In Situ Tests

- SPT (Standard Penetration Test)
- CPT (Cone Penetration Tests)
- In Situ Vane Test
- Pressuremeter Test
- Plate Loading Test

CPT (cone penetration test)

- During this test,

q_c=tip resistance=point resistance=cone resistance

q_s=side friction=sleeve friction=skin friction

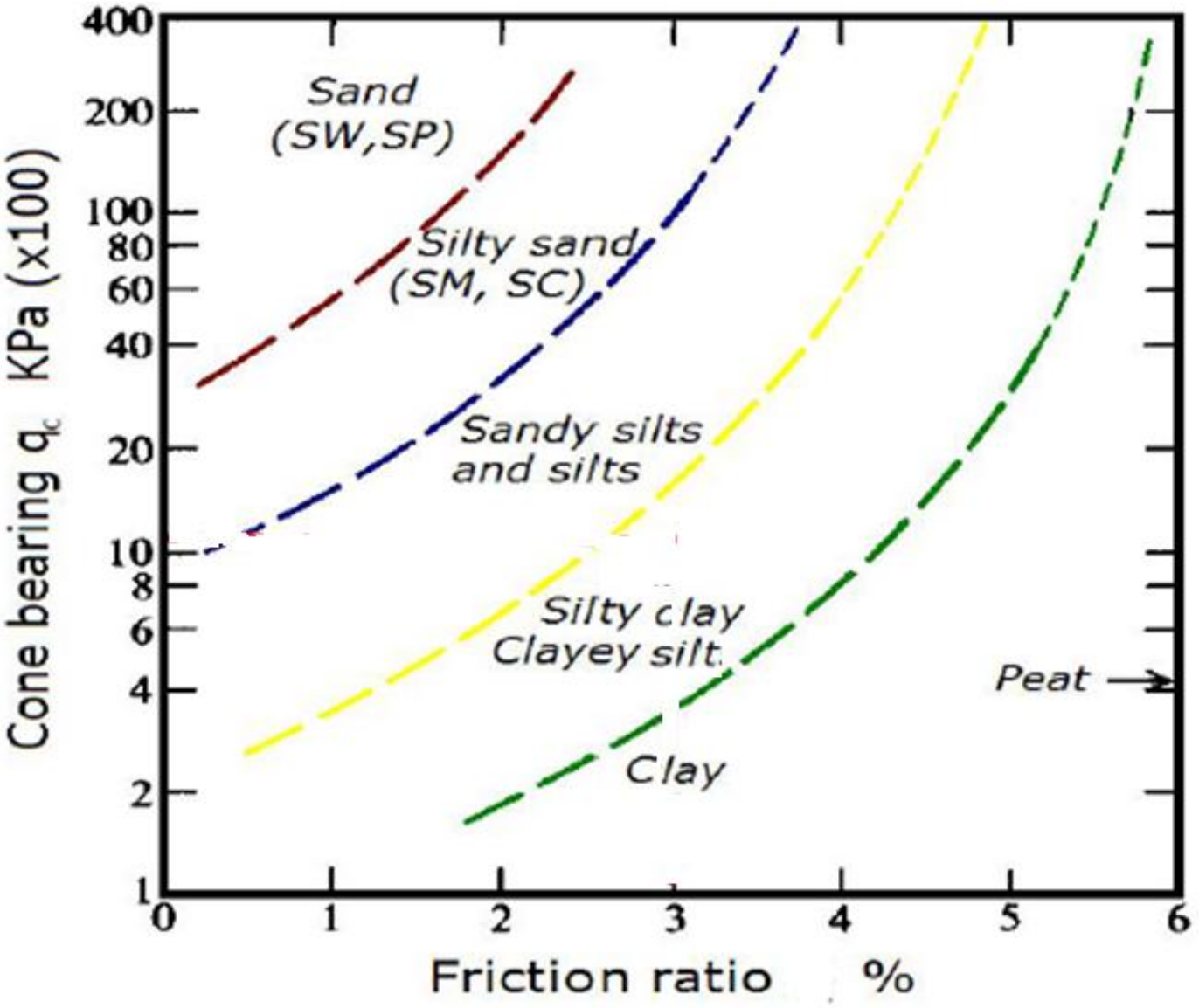
R_f=friction ratio are measured to calculate **c_u, ∅, D_r, E**(modulus of elasticity).

