Emerging Technology

Development of
Pneumatic Flow Mixing Method

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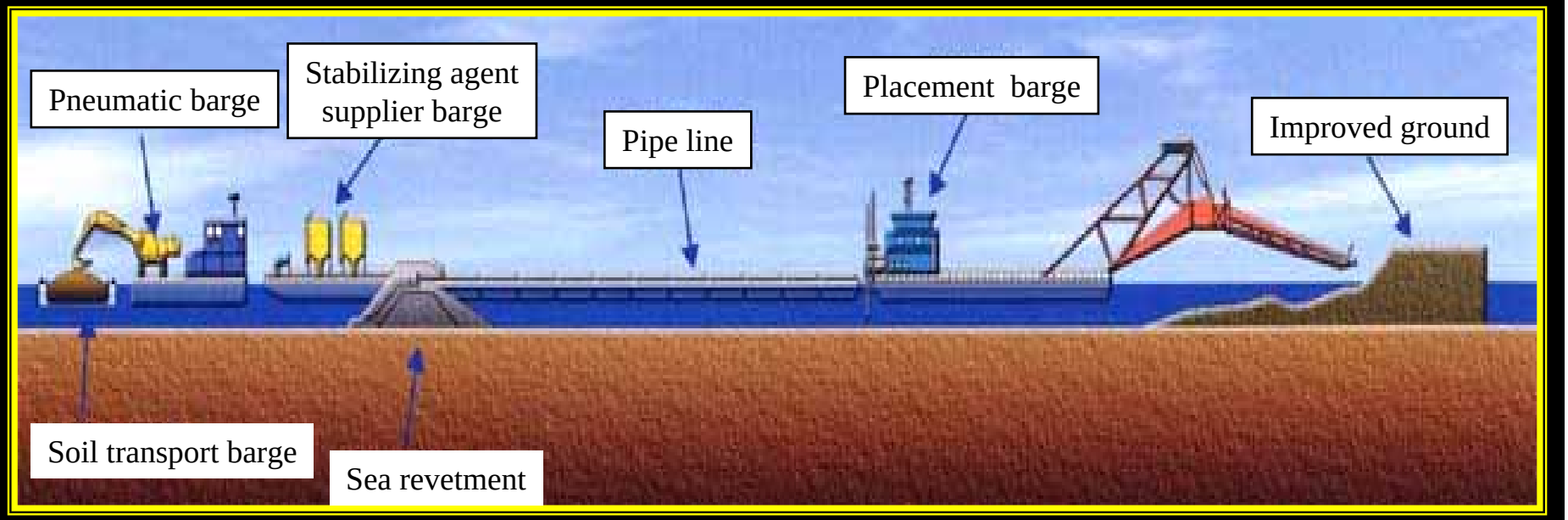
background

man-made island construction project requires huge amount of soil with high quality soil. But recently it becomes difficult to obtain it with reasonable expense.

A huge amount of soft soil is dredged at many ports every year to maintain enough sea route and sea berth. But it becomes difficult to construct the disposal area for dredged soil and subsoil.

