Lab Manual

Standard Penetration Test (SPT)

Dynamic Cone Penetration Test (DCPT)

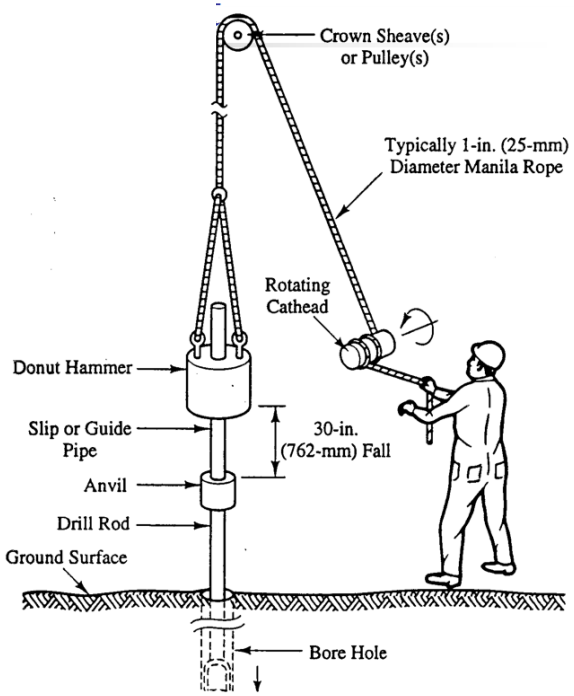
Real Life Projects and Challenges: Standard Penetration Test (SPT)

Project Type 1: Construction of a residential building

Depth of borehole: up to 30 m

Method of SPT: Using tripod (rope and pulley system)

Limitation: Chances of error due to < 750 mm free fall height of the hammer



SPT using Tripod (Rope and Pulley system)

