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# STANDARD PENETRATION TEST

**The most widely used in-situ test in geotechnical engineering - how it works, what it tells you, and how to use the results**

What is SPT - How It Works - N-value & Corrections - Soil Parameters from SPT - SPT vs CPT - Limitations

# WHAT IS THE STANDARD PENETRATION TEST?

SPT is a simple, robust in-situ test performed inside a borehole to measure soil resistance — giving engineers a direct feel for what's underground at every metre of depth.

## TEST SETUP

1. Borehole drilled to test depth
2. Split-spoon sampler driven into soil
3. 63.5 kg hammer dropped from 760 mm height
4. Blow count recorded for each 150 mm of penetration

| | |
|---|---|
| **N-value** | Blow count for last 300 mm of 450 mm drive (first 150 mm discarded as seating) |
| **Depth Interval** | Typically tested every 1.5 m throughout the borehole |
| **Standard** | ASTM D1586 / IS 2131 / BS 1377 |

**Key Principle:** The first 150 mm of driving is always discarded — only the last 300 mm blow count is the N-value.

# N-VALUE CORRECTIONS - WHY RAW DATA IS NEVER ENOUGH

The raw N-value is affected by equipment, borehole size, overburden pressure and energy delivery. Corrections must always be applied before using N for design.

### Energy Correction (CE)

SPT hammer delivers only 60–90% of theoretical energy

**N60 = N x (ER/60)**

ER = Energy ratio of hammer used — donut, safety or automatic

### Overburden Correction (CN)

Shallow soils give artificially low N

**N1(60) = N60 x CN**

CN = (100/sigma'v)^0.5 — normalises to 100 kPa reference stress

### Borehole & Rod Corrections

CB for borehole diameter > 115 mm

**CR for rod length < 3 m**

CS for liner presence — all multiply together

**(N1)60 = N x CE x CB x CR x CS x CN**

Corrected SPT value used in all design correlations

# SOIL PARAMETERS FROM SPT N-VALUE

Despite being a simple test, SPT N-values correlate with a surprisingly wide range of geotechnical design parameters through empirical relationships.

## FOR SANDY SOILS

**Relative Density :**
Dr (%) = (N1(60)/60)^0.5 x 100 — Terzaghi & Peck

**Friction Angle :**
phi = 27.1 + 0.3N60 - 0.00054 N60^2 — Wolff (1989)

**Liquefaction :**
(N1)60 < 15 -> susceptible - CRR derived from SPT curves

**Bearing Capacity :**
qa = N/0.05 kPa (Meyerhof, B < 1.2 m) - for shallow foundations

## FOR CLAYEY SOILS

**Undrained Shear Strength :**
Su = N x f1 kPa - f1 = 4-6.5, lower for high-plasticity clay - Stroud (1974)

**Consistency :**
N<2 V.Soft - 2-4 Soft - 4-8 Medium - 8-15 Stiff - 15-30 V.Stiff - >30 Hard

**Compressibility :**
Used to estimate Cc and mv for settlement predictions

**Foundation Depth :**
Refusal N > 50 often taken as practical end of soft layer

# SPT vs CPT - WHICH ONE TO USE?

Both tests measure soil resistance in-situ - but they work differently, suit different soils, and give different quality of output.

| Parameter | SPT | CPT |
|---|---|---|
| **Method** | Dynamic impact — blow count | Static push — continuous resistance |
| **Output** | N-value (discrete) | qc and fs (continuous profile) |
| **Sample** | Yes — disturbed sample | No sample retrieved |
| **Repeatability** | Moderate — operator dependent | High — fully automated |
| **Best in** | Gravel, cobbles, hard soils | Sand, silt, soft clay |
| **Cost** | Lower — simpler equipment | Higher — specialist rig |
| **Data quality** | Good for preliminary design | Excellent for detailed design |

**Use SPT** when you need a sample and the ground has gravel or cobbles. **Use CPT** when you need a continuous detailed profile in fine-grained soils.

**In Practice:** Both tests are often run together - SPT gives the sample, CPT gives the profile.

# SPT LIMITATIONS & BEST PRACTICE

SPT is powerful but misused constantly. Understanding its limitations is as important as knowing how to apply it.

## KEY LIMITATIONS

**Operator Dependent —** Energy delivery varies with hammer type, operator skill and rod condition — up to 40% variation in same soil

**Discrete Data —** Only tested every 1.5 m — thin critical layers can be completely missed

**Poor in Gravel —** Overestimates N in coarse gravelly soils — gravel particles jam the sampler

**Not for Rock —** Refusal (N > 50) tells you nothing about rock quality — use RQD instead

## BEST PRACTICE RULES

- Always specify and record the hammer type and energy ratio
- Never use raw N — always apply (N1)60 corrections before design
- Supplement with CPT in soft clays for continuous profiling
- Log borehole conditions — groundwater level, caving, drilling fluid
- Always take lab samples at critical depths alongside SPT
- Use local SPT-to-parameter correlations — published values have wide scatter

**Remember:** SPT is a tool — not a complete answer. Always combine with lab testing, CPT and engineering judgement.

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# THANK YOU

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