Pneumatic Flow Mixing Method

- new developed soil improvement technique -



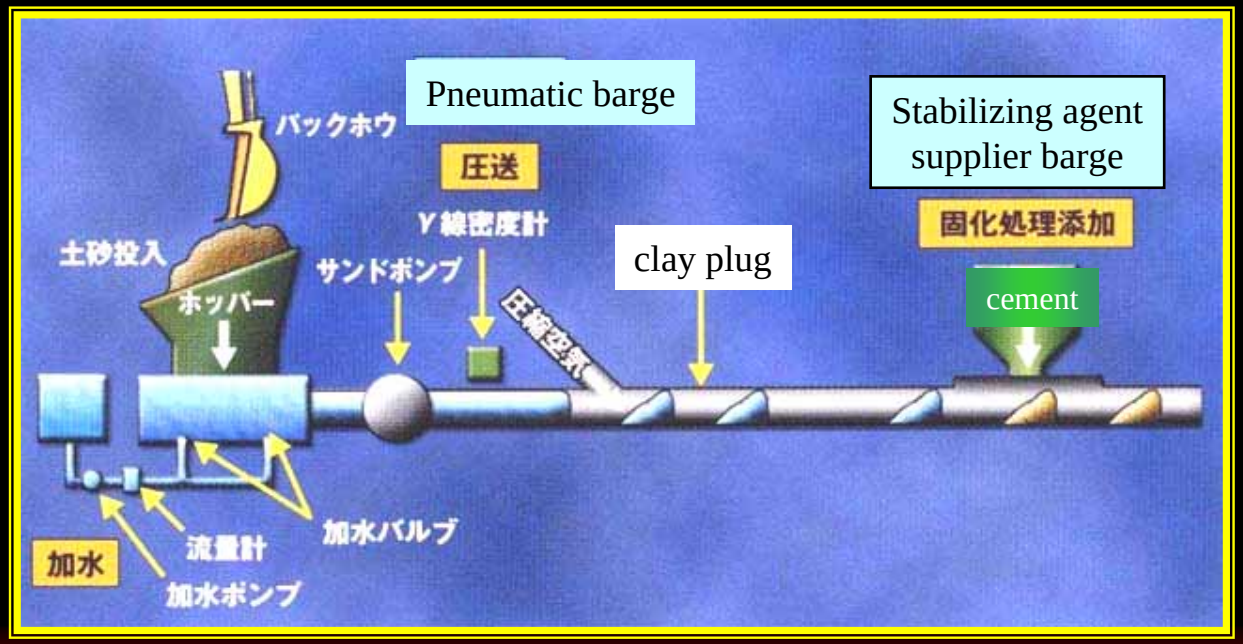
Dredged soft soil is mixed with small amount of stabilizing agent, usually cement, in a pipe during transporting by compressed air.

Mechanism of the method

‘plug’

- soft soil separated by the injected air in the pipe.
- has a function to reduce the friction on the pipe surface

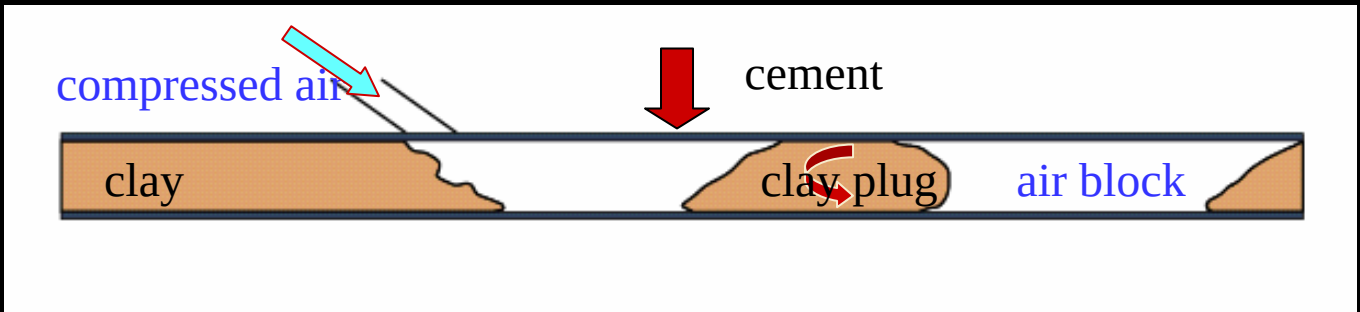
⇒ reduce the air pressure required to transport.



