Metode Preloading

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Metode Stabilisasi Tanah

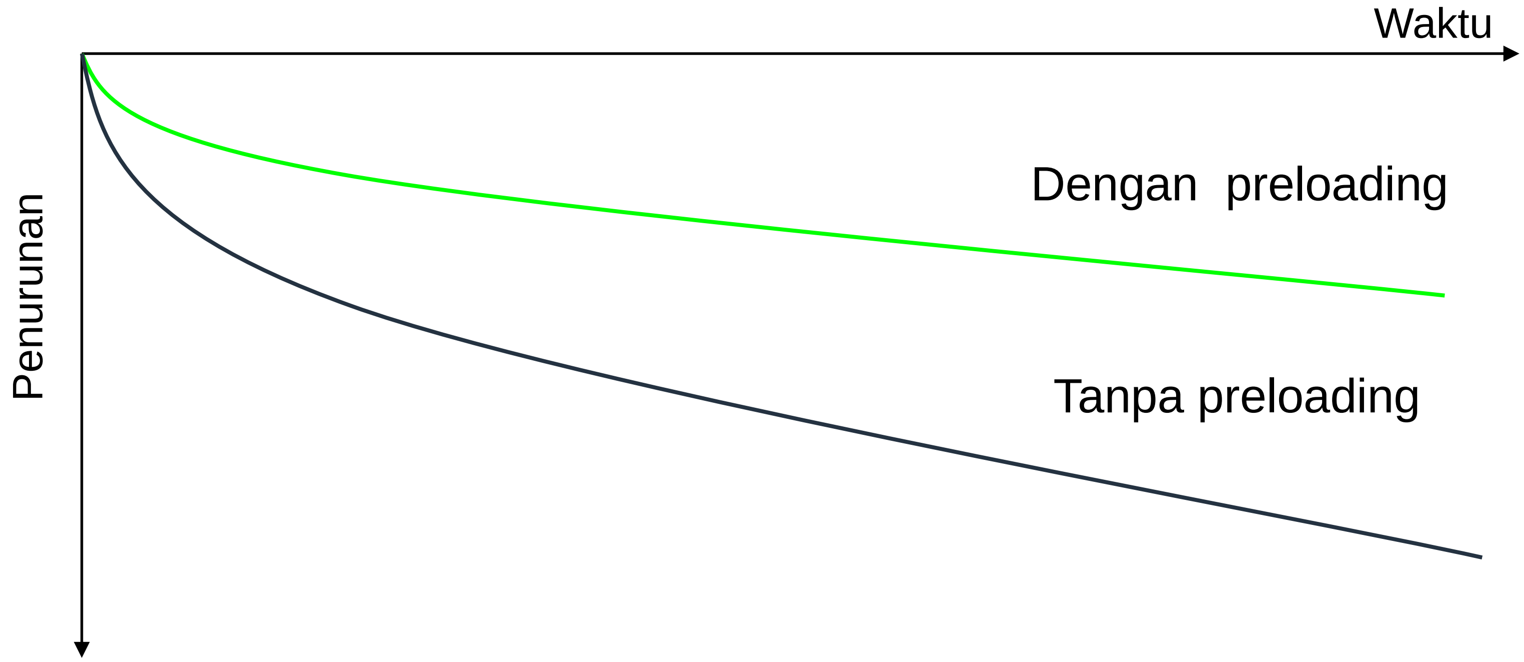
- Soil Stabilization Techniques
  - Mechanical (Shallow Compaction, Deep Compaction)
  - Hydraulic Modification (Drainage, Dewatering, **Preloading and Use of Vertical Drains**, Electronic Dewatering and Stabilization)
  - Physical and Chemical Modification (Use of Admixtures, Grouting, Thermal modification)
  - Modification by Inclusion and Confinement (Soil Reinforcement)

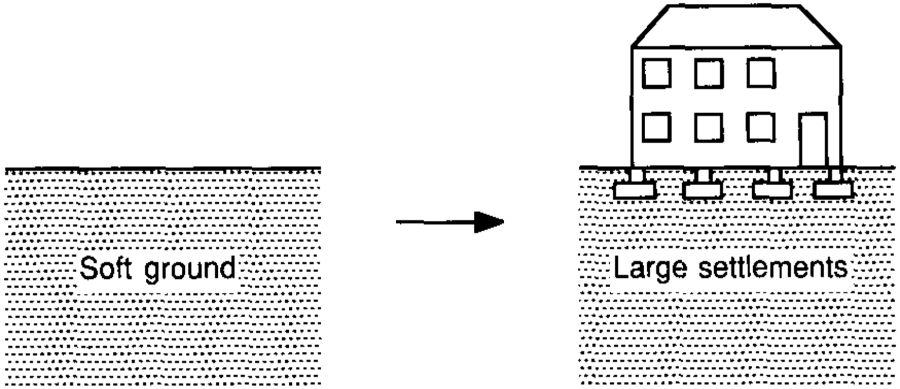
Ref: Hausman M.R (1990) Engineering Principles of Ground Improvement, Mc-Graw Hill.

PRELOADING (PEMBEBANAN AWAL)

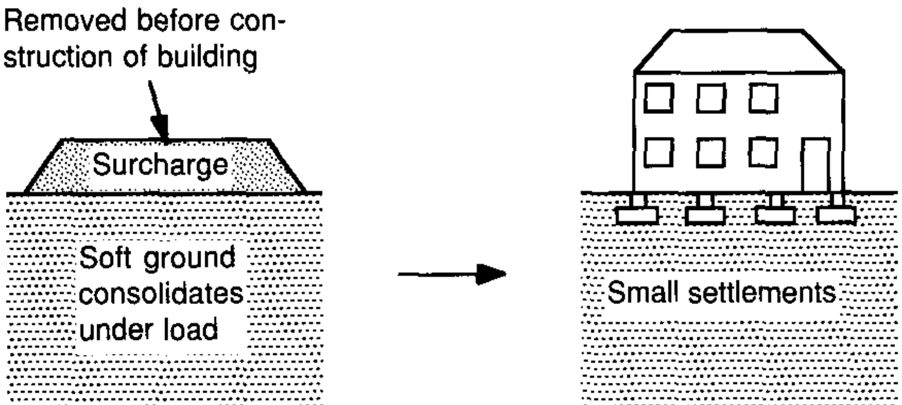
Mengurangi Penurunan:

- Pondasi di atas tanah lunak
- Beban yang diberikan > tekanan pra-konsolidasi ($\sigma'_o + \Delta\sigma > \sigma'_c$)

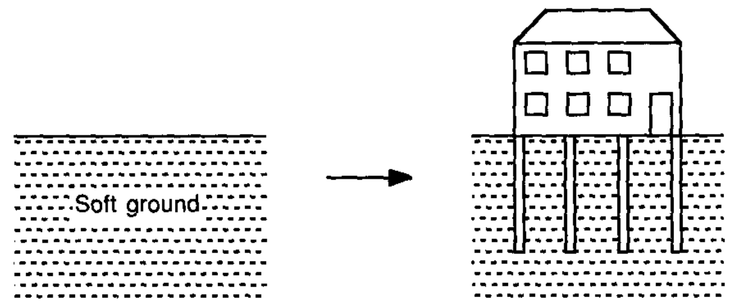




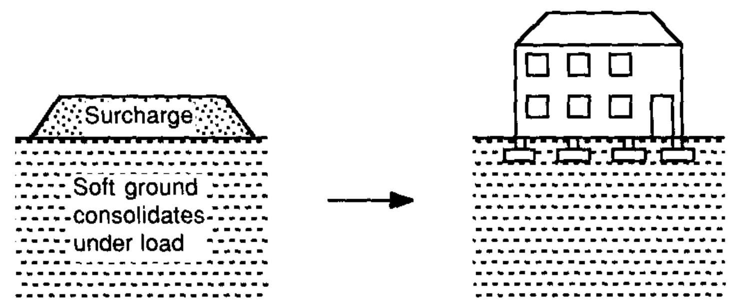
Soft ground causes large settlements



Preloading reduces settlements



Soft ground requires pile foundations



Preloading allows cheaper spread footings

b. Preloading may allow savings in foundation costs

Assessment of Ground Conditions

Data yang diperlukan

- ✓Stratifikasi tanah
- ✓Kondisi aliran air dalam tanah (satu arah / dua arah)
- ✓Koefisien Konsolidasi dan permeabilitas(C_v , k_v)
- ✓Sejarah pembebanan (σ'_c)

Pertimbangan Perencanaan

The criteria of settlement after construction, e.g.: *maximum total settlement of 25 mm (1”) and differential settlement of 10 mm (0.4”), within a period of 6 month after construction*

Bearing capacity or shear strength of foundation soil (in term of maximum height of embankment)