In addition,

V_s(shear wave velocity) can be directly measured

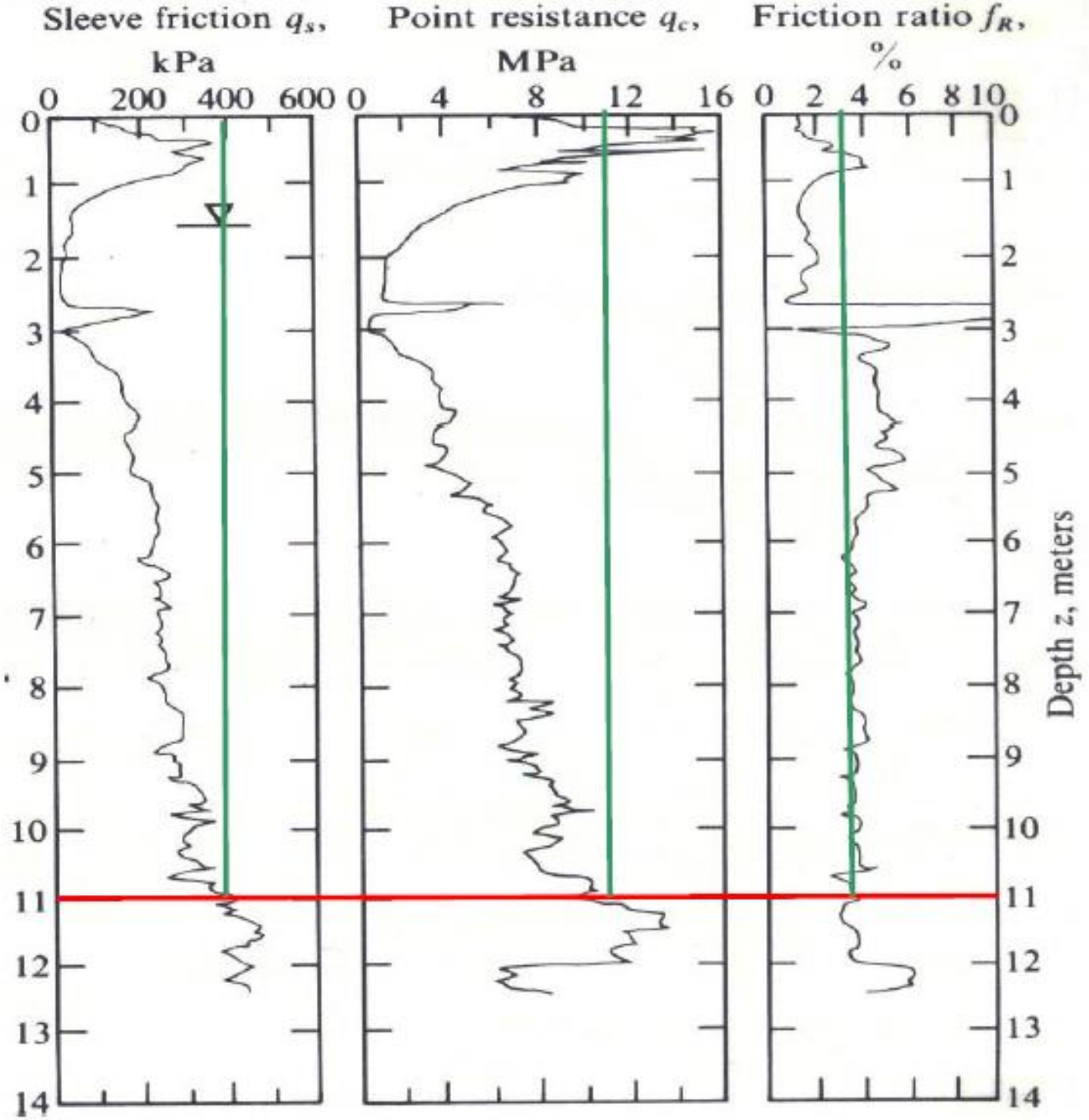
u (pore water pressure) can be directly measured.

Note: Soils can be classified by CPT.


