Compressibility of Soils (Settlement)

Chapter 10

Total Settlement due to an Increase in Vertical Stress ($\Delta\sigma$)

$$S_T = S_{e+}\, S_c + S_s$$

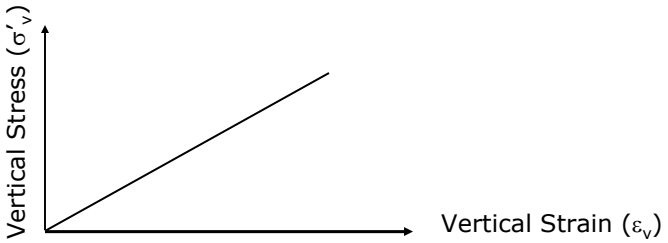
S_T = total settlement

S_e = immediate (elastic) settlement
S_c = primary consolidation settlement

S_s= Secondary settlement

S_e - Elastic (Immediate) Settlement

- Elastic compression of dry, moist and saturated soil without any change in the moisture content
- Calculations based on theory of elasticity
- Occur immediately after load application

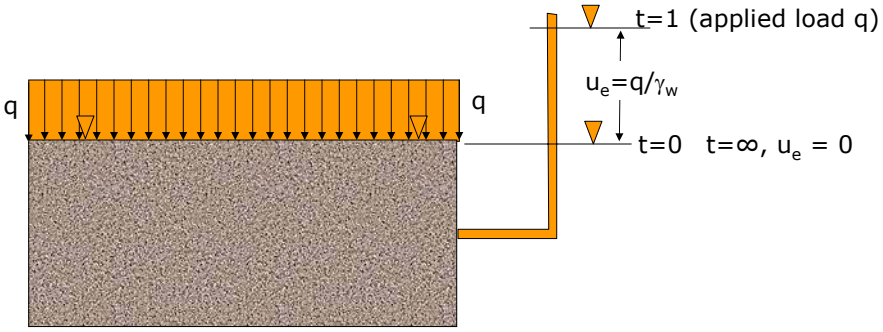


S_c - Primary Consolidation

- Volume change in saturated cohesive soils (clayey soils) due to expulsion of water that occupies the voids (i.e. reduction in void ratio)
- Result of dissipation of excess pore water pressure due to an applied load.
- Rate of consolidation is a function of soil hydraulic conductivity

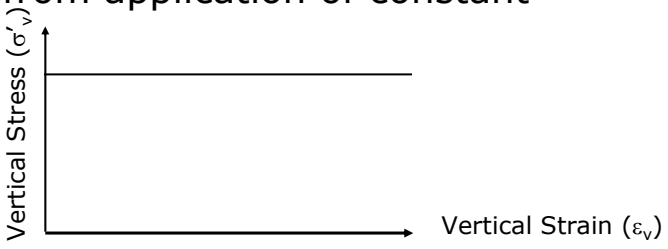
Excess Porewater Pressure (u_e)

- Pore water pressure that is in excess (greater than) steady state water level.



S_s - Secondary Settlement (Creep)

- Observed in saturated soft clays and is the result of plastic adjustment of soil fabric (i.e. reduction in void ratio)
- Compression after dissipation of excess pore water pressure.
- Results from application of constant stress.



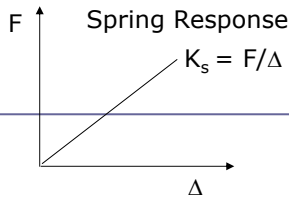
Total Settlement

- Elastic settlement occurs during construction
  - Magnitude small compared to primary and secondary
- Primary and Secondary consolidation occurs after construction is completed
  - Primary consolidation can take months to years to be completed – magnitude large compared to elastic and secondary settlements
  - Secondary consolidation occurs during and following primary consolidation
    - magnitude can be significant in very soft organic clays,
    - typically in significant in stiff clays

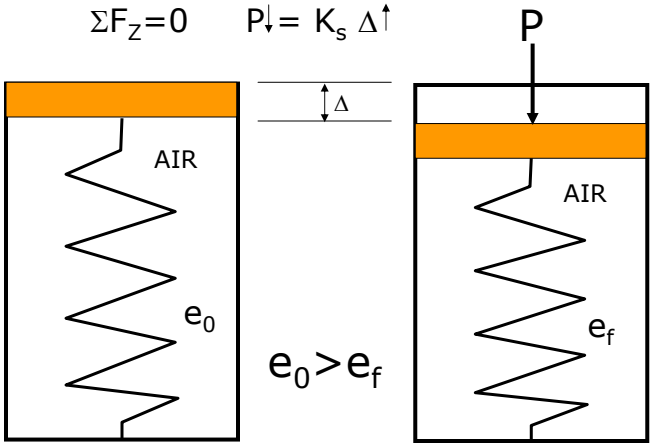
Primary Consolidation Theory

Consolidation Pot Analogy

Case I (Air filled)