Pneumatic Flow Mixing Method

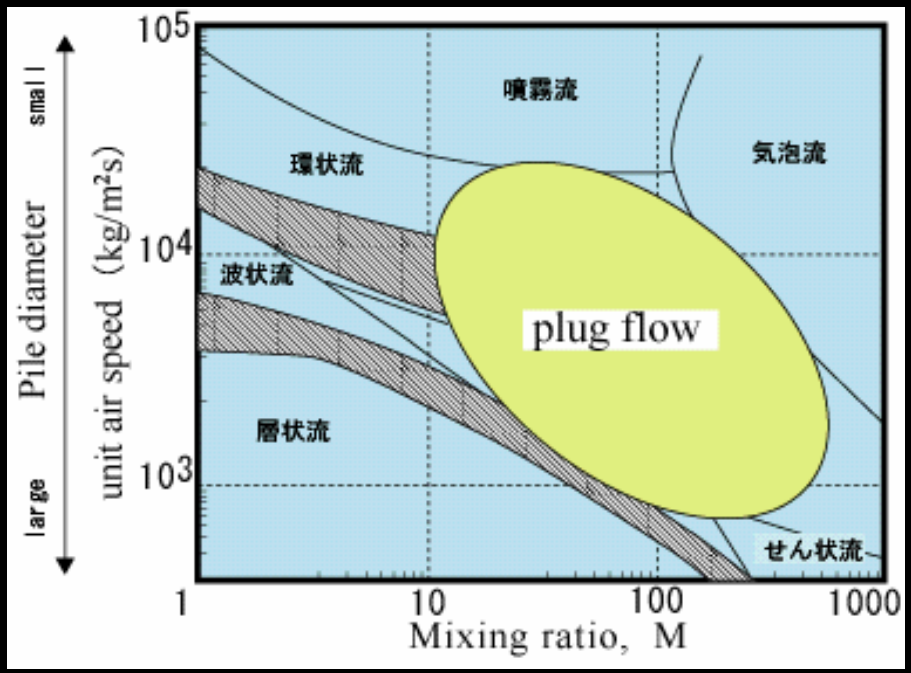
Mechanism of the method

soft soil is separated by the injected air in the pipe and forms ‘plug’. ‘plug’ has a function to reduce the friction on the pipe surface and in turn can reduce considerably the air pressure required to transport. During the transport, cement and clay are mixed by the turbulent flow within the ‘plug’.



Forming of plug

The formation of plug is dependent upon the mixing ratio of soil and air, and the pile diameter. The horizontal axis in the figure indicates the mixing ratio of soil and air, M. ‘Plug’ is generated at the mixing ratio, M of about 20 to 400.

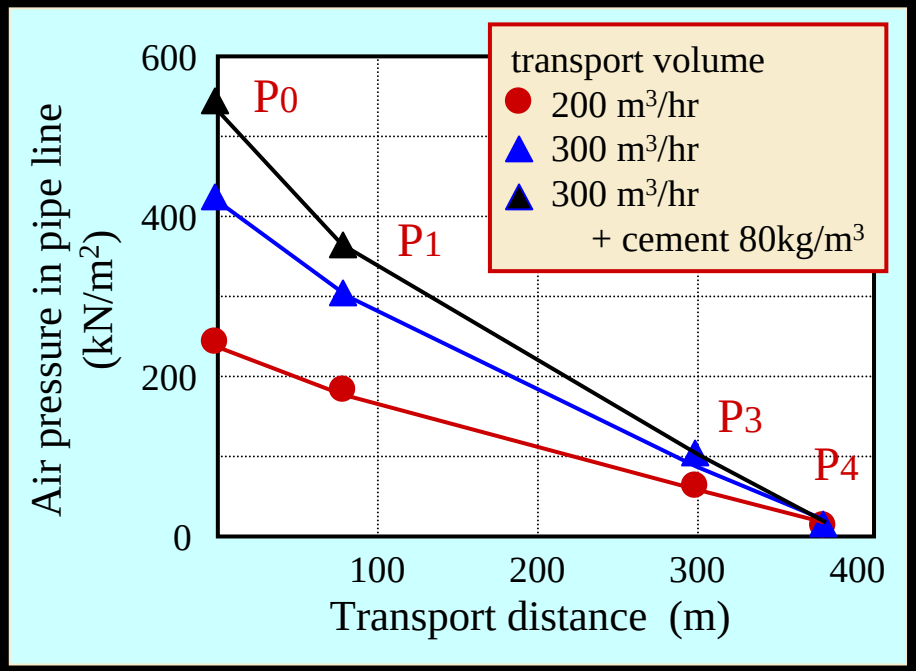


$$Mixing\ Ratio = \frac{\rho_L \times Q_L}{\rho_A \times Q_A}$$

in which

M:	mixing ratio
ρ L:	unit weight of soil (kg/m3)
ρ A:	unit weight of air (kg/m3)
QL:	flow volume of soil (g/m3)
QA:	flow volume of air (g/m3)

Air pressure distribution in the pipe



Major influence factors for air pressure

1) the volume, properties of clay
   increasing volume, addition of cement make air pressure increase.
2) the injected air volume
3) the pipe diameter
4) the pipe length

An inlet air pressure of 400 to 500 kN/m² is frequently adopted, in the current practice.