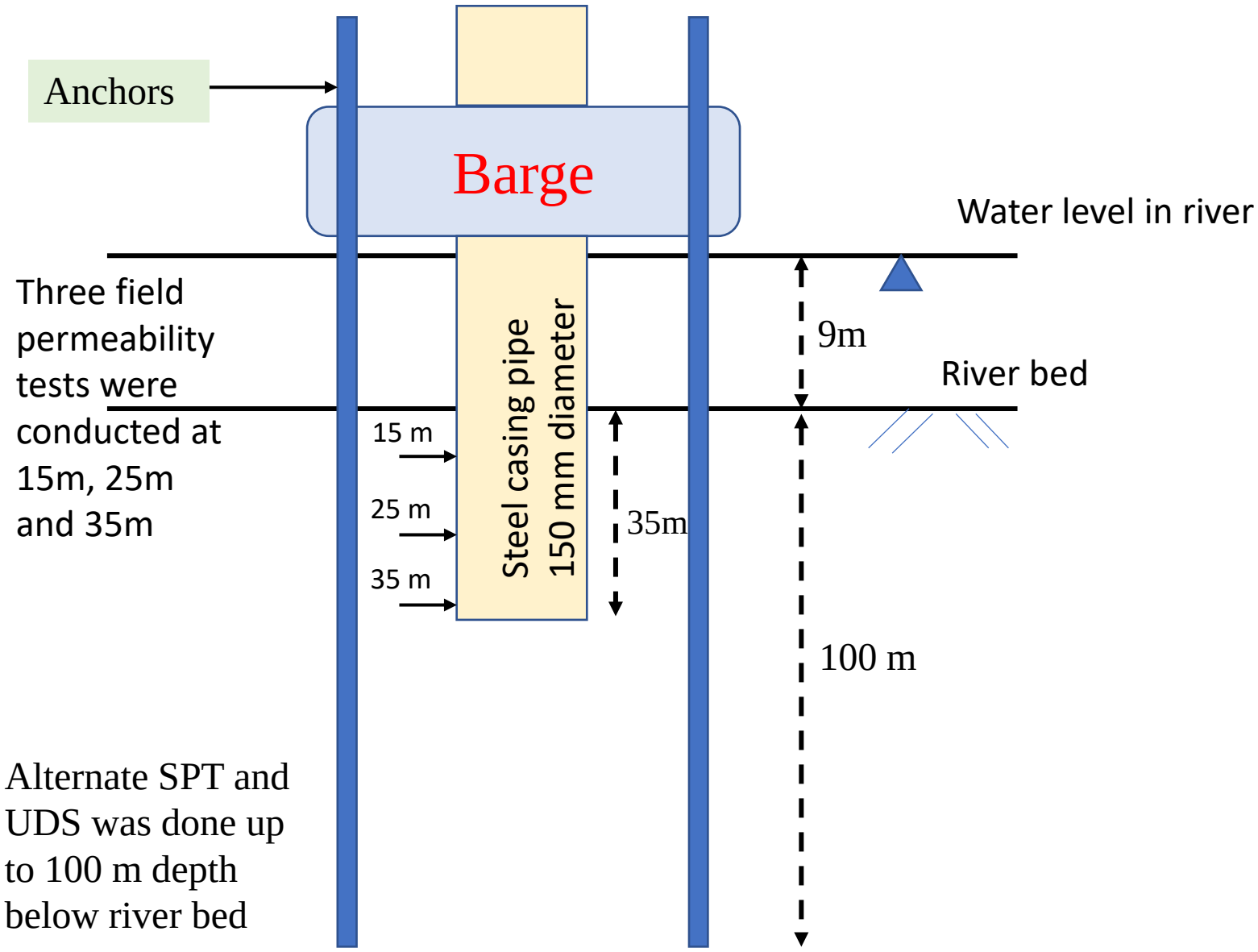
Project Type 2: Construction of Barrage

Major challenge: Underwater SPT

Method of SPT: Both Semi-automatic and fully-automatic SPT

Depth of borehole: 100 m below the river bed

Under water SPT and sample collection



Jack up Barge

Underwater SPT

Fully-Automatic SPT

Project Type 3: Construction of Six-Lane Elevated Corridor

Depth of borehole: 18 m

Salient points:

Rock strata found below 3m

Rock cores were collected using rock cutting bits

Rock core bit

Rock coring

Collected rock cores (Arranged depth wise)

Project Type 4: Restoration of Canal Lining

Depth of borehole: 25m

Method of SPT: Semi-automatic SPT

Special feature: **Requirement of borehole stabilization**

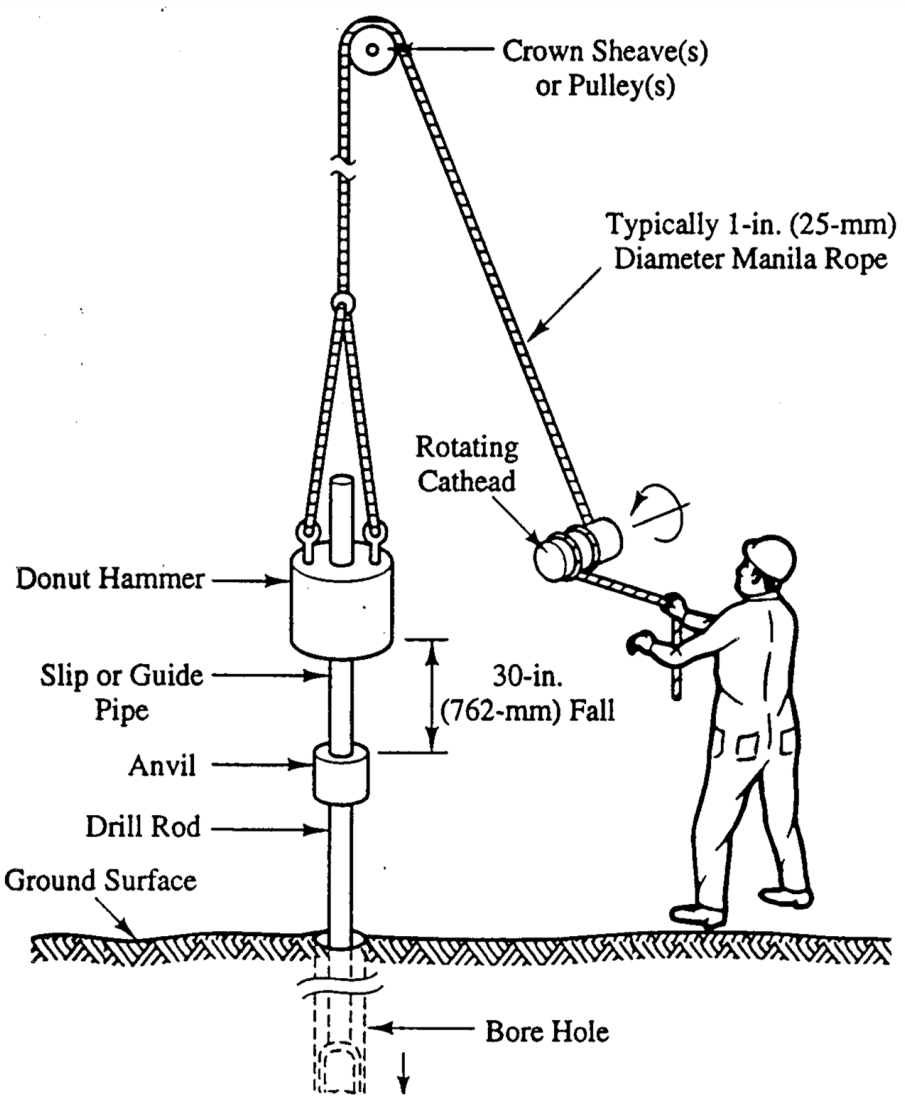
https://wrd.maharashtra.gov.in

UDS sample collected

Standard Penetration TEST

IS 2131: 1981 (Reaffirmed 2002)

Standard Penetration Test



Components

- Drilling Equipment
  - Inner diameter of hole → 100 to 150 mm
  - Casing may be used in case of soft/non-cohesive soils
- Split spoon sampler → IS:9640-1980
- Drive weight assembly
  - Falling Weight = **63.5 Kg**
  - Fall height = **75 cm**
- Others → Lifting bail, Tongs, ropes, screw jack, etc.

