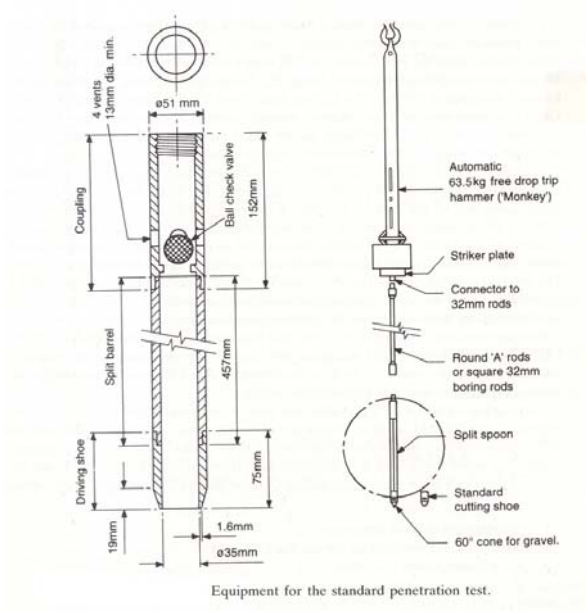
3.2 Standard Penetration Test (SPT)

(1) General



Equipment for the standard penetration test.

- The SPT is carried out in a borehole, by driving a standard spilt spoon sampler using repeated blows of a 63.5 kg hammer falling through 762 mm.
- The penetration resistance (N) is the number of blows required to drive the spilt spoon for the 30cm penetration.

(2) Influence factors on test results (N values)

i) Hammer efficiency

- SPT N values should be converted to N_{60} equivalent to a delivered energy of 60%

$$N_{60} = N_{measured} \times \frac{E_{mesured}}{E_{60}}$$

ii) Rod length

- Overestimate N value when rod length < 10 m

Variation of η_R

Rod length		η_R
m	ft	
>10	>30	1.0
6-10	20-30	0.95
4-6	12-20	0.85
0-4	0-12	0.75

iii) Overburden effective stress – cohesionless soil

$$N' = C_N \times N$$

Liao and Withman (1986) $C_N = 9.8\sqrt{\frac{1}{\sigma_v'}}$

Skempton (1986) $C_N = \frac{2}{1+\frac{\sigma_v'}{95.6}}$

$$C_N = \frac{3}{2+\frac{\sigma_v'}{95.6}}$$

$$C_N = \frac{1.7}{0.7+\frac{\sigma_v'}{95.6}}$$

Other factor

- Borehole diameter
- Difference water-table between borehole and original ground
- Sampler liner

- **Corrected N values → N'**

$$N' = N_{60} \times C_N \times \eta_1 \times \cdots \times \eta_n$$

(3) Determination of soil parameters

i) D_r and ϕ'

N	Soil condition	D_r (%)	Friction angle (ϕ')	
			Peck	Meyerhof
0 ~ 4	Very loose	0 ~ 20	< 28.5	< 30
4 ~ 10	Loose	20 ~ 40	28.5 ~ 30.0	30 ~ 35
10 ~ 30	Medium	40 ~ 60	30.0 ~ 36.0	35 ~ 40
30 ~ 50	Dense	60 ~ 80	36.0 ~ 41.0	40 ~ 45
50 이상	Very dense	80 ~ 100	>41.0	> 45

Peck(1974), Meyerhof (1956)

- Marcuson & Bieganousky (1977)

$$D_r(\%) = 11.7 + 0.76(222N + 1600 - 53\sigma_v' - 50C_u^2)^{0.5}$$

(where, σ_V': *psi* (unit), C_u : coefficient of uniformity)

- Dunham, 1954

Soil type	Friction angle (ϕ')
Round and poorly graded sand	$\sqrt{12N} + 15$
Round and well graded sand Angular and poorly graded sand	$\sqrt{12N} + 20$
Angular and well graded sand	$\sqrt{12N} + 25$

- Peck-Hanson-Thornburn (1974) $\phi' = 271 + 0.3N' - 0.00054N'^2$

- Schmertmann (1975) $\phi' = \tan^{-1}\left[\dfrac{N}{12.2 + 20.3(\dfrac{\sigma_v'}{p_a})}\right]$

- Ohsaki (1959) $\phi' = \sqrt{20N} + 15$

- Hatanaka & Uchida (1996) $\phi' = \sqrt{20N} + 20$

ii) Consistency and q_u of clayey soils

- Terzaghi & Peck (1948)

Consistency	N	q_u (kPa)
Very soft	< 2	< 25
Soft	2 ~ 4	25 ~ 50
Medium	4 ~ 8	50 ~ 100
Stiff	8 ~ 15	100 ~ 200
Very stiff	15 ~ 30	200 ~ 400
Hard	> 30	> 400

cf) Estimation of q_u or s_u based on SPT results, can be erratic and thus, is recommended careful. s_u values estimated from SPT N values are used as a reference values, not design parameters.