● Comments on Rate-Dependent Behavior of Soils

- Assumptions on the theory of consolidation and their possible solutions

i) k_v (or k_h) remains constant during consolidation.

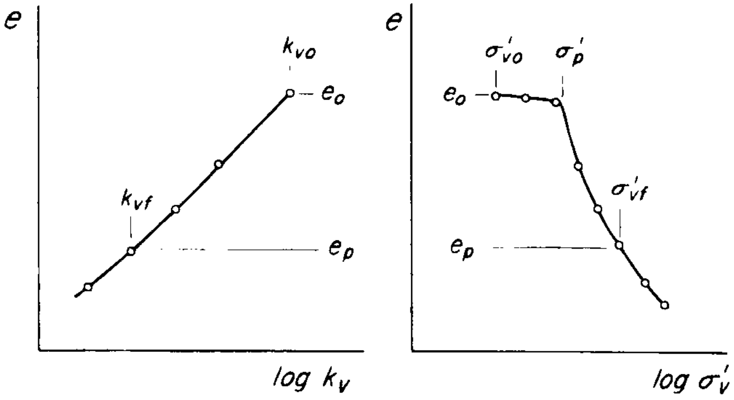

Figure 25.15 Changes in permeability and compressibility during an increment of consolidation pressure.

Compression loading, decrease e and thus decrease k.

$e \propto$ log k (C_k $(=\Delta e/\Delta \log k)$ = constant)

$\Rightarrow$ if e-log σ'_v relationship and C_k are given, variation of k during consolidation can be considered. ($c_v = \dfrac{k}{\gamma_w m_v}$)

ii) a_v or m_v remains constant during consolidation.

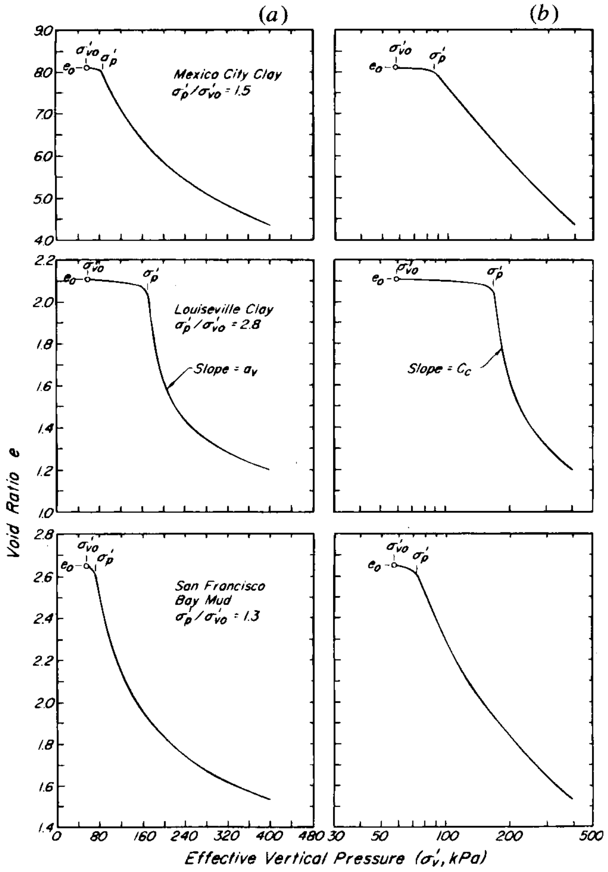

Figure 16.1 Relation between end-of-primary void ratio and effective vertical pressure for natural clays from Mexico City, Louiseville, and San Francisco (top to bottom). Effective vertical pressure plotted (*a*) to natural scale and (*b*) to logarithmic scale.

For virgin compression range, a_v (or m_v) decreases with increasing σ'_v.

$\Rightarrow$ If $m_v = f(\sigma'_v)$ is given, non-linear compressibility can be considered.

- No drained creep effect throughout the primary consolidation process.

