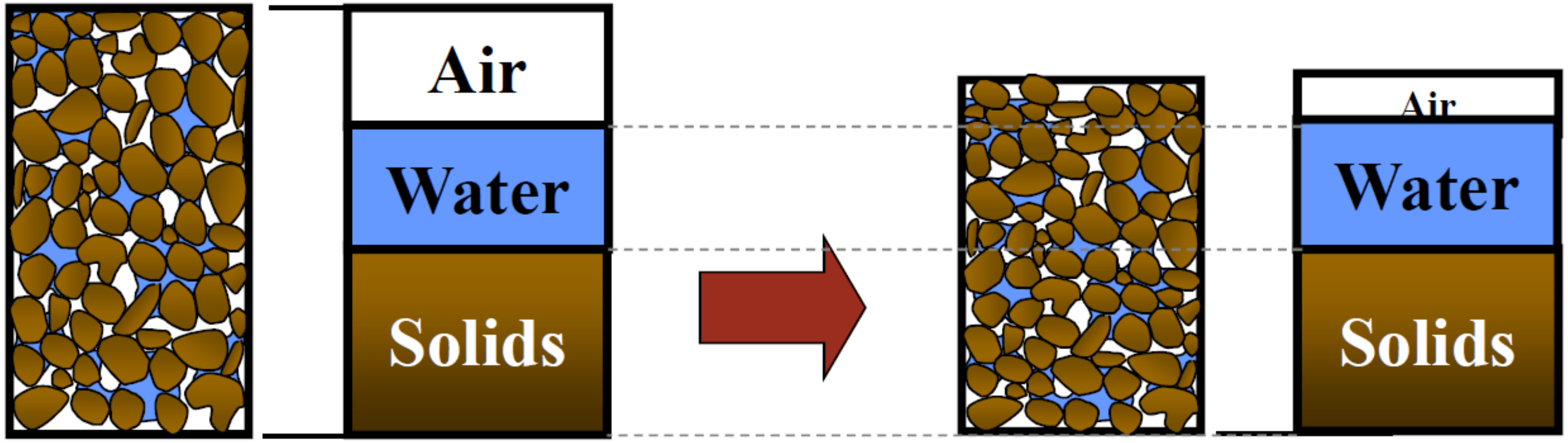
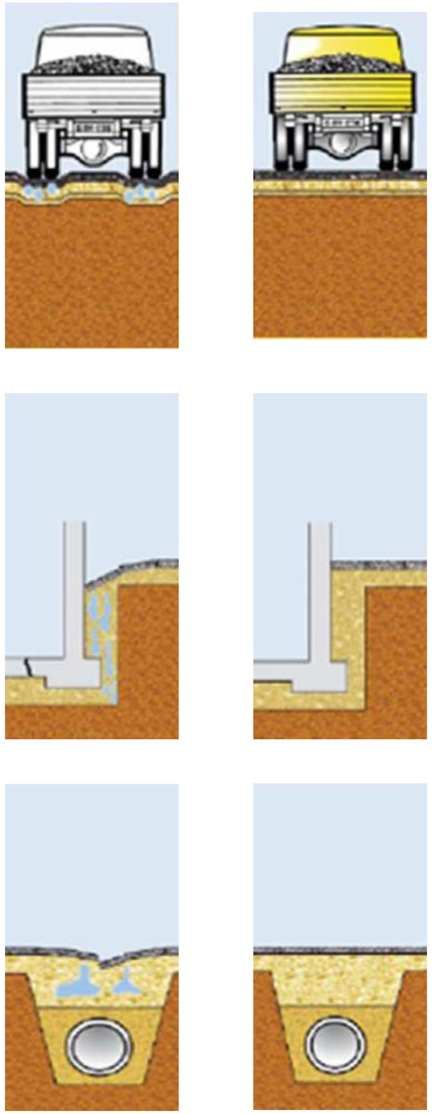
Dr. Khalil Qatu

ENCE 331: Soil Compaction

Why compact soil ????

