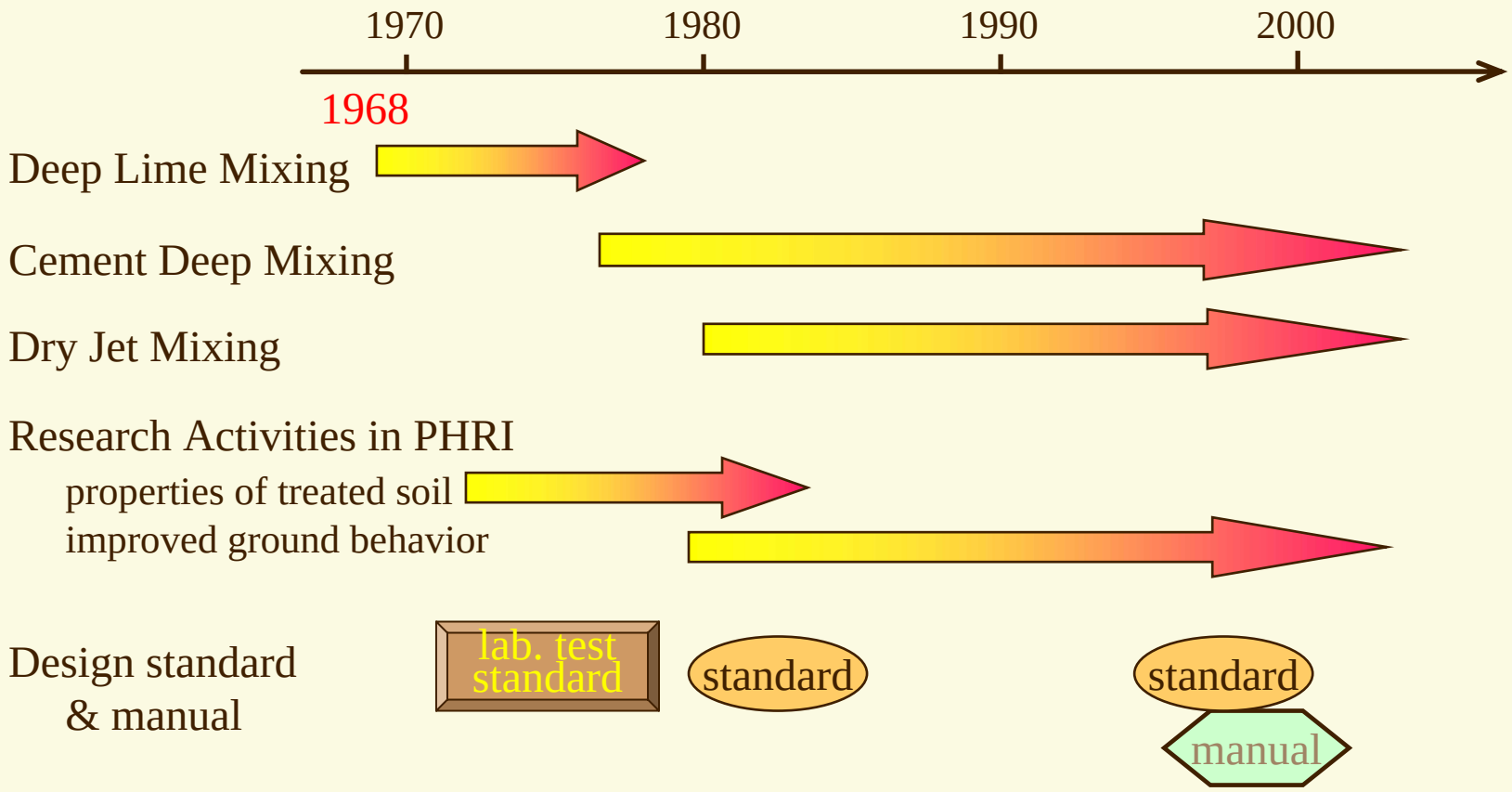
Deep Mixing Method

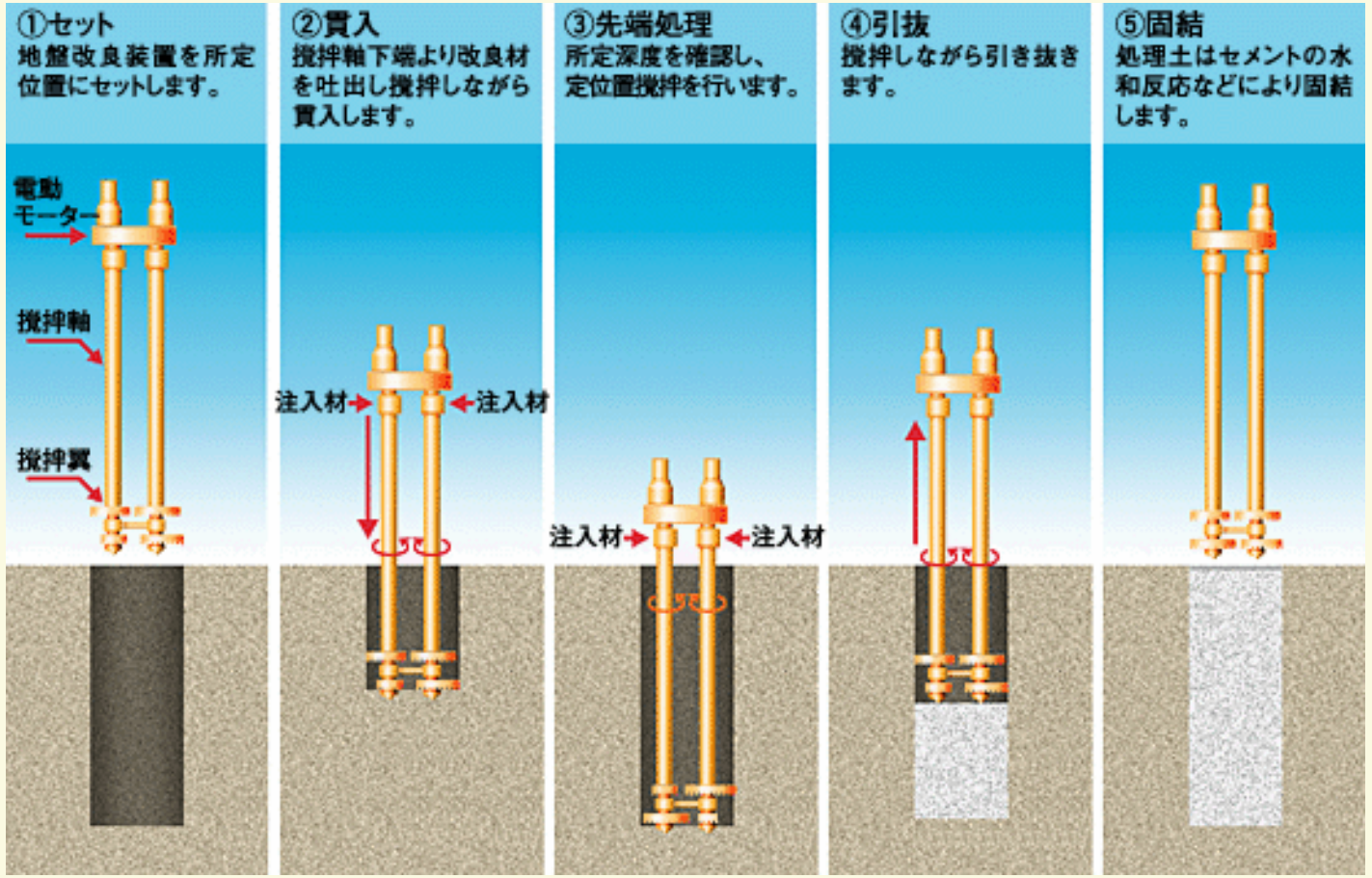
Masaki KITAZUME

Deep Mixing Method

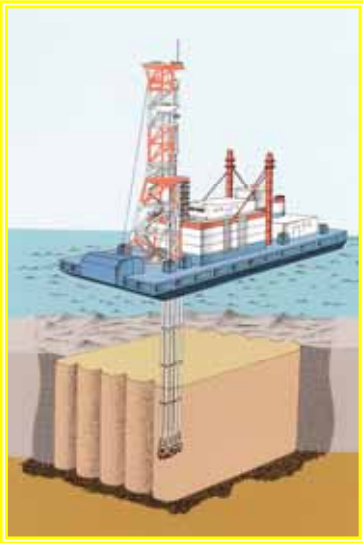
-historical review of R&D in Japan-

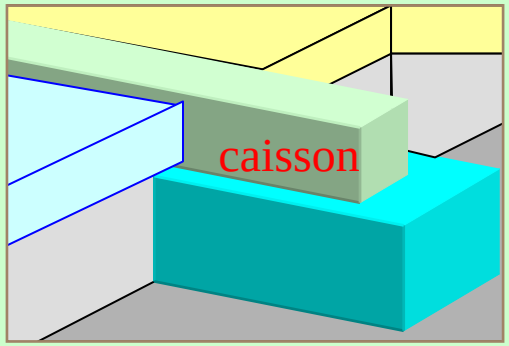


execution procedure

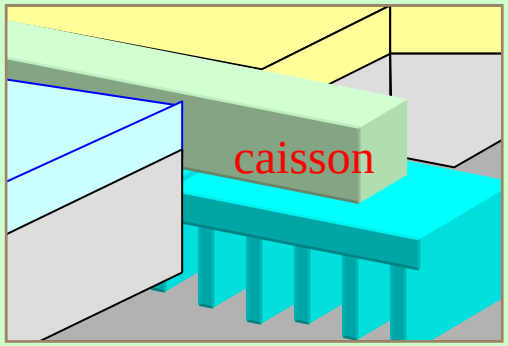


