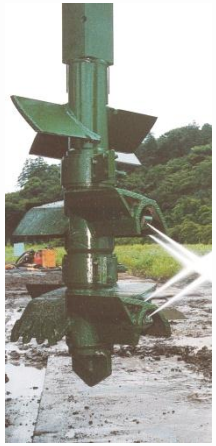
QA/QC for deep mixing method

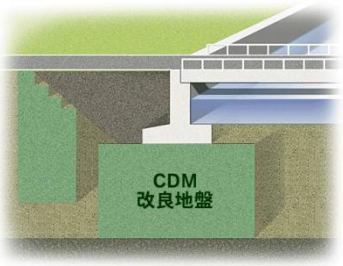
Masaki Kitazume
Tokyo Institute of Technology

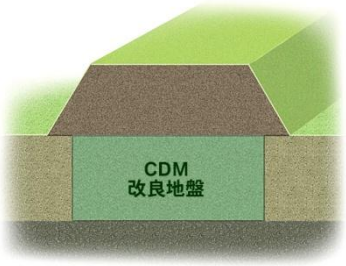
Deep Mixing Method

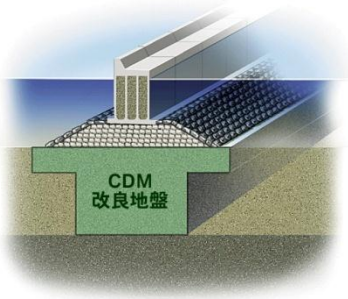


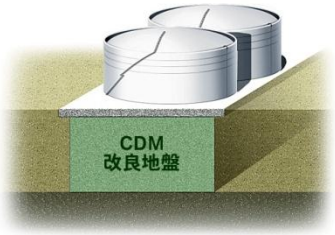
- Deep Mixing method
  - Mechanical mixing
    - Slurry type (wet method) — Cement slurry
      - CDM method
        - CMC method
        - DCM method
        - POCOM method
        - Demmick method
        - DECOM method
        - Oval-DM method
      - Tenocolumn method; MR-D method; JST method; SWING method; 5 others
    - Powdery material type (dry method)
      - Lime — DLM method
      - Pulverized cement — DJM method
  - Combination of mechanical and high pressure injection (cross-jet compound mixing) — JACSMAN
  - High pressure injection
    - Grout injection — Cement slurry
      - CCP method
      - Minimax method
      - JMM method
    - Air and grout injection — Cement slurry — JSG method
    - Water, air and grout injection — Cement slurry
      - Column jet grout method
      - SSS-MAN method
      - TSK method

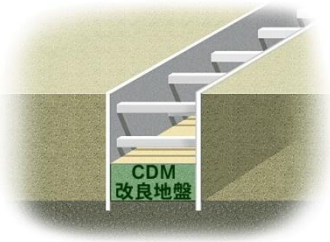
Applications of Deep Mixing

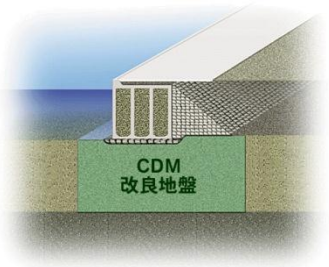










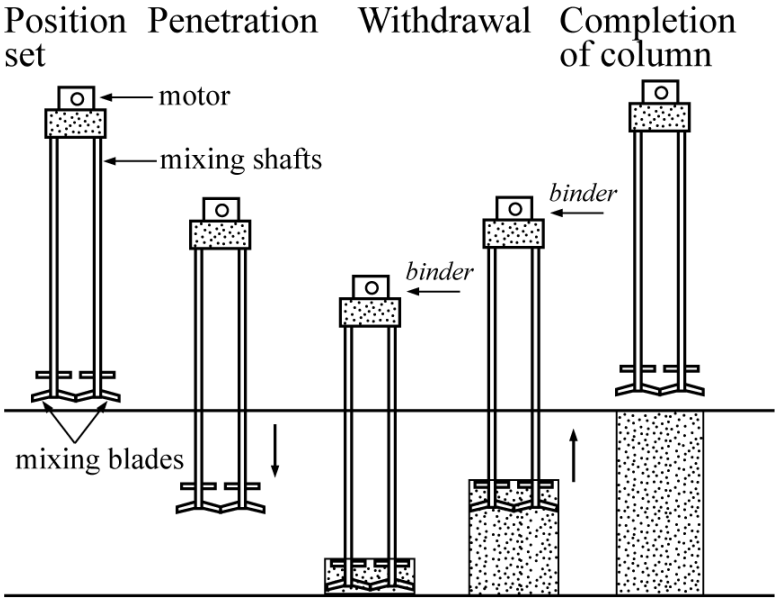


improvement purpose:
increasing bearing capacity and stability
decreasing settlement
preventing liquefaction, etc.