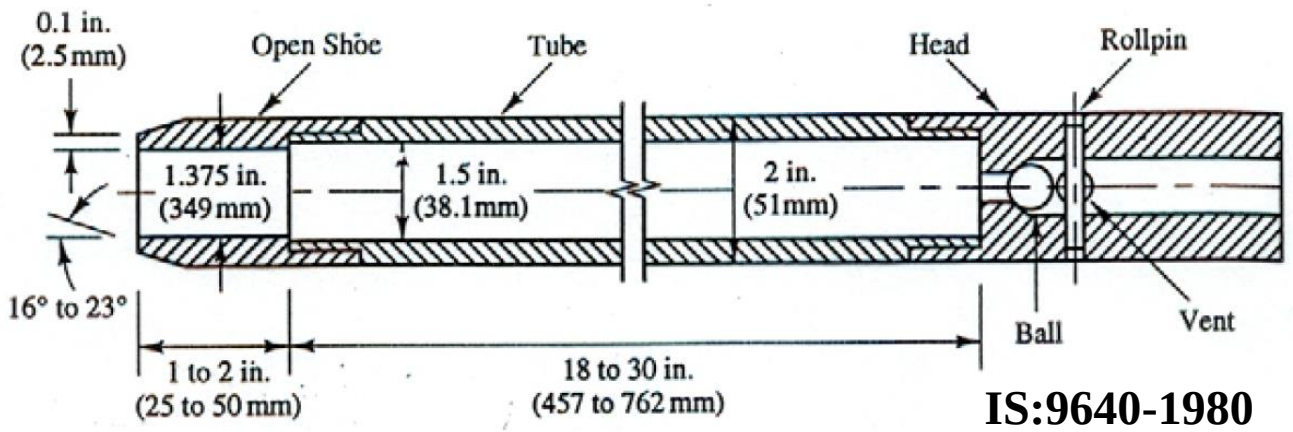
Drilling Equipment

- Inner diameter of hole → 100 to 150 mm
- Casing may be used in case of soft/non-cohesive soils

Open hole Auger

Helical Auger

Standard Split Spoon-Sampler



IS:9640-1980

Thick wall (0.25in) cylinder

Sampling tube (dia 51 mm) is split along the length

Representative Disturbed soil samples

Shelby Tube- Sampler

Thin wall (1/16in = 0.0625 in) sampling tube

Sampler pushed into the ground hydraulically

Sample extruded from tube and "Undisturbed" soil sample is obtained

Procedure

- The bore hole is advanced to desired depth and bottom is cleaned
- Split spoon sampler is attached to a drill rod and rested on bore hole bottom
- Driving mass is dropped onto the drill rod repeatedly and the sampler is driven into soil for a distance of 450 mm. The number of blow for each 150 mm penetration are recorded
- N-value
  - First 150 mm penetration is considered as seating penetration
  - The number of blows for the last two 150 mm penetration are added together and reported as N-value for the depth of bore hole
- The split spoon sampler is recovered, and sample is collected from split barrel so as to preserve moisture content and sent to the laboratory for further analysis
- SPT is repeated at every 750 mm or 1500 mm interval for larger depths