Cone bearing q_c KPa (x100)
400
200
100
80
60
40
20
10
8
6
4
2
1
0
1
2
3
4
5
6
Friction ratio %
Sand
(SW,SP)
Silty sand
(SM, SC)
Sandy silts
and silts
Silty clay
Clayey silt
Peat
Clay

Example: Find the value of s_u and classify the soil using the data at 11.0m using the CPT results shown in the figure below.(γ=19 kN/m^3)

$$\tau = c_u = S_u$$


Sleeve friction q_s, kPa
0 200 400 600
Point resistance q_c, MPa
0 4 8 12 16
Friction ratio f_R, %
0 2 4 6 8 10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Depth z, meters

$$q_c = 11MPa = 11000kPa$$

$$\sigma_{v0} = 19k\,N/m^3\,x11m = 209kPa$$

$$s_u = c_u = \frac{q_{c-\sigma_{v0}}}{N_k} = \frac{11000-209}{18.3} \cong 600kPa$$

Pressuremeter Test

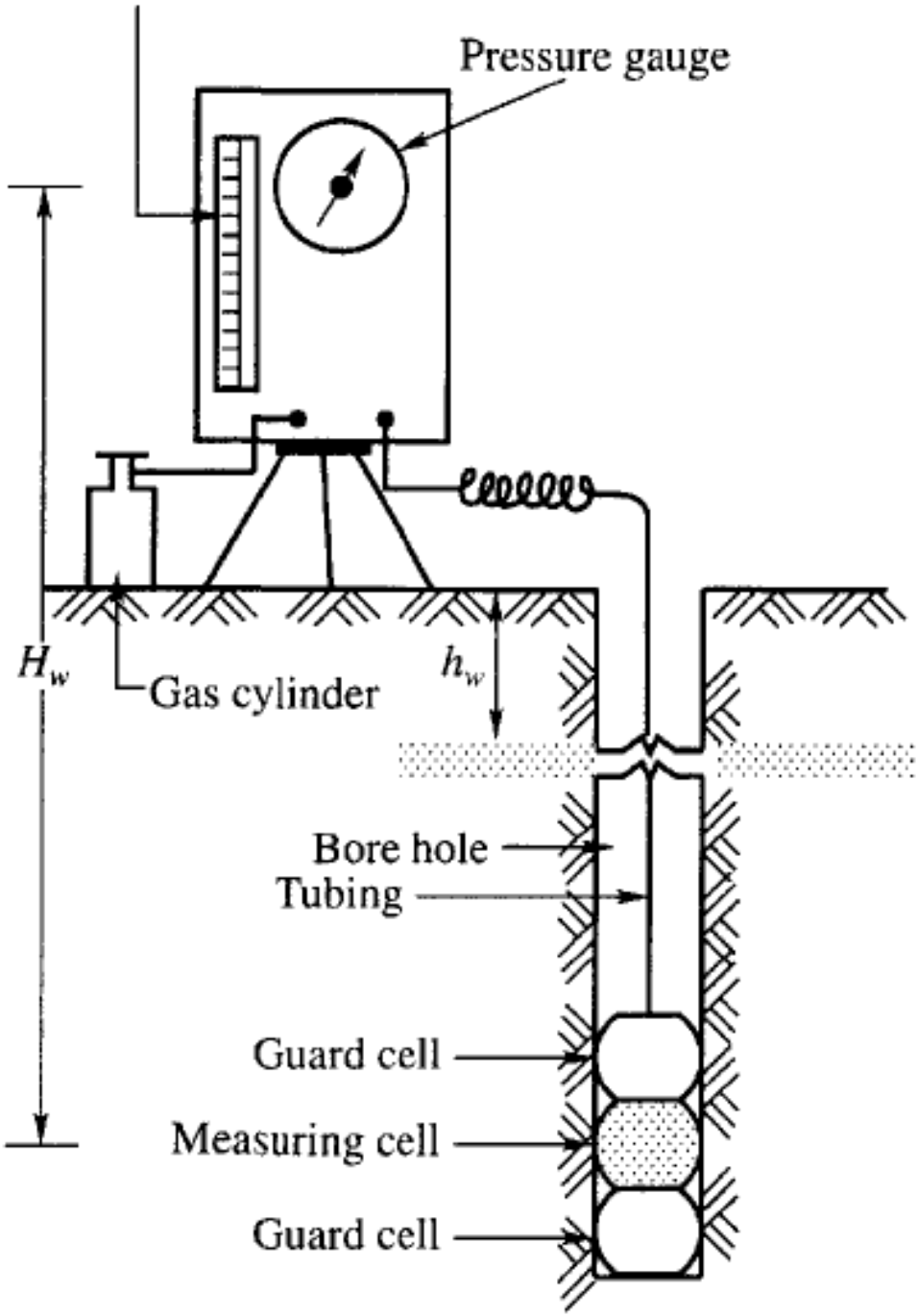
- From this test,

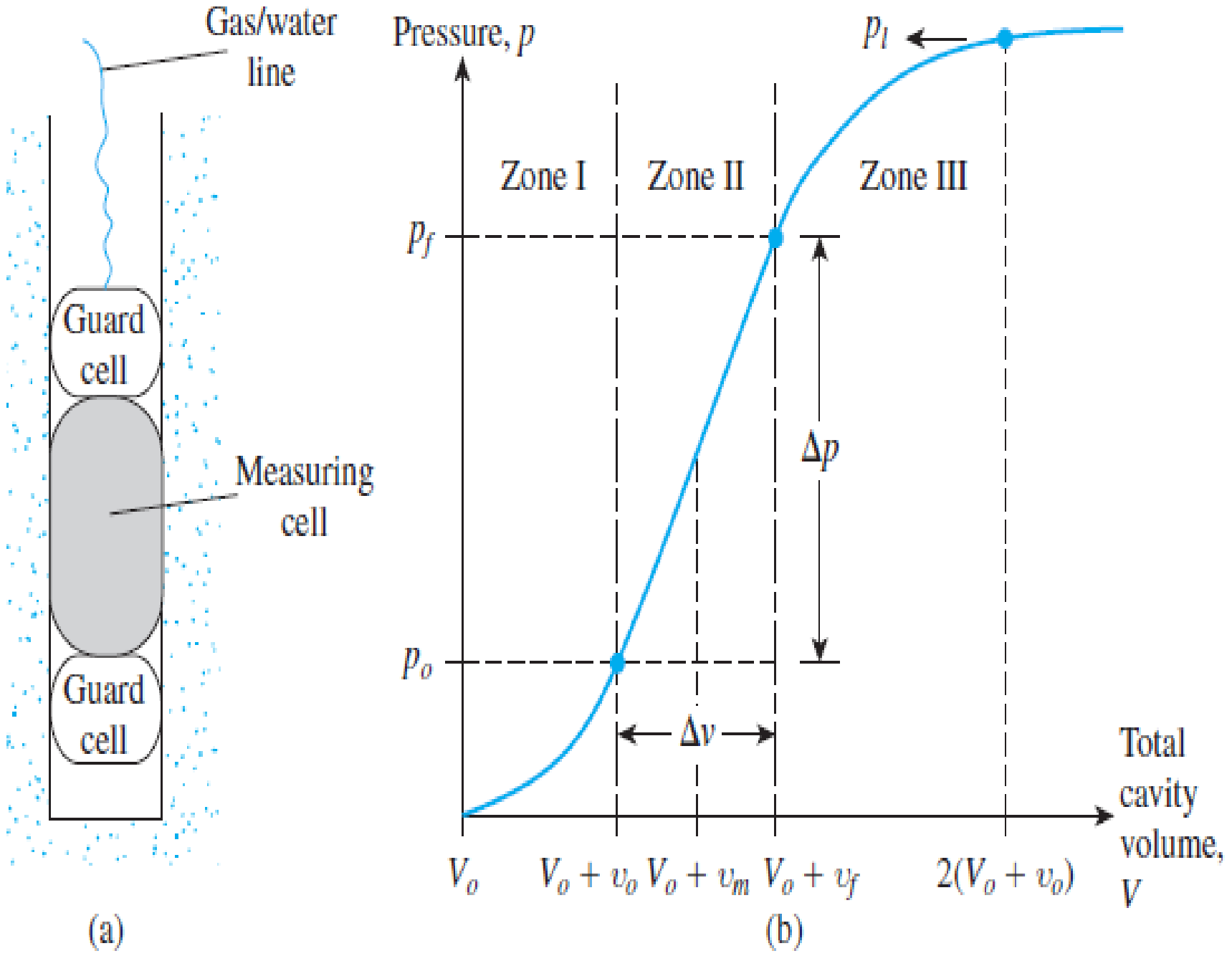
c_u (undrained cohesion)

and

E(modulus of elasticity)

can be easily obtained.