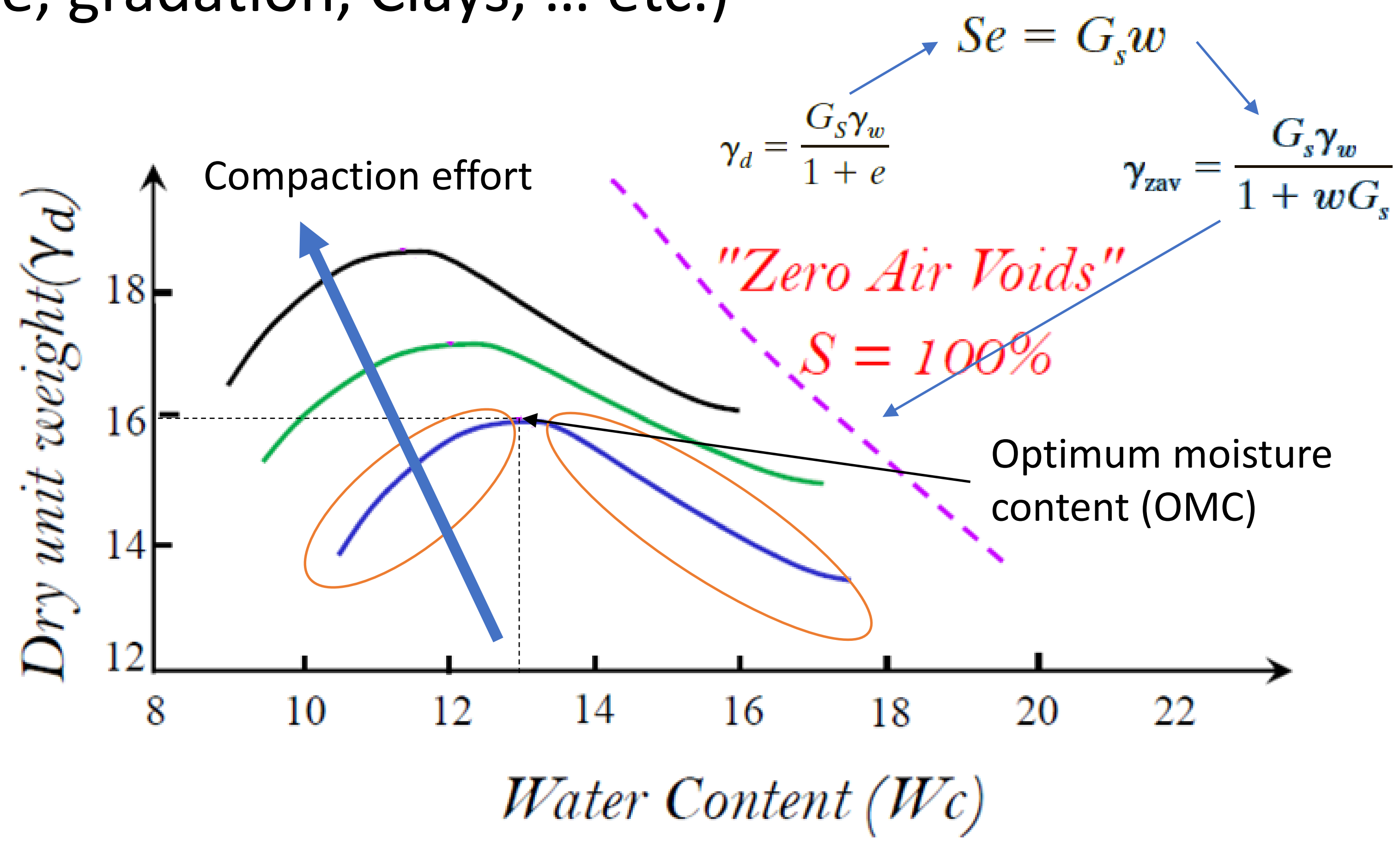
1. Increase bearing capacity (strength) and durability.
2. Increase stability
3. Control swelling and shrinkage potential
4. Lower compressibility (settlement)
5. Lower permeability
6. Lower liquefaction potential





Factors affecting soil compaction

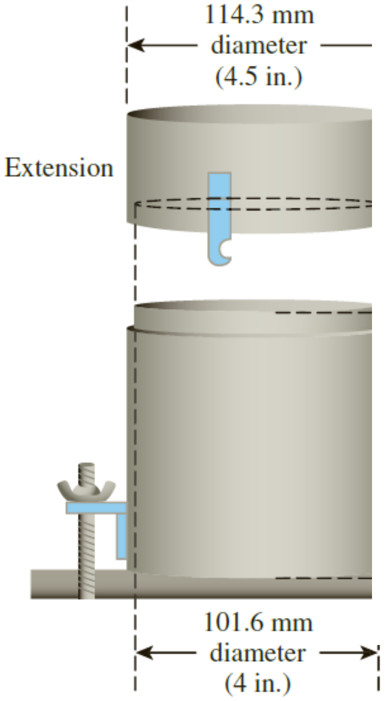
- Soil Type (granular vs. Fine, gradation, Clays, … etc.)
- Moisture content
- Layer Thickness
- Method of compaction
- Compaction effort