improvement pattern

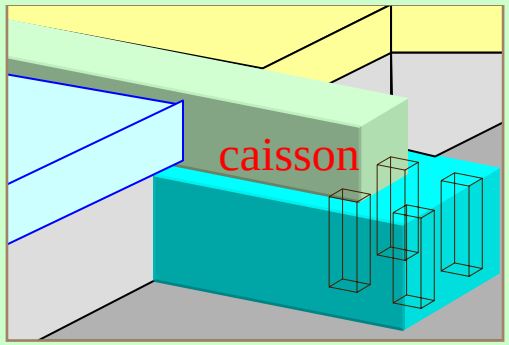




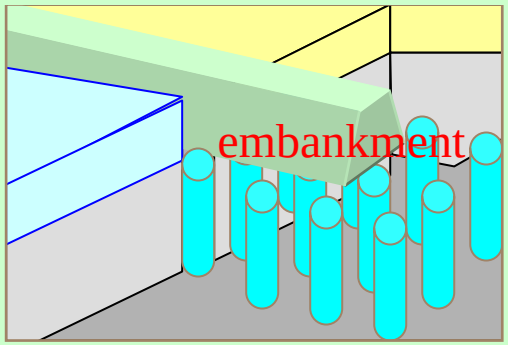
Block type



Wall type



Lattice (Grid) type



Group column type

comparison of improvement pattern

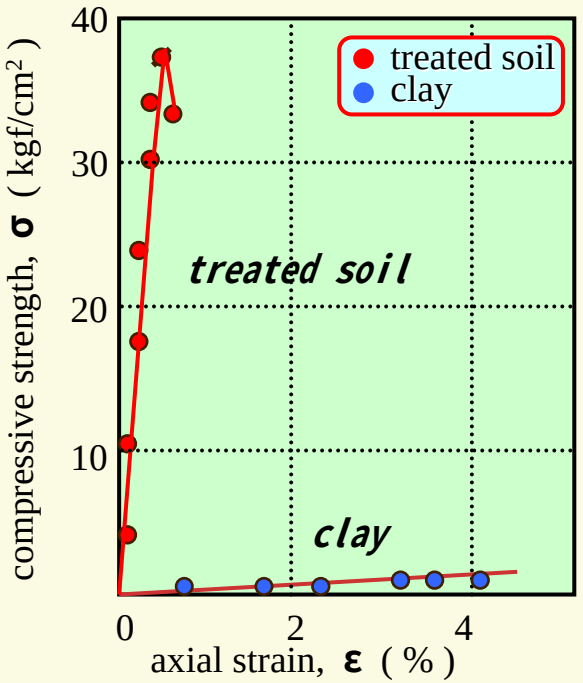
improvement type	stability	cost	installation
block	highly stable	high cost	takes longer time due to overlapping
wall	high stable	lower cost	requires precise operation
lattice (grid)	high stable	between block & wall type	requires complicated sequences
group column	stable when lateral force is small	low cost	requires no overlapping