Factors affecting the strength increase

I.	Characteristics of stabilizing agent	1. Type of stabilizing agent 2. Quality 3. Mixing water and additives
II.	Characteristics and conditions of soil (especially important for clays)	1. Physical chemical and mineralogical properties of soil 2. Organic content 3. pH of pore water 4. Water content
III.	Mixing conditions	1. Degree of mixing 2. Timing of mixing/re-mixing 3. Quantity of stabilizing agent
IV.	Curing conditions	1. Temperature 2. Curing time 3. Humidity 4. Wetting and drying/freezing and thawing, etc.

QA/QC during execution



monitor and control the position of column, speed of shafts, rotation speed of mixing blades, volume of binder, etc. to assure continuity and design strength of stabilized column

QA/QC after execution

core sampling

vane penetration test

wet grab sampling

measure strength and stress - strain curve of stabilized soil

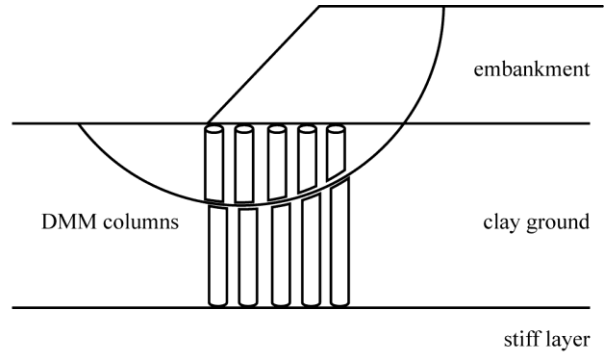
remind whether the measurements assure the function of improved ground ?

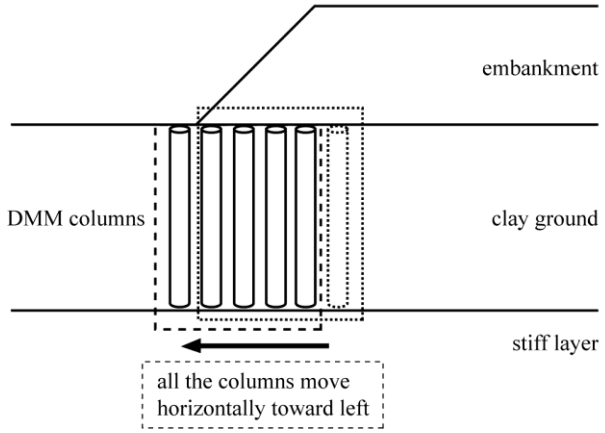
Current design method for embankment stability