Characteristics of clay plug

plug speed：
11.8m/sec (1.5- 25.0m/sec)

length：
3.7m (2.6-4.7m)

volume：
0.36m^3 (0.25- 0.45m^3)

interval：
6 sec (0.5- 18.2sec)

Test condition：

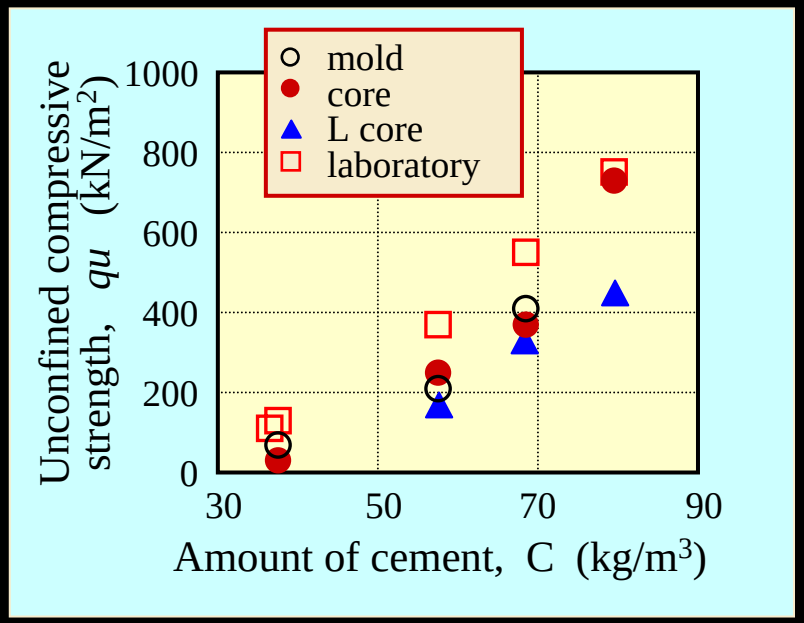
soil volume:	296m^3/h
water content：	117%
amount of cement：	78kg/m^3
pipe diameter：	35cm
transport capacity：	300m^3/h
transporting length：	180m

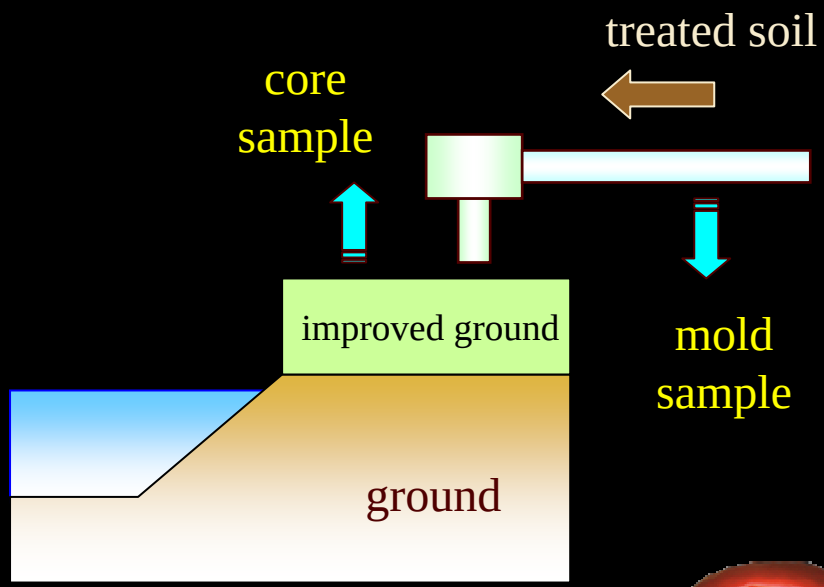
facility

facility	capacity
Pneumatic barge	
max. of main power	2,000-ps
max. of transporting capacity	150 m^3/h, two lines
max. of stability supplier	30 ton/hr
Stabilizing agent supplier barge	
max. capacity	300-m^3/hr
Placement barge	
diameter of cyclone	ϕ1500, two sets
Pipe line	
diameter	ϕ350 mm
length	180 to 373 m

