2.6 Methods of Soil Sampling

- Disturbed sampling ⇒ Grain-size distribution, w_n, LL, PL, G_s, classification of soil, and shearing characteristics for cohesionless soils
- Undisturbed sampling (Tube sampling, Block sampling)
  ⇒ Consolidation and shearing characteristics for cohesive soils

1) Sample disturbance

- Sample disturbance can occur during boring (or drilling), during sampling, during transportation and storage, or during preparing for testing.
- The mechanisms associated with sample disturbance can be classified as
  1. Changes in stress conditions :
     - the reduction of total horizontal and vertical stresses from their in situ value.
  2. Mechanical deformation :
     - shear distortions applied to sample, for example by tube sampling.
  3. Changes in water content and void ratio :
     - can occur as an overall swelling or consolidation of the soil sample, or a redistribution of moisture in reponse to pore pressure gradients.
  4. Chemical change :
     - may result from contact with drilling fluid or with sampling tubes.

2) Type of sampling for undisturbed samples

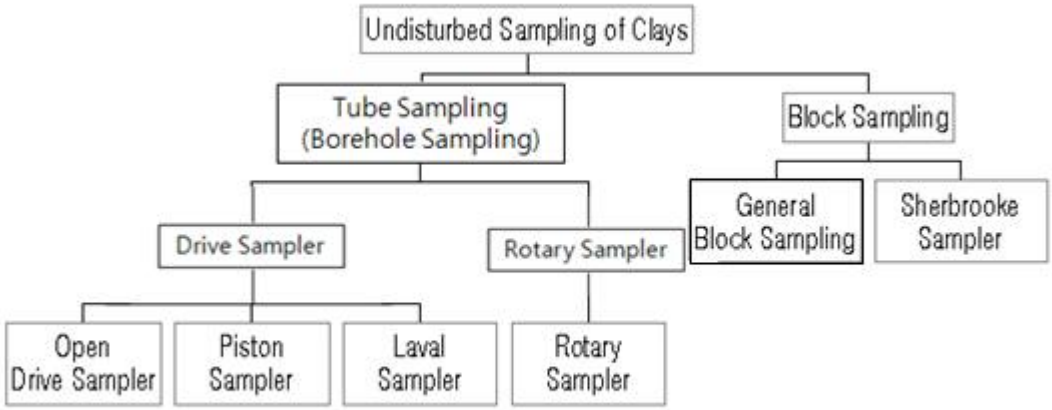


Fig. General classification of sampling techniques

1. Tube sampling

: Effective to obtain soil samples from deep soil deposits.

1) Sample Disturbance

- Disturbance occurs due to stress release + mechanical deformation.
- Design parameters for tube samplers; Area ratio, Cutting edge tapered angle, Inside clearance and L/D ratio

a) Area ratio

$$A_R(\%) = \frac{D_0^2 - D_i^2}{D_i^2} \times 100$$

$\Rightarrow$ Undisturbed state can be defined with $A_R \leq$ 10%.

where D_o = outside diameter of sampler,

D_i = inside diameter of sampler

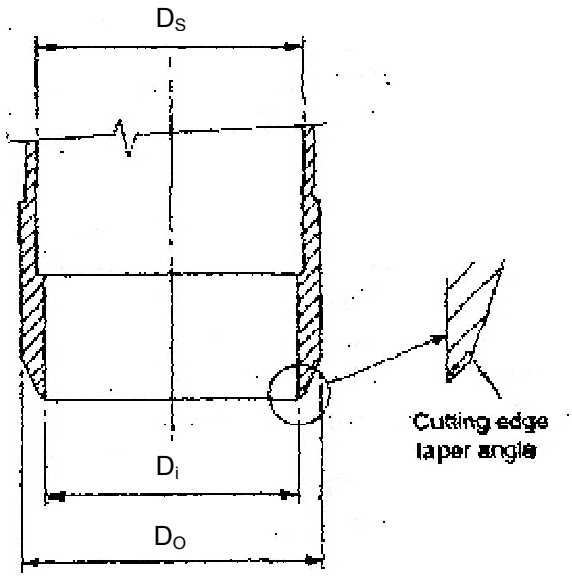


Fig. Sampler with screw-on cutting shoe

b) Cutting Edge Tapered Angle

- Enable to use thick tubes with minimizing sample disturbance in order to preventing their bending or buckling during driving the sampler into the soil.
- ISSMFE suggested the combinations of area ratio and cutting edge tapered for samplers of about 75mm dia. as given below.

Area ratio (%)	Cutting edge taper (deg.)
5	15
10	12
20	9
40	5
80	4

c) Inside clearance and *L/D* ratio

- To prevent sample jamming due to the friction or a adhesion of the

soils inside of the sampler tube. (The soil beneath the bottom will be severely remolded due to induced bearing capacity failure.)

- The less *L/D* ratio, the easier the penetration of the sampler tube. In an ultimate condition, a maximum permissible *L/D* of 2.5 is considered.
- Inside clearance (= $(D_s - D_i)/D_i$) reduces or eliminates wall friction but gives the room for some swelling and lateral strain. It is usually less than 4%. Hvoslev recommends inside clearance 0.75 – 1.5%.