Exploration extent and Refusal stage

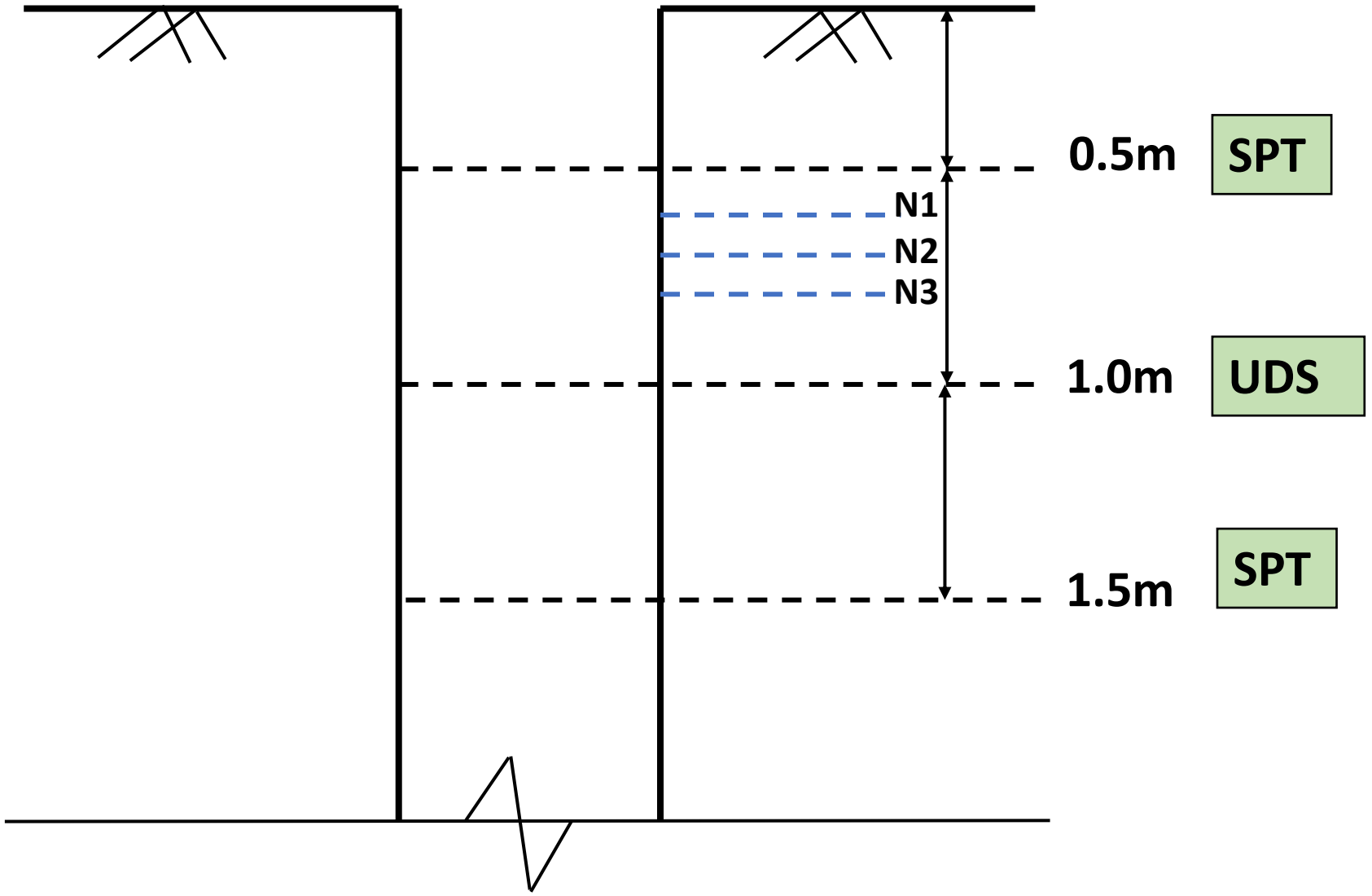
- Exploration extent depends on:
  - Type of structure - Intensity of loading
  - Cost of project
  - Variability of strata
  - Zone of influence
    - Bearing capacity
    - Settlement

- Under the following conditions the penetration is referred to as Refusal/Rebound and test is halted
  a) 50 blows are required for any 150 mm penetration
  b) 100 blows are required for last 300 mm penetration
  c) 10 successive blows produce no advancement

Precautions

- The ht. of free fall Must be 750 mm
- The fall of hammer must be free, frictionless and vertical
- Cutting shoe of the sampler must be free from wear & tear
- The bottom of the bore hole must be cleaned to collect undisturbed sample
- When SPT is done in a sandy soil below water table , the water level in the bore hole MUST be maintained higher than the ground water level.
  Otherwise: QUICK condition!!
  Very Low N value

Standard Penetration Test (SPT)