Mechanical properties of treated soil

- comparison of strengths (placed on land) -

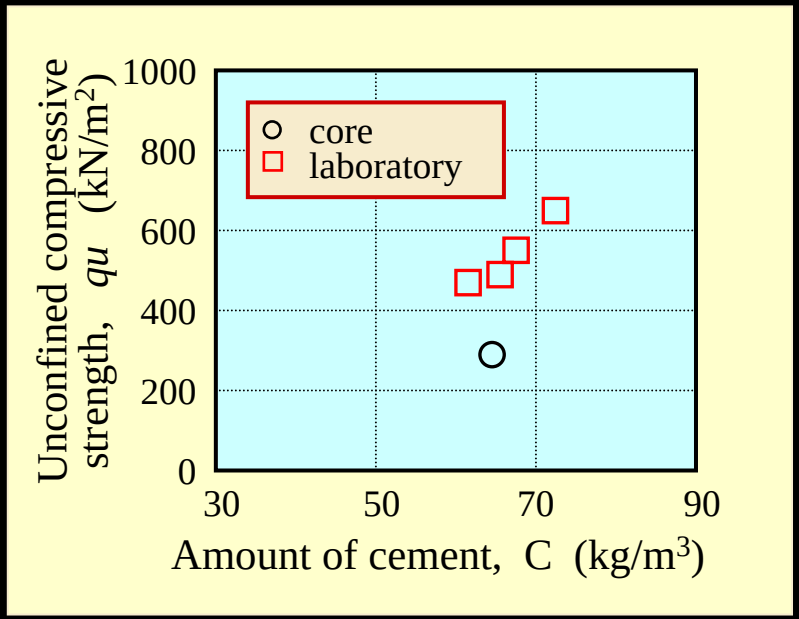




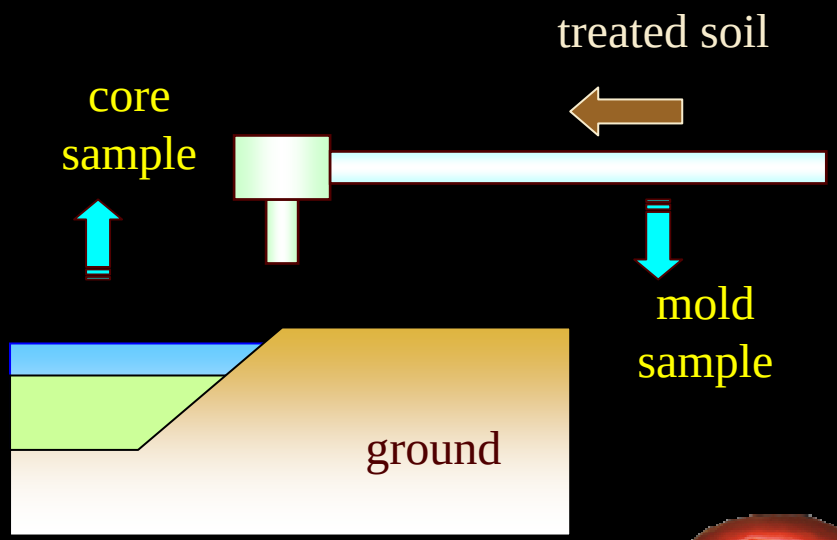
placement on land

Mechanical properties of treated soil

- comparison of strengths (placed under seawater) -

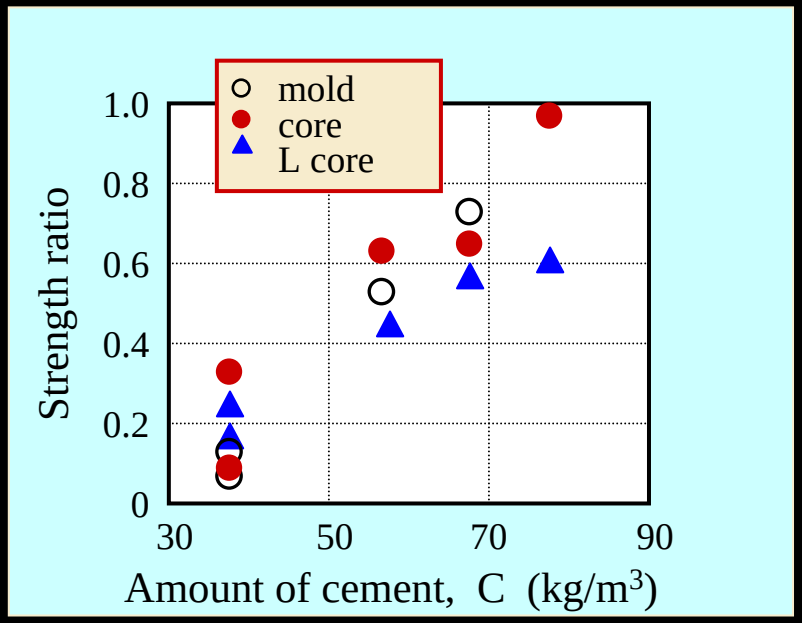


placement under seawater

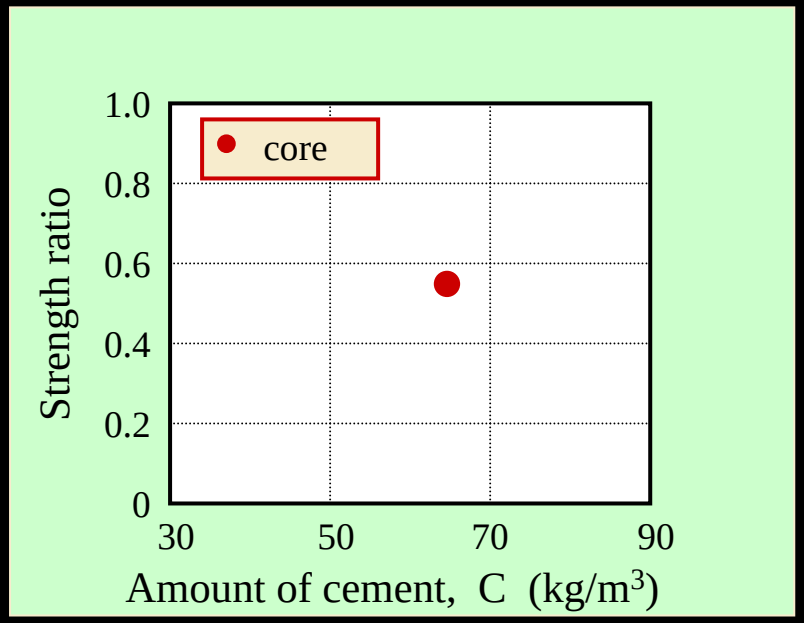


CHARACTERISTICS OF TREATED SOIL