basic concept of design procedure for block & wall types

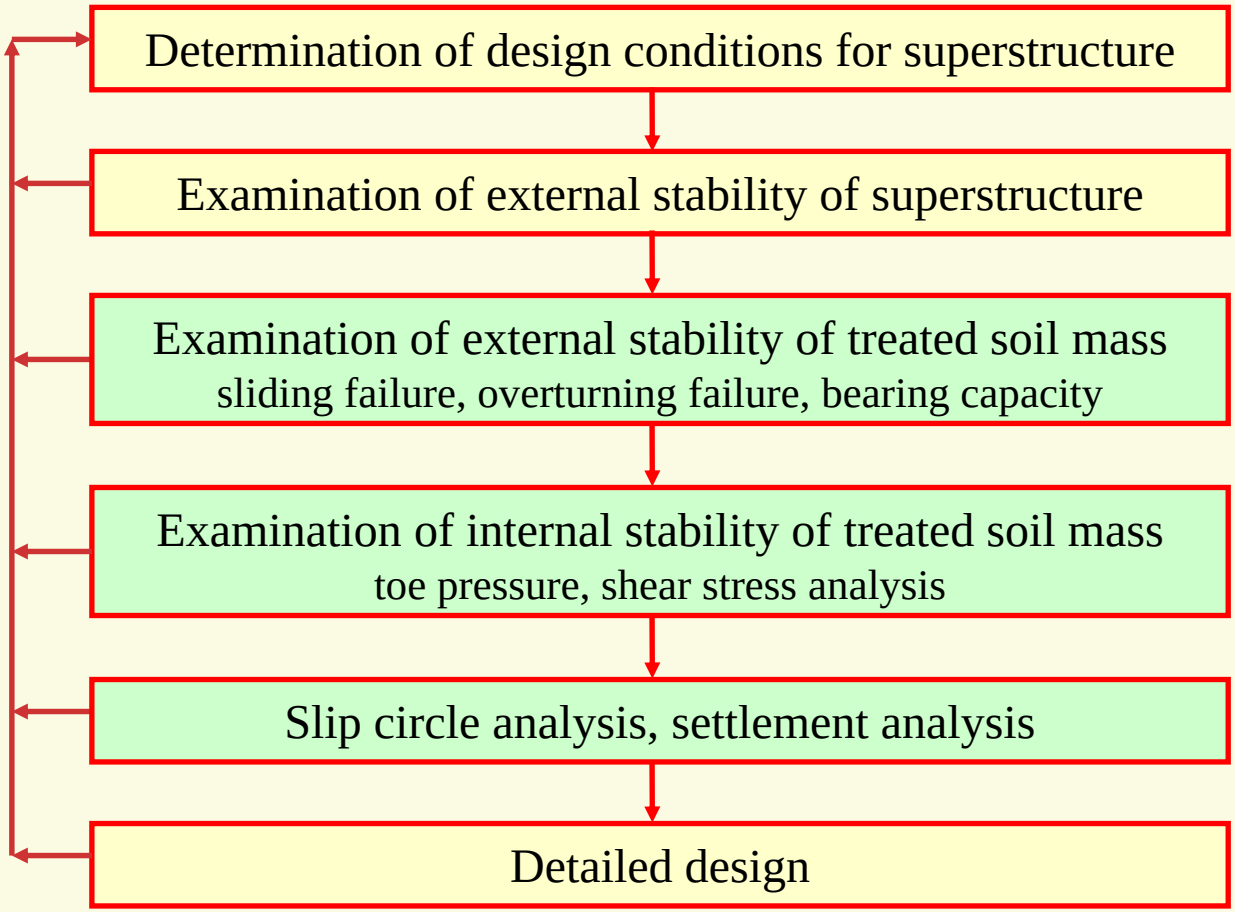
improved ground is considered as a rigid structural member