SPT Corrections

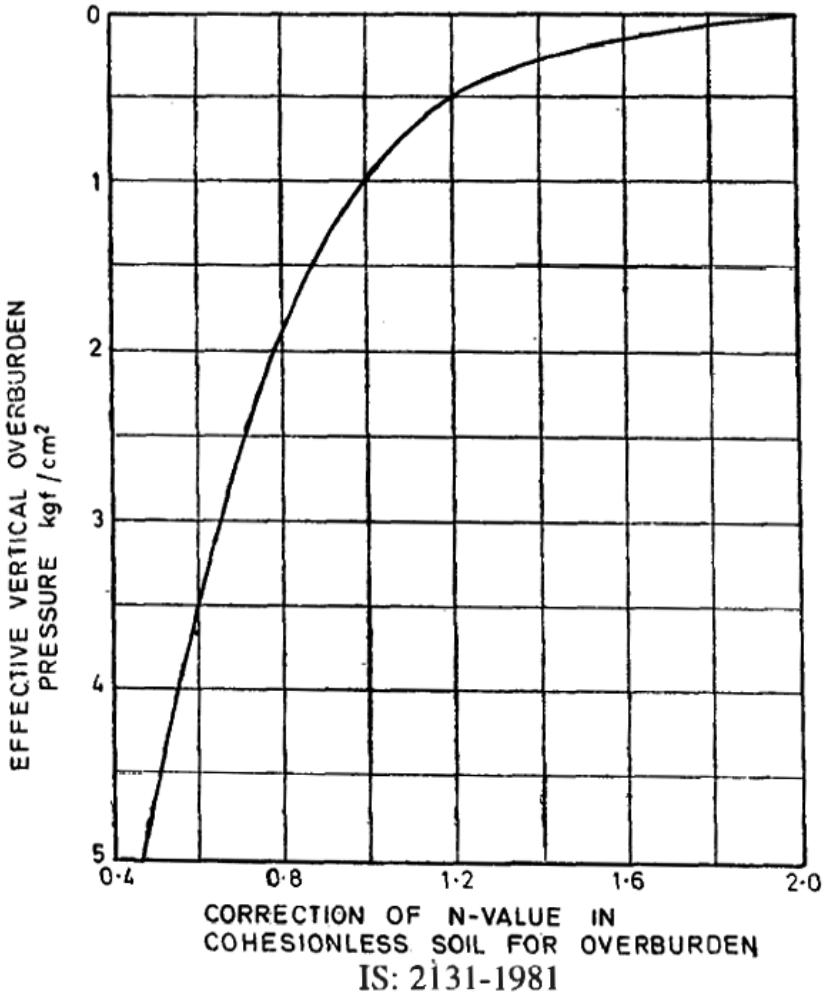
- **Overburden correction**
- **Dilatancy correction**