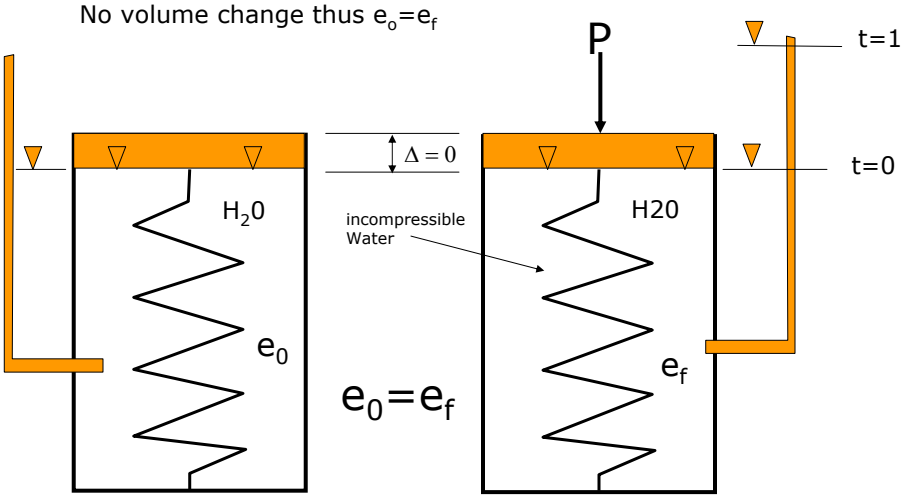
$\Sigma F_Z = 0$ $\quad P\downarrow = K_s\,\Delta\uparrow$



$e_0 > e_f$

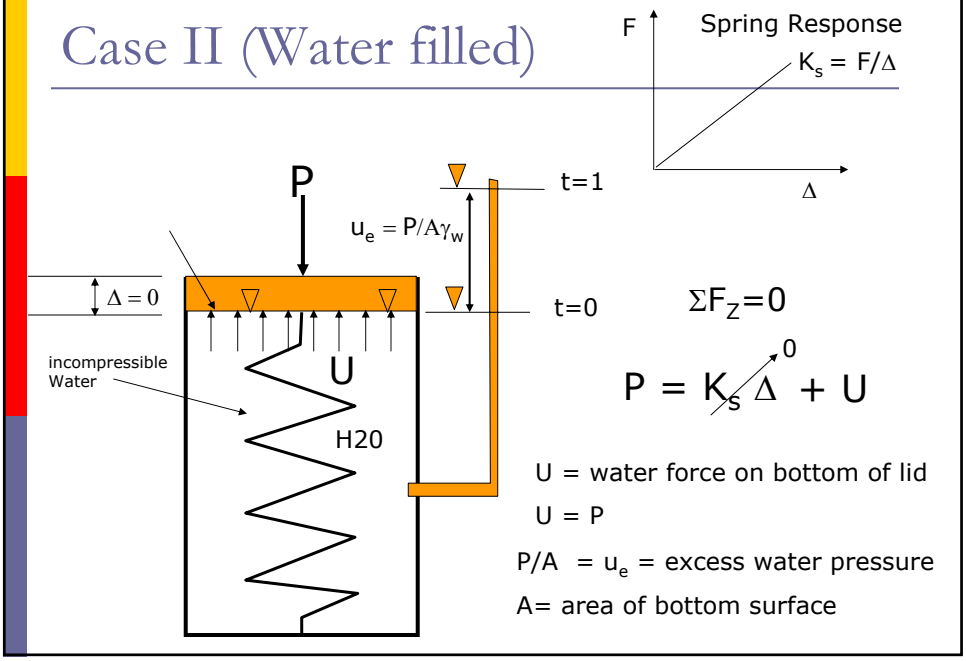
Case II (Water filled)

No volume change thus $e_o = e_f$



$e_0 = e_f$

Case II (Water filled)



