurs by shearing of soil, it never occurs by the crushing of the soil particles. Failure occurs when shear stress exceeds the shear strength at any point.

10.2 Mechanism of Shear Resistance

Shear strength is categorised into two broad categories,

a. Frictional strength → friction + interlocking.

b. Cohesion strength → a. True cohesion

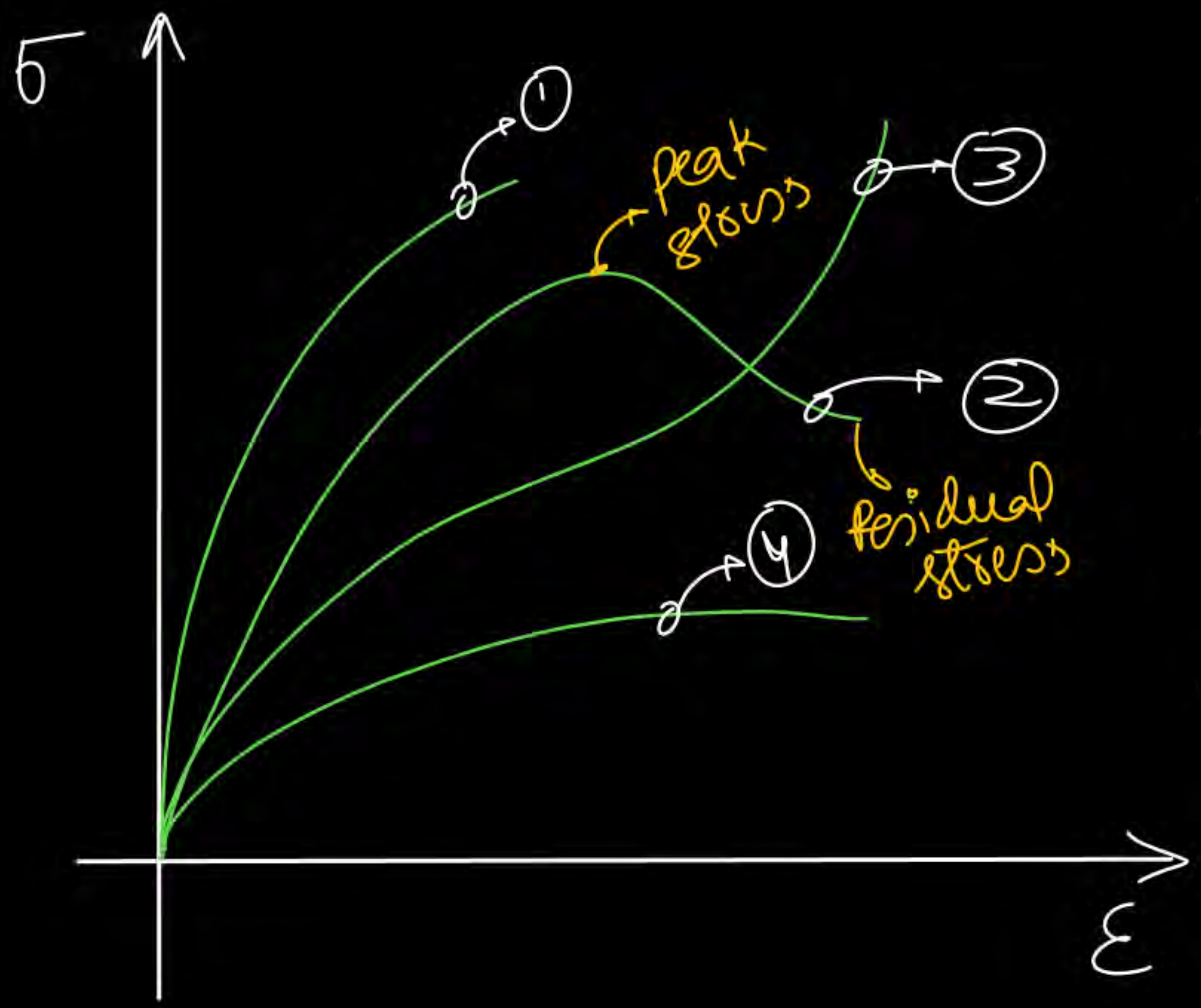
b. Apparent cohesion.

→ True cohesion is due to electrostatic attraction.

→ Apparent cohesion is due to negative pressure in the pores which causes the attraction b/w the particles.

10.3 STRESS-STRAIN CURVE FOR SOIL

$\varepsilon = \frac{\Delta l}{l}$



→ cohesive soil at low moisture content → 1

→ Work softening soil → 2
(dense sand & sensitive clay).

→ Work hardening soil → 3
(loose sand & compact clay)

→ Plastic or remoulded clay
↳ 4

- → For brittle and work softening material failure is taken corresponding to the peak point.
- → In plastic and work hardening material failure point is taken corresponding to acceptable strain.
- → Stress - Strain curve is drawn to identify the failure stress.
- → For NC soil, residual stress is slightly less than the peak stress
- → In sensitive clays, the difference b/w peak and residual stress is large due to change in fibre of clays (flocculated to dispersed).

→ In dense sand the difference b/w peak and residual stress is large due to increase in void ratio

→ In OC clays, the difference is again large, due to

a. Breakage of soil structure

b. Increase in void ratio during shearing.

OC clay ⟷ Dense sand.

NC clay ⟷ loose sand.

Q. Consider the following statements:

1) Brittle behavior of soils can be obtained when the soil is heavily over-consolidated clay.

2) Remoulded cohesive clays show a tendency towards progressive failure. → ductile failure

3) Undisturbed sensitive clays show a tendency towards progressive failure. ✗

Which of these statements are correct? [ESE:2013]

9:40 PM

(a) 1, 2 and 3

(b) 1 and 3 only

(c) 1 and 2 only

(d) 2 and 3 only

c

Thank You
GW Soldiers