2) Types of Tube sampler

a) Open – drive sampler

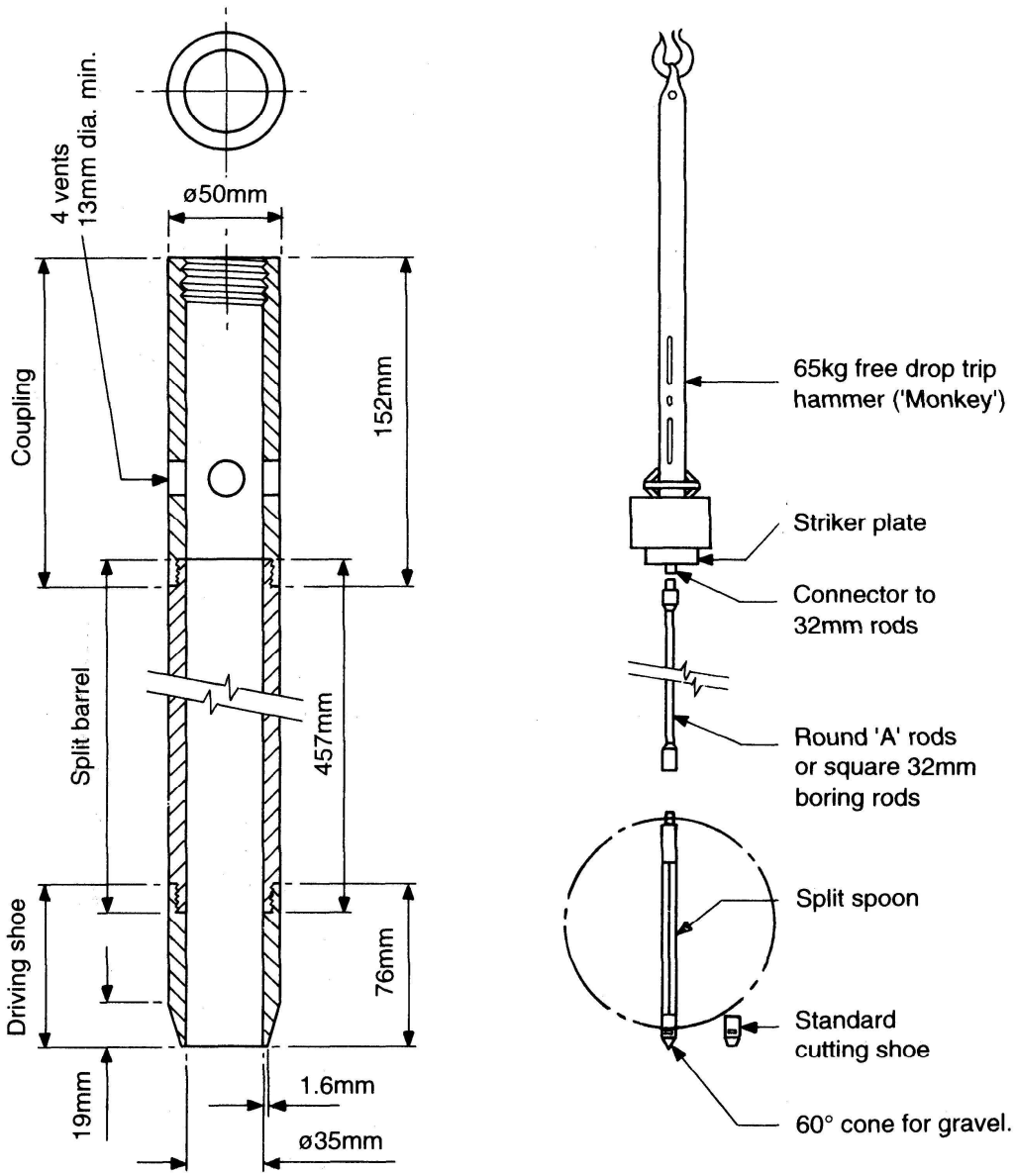
- Consist of a tube which is open at its lower end.
- Advantage : Cheapness and simplicity of operation.
- Disadvantage : Poor cleaning of borehole, problem of sample retension during withdrawal.
- Can be divided into two types based on thickness of tube or area ratio:
  - Thick-wall open drive sampler (A_R >20%)
  - Thin-wall open drive sampler (A_R<20% with a suitable cutting shoe angle)

i) Thick-walled split barrel sampler (Split-spoon sampler)

⇒ Disturbed sample (A_R=112%)

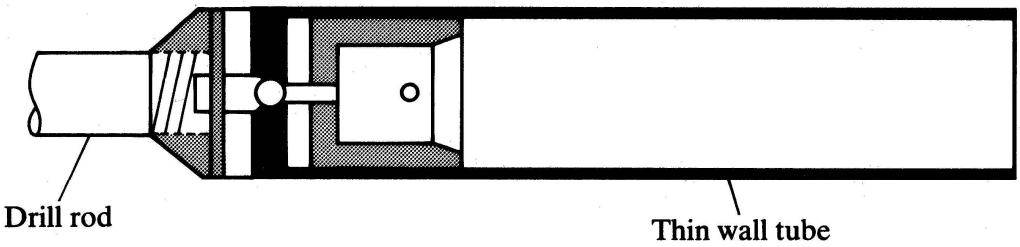
⇒ Split-spoon sampler is used during standard penetration test (SPT).

⇒ During SPT, the sampler is driven into the soil by repeated blows of a 65kg hammer falling freely through 760mm.



ii) Thin-wall open-drive sampler (Shelby tubing sampler)

- Pushing rather than hammering is preferred.
- Typically 750 – 900 mm long (or 612 – 762 mm long)
- Inside clearance : 0.5 – 1.0 % (or 1.0 – 1.5%)
- Internal tube diameter : 48 mm, 60 mm, 73 mm, 86 mm, 121 mm
- A_R = 8 – 15 % (decrease with increasing tube diameter)



Thin wall tube

iii) Laval Sampler

- One of the most effective tube sampler available for sampling soft and sensitive clays.
- Can obtain the sample of large diameter (D=208mm) with good quality.
- Consists of a thin-walled sampling tube within an external corebarrel.
- Bentonite slurry provides the support of borehole.
- No inside clearance.
- Area ratio: 10%

Ref) C.R.I. Clayton et al. “Site Investigation”, pp. 377~380.