- Effect of amount of agent on strength -



placement on land

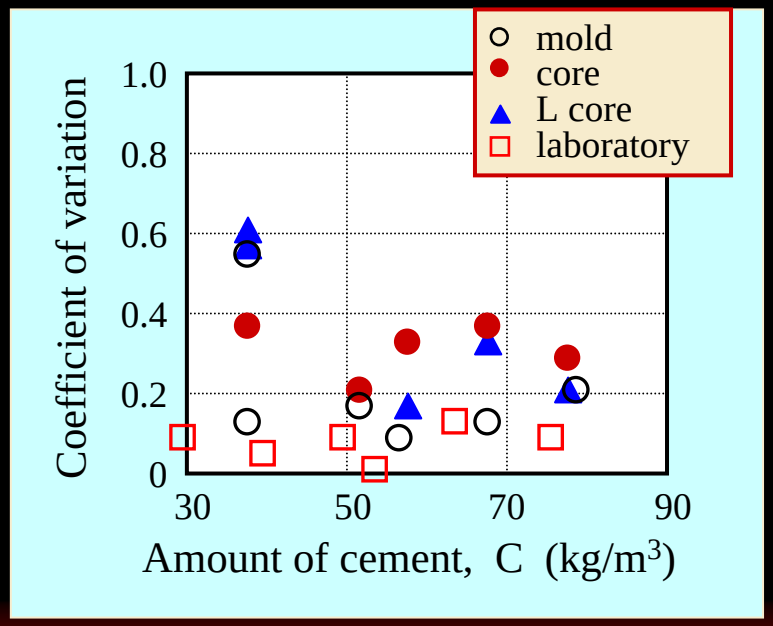


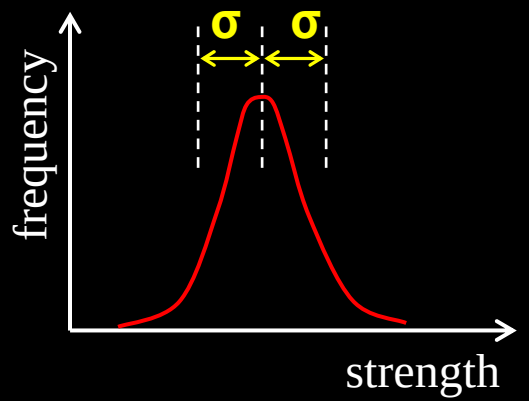
placement under seawater

CHARACTERISTICS OF TREATED SOIL

coefficient of deviation

- quite small of about 15 % for ‘laboratory’ treated soil and almost constant.
- relatively large for the field manufactured treated soils
  - about 35 % for ‘core’ irrespective of the amount of stabilizing agent.