Correction for Overburden Pressure

$$N' = C_N . N$$

N' = Corrected value of observed N

C_N = Correction factor for overburden pressure



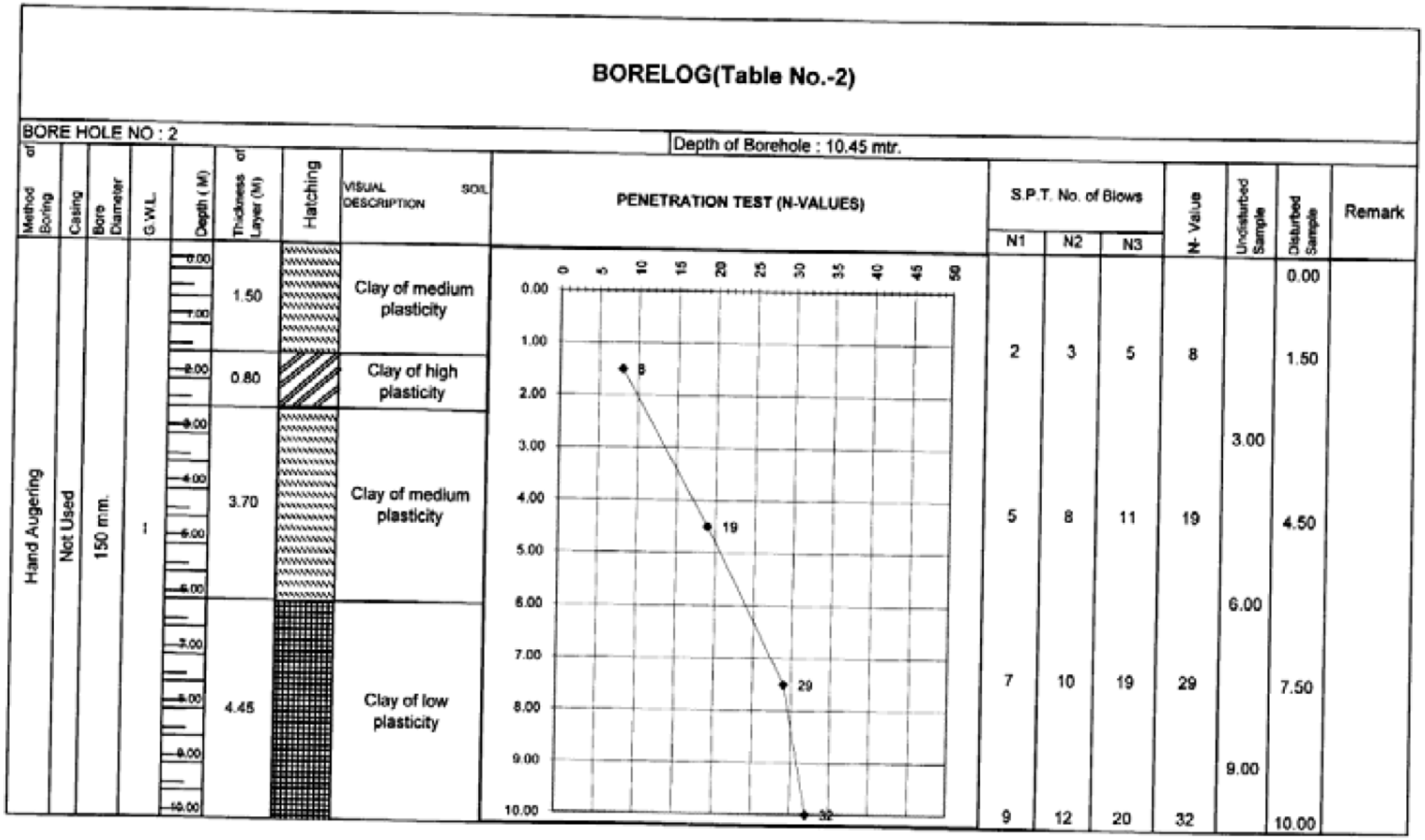
Correction for Dilatancy

If the stratum consists of fine sand and silt below water table, for $N' > 15$, the dilatancy correction is applied as

$$N'' = 15 + 0.5\,(N' - 15) \qquad (\text{when } N' > 15)$$
$$\text{If } N' \leq 15,\ N'' = N'$$

← IS: 2131-1981

SPT Test data



BORELOG(Table No.-2)

BORE HOLE NO : 2

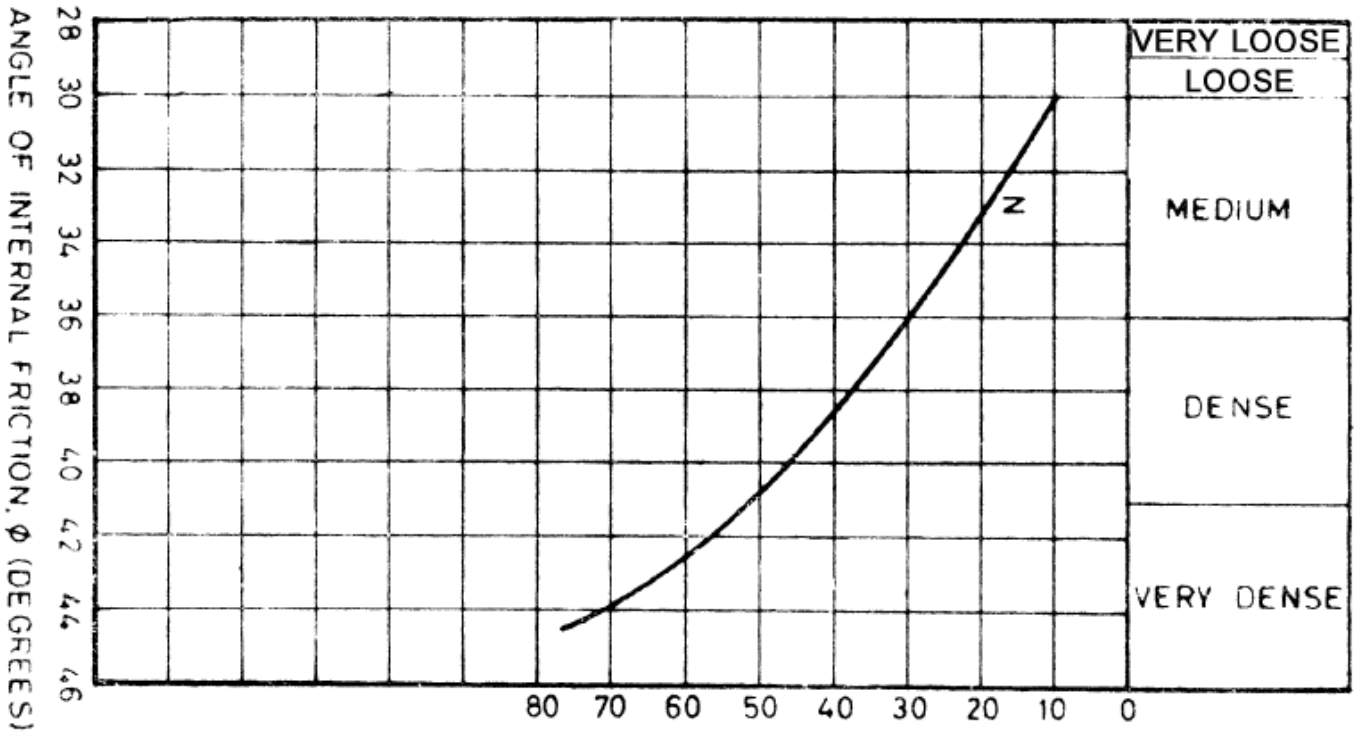
Depth of Borehole : 10.45 mtr.