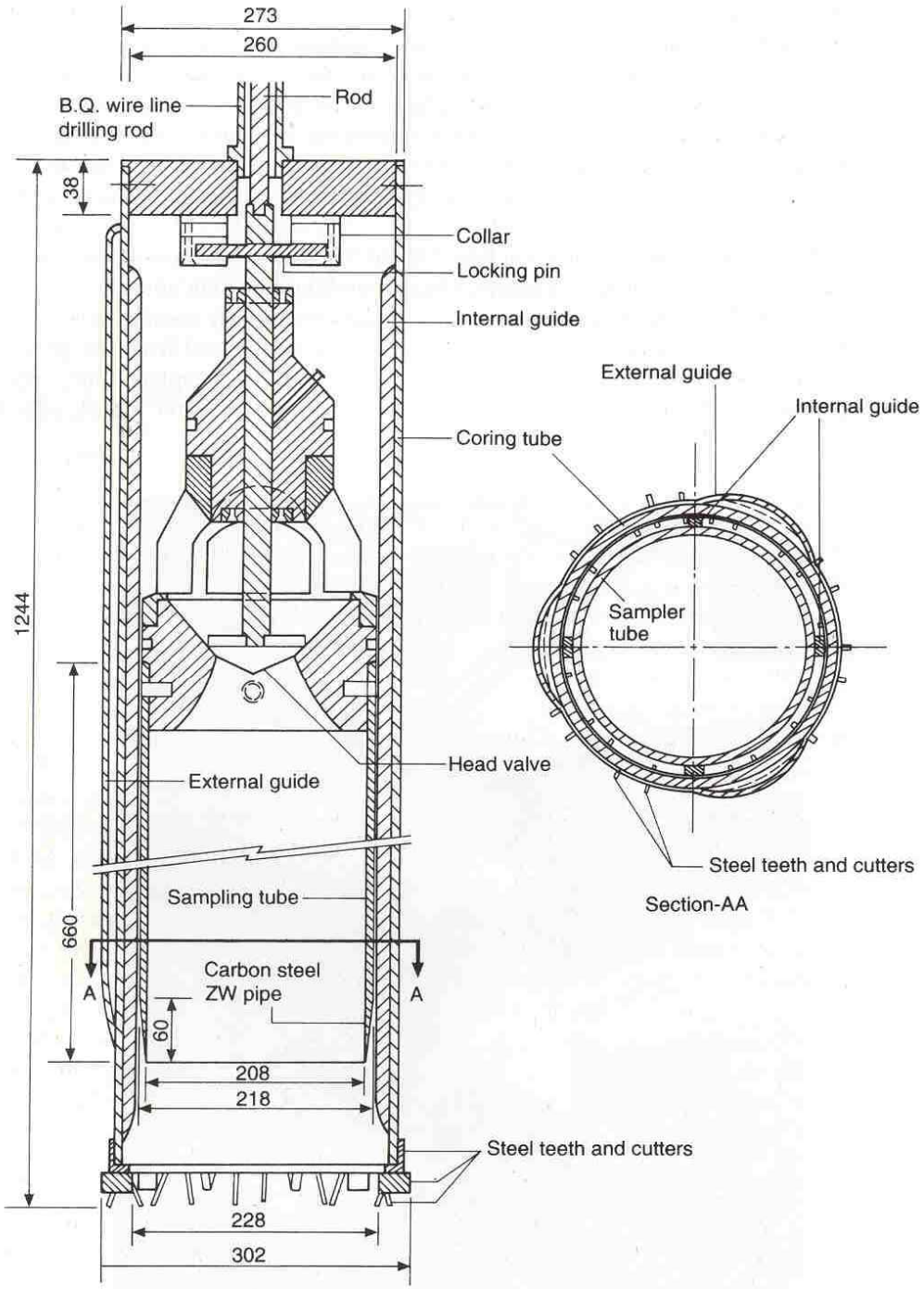


Fig. 7.9 The Laval 200 mm diameter tube sampler (La Rochelle, Sarrailh, Tavenas, Roy and Leroueil 1981).