  - about 60 % for ‘L core’ when the amount of agent decreases to 38 kg/m^3.

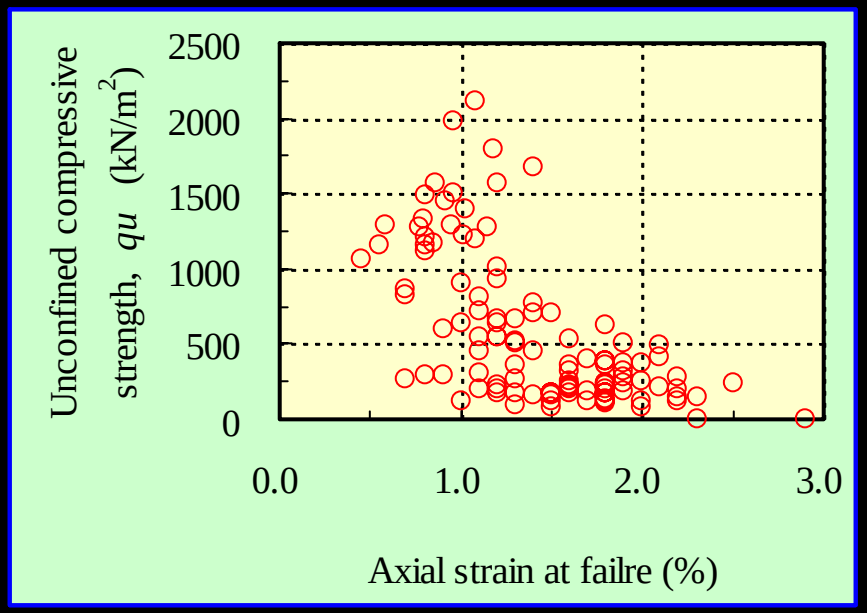


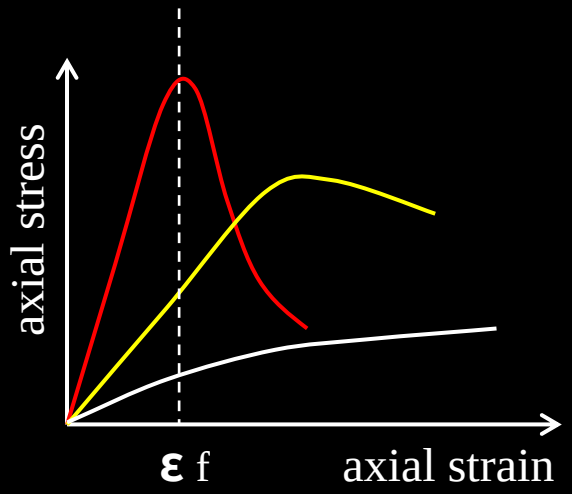


Stress - strain relationship of treated soil

- axial strain at failure vs. strength -

Axial strain at failure is quite small of the order of few percentage, and decreases with increasing the unconfined compressive strength.