assumed failure pattern

slip circle failure for internal stability

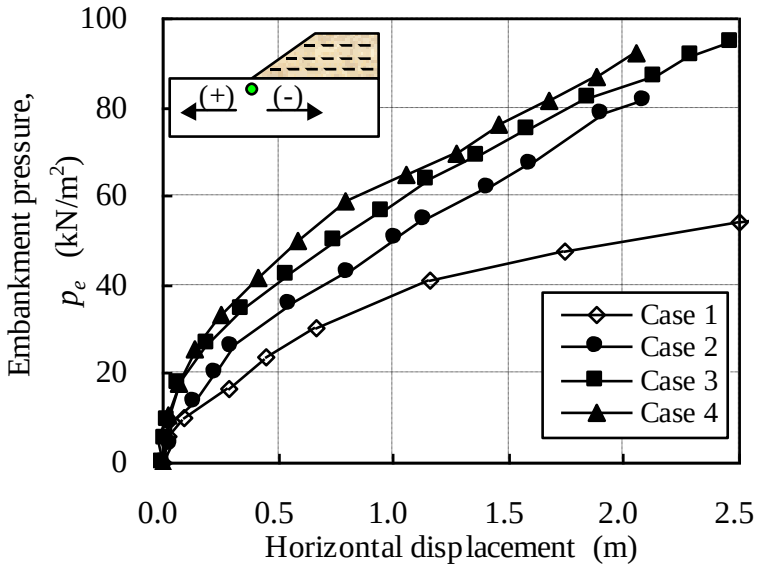
sliding failure for external stability



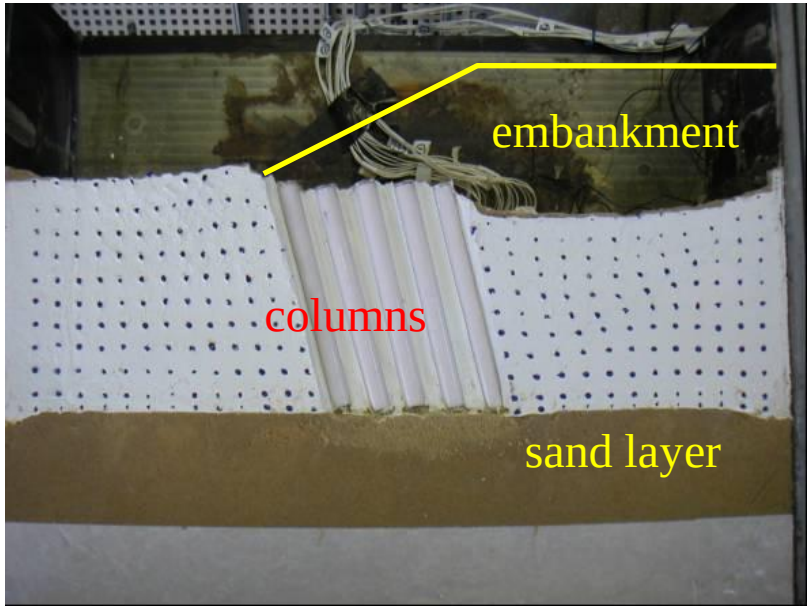


Failure pattern – for external stability –

embankment - horizontal displacement

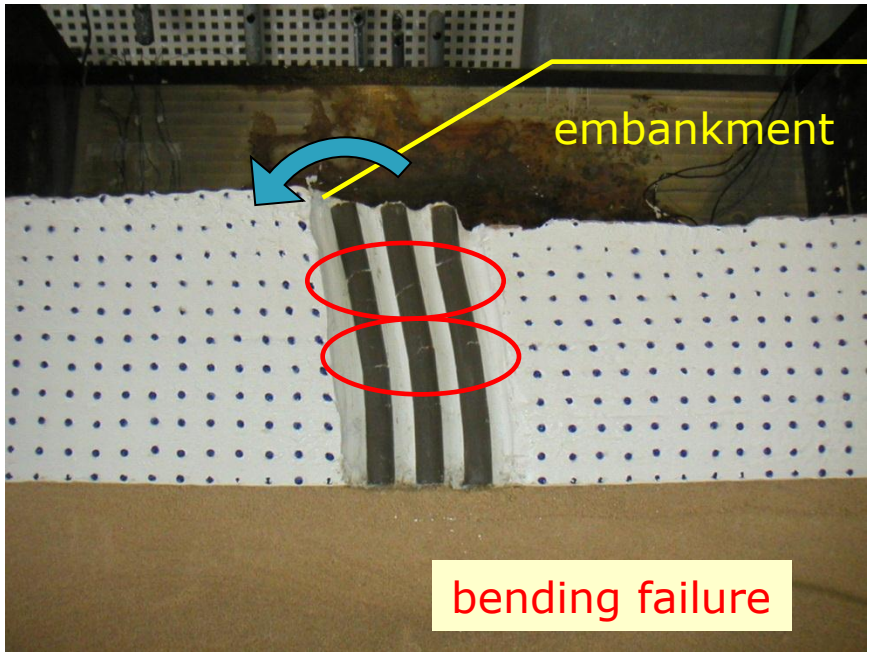