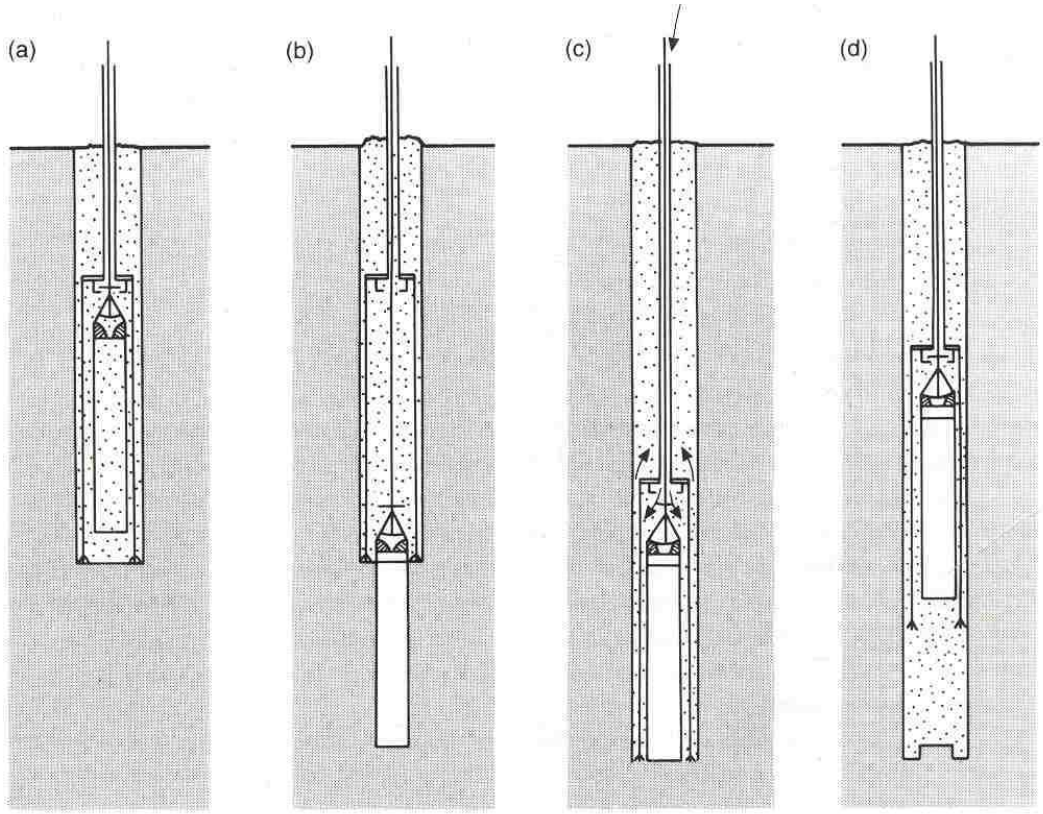


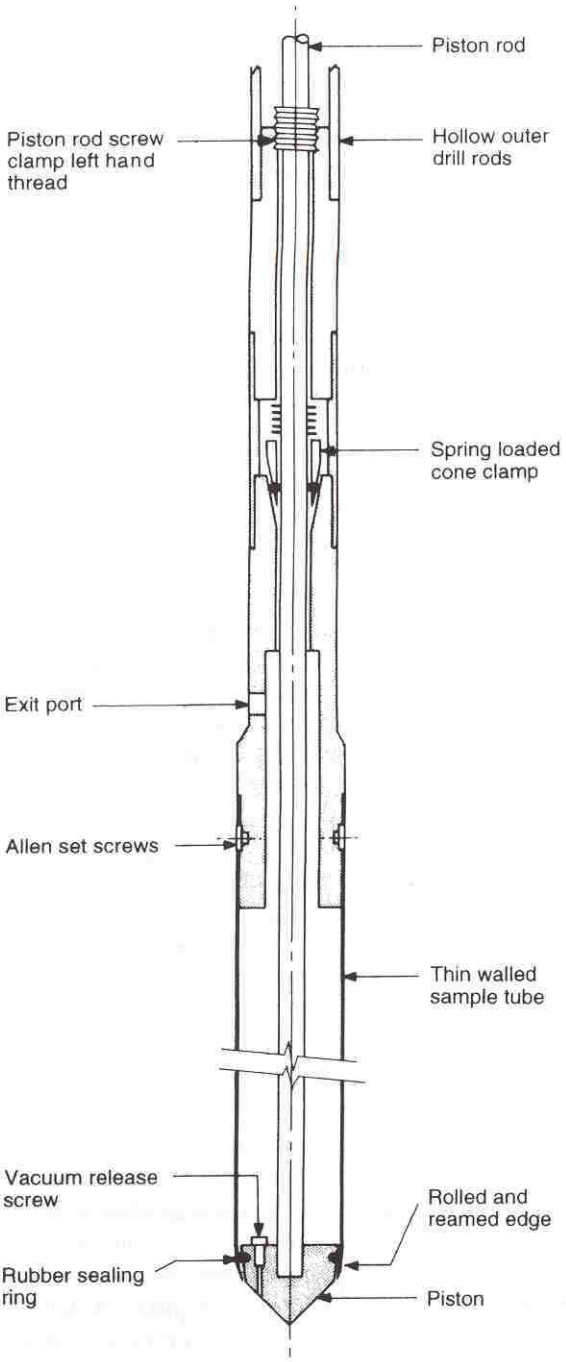
Fig. 7.10 General operation of the Laval sampler (La Rochelle *et al*. 1981).

b) Piston sampler

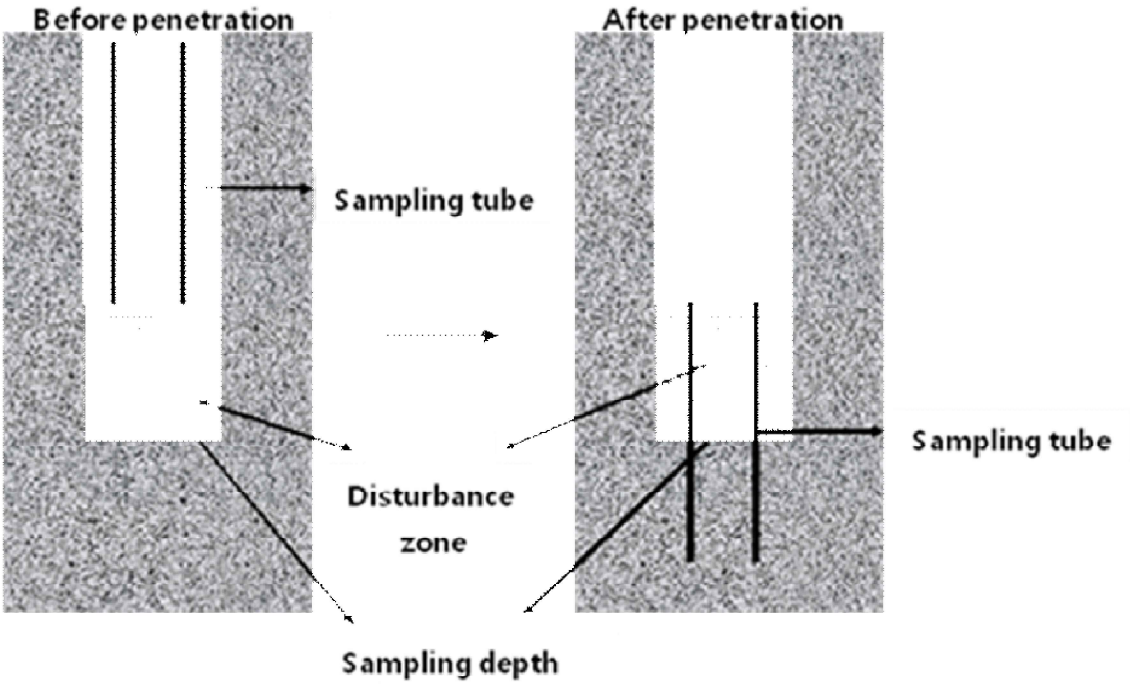
- Can obtain larger diameter samples with better quality than thin-wall open driver sampler.
- Has a piston contained within the sampler tube, which is moved upwards relatively to the sample tube.
- Types of piston samplers
  - i) Free Piston Sampler: Piston is fixed during driving and withdrawing of the sampler, but free when the sampler tube is being pushed into the soil.
  - ii) Fixed Piston Sampler : Piston is fixed at each 3 stages (driving and withdrawing the sampler and pushing sampler tube).