Method of Boring	Casing	Bore Diameter	G.W.L.	Depth (M)	Thickness of Layer (M)	Hatching	VISUAL DESCRIPTION OF SOIL
Hand Augering	Not Used	150 mm.	-	0.00 – 1.50	1.50		Clay of medium plasticity
				1.50 – 2.30	0.80		Clay of high plasticity
				2.30 – 6.00	3.70		Clay of medium plasticity
				6.00 – 10.45	4.45		Clay of low plasticity

PENETRATION TEST (N-VALUES)

S.P.T. No. of Blows N1	N2	N3	N- Value	Undisturbed Sample	Disturbed Sample	Remark
					0.00	
2	3	5	8		1.50	
				3.00		
5	8	11	19		4.50	
				6.00		
7	10	19	29		7.50	
				9.00		
9	12	20	32		10.00	

Interpretations from SPT



IS 6403-1981

N''	ϕ'	D_r (%)	consistency
0-4	25-30	0-15	very loose
4-10	27-32	15-35	loose
10-30	30-35	35-65	medium
30-50	35-40	65-85	dense
>50	38-43	85-100	very dense

Interpretations from SPT-Cohesive soil

not corrected for overburden

$$c_u = 6.25.N \quad \text{in kPa}$$

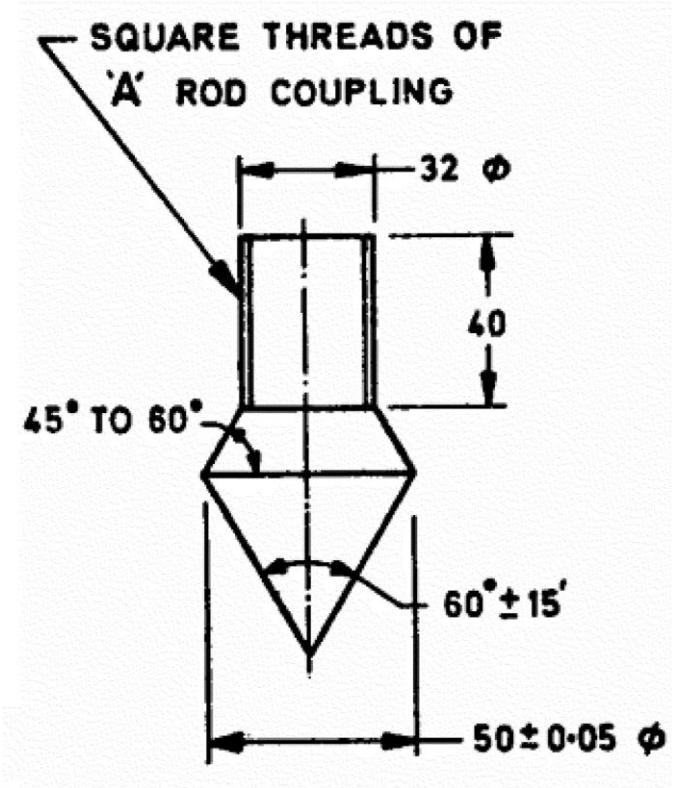
N	c_u (kPa)	consistency	visual identification
0-2	0 - 12	very soft	Thumb can penetrate > 25 mm
2-4	12-25	soft	Thumb can penetrate 25 mm
4-8	25-50	medium	Thumb penetrates with moderate effort
8-15	50-100	stiff	Thumb will indent 8 mm
15-30	100-200	very stiff	Can indent with thumb nail; not thumb
>30	>200	hard	Cannot indent even with thumb nail

Dynamic Cone Penetration TEST

IS 4968: 1981

Components

Cone (dia = 50 mm)