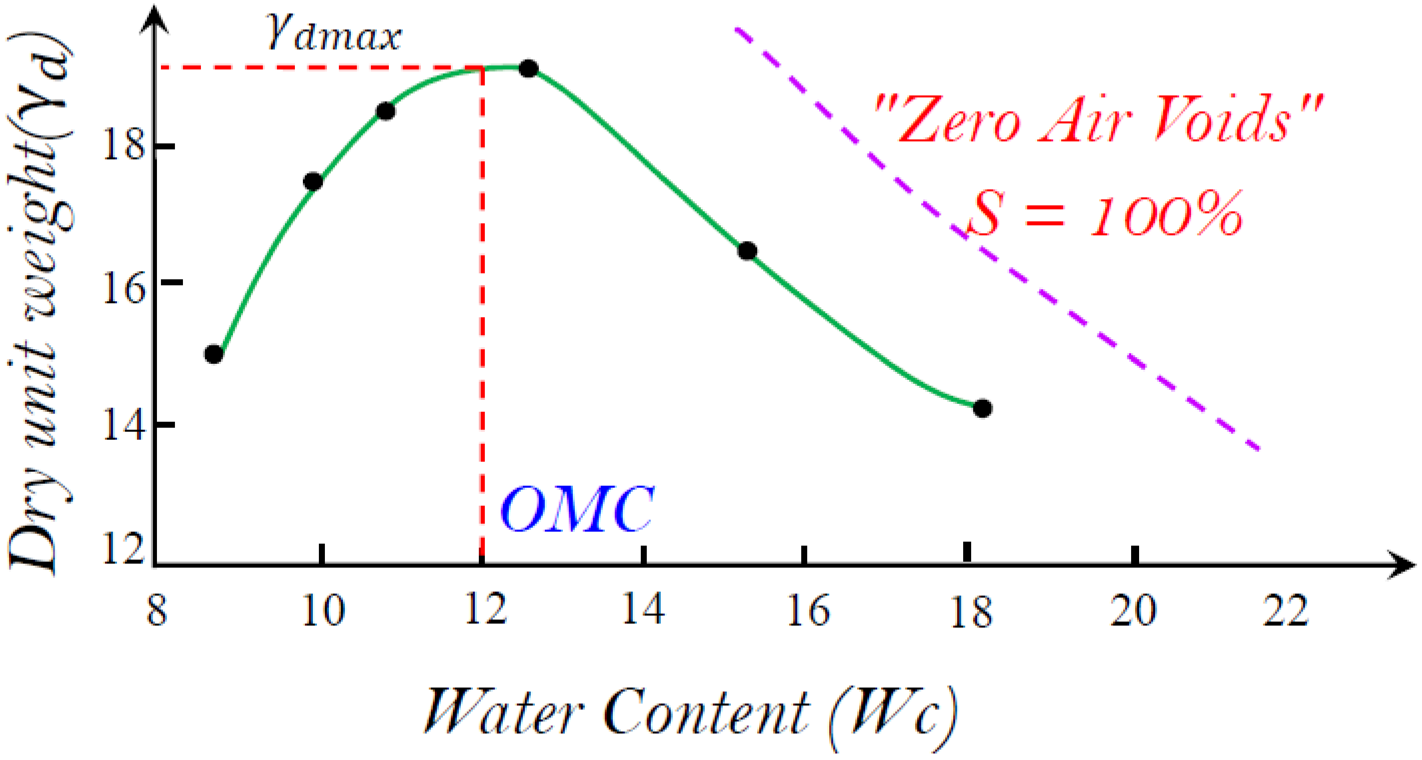


Compaction tests

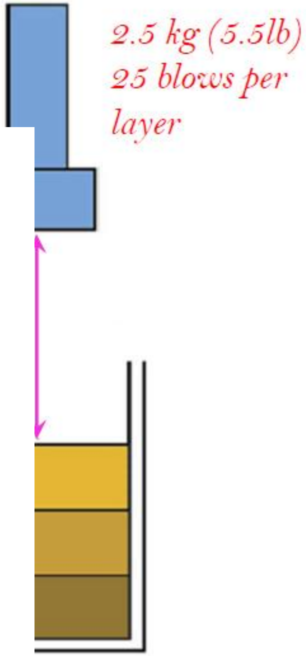
- Standard proctor test

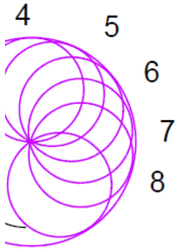
(Number of blows) × (Number of) × (Weight of) × (Height of drop of)





50.8 mm
(2 in.)