$\Sigma F_Z = 0$

$P = K_s \Delta^{0} + U$

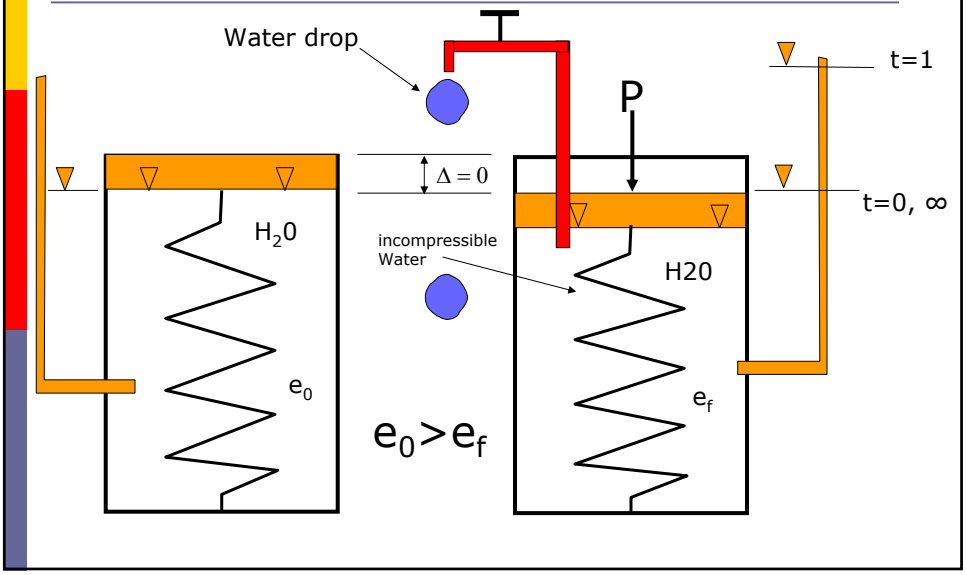
U = water force on bottom of lid

U = P

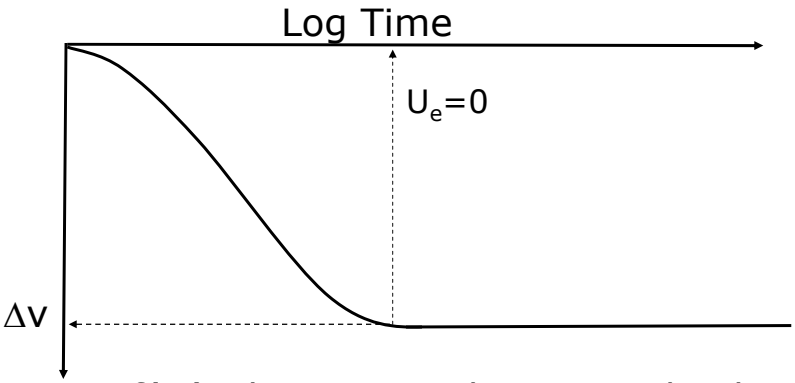
P/A = u_e = excess water pressure

A= area of bottom surface

Case III (Water filled and valve)

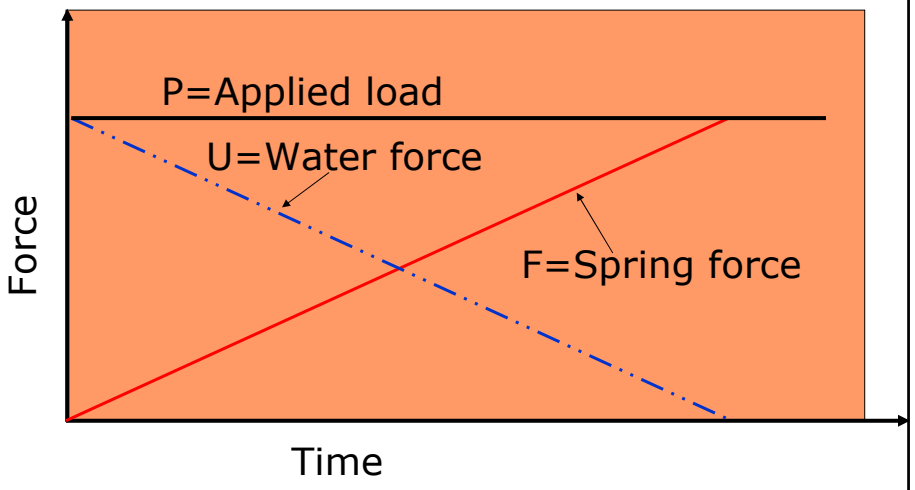


Case III (Water filled and valve)



$\Delta v = f(e_f)$ Change in volume equal volume of water removed from soil voids

Case III (Water filled with valve)



Case III (Water filled and valve)

$$\Sigma F_Z = 0$$

$t=1 \qquad P= U \quad \Delta=0$

$1 \le t \le \infty \quad P = K_s\Delta + U$

$t = \infty \quad P = K_s\Delta \quad U= 0$