$$H_{cr} = \frac{c_u \, Nc}{\gamma_f \, FS}$$

Time available

JENIS PRELOADING

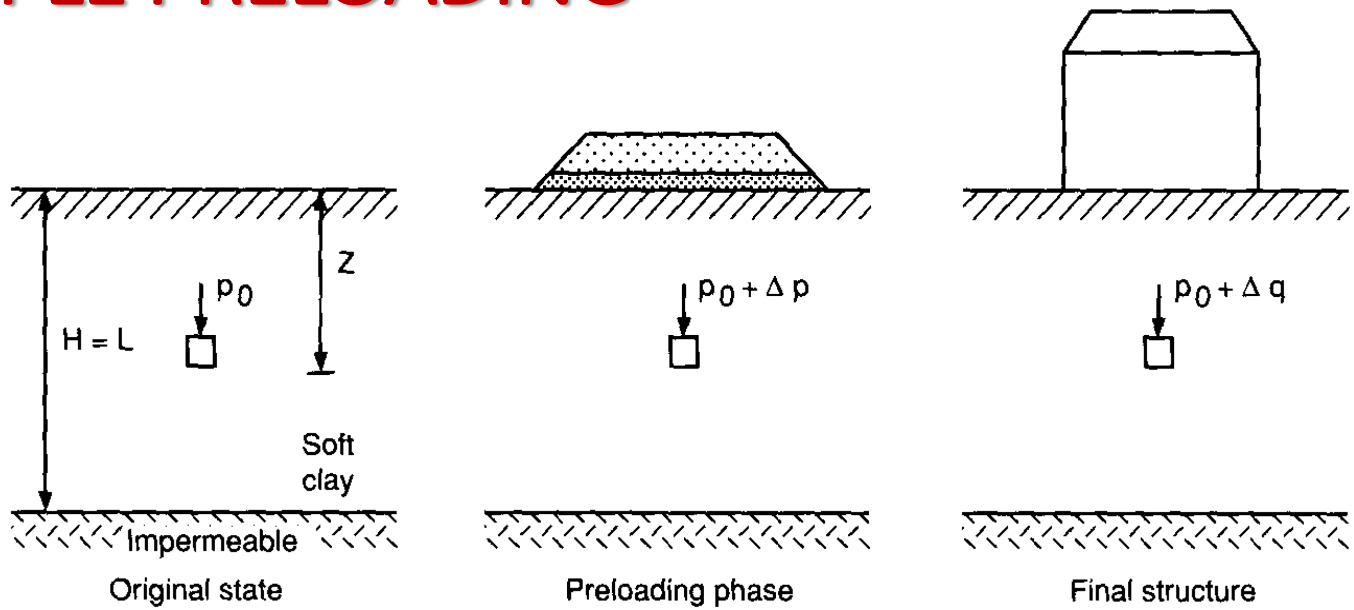
Simple Preloading

Surcharge Preloading

Staged Loading

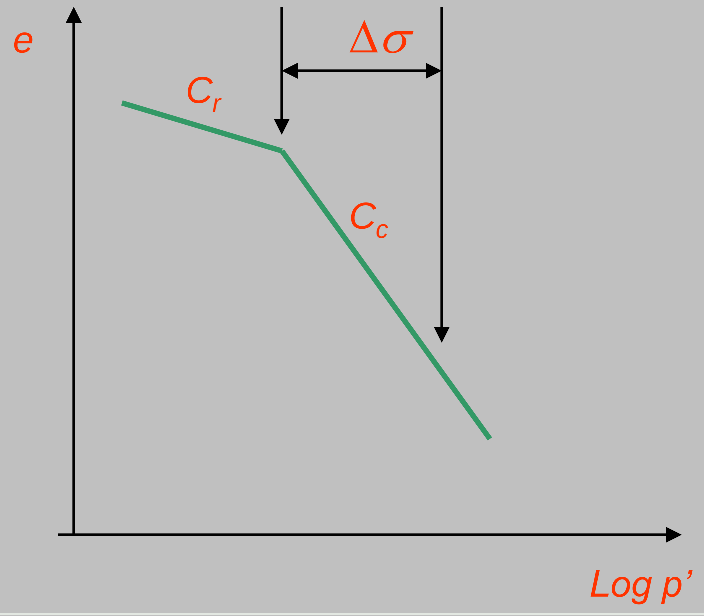
Preloading with Vertical drain

SIMPLE PRELOADING

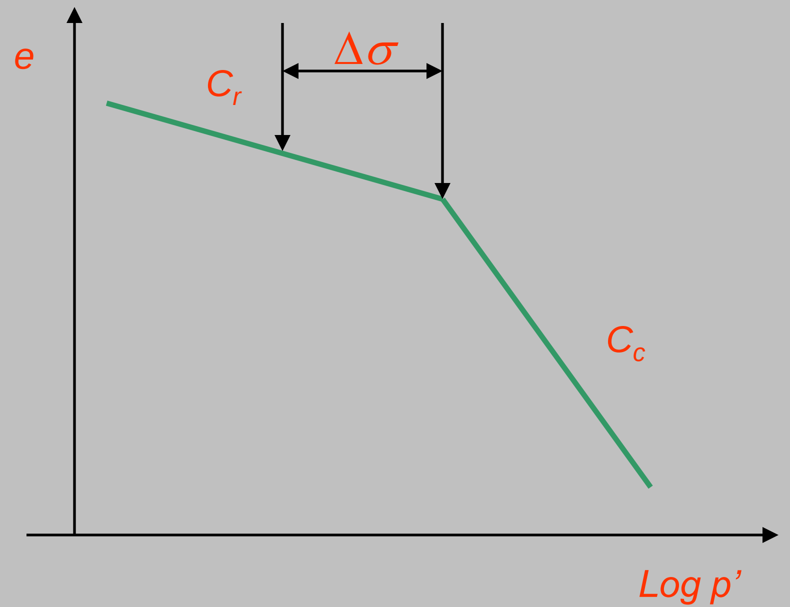


a. Simple preloading of a building site

- A surcharge equal to a future site load is applied ($\Delta p = \Delta q$)
- When consolidation of the foundation soil is reaching **90%** complete, then the surcharge is removed and the new building is erected



$$S_c = C_c \frac{H}{1+e_o} \log \frac{\sigma_o + \Delta\sigma}{\sigma_o}$$



$$S_c = C_r \frac{H}{1+e_o} \log \frac{\sigma_o + \Delta\sigma}{\sigma_o}$$

$$S_c = C_r \frac{H}{1+e_o} \log \frac{\sigma_c}{\sigma_o} + C_c \frac{H}{1+e_{o1}} \log \frac{\sigma_o + \Delta\sigma}{\sigma_c}$$

Perhitungan penurunan tanah

Final settlement due to surcharge:

$$S_{sf} = C_c \frac{H}{1+e_o} \log \frac{\sigma_o + \Delta p}{\sigma_o}$$

Final settlement of the building:

$$S_{bf} = C_r \frac{H}{1+e_o} \log \frac{\sigma_o + \Delta q}{\sigma_o}$$

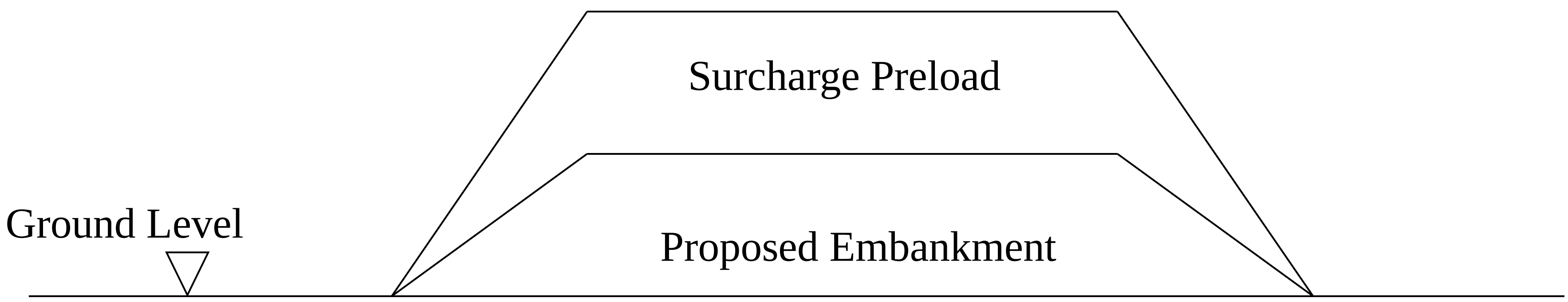
→ Less settlement (in order of 1 tenth)

C_c vs. C_r typical values: $C_c = 0.1 - 0.8$
$C_r/C_c = 0.1 - 0.2$

Empirical formula	Soil type
$C_c = 0.009\,(LL - 10)$	All clay (undisturbed)
$C_c = 0.007\,(LL - 10)$	Remolded soil
$C_c = 1.15\,(e_o - 0.35)$	All clay (undisturbed)
$C_c = 0.30\,(e_o - 0.27)$	An organic soil
$C_c = 1.15 \times 10^{-2}\,\omega_n$	Organic soil
$C_c = 0.75\,(e_o - 0.50)$	Low plasticity soil
$C_c = G_s \dfrac{PI}{200}$	Wroth & Wood (1978)