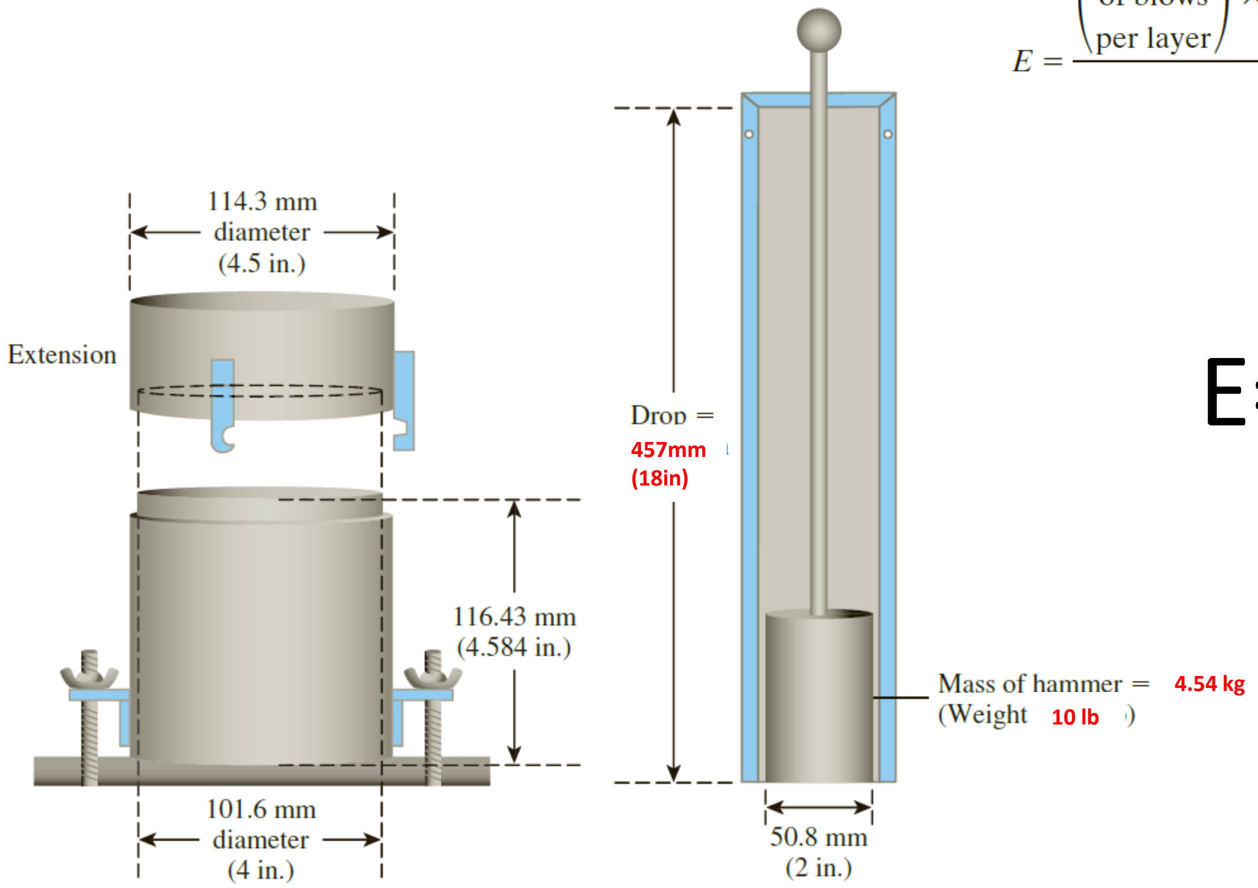




The first four blows *The successive blows*

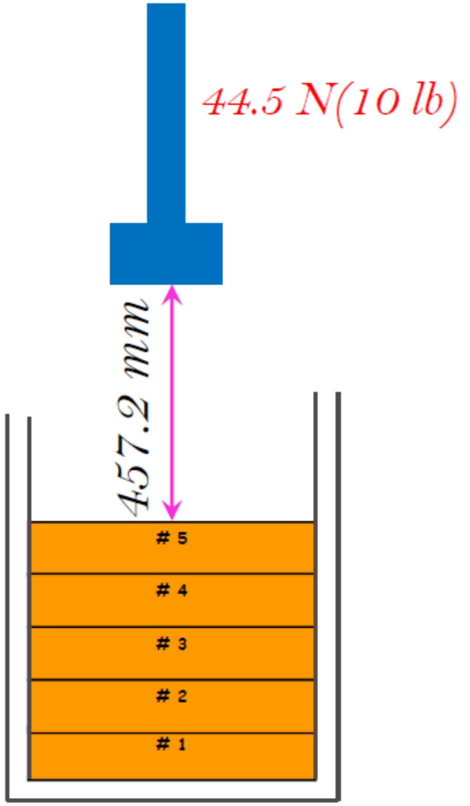
Compaction tests

- Modified proctor test



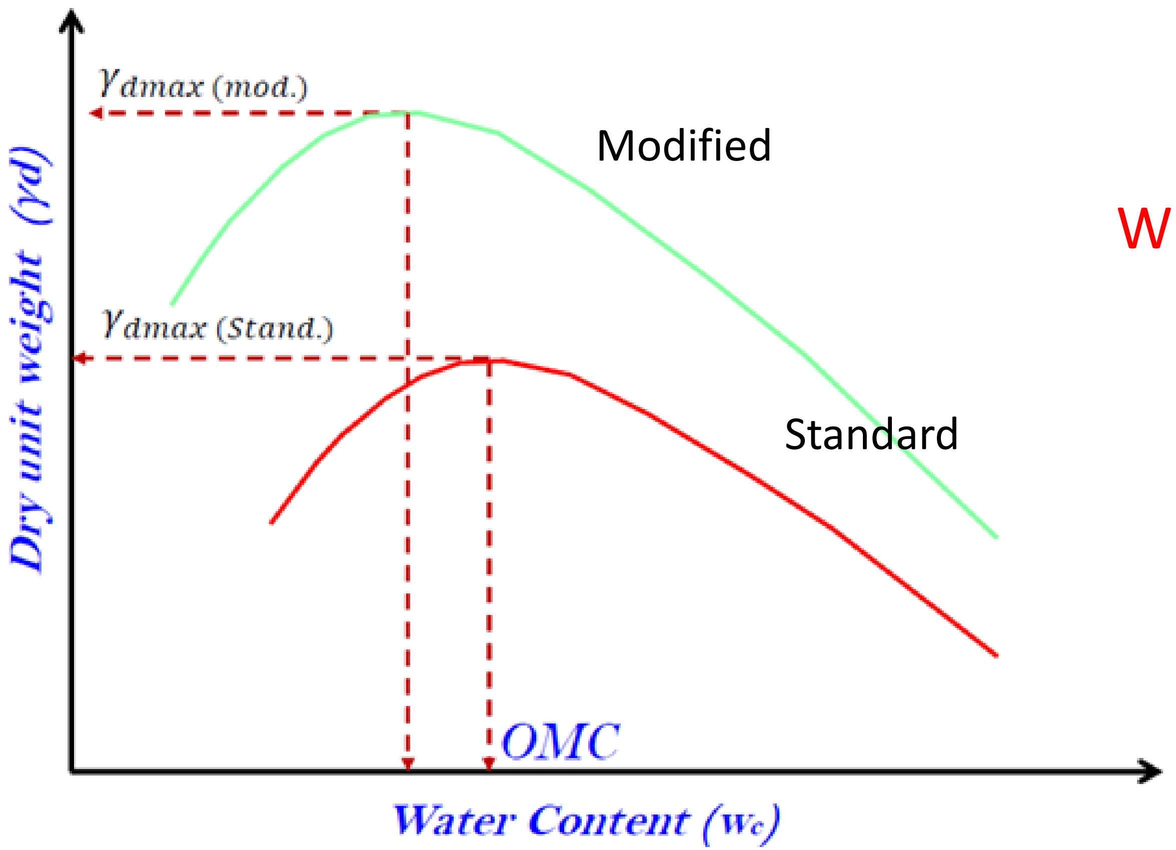
$$E = \frac{\begin{pmatrix}\text{Number}\\ \text{of blows}\\ \text{per layer}\end{pmatrix} \times \begin{pmatrix}\text{Number}\\ \text{of}\\ \text{layers}\end{pmatrix} \times \begin{pmatrix}\text{Weight}\\ \text{of}\\ \text{hammer}\end{pmatrix} \times \begin{pmatrix}\text{Height of}\\ \text{drop of}\\ \text{hammer}\end{pmatrix}}{\text{Volume of mold}}$$

E=



Compaction tests

- Modified proctor test vs standard proctor test



Why??

