Soils Samples

Disturbed
Identification and Classification Tests

Undisturbed
Consolidation, Shear Strength, and Permeability Tests
Standard Penetration Test

Advantages

• Widely used
• Substantial data available
• Simple & inexpensive
• Provides disturbed soil samples

Disadvantages

• Highly variable
• N-value determined from test is influenced by many factors
Standard Penetration Test (SPT) Per ASTM D 1586

- **Anvil**: Used to drop a hammer repeatedly falling 760 mm (30 inch).
- **Drill Rod**: Used to drive the sampler into the soil.
- **Split-Barrel (Drive) Sampler [Thick Hollow Tube]**: Used to collect soil samples.
- **Seating**: The depth at which the sampler is seated.
- **N = No. of Blows per 0.3 m (1 ft)**: The number of blows required to drive the sampler into the soil.

**First Increment**
- Depth: 0.15 m (6 in.)
- Hollow Sampler Driven in 3 successive increments.

**Second Increment**
- Depth: 0.15 m (6 in.)

**Third Increment**
- Depth: 0.15 m (6 in.)

SPT Resistance (N-value) or “Blow Count” is the total number of blows to drive the sampler last 300 mm (1 ft).
SPT Split-Barrel Sampler
SPT Hammer Types

- Donut
  - Cable
  - Hammer
  - Gulde Tube
  - Impact Block
  - Drill Rod

- Safety
  - Hammer
  - Anvil
  - Sleeve
  - Centering Rod
  - Plug
  - Drill Rod

- Automatic
  - Cylinder
  - Window
  - Hammer
  - Sprocket
  - Chain
  - Tooth
  - Anvil
  - Drill Rod
Cat Head & Rope
SPT N Value Comparison for Safety and Automatic Hammers
SPT Hammer Calibration

\[ N_{60} = N \left( \frac{ETR}{60} \right) \]

\[ ETR = \frac{EMX}{350 \text{ ft-lbs}} \]
SPT Error Sources

• Effect of overburden pressure
• Variations in hammer drop heights
• Interference with hammer free-fall
• Damaged or worn sampler drive shoe
• Failure to properly seat sampler at bottom of hole
\[ N' = C_N(N) \]

- \( N' \) = corrected SPT \( N \) value
- \( C_N \) = correction factor for overburden pressure
- \( N \) = uncorrected or field SPT \( N \) value

See text page 284
Figure 291-1  Relationship between standard penetration resistance $N$ (corrected for overburden) and friction angle $\bar{\phi}$. (After Peck, Hanson, and Thornburn, 1974.)  See text, page 291
<table>
<thead>
<tr>
<th>Description</th>
<th>Very Loose</th>
<th>Loose</th>
<th>Medium</th>
<th>Dense</th>
<th>Very Dense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative density $D_r$</td>
<td>0 - 0.15</td>
<td>0.15 - 0.35</td>
<td>0.35 - 0.65</td>
<td>0.65 - 0.85</td>
<td>0.85 - 1.00</td>
</tr>
<tr>
<td>Corrected Standard Penetration N’ value</td>
<td>0 to 4</td>
<td>4 to 10</td>
<td>10 to 30</td>
<td>30 to 50</td>
<td>50+</td>
</tr>
<tr>
<td>Approximate angle of internal friction $\phi$ *</td>
<td>25 - 30˚</td>
<td>27 - 32˚</td>
<td>30 – 35˚</td>
<td>35 - 40˚</td>
<td>38 - 43˚</td>
</tr>
<tr>
<td>Approximate range of moist unit weight, $\gamma$, kN/m³ (lb/ft³)</td>
<td>11.0 - 15.7</td>
<td>14.1 - 18.1</td>
<td>17.3 - 20.4</td>
<td>17.3 - 22.0</td>
<td>20.4 - 23.6</td>
</tr>
<tr>
<td></td>
<td>(70 - 100)</td>
<td>(90 - 115)</td>
<td>(110 - 130)</td>
<td>(110 - 140)</td>
<td>(130 - 150)</td>
</tr>
</tbody>
</table>

Correlations may be unreliable in soils containing gravel. See discussion in Section 9.5 of Chapter 9.

* Use larger values for granular material with 5% or less fine sand and silt.
### TABLE 4-6 EMPIRICAL VALUES FOR UNCONSTRAINED COMPRRESSIVE STRENGTH ($q_u$) AND CONSISTENCY OF COHESIVE SOILS BASED ON UNCORRECTED N (after Bowles, 1977)

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Very Soft</th>
<th>Soft</th>
<th>Medium</th>
<th>Stiff</th>
<th>Very Stiff</th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$q_u$, kPa</td>
<td>0 – 24</td>
<td>24 – 48</td>
<td>48 – 96</td>
<td>96 – 192</td>
<td>192 – 384</td>
<td>384+</td>
</tr>
<tr>
<td></td>
<td>(0 – 0.5)</td>
<td>(0.5 – 1.0)</td>
<td>(1.0 – 2.0)</td>
<td>(2.0 – 4.0)</td>
<td>(4.0 – 8.0)</td>
<td>(8.0+)</td>
</tr>
<tr>
<td>Standard Penetration N value</td>
<td>0 - 2</td>
<td>2 - 4</td>
<td>4 – 8</td>
<td>8 - 16</td>
<td>16 - 32</td>
<td>32+</td>
</tr>
<tr>
<td>$\gamma$ (saturated), kN/m$^3$</td>
<td>15.8 - 18.8</td>
<td>15.8 - 18.8</td>
<td>17.3 - 20.4</td>
<td>18.8 - 22.0</td>
<td>18.8 - 22.0</td>
<td>18.8 - 22.0</td>
</tr>
<tr>
<td></td>
<td>(100 – 120)</td>
<td>(100 – 120)</td>
<td>(110 – 130)</td>
<td>(120 – 140)</td>
<td>(120 – 140)</td>
<td>(120 – 140)</td>
</tr>
</tbody>
</table>

The undrained shear strength is 1/2 of the unconfined compressive strength.

**Note:** Correlations are unreliable. Use for preliminary estimates only.