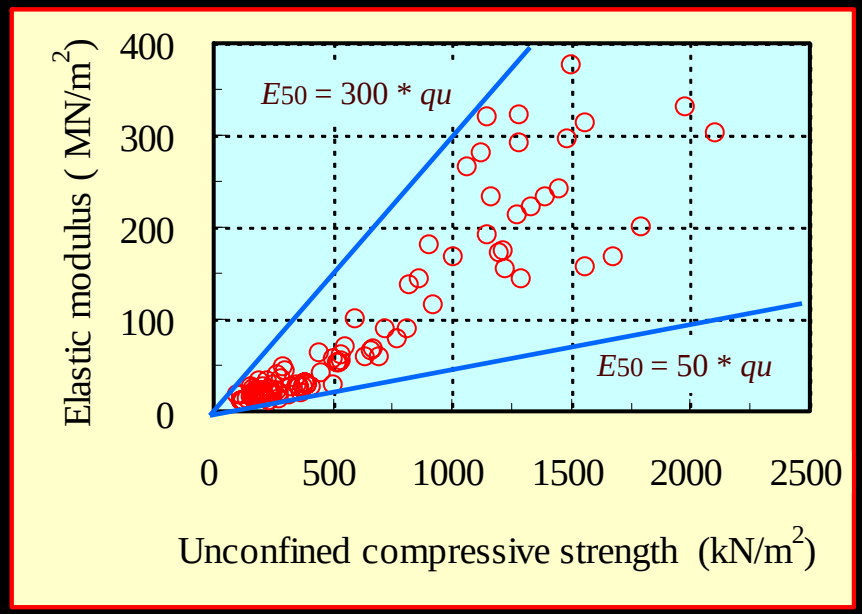


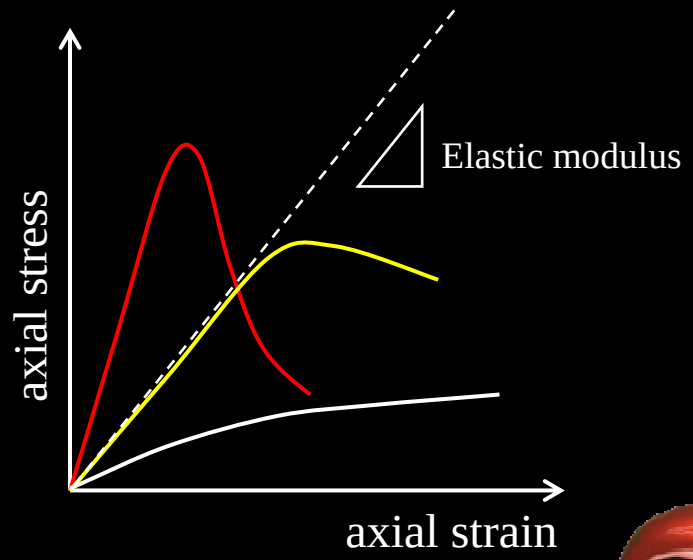


Stress - strain relationship of treated soil

- elastic modulus vs. strength -

The elastic modulus, E_{50} of treated soil increases almost linearly with the increase of unconfined compressive strength, *qu*.
The E_{50} is around 50 to 300 * *qu*.



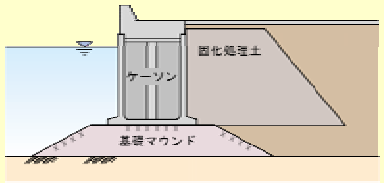
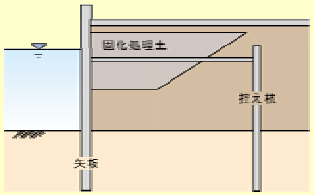
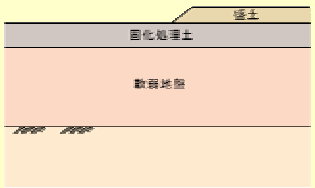
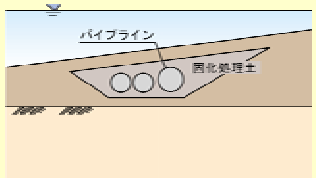


Merits of the method

The Pneumatic Flow Mixing Method can create high strength soil material from dredge soft clay rapidly.

The Pneumatic Flow Mixing Method has high applicability to sea reclamation, backfilling, man-made island, etc.

Applications of the method

reduce earth pressure	
improve dynamic response	
shallow improve-ment	
back fill	

1. reduce earth pressure
   reduce size of sea revetment and mound
2. improve dynamic response
   prevent liquefaction
3. shallow improvement
   assure trafficability
4. back fill
   protect underwater structure

Thank you for your attention