HOW to compact soil?

Kneading

Vibration

How to test field compaction ?

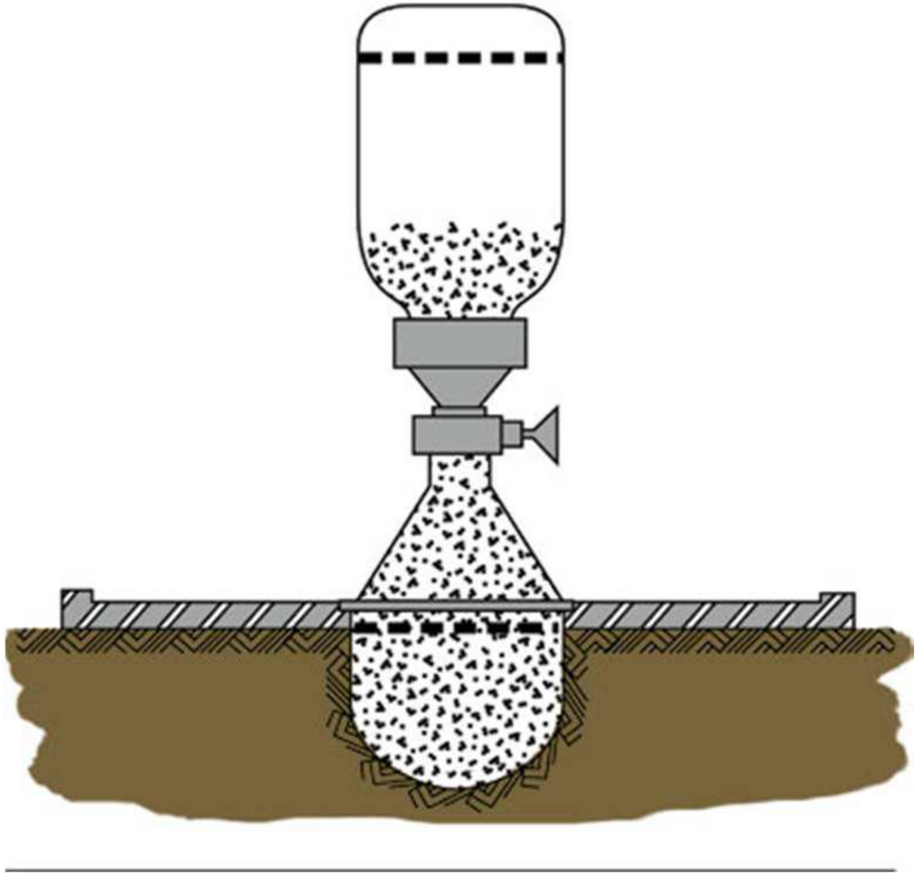
- Degree of compaction (DOC)

$$DOC = \frac{\gamma_{d(field)}}{\gamma_{d(max)}}$$

- Contractors are usually asked to get 95% from $\gamma_{d\ max}$ →(DOC=0.95)

Field density test

- Sand cone method



Example

A modified Proctor compaction test was carried out on a clayey sand in a cylindrical mold that has a volume of 944 cm^3. The specific gravity of the soil solids is 2.68. The moisture content and the mass of the six compacted specimens are given.

- Using the compaction test data determine the optimum moisture content and the maximum dry unit weight.
- Plot the zero-air-void curve and check whether it intersects the compaction curve.
- Plot the void ratio and the degree of saturation against the moisture content.
- What are the void ratio and degree of saturation at the optimum moisture content?

W%	Mass of moist soil (g)
5	1776
7	1890
9.5	2006
11.8	2024
14.1	2005
17	1977

In-situ Compaction (soil enhancement)

- Vibroflotation
  - Water jet -> quick conditions (vibration unit sinks)
  - Water pumped -> add granular soil from the top
  - Vibration unit raised by 0.3m increments