iii) Retracted Piston Sampler : Piston is fixed only during driving the sampler and then piston is retracted to the top of the tube. (Fig 7.12)

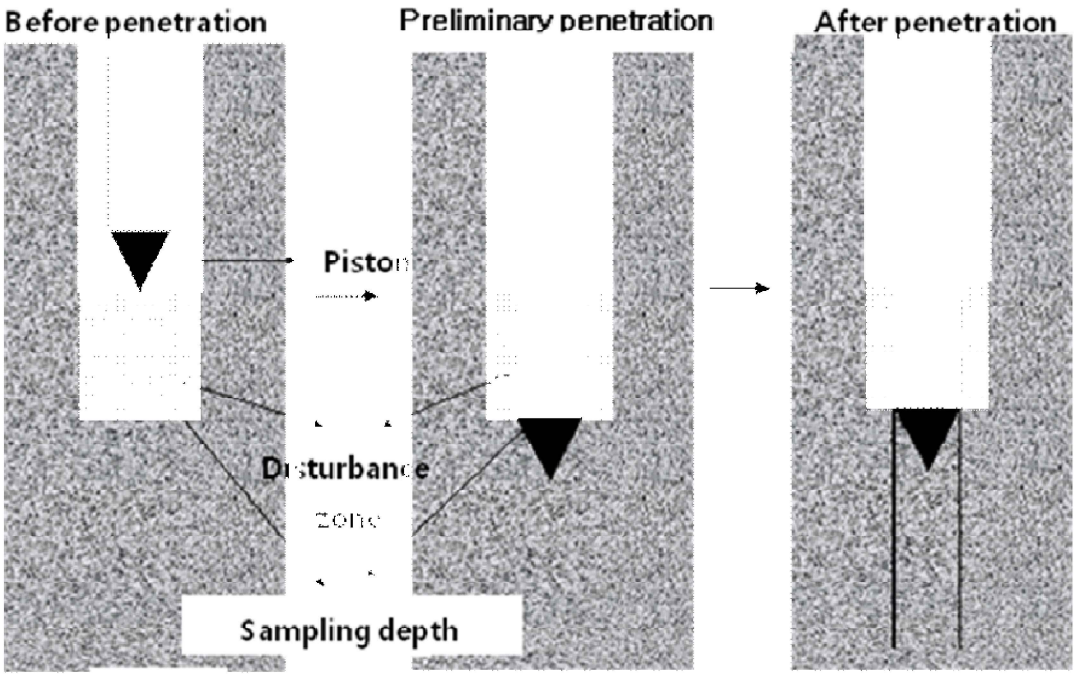
- Advantages based on fixed piston sampler
  - i) Can prevent soil (which is remolded) entering the sampler tube before the sampling position is reached.
  - ii) Can reduce losses of samples, by providing an efficient airtight seal to the top of the soil in the tube during withdrawal.
  - iii) Can reduce the excess soil into the tube during driving sampler tube.
  - iv) Can reduce the possibility of blocking the tube by soil samples in it. (Can increase the acceptable length to diameter ratio.)