Pressure gauge
H_w
Gas cylinder
h_w
Bore hole
Tubing
Guard cell
Measuring cell
Guard cell


Gas/water line
Guard cell
Measuring cell
Guard cell
(a)
Pressure, p
p_l
Zone I
Zone II
Zone III
p_f
Δp
p_o
Δv
Total cavity volume, V
V_o
$V_o + v_o$
$V_o + v_m$
$V_o + v_f$
$2(V_o + v_o)$
(b)

Example: For a pressuremeter test;

$\Delta P = 350kPa$; $\Delta V = 150cm^3$

$V_0 = 535cm^3$; $v_m = 200cm^3$

Calculate the value of E.

$$E = 2 \quad (1 + \mu) \quad \frac{\Delta P}{\Delta V} \quad (V_0 + v_m)$$

$$E = 2 \quad (1 + 0.33) \quad \frac{350kPa}{150cm^3} \quad (535cm^3 + 200cm^3)$$

$$E \cong 4500kPa = 4.5MPa$$

In situ Vane Test

- From this test,

$c_{u,\ vane}$(undrained cohesion) is obtained.

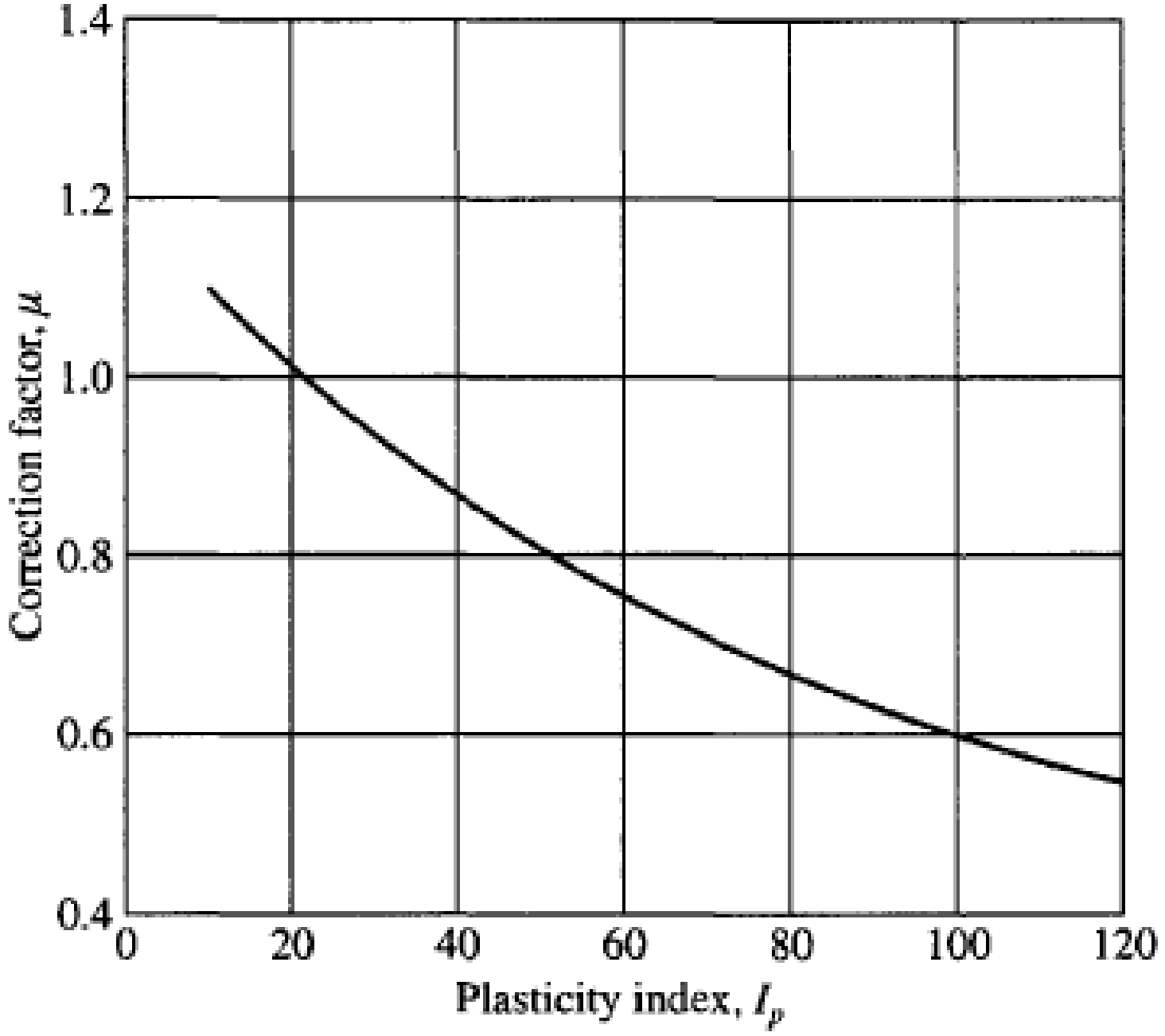
$c_{u,\ vane}$ is corrected to obtain $c_{u,\ field}$