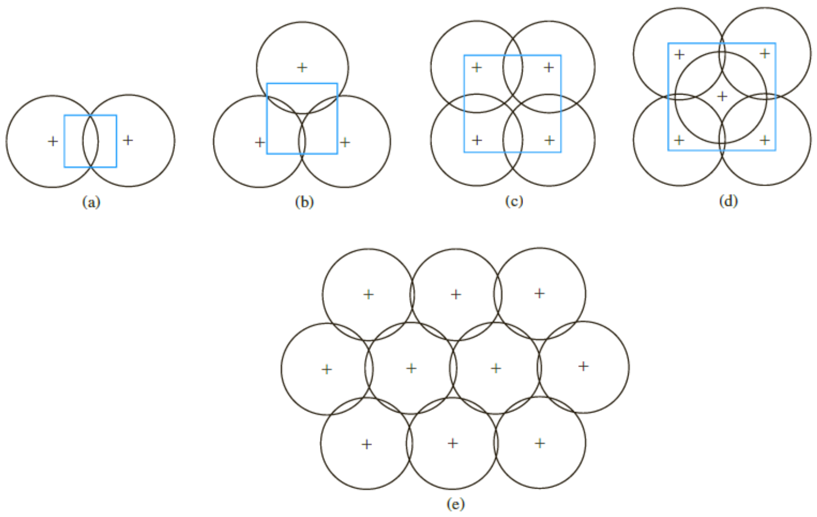
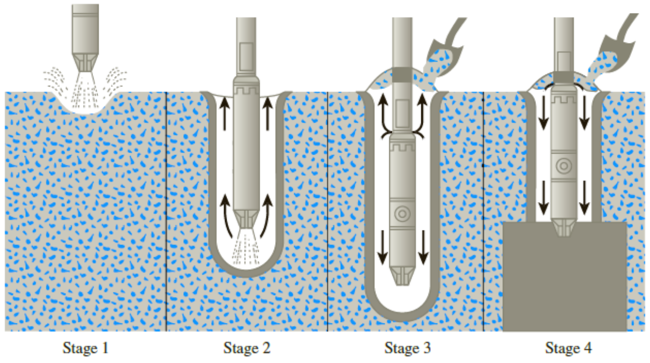
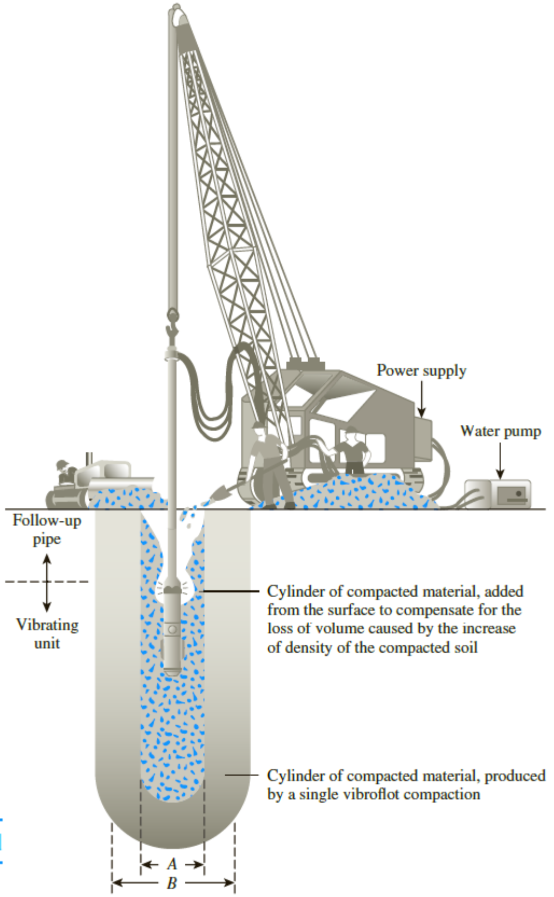


Figure 6.33 Typical patterns of Vibroflot probe spacings for a column foundation (a, b, c, and d) and for compaction over a large area (e)