7.12 Thin-walled seamless steel tube fixed piston sampler.

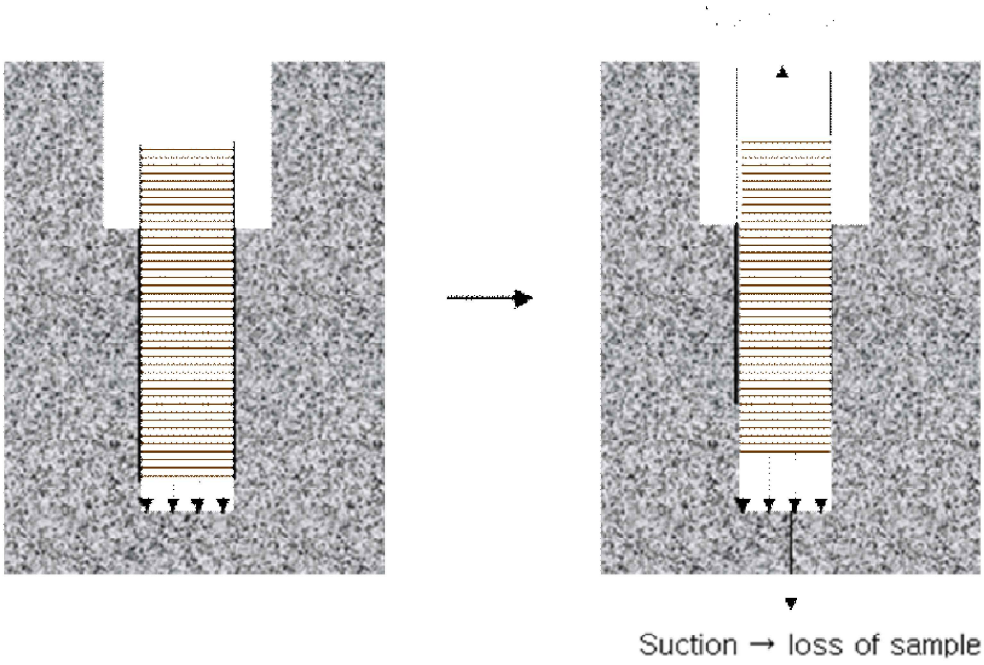


(a) Open drive sampler

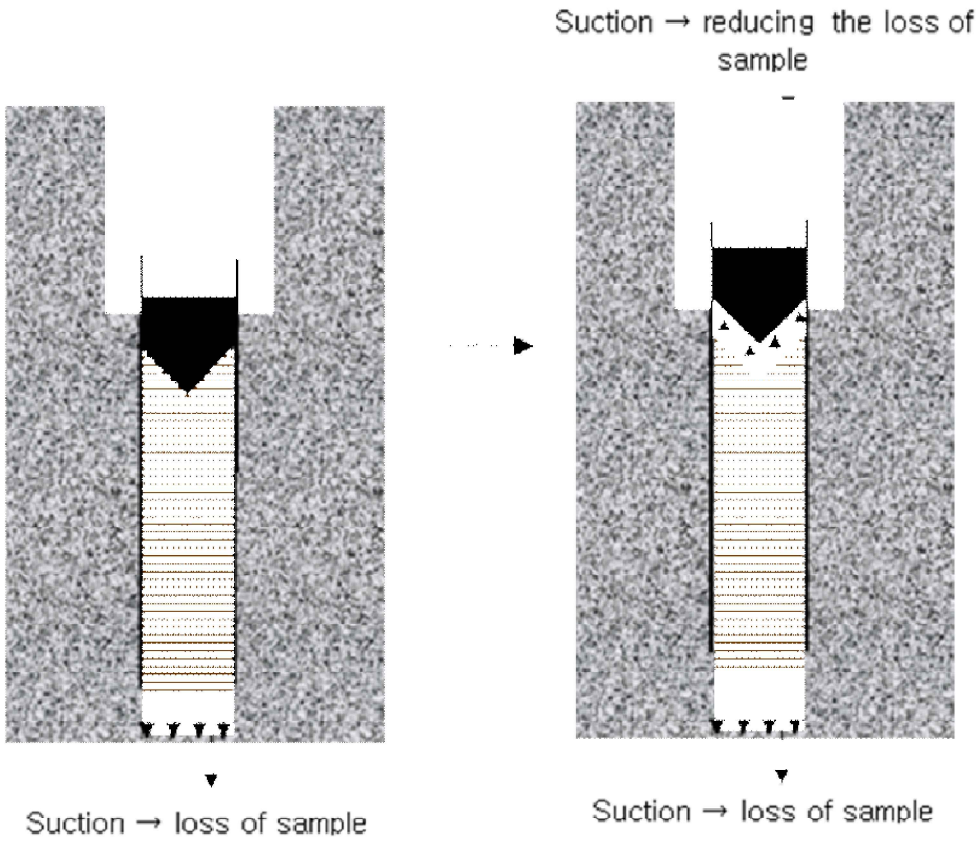


(b) Piston sampler

figure . Penetration of piston sampler (case 1)

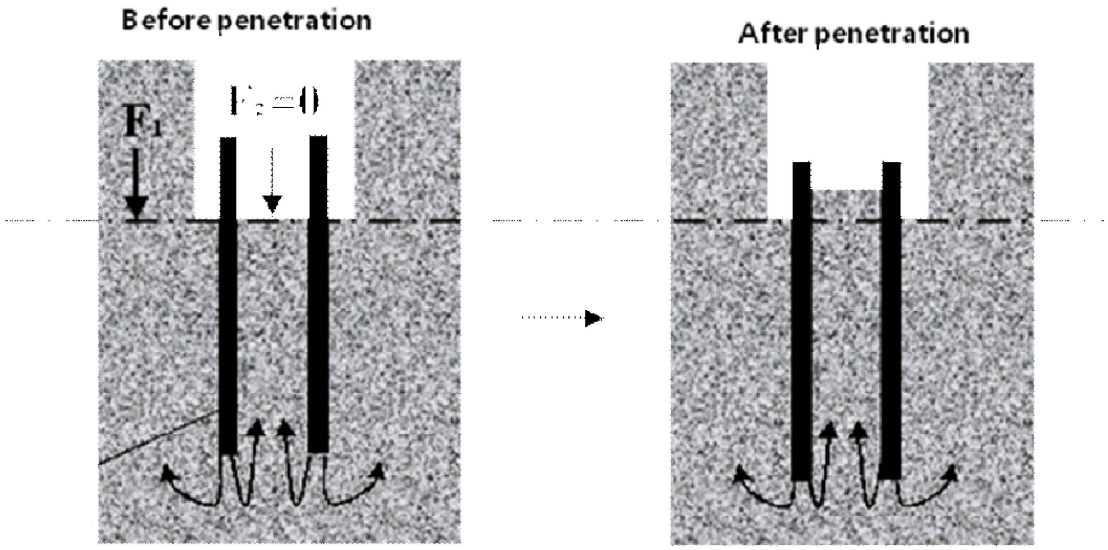


(a) Open drive sampler

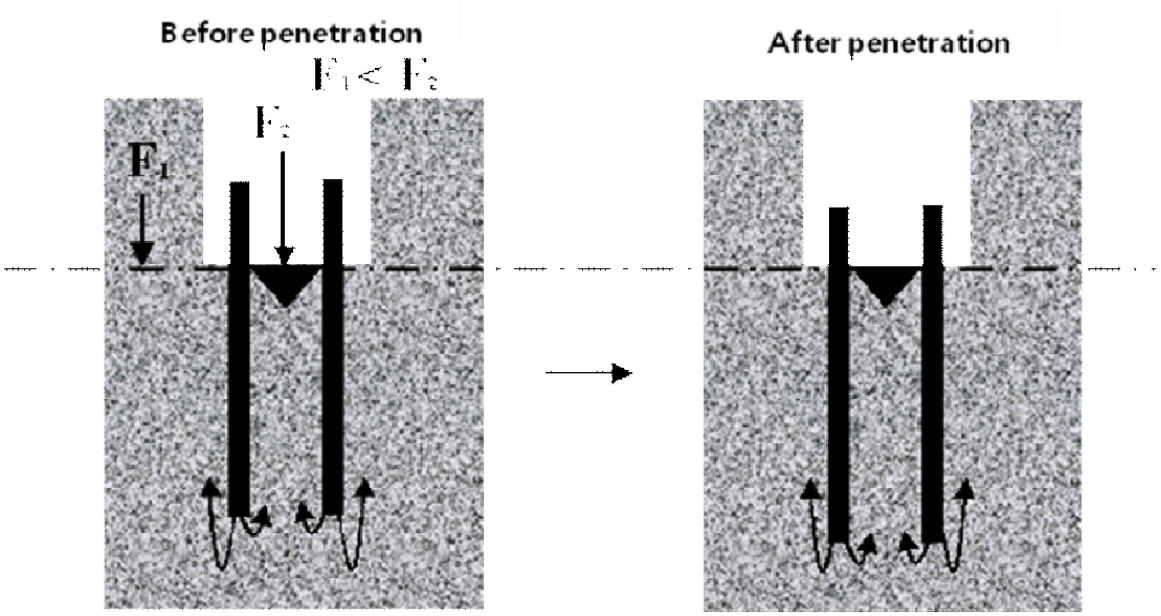


(b) Piston sampler

Figure. Recovery of piston sampler (case 2)