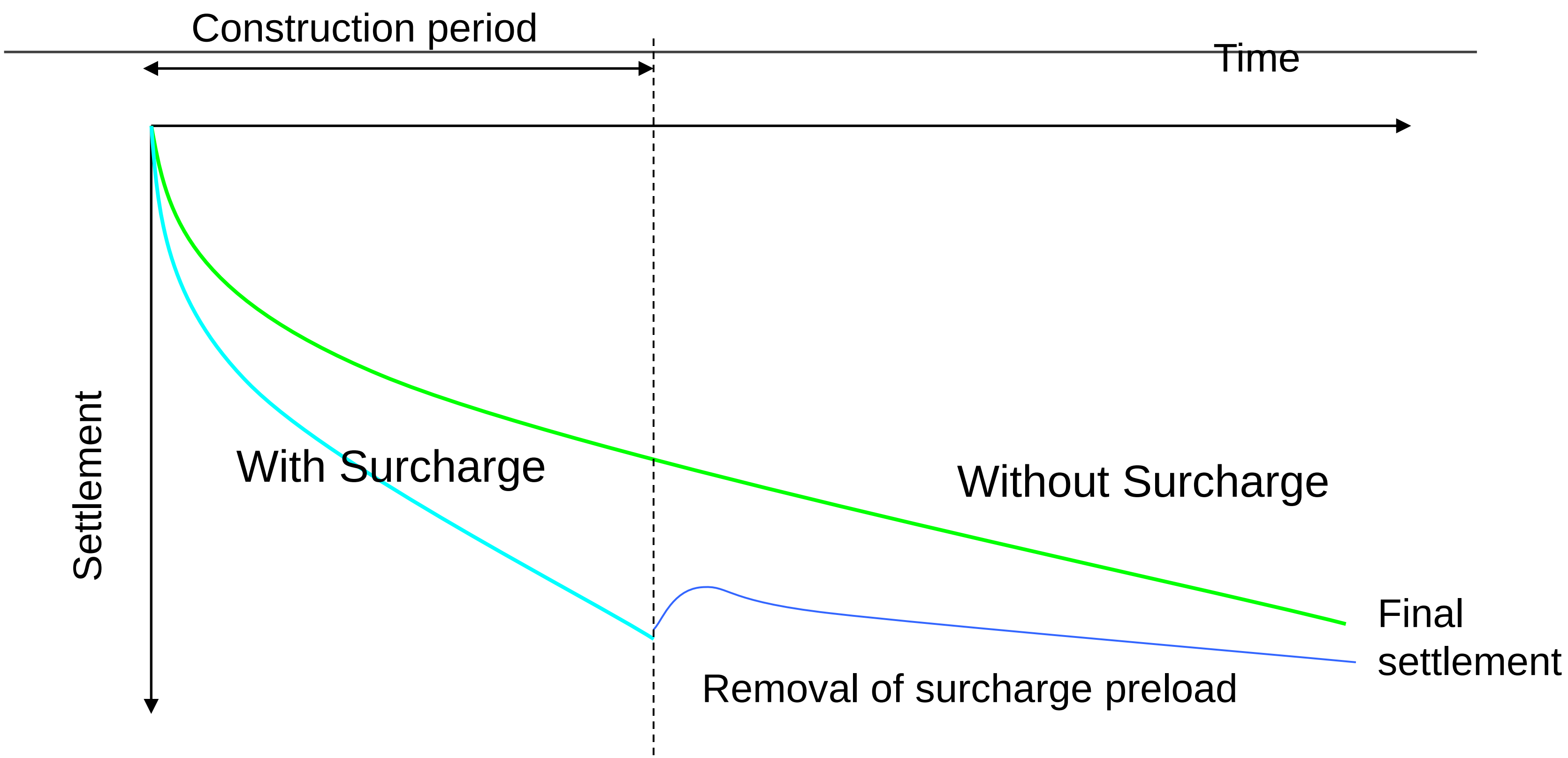
There are other relationships in textbooks

SURCHARGE PRELOADING

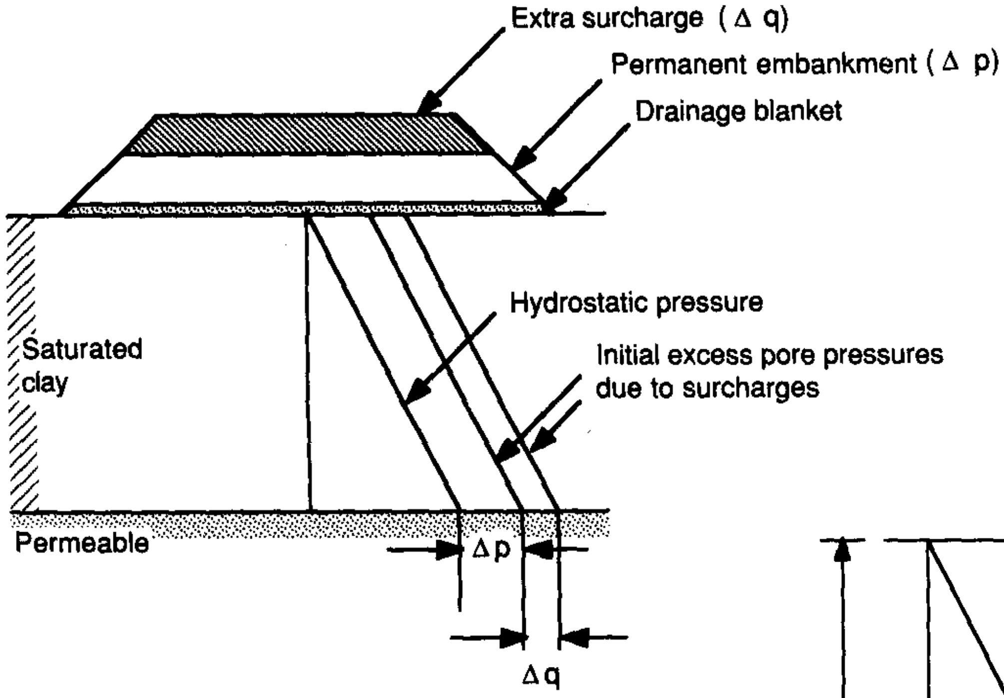


A permanent load (Δp) + surcharge (Δq) is placed, then after a certain period of time surcharge is removed