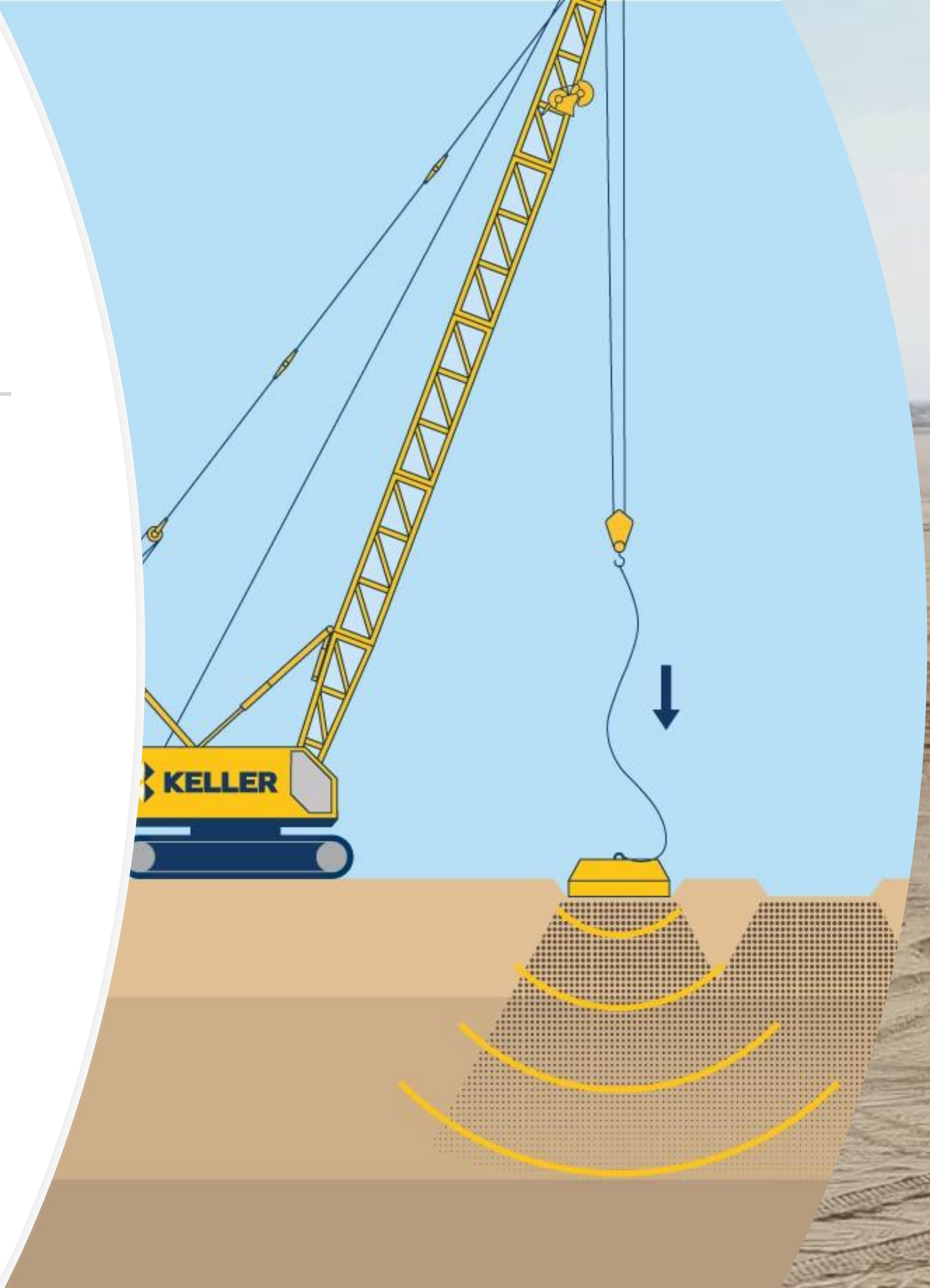


$$S_N = 1.7\sqrt{\frac{3}{(D_{50})^2} + \frac{1}{(D_{20})^2} + \frac{1}{(D_{10})^2}}$$

Range of S_N	Rating as backfill
0–10	Excellent
10–20	Good
20–30	Fair
30–50	Poor
>50	Unsuitable

In-situ Compaction (soil enhancement)

- Dynamic compaction
  - Weight of hammer
  - Hight of hammer drop
  - Spacing of drops
  - Depth of influence
  - Spacing

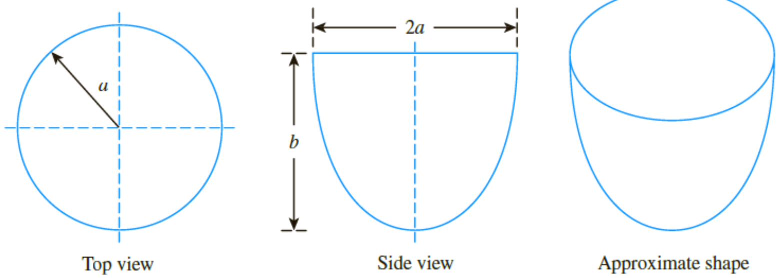


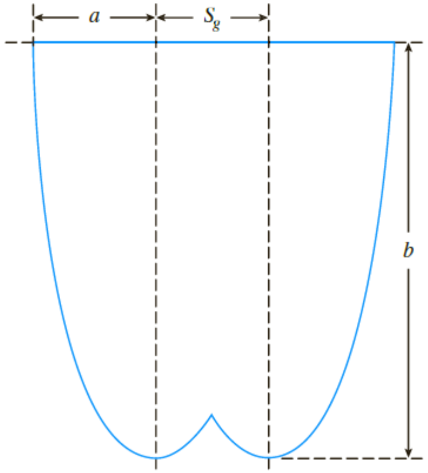
In-situ Compaction (soil enhancement)