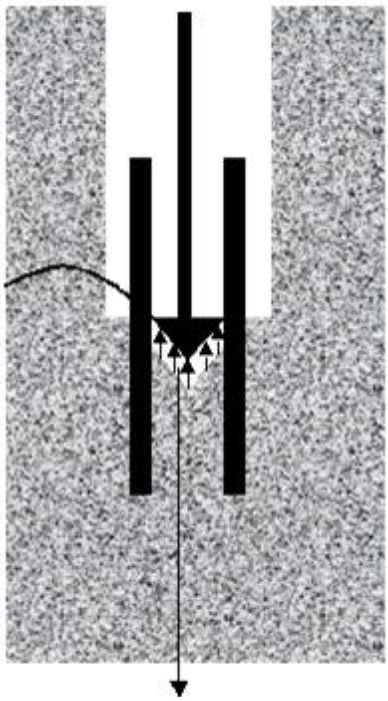


(a) Open drive sampler



(b) Piston sampler
Reducing the excess soil into the tube.

Figure. The effect of penetration of relatively high area ratio of tube (case 3)



When tube cannot be penetrated due to adhesion force between tube wall and soil, suction below piston enables tube to penetrate further

Figure. Increase of tube penetration (case 4)

- Note
  (Chung et al. (2003), Geotechnique 53)

  For the sampling tube of 73.8mm I.D. (NX size) and 854mm length in hydraulic piston sampler (1.2mm wall thickness and 6° of cutting edge taper),

  ⇒ the top 30cm length of the sample is subjected to experience significant disturbance, due to the high drilling pressure (high hydraulic pressure) and the remainder of slurry (slime).

