● 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.

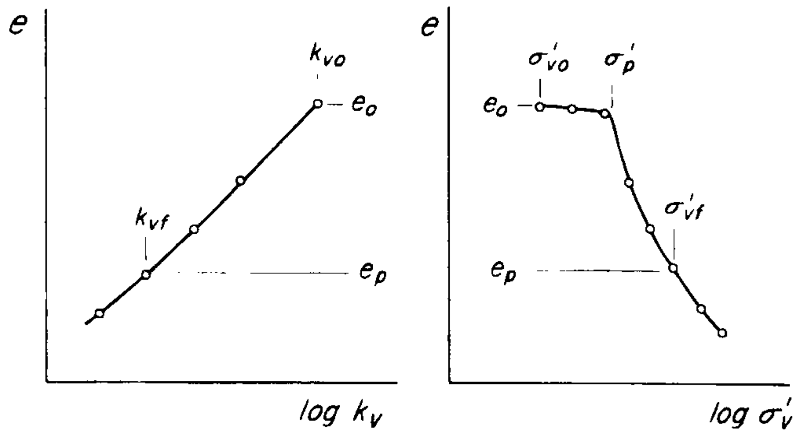

Fig. 2-61 Changes in Permeability and compressibility during an increment of consolidation pressure

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.

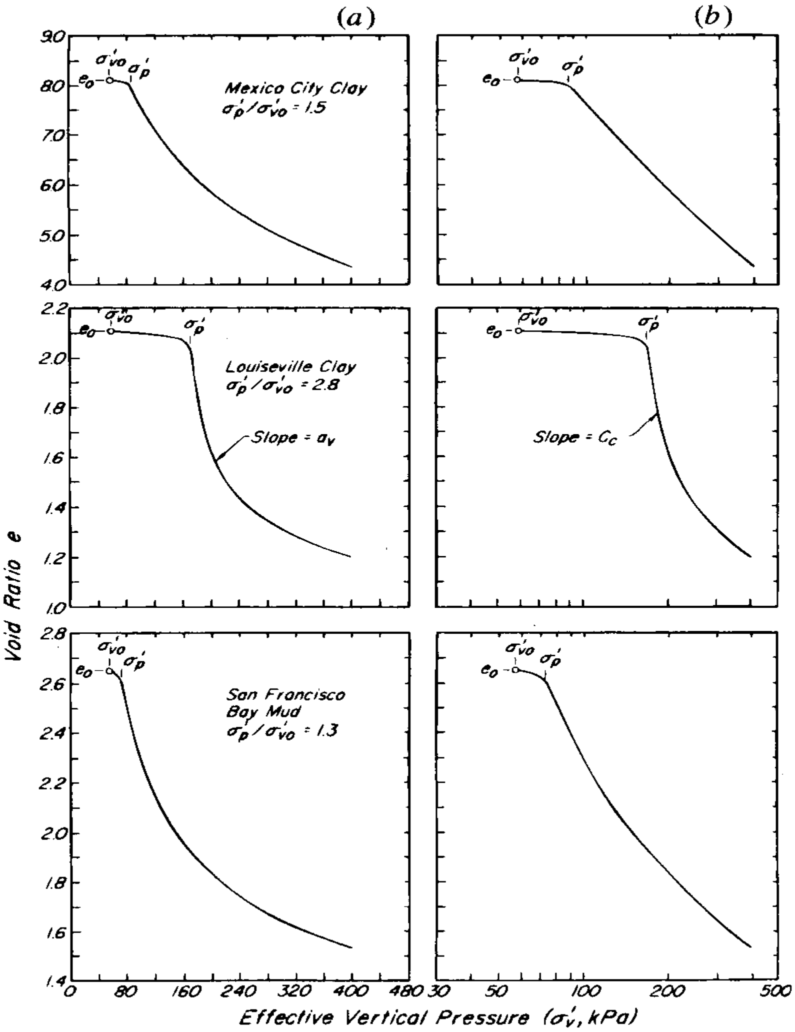

Fig. 2-62 Relation between end-of-primary void ratio and effective vertical pressure for natural clays from Mexico City, Louiseville, and San Francisco (top to bottom). Effective vertical pressure plotted (a) to natural scale and (b) to logarithmic scale.

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

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

$$\int_0^t de = \int_0^{t_p}\left(a_{vs}\frac{d\sigma_v^{'}}{dt} + \cancel{a_{vt}}^{\,0}\right)dt + \int_{t_p}^{t} a_{vt}\,dt$$

→ assumed to be zero

- **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 2-11 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 2-159

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

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.

How about effect of a_{vt} ?

- **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} ⇒ 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.).