Large difference of engineering characteristics between treated & untreated soils

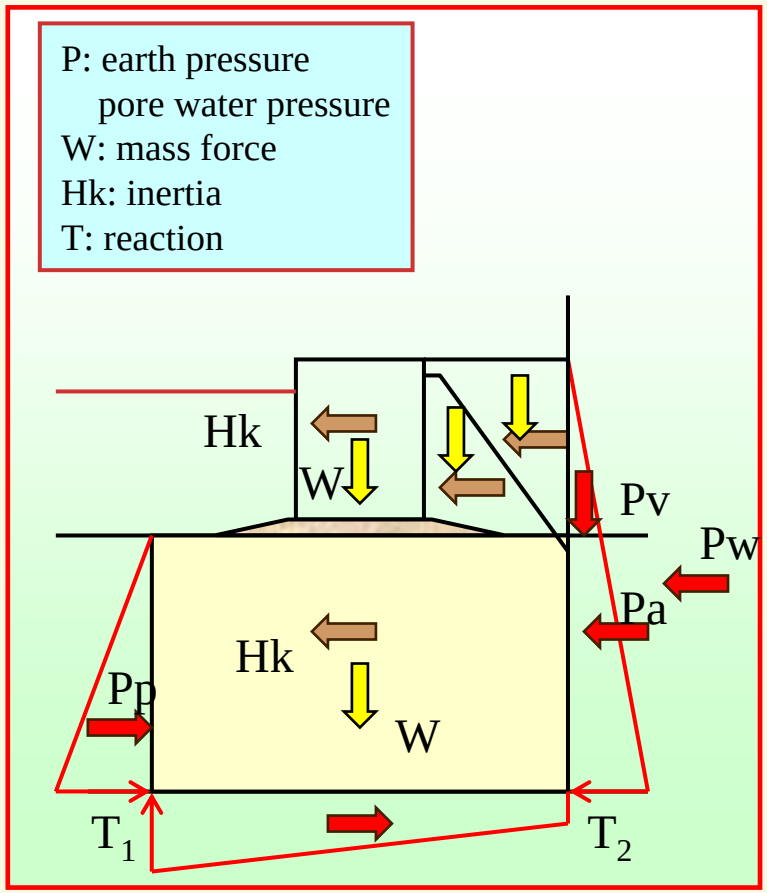
- high unconfined compressive strength
- small strain at failure
- low tensile and bending strength
- low permeability



Design procedure for block / wall type improvement



stability calculations
- external stability -



Safety factor for sliding failure

$Fss = (Pp+Fr) / (Pa+Pw+ \Sigma Hki)$

> 1.2 (for static), 1.0 (for dynamic)

Safety factor for overturning failure

$Fso= \Sigma M_R / \Sigma M_A$

> 1.2 (for static), 1.1 (for dynamic)

Bearing capacity

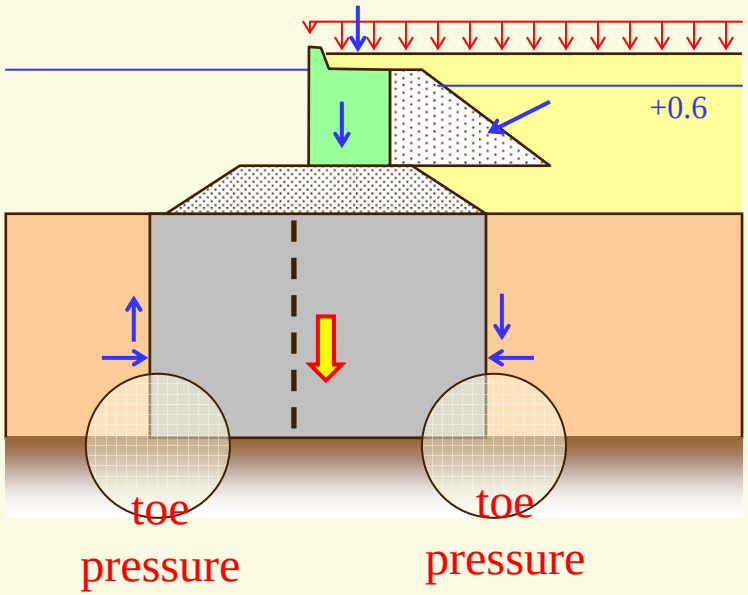
$T_1, T_2 = W/B * (1 \pm 6e/B)$ for $e \leqq B/6$