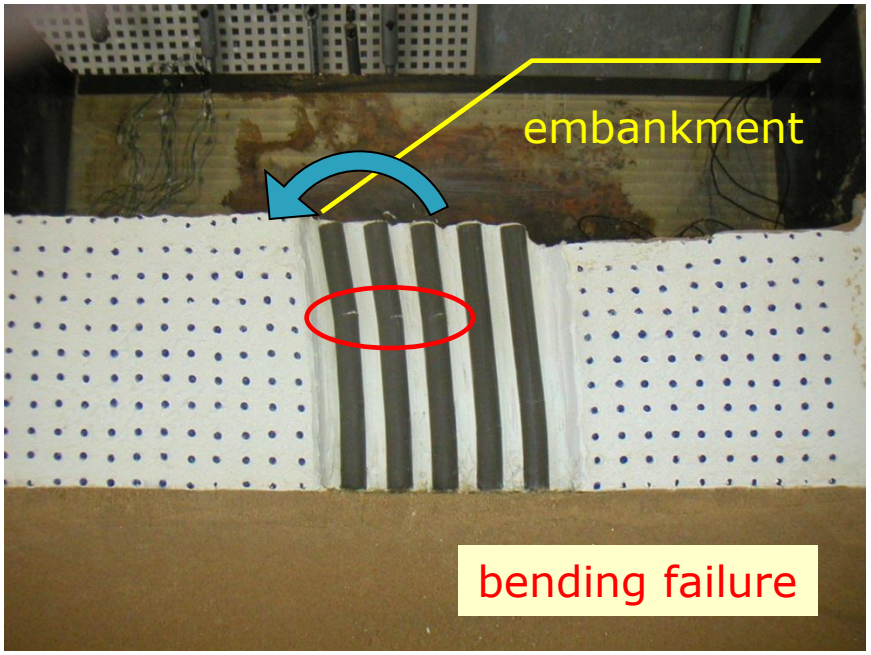
failure pattern



Overturning failure

Failure pattern – for internal stability –





Failure pattern – FEM analyses –

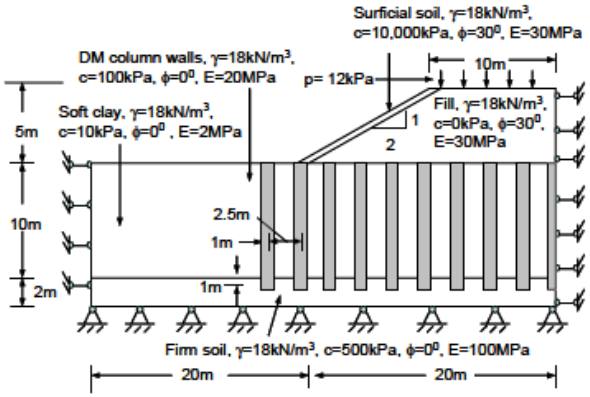
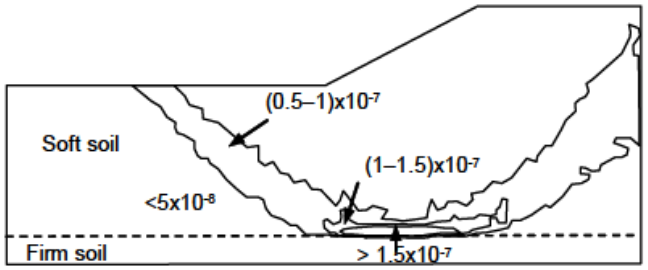
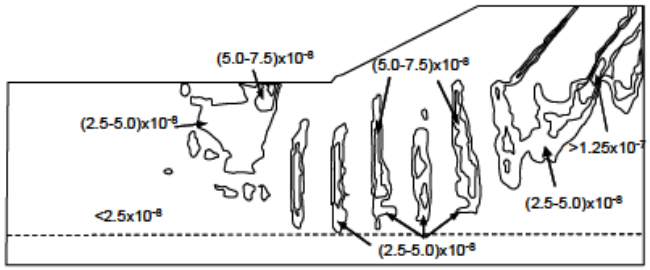


Figure 12. Numerical analysis model (Han et al. 2005).