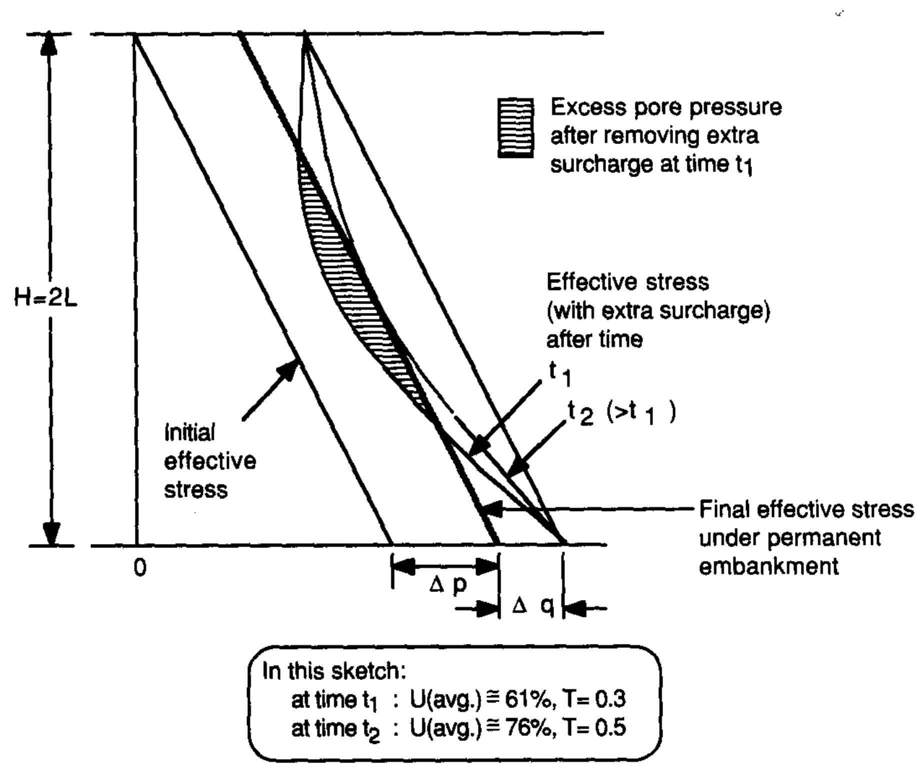
Effect of Surcharge on Final Settlement



Effect of surcharge on excess pwp



a. Initial pore pressures



b. Effective stresses

Rate of Consolidation

Settlement at time *t*

$$S_t = U_v S_f$$

U_v = degree of consolidation (vertical direction) which can be correlated with the time factor T_v

$$T_v = \frac{C_v t}{H_d^{\,2}}$$

$U_v < 60\% \rightarrow T_v = (\pi/4)\, U^2$

$U_v > 60\% \rightarrow T_v = -0.933 \log(1-U) - 0.085$

$= 1.781 - 0.933 \log(100\% - U\%)$

t = time (sec)

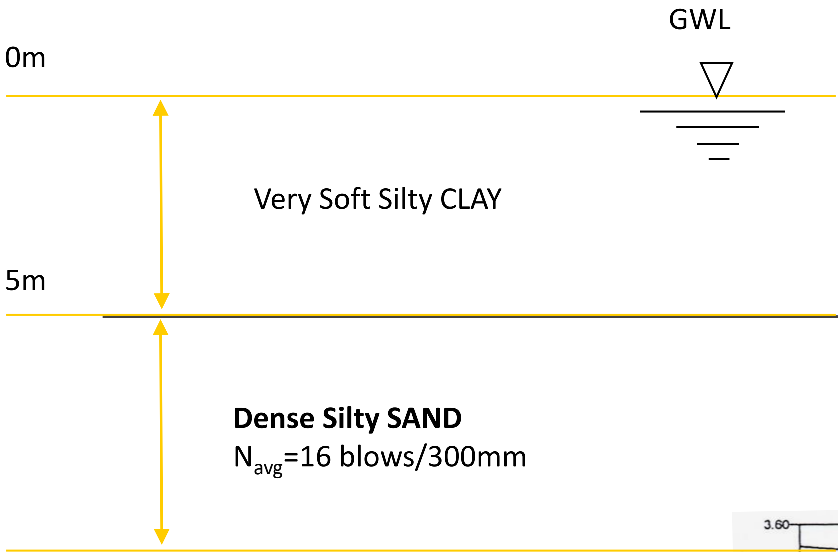
C_v = coefficient of vertical consolidation (m^2/sec)

H = length of drainage paths

Perhitungan muatan surcharge

1. Calculate S_{pf} and $S_{p+q\ (f)}$ for an assumed q value
2. $S_{p+q\ (t)} = x\ S_{pf}/100$
3. $U_v = S_{p+q\ (t)} / S_{p+q\ (final)}$
4. Find T_v for given U_v
5. $t_{calc} = T_v\ H_d^2/C_v$
6. If $t_{calc} > t$; increase q

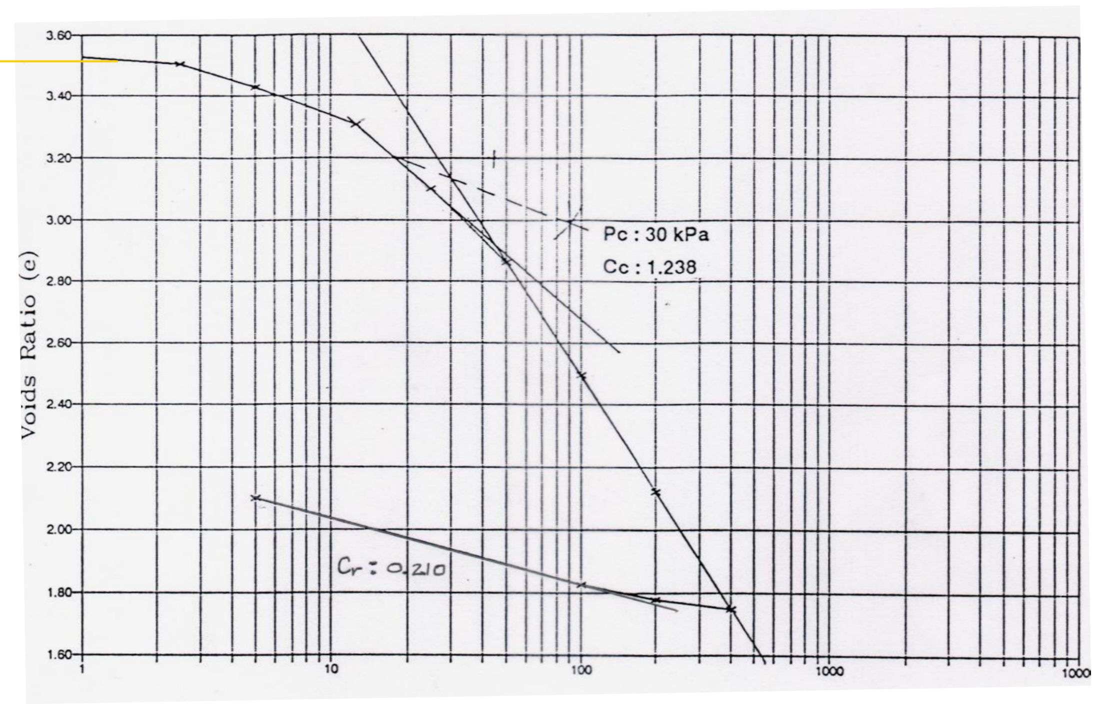
   If $t_{calc} < t$; decrease q
7. Repeat calculations until If $t_{calc} = t$