In terms of void ratio, the rate of compression of a sublayer is expressed by

$$\frac{de}{dt}=\left(\frac{\partial e}{\partial \sigma_v^{'}}\right)\frac{d\sigma_v^{'}}{dt}+\left(\frac{\partial e}{\partial t}\right)_{\sigma_v^{'}}=a_{vs}\frac{d\sigma_v^{'}}{dt}+a_{vt} \qquad \text{--------- ①}$$

$$\int_0^t de=\int_0^{t_p}\left(a_{vs}\frac{d\sigma_v^{'}}{dt}+\underbrace{\cancelto{0}{a_{vt}}}_{\text{assumed to be zero}}\right)dt+\int_{t_p}^{t}a_{vt}dt$$

- **Comments on secondary compression settlements**

$$S = \frac{C_\alpha}{1+e_0} H \log \frac{t}{t_p}$$

1. C_α is assumed to be constant with time.
2. C_α / C_c^* is constant in both the compression and recompression ranges.

Table 16.1 Values of C_α / C_c^* for Geotechnical Materials

Material	C_α / C_c^*
Granular soils including rockfill	0.02 ± 0.01
Shale and mudstone	0.03 ± 0.01
Inorganic clays and silts	0.04 ± 0.01
Organic clays and silts	0.05 ± 0.01
Peat and muskeg	0.06 ± 0.01

3. C_α is assumed to be not influenced by thickness of clay layer and magnitude of stress increment and to be a function of applied stress level and soil type.

4. t_p for compression range > t_p for recompression range.

   C_α for compression range > C_α for recompression range.

→ Preloading provides significant effect on reducing secondary compression settlement and controlling consolidation behavior by decreasing both C_α and t_p values after treatment, in addition to reduce primary consolidation settlement.

- **Influence of stress increment range, based on stress history.**

$$\frac{d\sigma_v'}{dt} = -\frac{du}{dt}$$ From eq. ① in page 2-146

$$-\frac{du}{dt} = \frac{\frac{de}{dt} - a_{vt}}{a_{vs}}$$

Increase in either a_{vs} or a_{vt} slows dissipation.

In recompression range, a_{vs} is low. → dissipation rate is fast.

In compression range, a_{vs} is high. → dissipation rate is slow.

● Excess porewater pressure behavior for a pressure increment spanning the preconsolidation pressure

→ Test conditions

- Free drain to the top, impermeable at the bottom.
- Four piezometer at the quarter points in depth.
- Apply the pressure increments form 28 to 55 kPa (recompression range) and from 110 to 152 kPa (spanning preconsolidation pressure).
- Determine pore pressure of various points from top to bottom with time.

→ The pressure increment from 28 to 55 kPa and initial part of the pressure increment from 110 to 152 kPa ; small $a_{vs} \Rightarrow$ pore pressure dissipate rapidly.

→ But approaching σ_p' for $\Delta\sigma_v'$ from 110 to 152 kPa, a_{vs} abruptly increases and there is a dramatic reduction in the rate of pore pressure dissipation (No significant effect of reduction in permeability which is always gradual.)

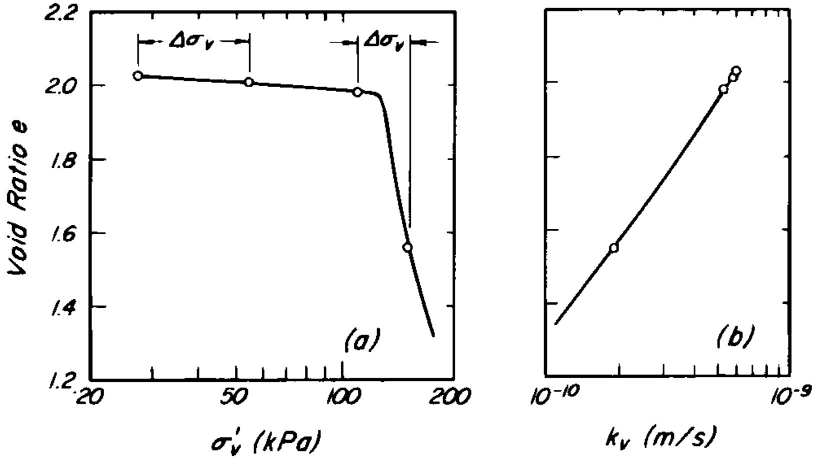

Figure 16.15 (*a*) Relation between *e* and log σ_v and (*b*) Corresponding relation between *e* and log k_v for the pressure increments in Figs. 16.13 and 16.14.