(a) soft soil without improvement

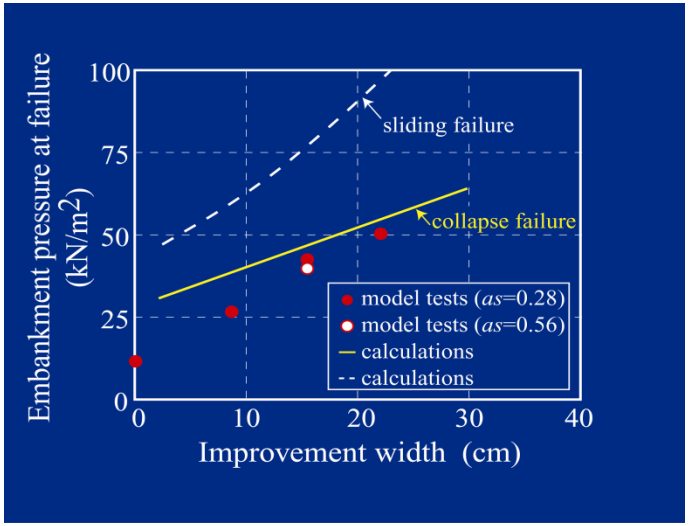


(b) soft ground improved by treated soil

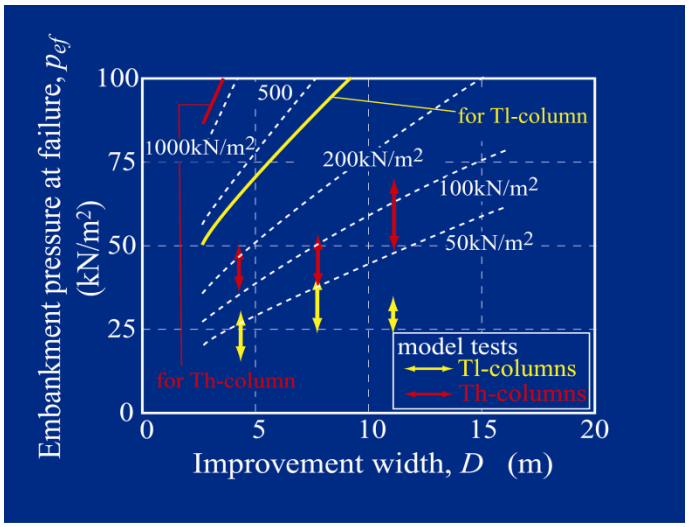
by Han et al., 2005

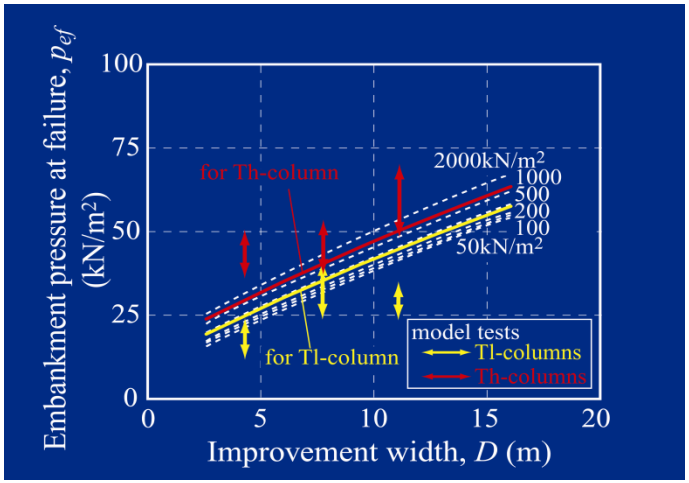
Evaluation of stability

external stability

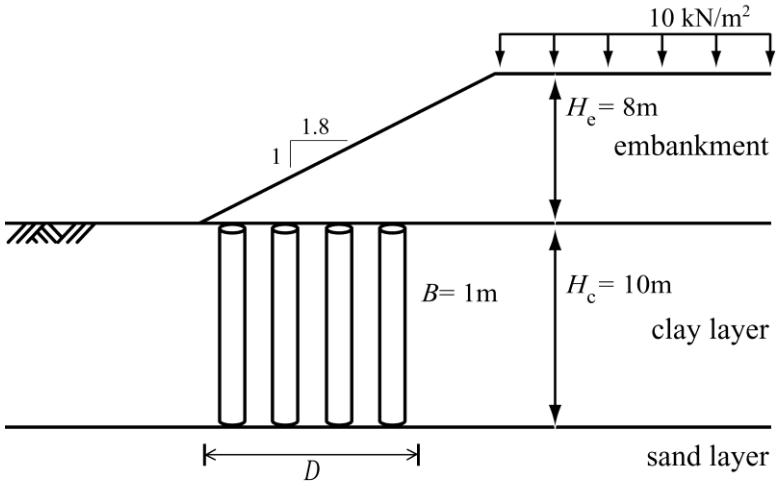


internal stability

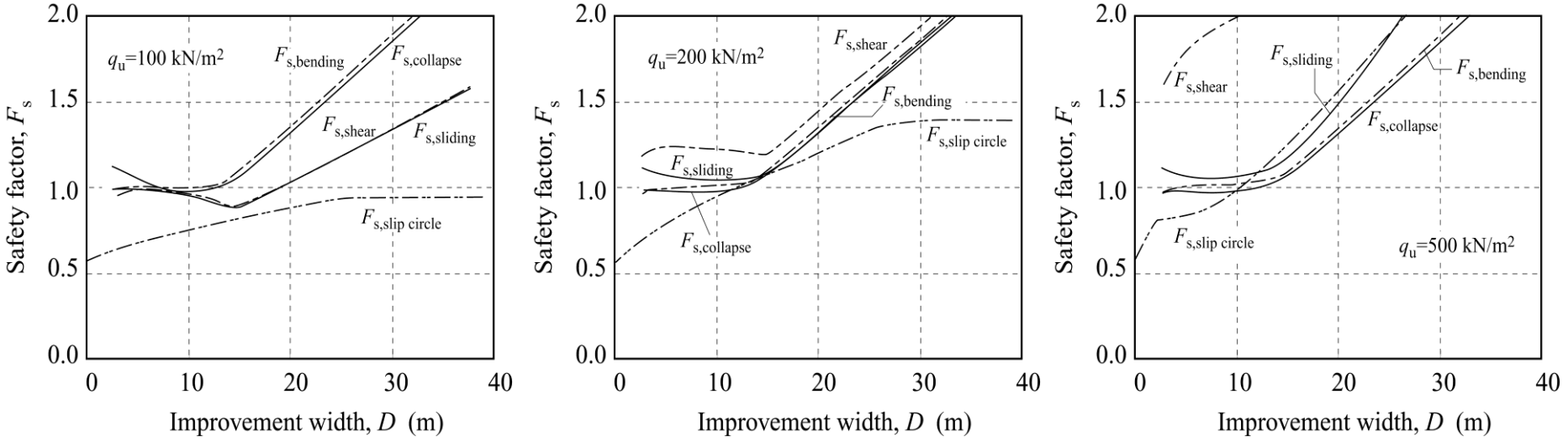




Parametric study on slope stability



Effect of column strength



In case the column strength < 200 kN/m², slip circle is the critical failure mode.

In case the column strength > 500kN/m², collapse failure is critical failure mode.

Impact of geotechnical design on QA/QC

(1) Conventional approach

The current simple design procedure together with simple QA/QC might be preferred in a future as well, because they enjoyed happy harmony each other with the aid of commentaries based on the practitioners' experience.