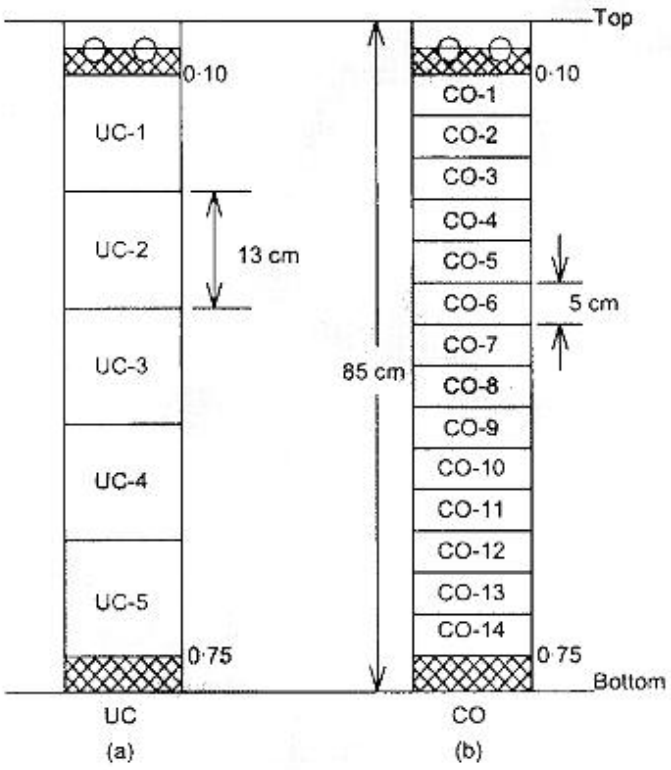


Fig. 2. Position of specimens in a sample tube: (a) UC test; (b) CO test

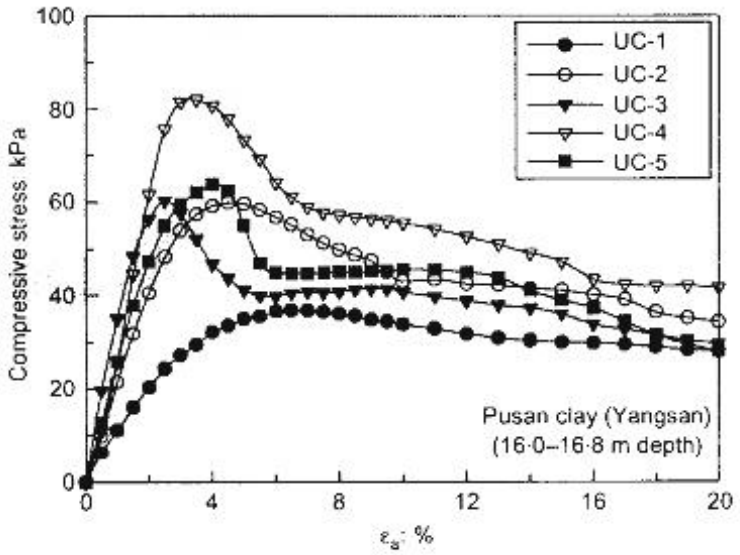


Fig. 3. Relationship of compressive stress against axial strain in UC test

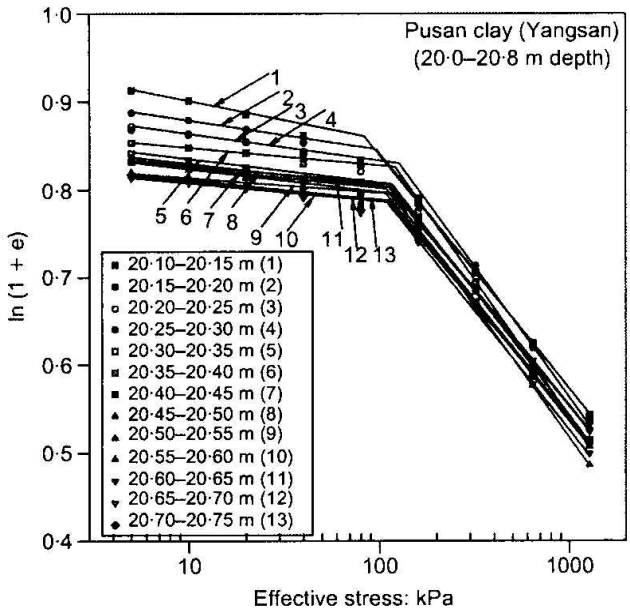
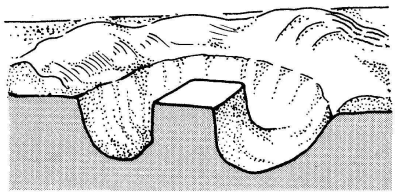


Fig. 4. Plot of ln(1 + *e*) against log σ'_v for samples between 20·0 m and 20·8 m depths

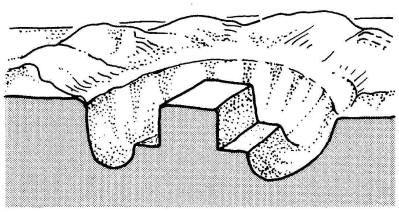
2. Block Sampling

- The sample is cut from the ground, either from the base or side of a trial pit.
  i) Involving the careful hand excavation of soil around the sample position and the trimming of a regular-shaped block.
  ii) Sealing soil block with layers of wax.
  iii) Encasing it into the box, cutting sample bottom and placing wooden lid.

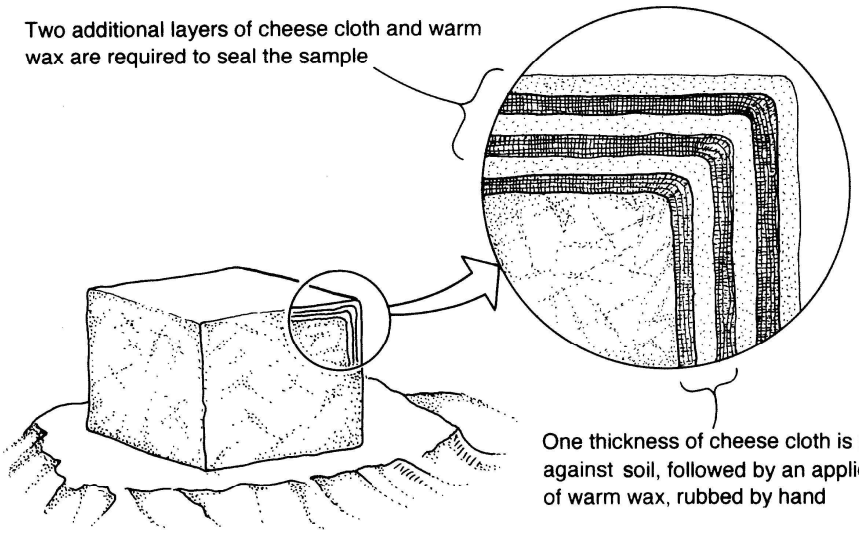
- Block samples undergo stress relief, and swelling, but should not be subjected to severe shear distortions.



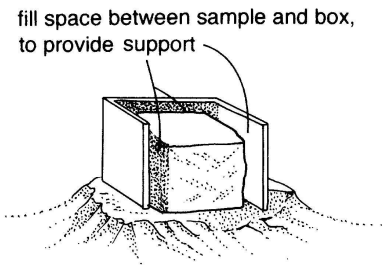
(a) Level ground surface, mark outline of sample and carefully excavate trench



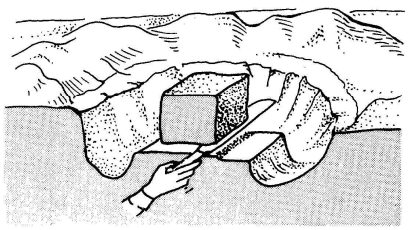
(b) Deepen excavation below base of sample, and trim to size with a knife



(c) Seal with three layers of cheese cloth or plastic foodwrapping, waxing each layer by brush, or hand



(d) Encase sample in a wooden box, packed with foam or damp woodshavings, if soil is easily disturbed



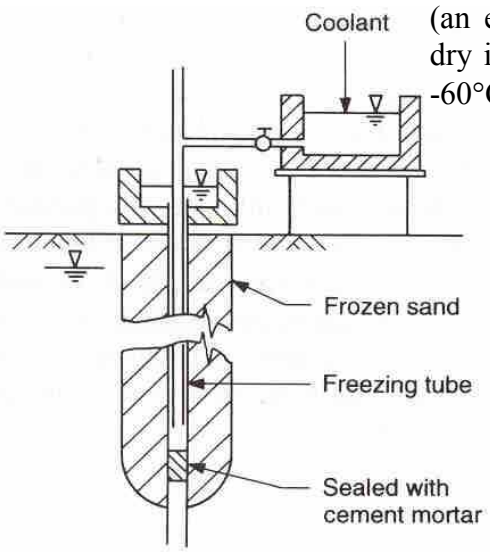
(e) Cut sample from bottom of pit, and seal base as in (c). Place wooden lid, if box is used

Block sampling

3) Sand sampling

- The structure of sand is highly dependent both on stress history and current effective stress level. Small changes in shear stress can destroy its present state, leading to considerable reduction in stiffness.
- Undisturbed sand sampling can be very expensive and is not generally used.

- Freezing method



(an ethanol and crushed dry ice coolant at -40 to -60°C.)

Fig. 7.21 Method of sand sampling by freezing adopted by Yoshimi, Oh-Oka (1977).