Threaded Cone

Un-threaded Cone

Driving rods/drill rods

marked at every 100 mm

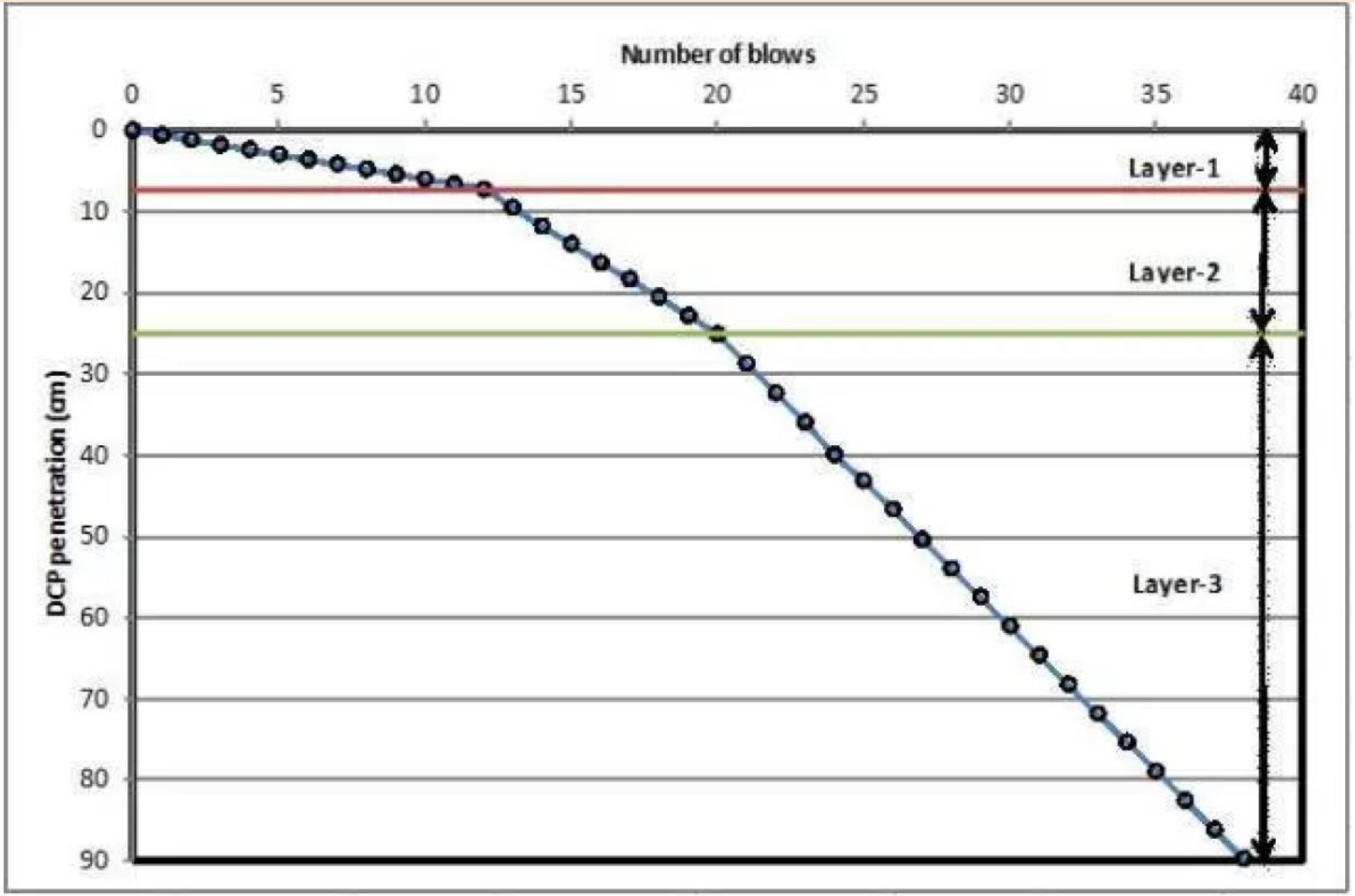
Connecting Rod

Procedure

- Cone – drill rod – driving head assembly is installed vertically on the ground and hammer is dropped from standard height repeatedly
- The blow counts are recorded for every 100 mm penetration. A sum of three consecutive values i.e. 300 mm is noted as the dynamic cone resistance, N_{cd} at that depth.
- The cone is driven up to refusal or the project specified depth.
- In the end, the drill rod is withdrawn. The cone is left in the ground if unthreaded or recovered if threaded.

- **No sample recovered**
- **Fast testing – less project cost / cover large area in due time**
- **Use of bentonite slurry is optional, which is used to reduce friction on the driving rods.**
  - **Modified cone is used in this case: diameter = 62.5 mm**

DCPT Test data



DCPT – SPT Correlations for 50 mm dia. cone

N_{cd} = 1.5 N	For depth < 3 m
N_{cd} = 1.75 N	For depth 3 m to 6 m
N_{cd} = 2.0 N	For depth > 6 m

DCPT – SPT Correlations for 62.5 mm dia. cone

Without bentonite slurry	N_{cbr} = 1.5 N	For depth < 4 m
	N_{cbr} = 1.75 N	For depth 4 m to 9 m
	N_{cbr} = 2.0 N	For depth > 9 m
With circulating bentonite slurry	N_{cbr} = N	For all depths

Soil Sampling

- **Disturbed Samples**: Natural soil structure is modified or destroyed during sampling
  - Representative Samples:
    - Natural water content and mineral constituents of particular soil layer are preserved
    - Good for soil identification and water content
  - Non-representative Samples:
    - Water content altered and soil layers mixed up
    - Of no use.
- **Undisturbed Samples**: Soil structure and the other mineral properties are preserved to an extent.
  - Some disturbance is always there, e.g. due to stress release. However it should be minimized in order to have suitable sample for our analysis.

Sample disturbance criteria:

- Area ratio:

$$A_r = \frac{Maximum\ cross-sectional\ Area\ of\ cutting\ egde}{Area\ of\ the\ soil\ sample} * 100$$

$$A_r = \frac{D_2^2 - D_1^2}{D_1^2} * 100$$

For good quality undisturbed sample Area Ratio must be:

- <10 – Soft sensitive clays
- <20 – Stiff formations