$T_1 = 2W/3X$ for $e \geqq B/6$

< 60 ton/m^2 (for static)

< 90 ton/m^2 (for dynamic)

stability calculations
- internal stability -



allowable strength

$\sigma ca = \alpha\ \beta\ \gamma\ quf / Fs = \alpha\ \beta\ \gamma\ \lambda\ qul / Fs$

$\tau a = \sigma ca / 2$

$\sigma ta = 0.15 * \sigma ca \leqq 200\ kN/m^2$

where

σca : allowable compressive strength

τa : allowable shear strength

σta : allowable tensile strength

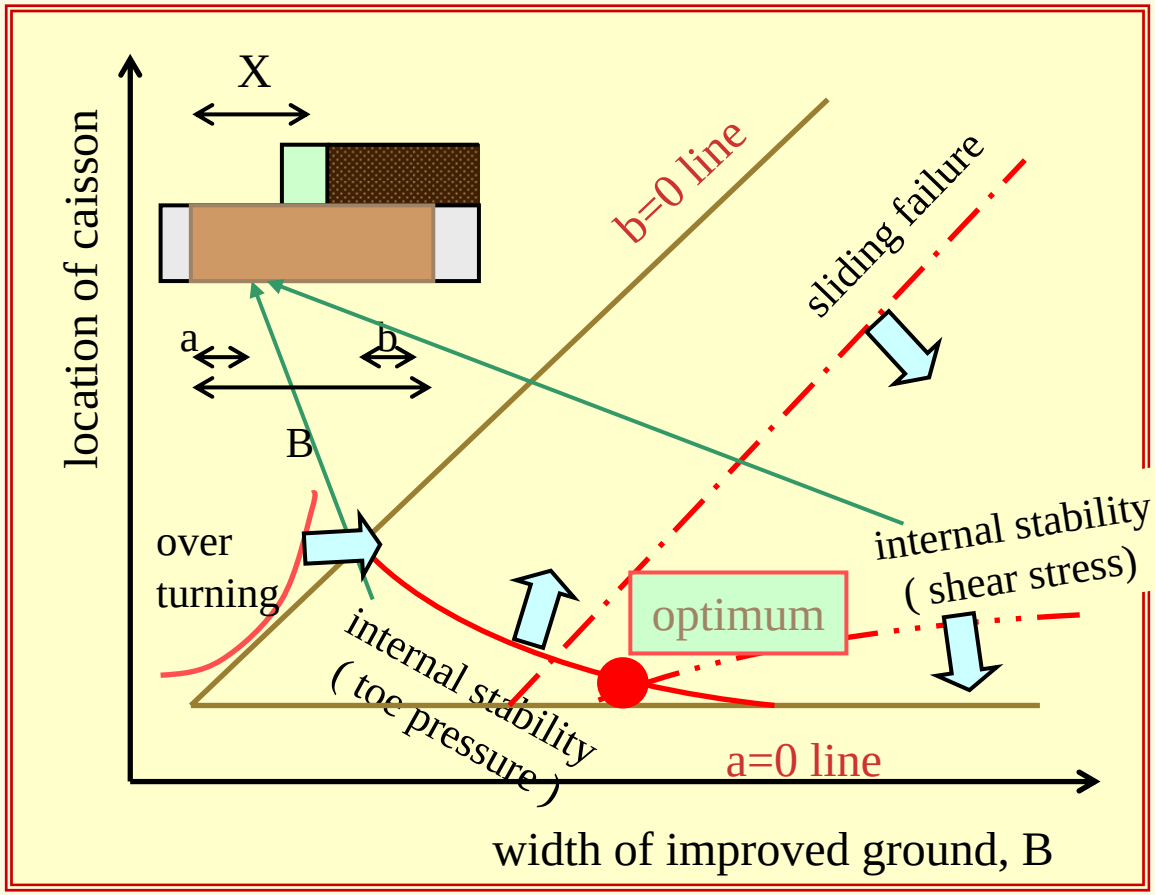
quf : average unconfined compressive strength of treated soils at site

qul : average unconfined compressive strength of treated soils manufactured in laboratory