NOTE:This test is just for clay soils.

$$T_{max} = (c_{u,vane})(\pi)(\frac{D^2 L}{2})(1 + \frac{D}{3L})$$

$$\mu = \lambda = [1.7 - (0.54)(\log PI)]$$

$$c_{u,site} = (\lambda) c_{u,vane}$$


1.4
1.2
1.0
0.8
0.6
0.4
Correction factor, μ
0
20
40
60
80
100
120
Plasticity index, I_p

Example: An in-situ vane test was carried out in a clay layer. The dimensions of the vane were D=6 cm and L=12 cm. During the test, maximum torque measured was 0.05 kN-m. If the LL and PL for this soil layer is 60% and 30% respectively, calculate the undrained shear strength of the clay layer. ($PI=I_p=60-30=30\%$)

$$T_{max} = (c_{u,vane})\ (\pi)\ \left(\frac{D^2 L}{2}\right)\ \left(1 + \frac{D}{3L}\right)$$

$$0.05kNm = (c_{u,vane})(3.14)\left(\frac{0.06^2 0.12}{2}\right)\left(1 + \frac{0.06}{0.36}\right)$$

$$c_{u,vane} \cong 60kPa$$

$$\mu = \lambda = [1.7 - (0.54)(\log PI)]$$

$$\mu = \lambda = [1.7 - (0.54)(\log 30)] = 0.9$$

$$c_{u,site} = (\lambda)c_{u,vane} = (0.9)(60kPa) = 54\ kPa$$

Plate Loading Test

- From this test,
- **$k_{0.3 \times 0.3}$ (modulus of subgrade reaction) is obtained.**
- **$k_{0.3 \times 0.3}$ are used to calculate $k_{B \times B}$ and $k_{B \times L}$**

For square foundations on sandy soils

$$k_{BxB} = k_{0.3}\left(\frac{B+0.3}{2B}\right)^2$$

For square foundations on clay soils

$$k_{BxB} = k_{0.3}\left(\frac{0.3}{B}\right)$$

For rectangular foundations

$$k_{BxL} = \frac{k_{BxB}}{1.5}\left(1+(0.5\frac{B}{L})\right)$$

Example: $k_{0.3}$ was calculated as 20 MN/m³ from a plate loading test.

a)If the soil is sand and the foundation is a square foundation (2m x 2m), k=?

$$k_{BxB} = k_{0.3}\left(\frac{B+0.3}{2B}\right)^2 = 20\left(\frac{2m+0.3}{4m}\right)^2$$ =6.6 MN/m³=6600 kN/m³

b)If the soil is clay and the foundation is a square foundation (2m x 2m), k=?

$$k_{BxB} = k_{0.3}\left(\frac{0.3}{B}\right) = 20\left(\frac{0.3}{2m}\right)$$ = 3 MN/m³=3000 kN/m³

c)If the soil is sand and the foundation is a rectangular foundation (2m x 3m), k=?

$$k_{BxL} = \frac{k_{BxB}}{1.5}\left(1+(0.5\frac{B}{L})\right) = \frac{6.6}{1.5}\left(1+(0.5\frac{2m}{3m})\right) =$$ 5.9 MN/m³=5900 kN/m³