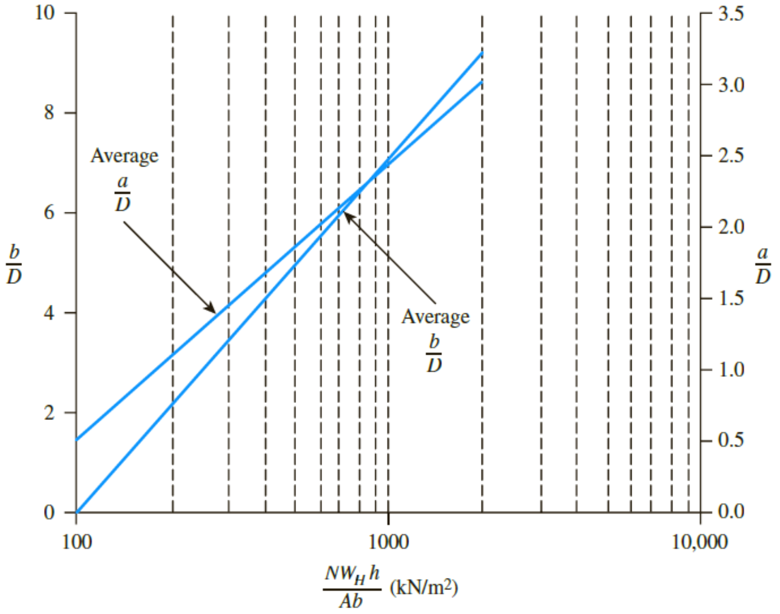
- Dynamic compaction

$$DI \simeq \left(\tfrac{1}{2}\right)\sqrt{W_H h} \qquad (6.30)$$

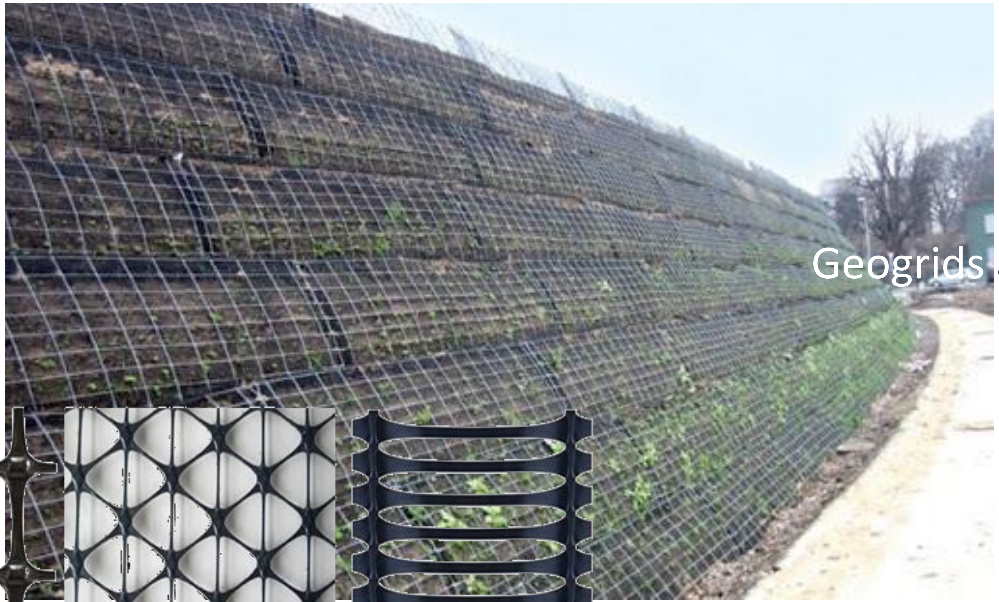
where DI = significant depth of densification (m)
W_H = dropping weight (metric ton) (*Note*: 1 metric ton = 1000 kgf = 9.81 kN)
h = height of drop (m)



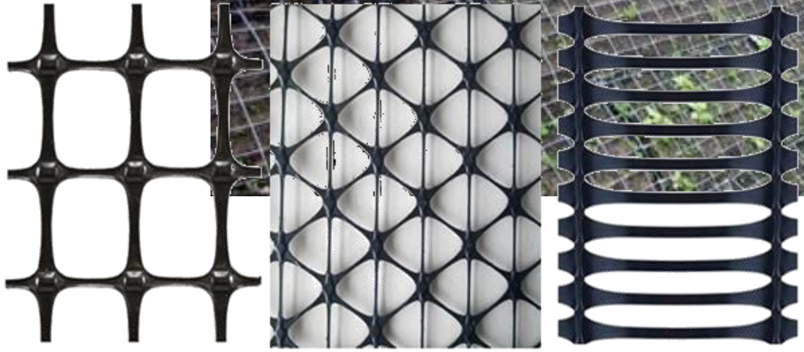


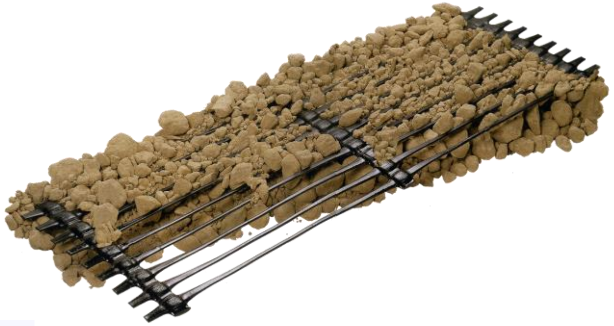


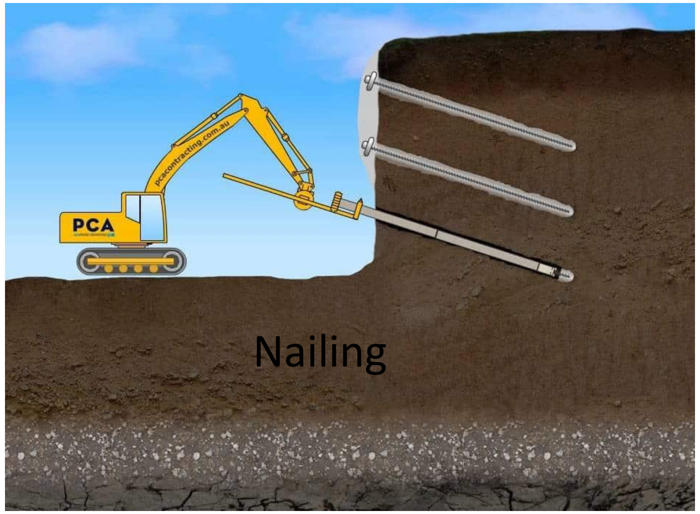
Other Methods



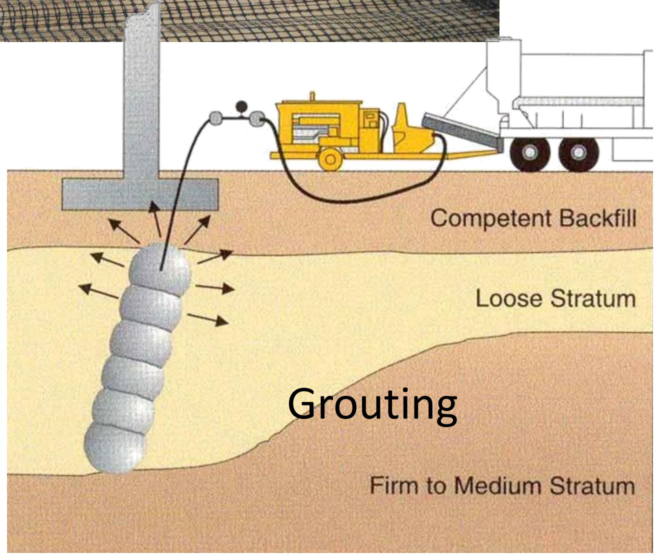
Geogrids and geotextiles







Nailing



Grouting