α, β, γ, λ : coefficients

Fs : factor of safety

optimum design



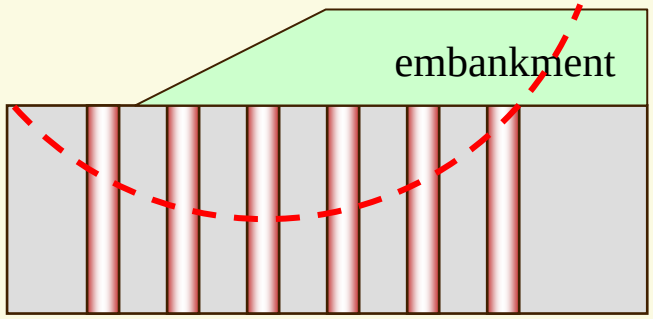
Design concept for group column type improvement

Improved ground can be considered as a composite ground consisting of stabilized columns and soft soil.

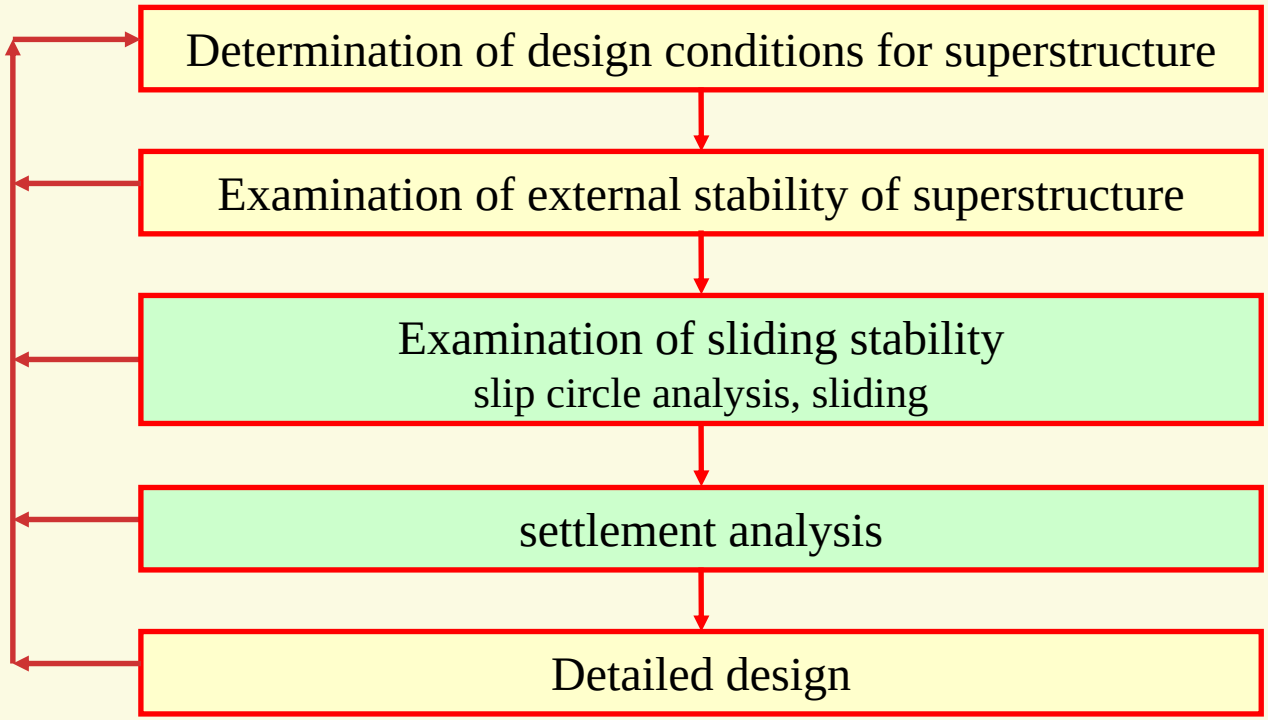
For assure composite ground,
stabilized columns should be