(2) New geotechnical design approach combined with new QA/QC approach

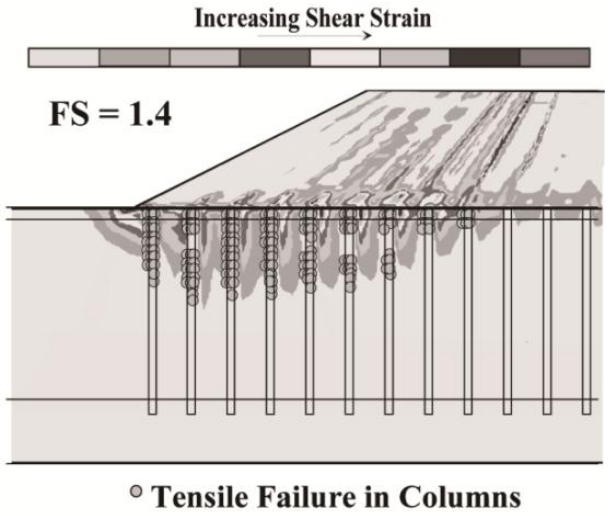
New geotechnical design procedures which can take the different modes of failures into account. QA/QC indices should be selected for the most critical mode of failure for a particular situation.

(3) The practitioners approach

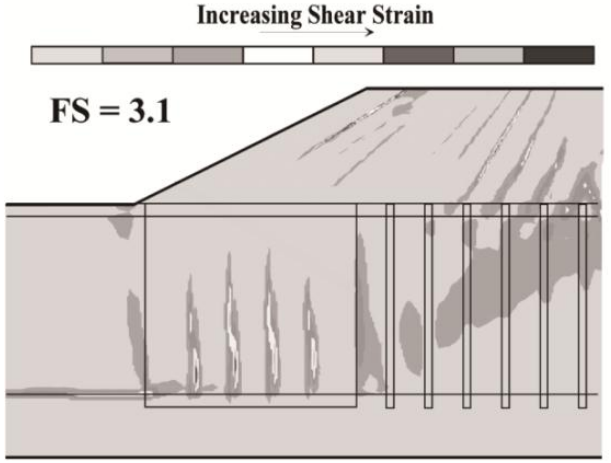
One of the practitioners selections may be bringing the problem simpler, easier to handle with the available technology. When the stability is the major issue in a project, it is better to employ deep-mixed panel or grid rather than the group of columns.

Effect of panel and grid improvements

column type improvement



panel type improvement



by Filz et al., 2005