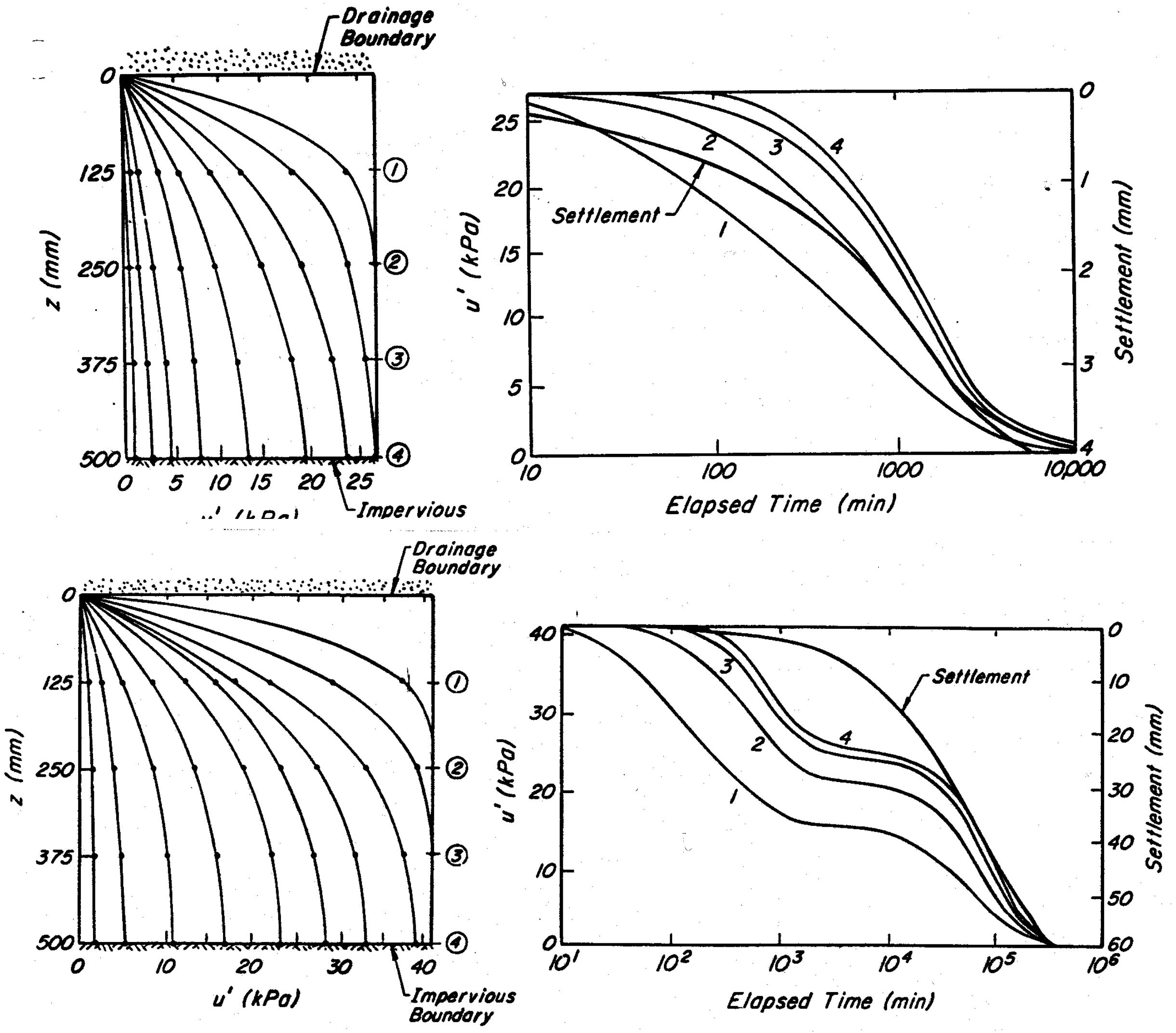

Figure 16.14 Excess porewater pressure behavior for a pressure increment spanning the preconsolidation pressure.