- low strength of less than 500 kN/m^2
- replacement ratio is larger than 0.5

The slip circle calculation in the current design can overestimates the stability
(Kitazume et al., 2000).



Design procedure for group column type improvement



stability calculation

average shear strength of improved ground

$$\tau = ap \cdot cu_p + (1 - ap) \cdot cu_{00}$$

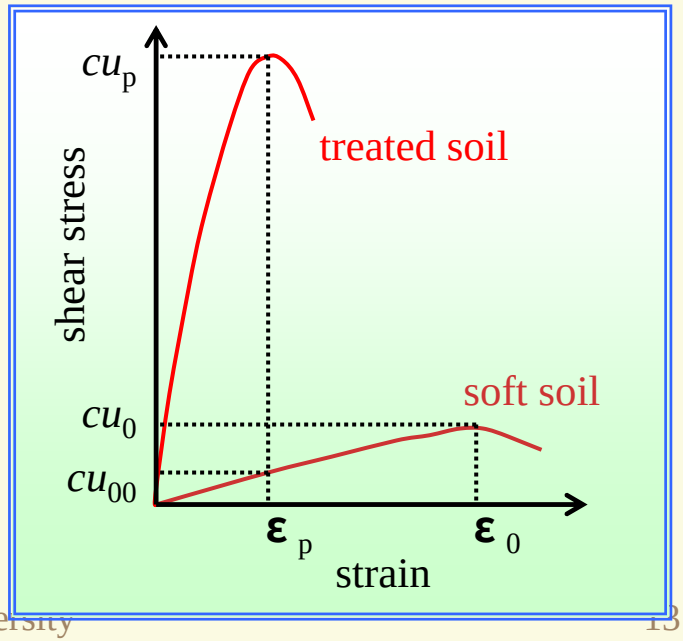
where

ap: replacement area ratio

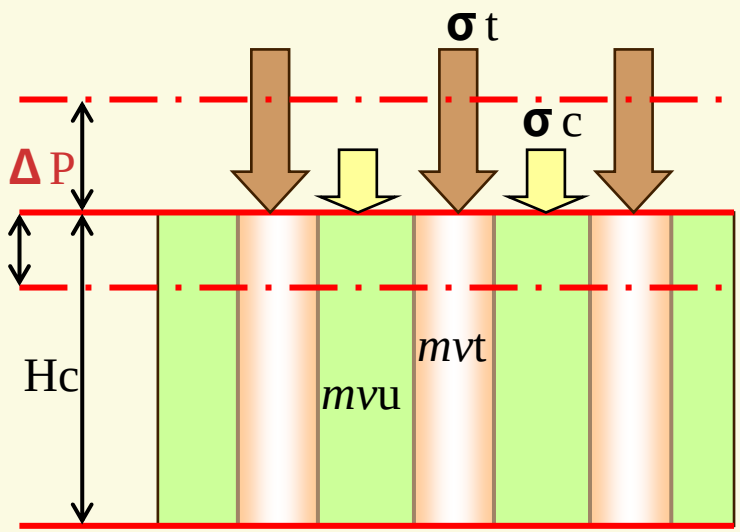
cu_p: shear strength of treated soil

cu_0: shear strength of soft soil

cu_{00}: shear strength of soft soil mobilized at a peak of treated soil



settlement calculation



settlement of improved ground

$S = \beta S_0$

$\beta = \sigma c / \sigma$

$= 1/((n-1) \cdot ap + 1)$

$S_0 = mvu \cdot Hc \cdot \Delta P$

where

n : stress concentration ratio

$= \sigma t / \sigma c$

$= mvu / mvt$

CDM improvement volume