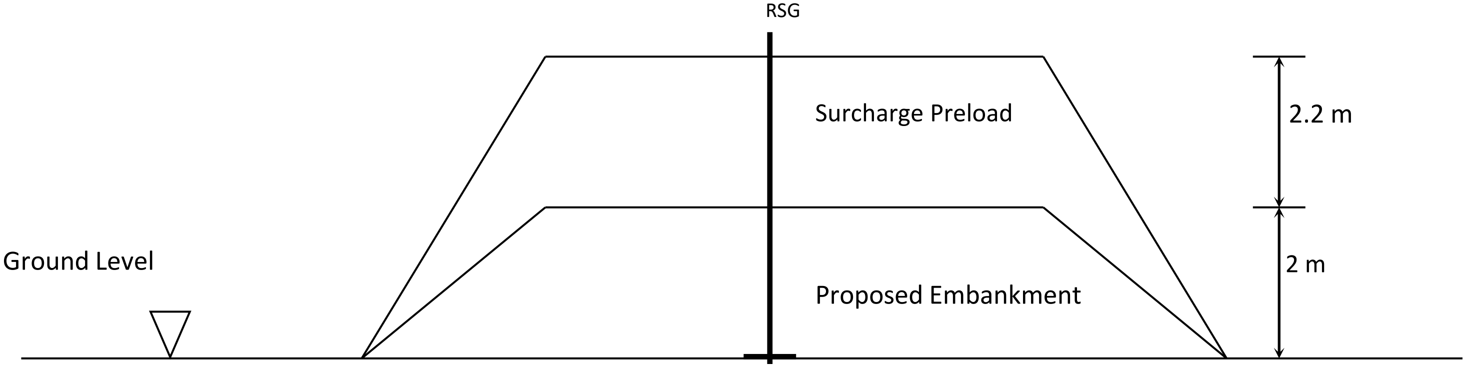


Very Soft Silty CLAY

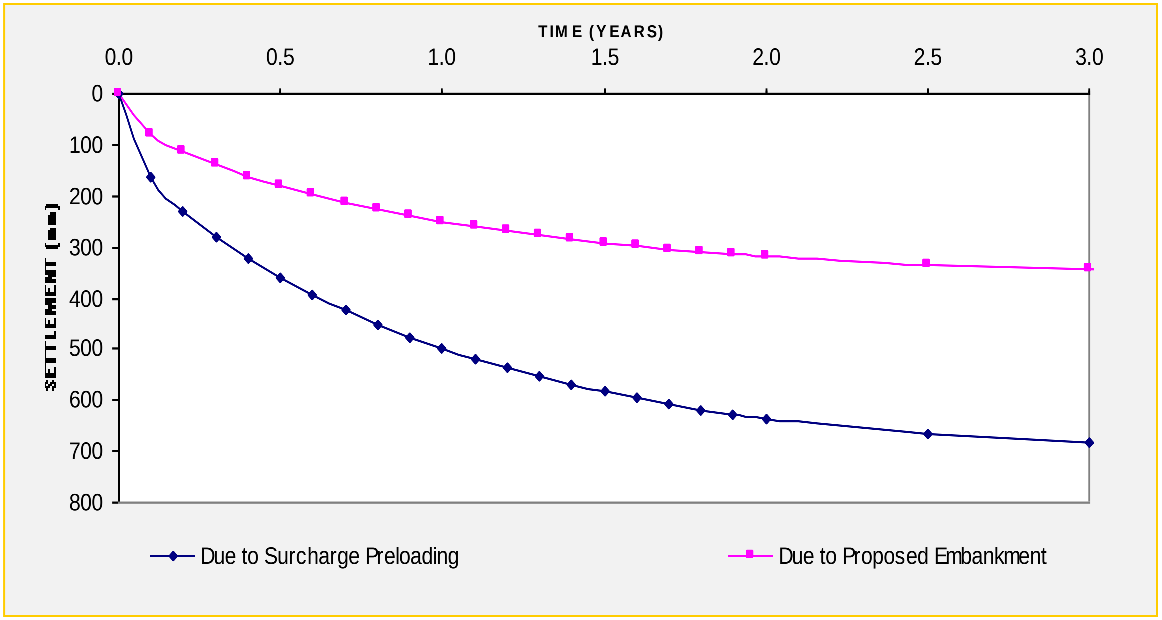
N_{avg}	=	Hammer Weight
γ	=	15 kN/m3
LL	=	75%
PL	=	42%
PI	=	33%
P_c	=	30 kPa
C_c	=	1.238
C_r	=	0.210
e_o	=	3.573
CR	=	0.271
RR	=	0.046
C_v	=	2.5 m^2/yr

CONTOH SOAL aplikasi





Drainage condition : Two way drainage



For 2 m embankment:

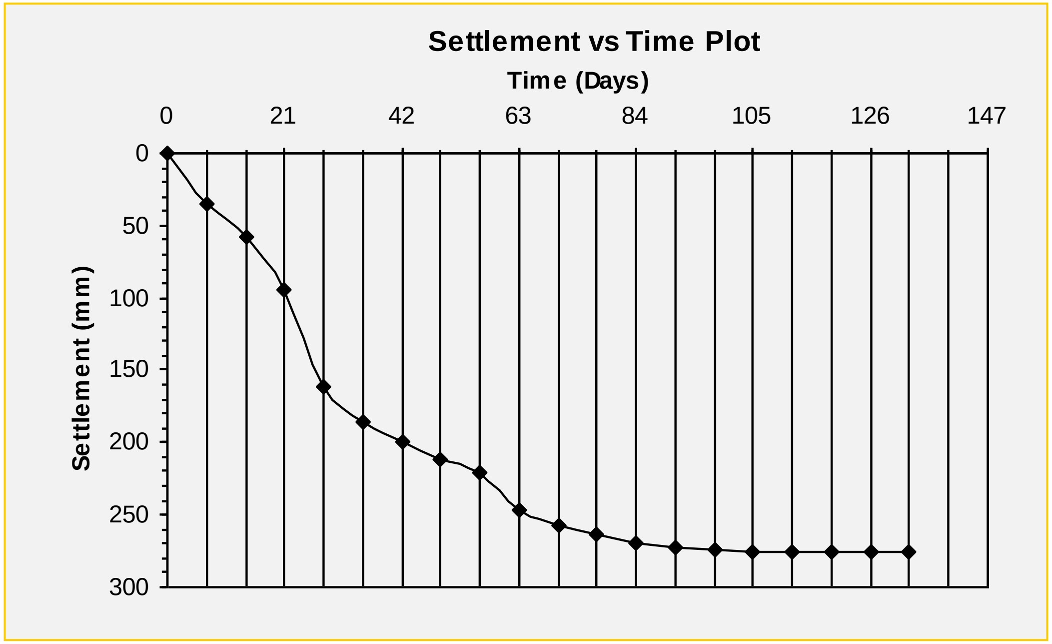
Total settlement = 359.3 mm

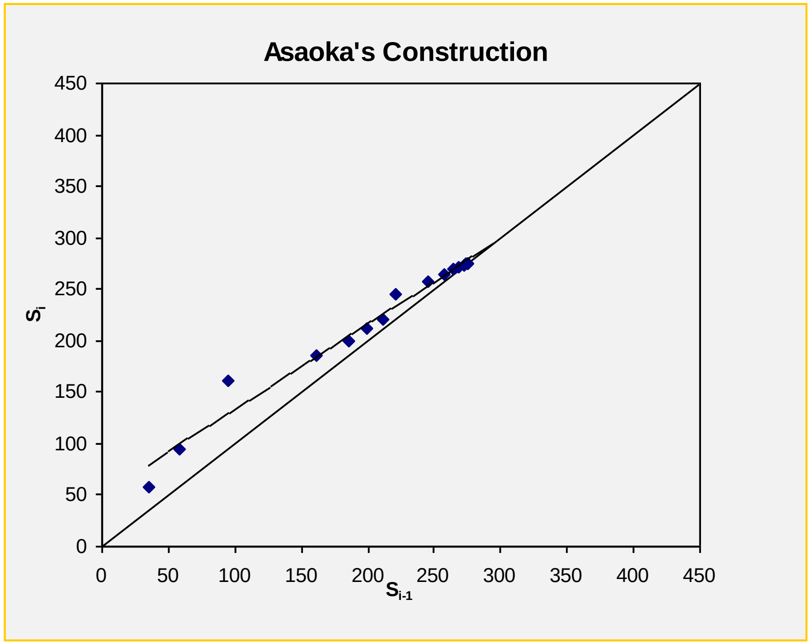
Time for 90% Consolidation Settlement = 2.1 years

With 2.2 m surcharge preload:

Time for total settlement to occur = 0.5 years

To be scraped off = 1.84 mm





Based on the comparisons of estimated and observed settlements, the following conclusion is drawn:

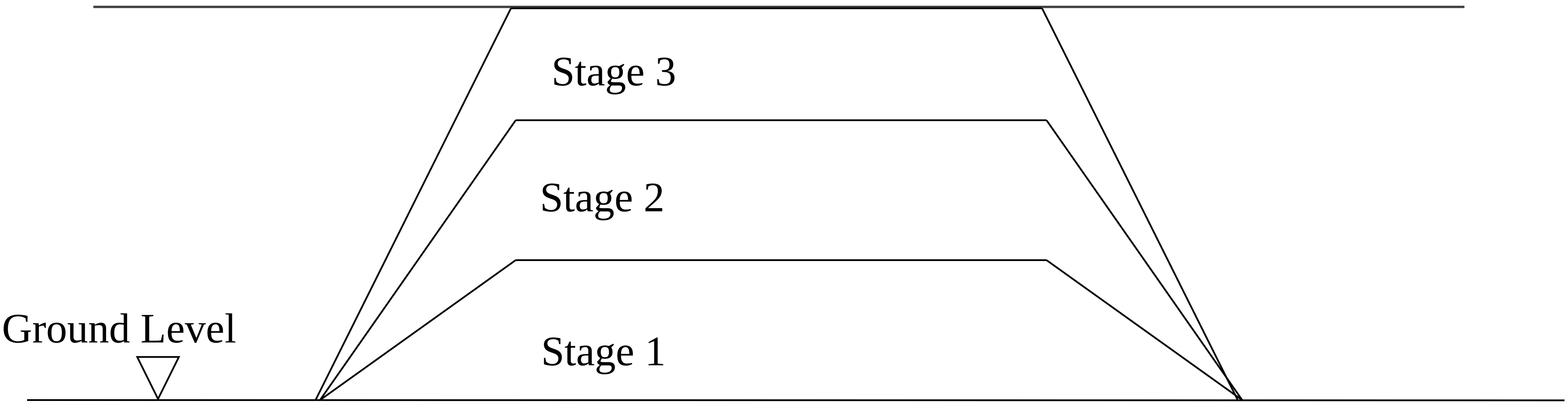
- Most of the settlements completed in 3.4 months.
- the difference between the estimated and observed settlement is about 30%.
- the rate of consolidation was much faster than anticipated.
- the accelerated rate of consolidation may be due primarily to irregular sandy seams within the clay layer. Thus reduces the drainage path distance significantly.