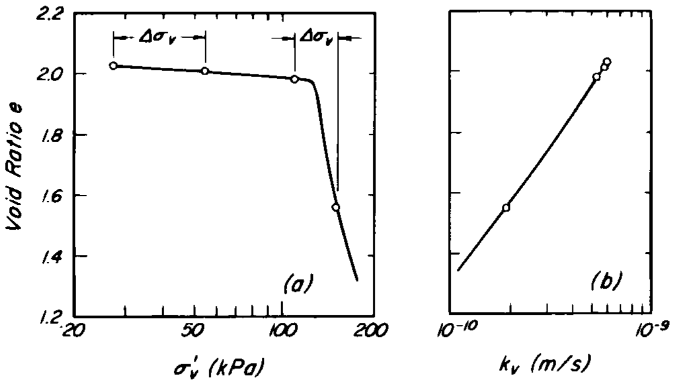

Fig. 2-63 (a)Relation between e and log σ_v and (b) Corresponding relation between e and log k_v for the pressure increments in Figs. 2-64 and 2-65

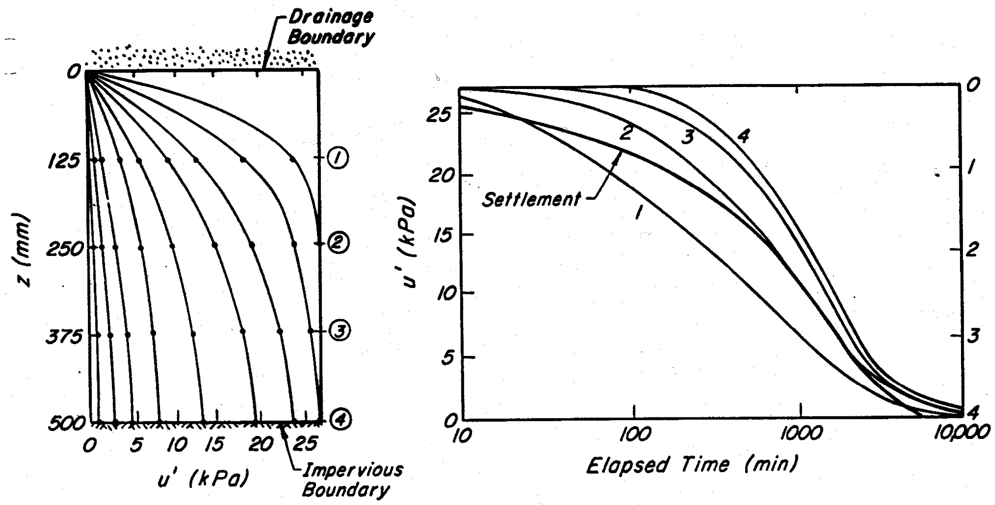

Fig. 2-64 Excess pore water pressure behavior for a pressure increment within the recompression range

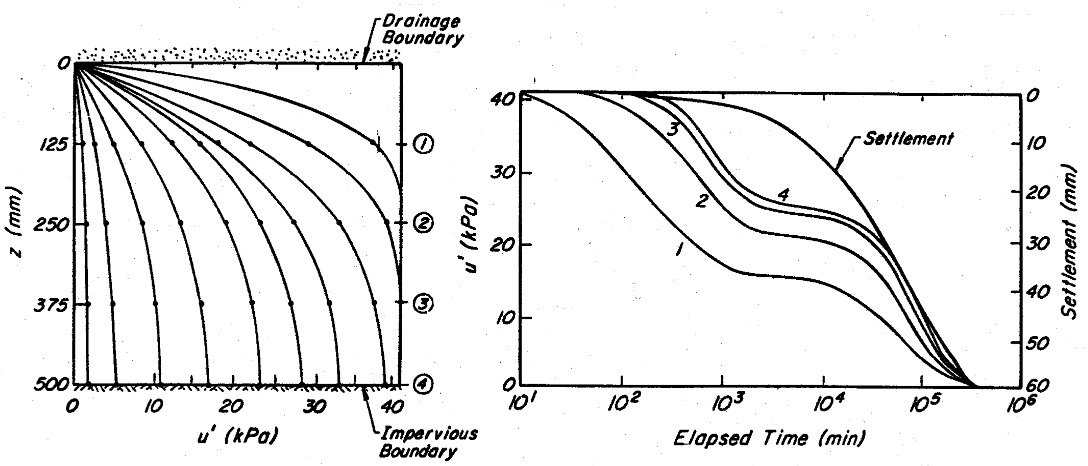

Fig. 2-65 Excess pore water pressure behavior for a pressure spanning the preconsolidation pressure