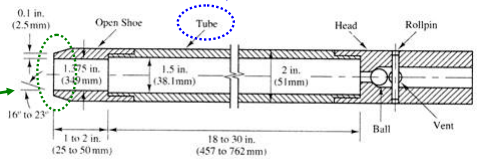
Standard **P**enetration **T**est

in-situ test …to get ϕ'

J. Valdes SDSU

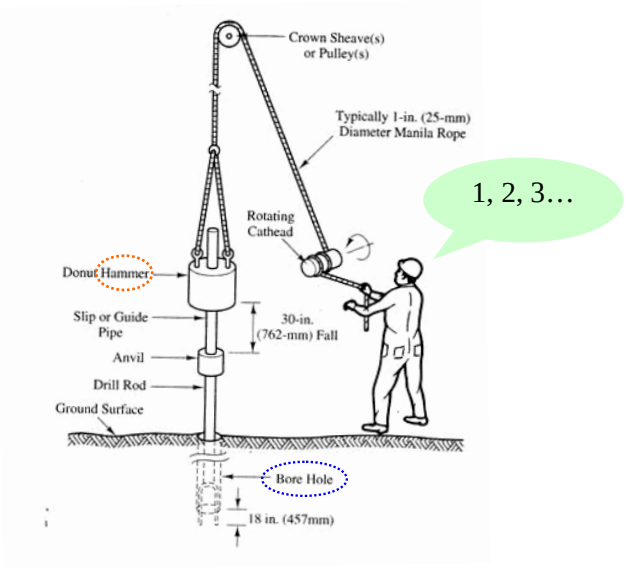
Sampler

The *split-spoon* sampler allows for **soil recovery**



Tapered tip facilitates penetration

Rig



Procedure

1) Drill boring (hole)

2) Insert sampler

3) Drive sampler into the ground 18” & count **<u># of hits</u>** (**N**) required to drive each 6” interval

if **N** for 6” > 50

or if **N** for all 18” >100 } *“Refusal”*

Procedure

4) $\boldsymbol{N_{SPT}}$ = Σ**N** for last two 6-inch intervals

5) Retrieve sampler & save soil

6) Drill to next depth & go to step 2

$\boldsymbol{N_{SPT}}$ = *fn* (soil **strength and stiffness**, method of drilling, boring cleanliness, hammer location, hammer type, "hangover level" of technician, and many others…)

Corrections

from "N_{SPT}" to "N_{60}"

$$N_{60} = \frac{E_m C_B C_S C_R N_{SPT}}{.60}$$

C_B = borehole dia. correction - table 3.4 (next slide)

C_S = sampler correction

C_R = rod length correction

C_B, C_S, C_R

TABLE 3.4 BOREHOLE, SAMPLER, AND ROD CORRECTION FACTORS (Adapted from Skempton, 1986).

Factor	Equipment Variables	Value
Borehole diameter factor, C_B	65 - 115 mm (2.5 - 4.5 in)	1.00
	150 mm (6 in)	1.05
	200 mm (8 in)	1.15
Sampling method factor, C_S	Standard sampler	1.00
	Sampler without liner (not recommended)	1.20
Rod length factor, C_R	3 - 4 m (10 - 13 ft)	0.75
	4 - 6 m (13 - 20 ft)	0.85
	6 - 10 m (20 - 30 ft)	0.95
	> 10 m (> 30 ft)	1.00

Efficiency: E_m

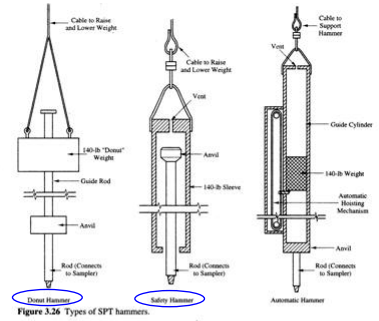


Figure 3.26 Types of SPT hammers.

TABLE 3.3 SPT HAMMER EFFICIENCIES (Adapted from Clayton, 1990).

Country	Hammer Type	Hammer Release Mechanism	Hammer Efficiency E_m
Argentina	Donut	Cathead	0.45
Brazil	Pin Weight	Hand Dropped	0.72
China	Automatic	Trip	0.60
	Donut	Hand dropped	0.55
	Donut	Cathead	0.50
Colombia	Donut	Cathead	0.50
Japan	Donut	Tombi trigger	0.78 - 0.85
	Donut	Cathead 2 turns + special release	0.65 - 0.67
UK	Automatic	Trip	0.73
USA	Safety	2 turns on cathead	0.55 - 0.60
	Donut	2 turns on cathead	0.45
Venezuela	Donut	Cathead	0.43

$$N_{60} = \frac{E_m C_B C_S C_R N_{SPT}}{.60}$$

Depth [stress] correction

Recall: S = σ' tan ϕ'

S ↑ as σ' ↑ ; therefore, N_{SPT} ↑ as z ↑

So, we ***normalize*** to remove the effect of σ' (remember: we are looking for ϕ')

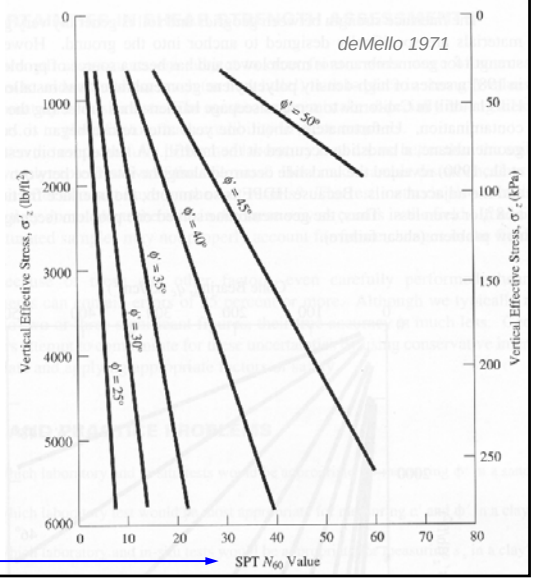
$$(N_1)_{60} = N_{60}\sqrt{\frac{p_a}{\sigma'}}$$

where p_a = 100 kPa (i.e., atm press)

and $(N_1)_{60} \leq 2N_{60}$

ϕ'

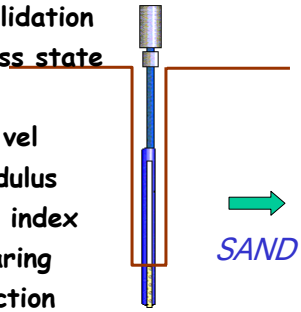
The stress effect is captured in the plot on the right, which is used to obtain an estimate of ϕ' from SPT data



Is One Number Enough???

c_u = undrained strength
γ_T = unit weight
I_R = rigidity index
ϕ' = friction angle
OCR = overconsolidation
K_0 = lateral stress state
e_o = void ratio
V_s = shear wave vel
E' = Young's modulus
C_c = compression index
q_b = pile end bearing
f_s = pile skin friction
k = permeability
q_a = bearing stress

CLAY



N

SAND

D_R = relative density
γ_T = unit weight
LI = liquefaction index
ϕ' = friction angle
c' = cohesion intercept
e_o = void ratio
q_a = bearing capacity
σ_p' = preconsolidation
V_s = shear wave
E' = Young's modulus
Ψ = dilatancy angle
q_b = pile end bearing
f_s = pile skin friction