$$m = \tan^{-1}\beta$$

$$C_v = \frac{-5H^2}{12\Delta t}\ln\beta$$

Computed $C_v = 11 m^2/yr$

STAGED LOADING



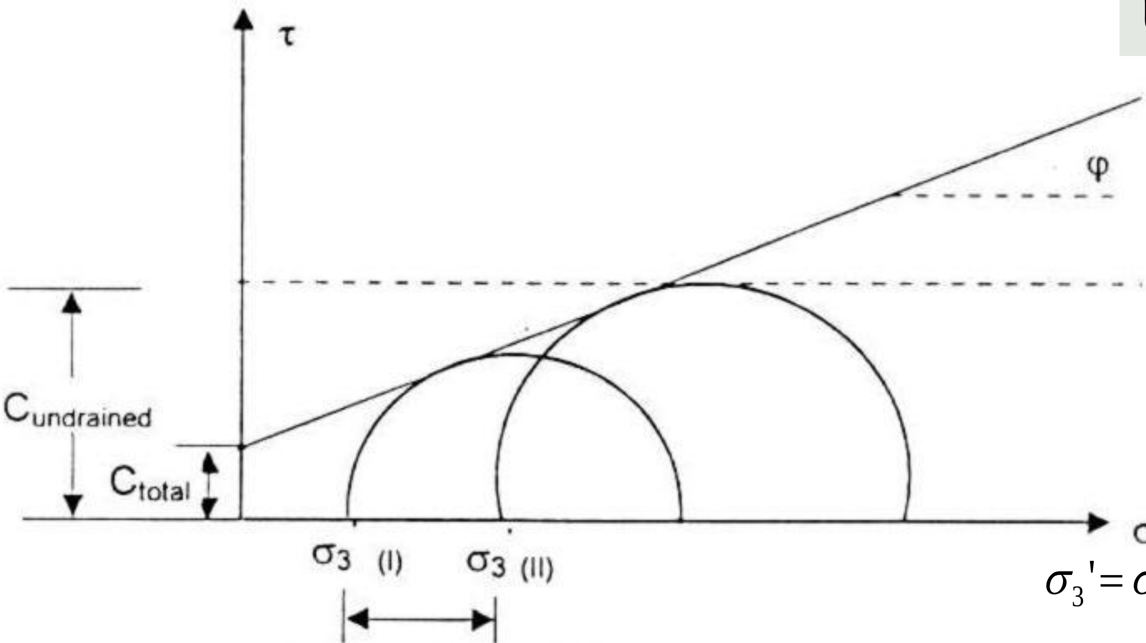
Staged construction may be considered for construction covers large area whereby waiting time could be used for other activities, biggest advantage is the increase in shear strength.

Peningkatan Kekuatan Geser Tanah

From CU Triaxial testing

Undrained shear strength

$$C_u = (\sigma_1' - \sigma_3')/2$$



$$\sigma_3' = \sigma_v' \left(\frac{1 + 2K_0}{3} \right)$$

$$\sigma_1' = 2c_u \tan(45 + \phi/2) + \sigma_3' \tan^2(45 + \phi/2)$$

Increase in effective stress

Determination of c_u from undrained Triaxial testing

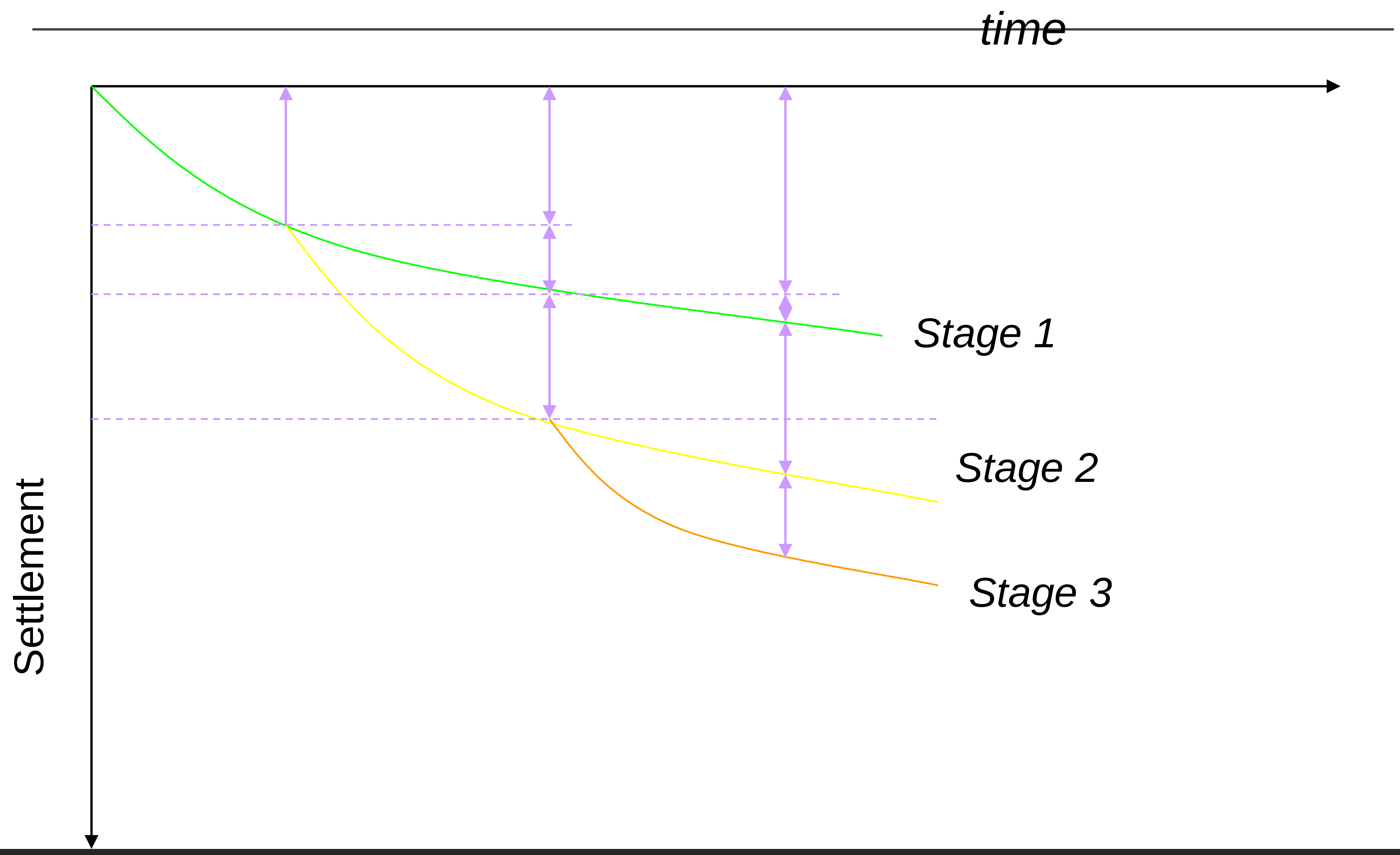
Peningkatan kekuatan geser tanah, Korelasi

Empirical correlation Increase in strength due additional overburden pressure after $U_{90\%}$ is reached:

$(\Delta C_u / \sigma'_o) = 0.11 + 0.0037\, I_p$ (Skempton)

$(\Delta C_u / \Delta\sigma) = 0.22$ (Ladd) for inorganic clay

Load-settlement relationship for different *t*



In staged construction, load can be added at any time, however it is better to wait for 90% consolidation of the previous loading stage. Settlement of each loading stage should be added when calculating the final settlement (see figure)

It should be noted that the increase in shear strength only take effect when the consolidation reached almost 100% (take 90%)

thank you