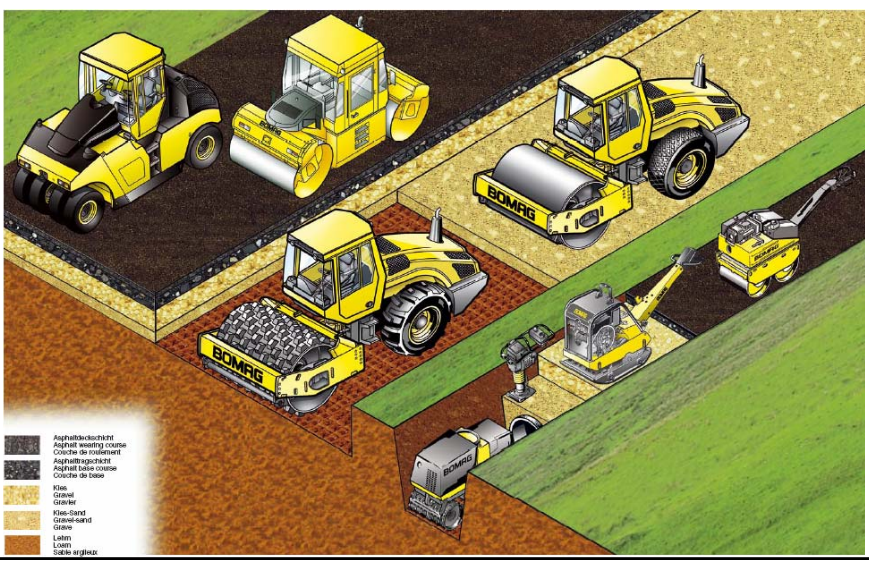
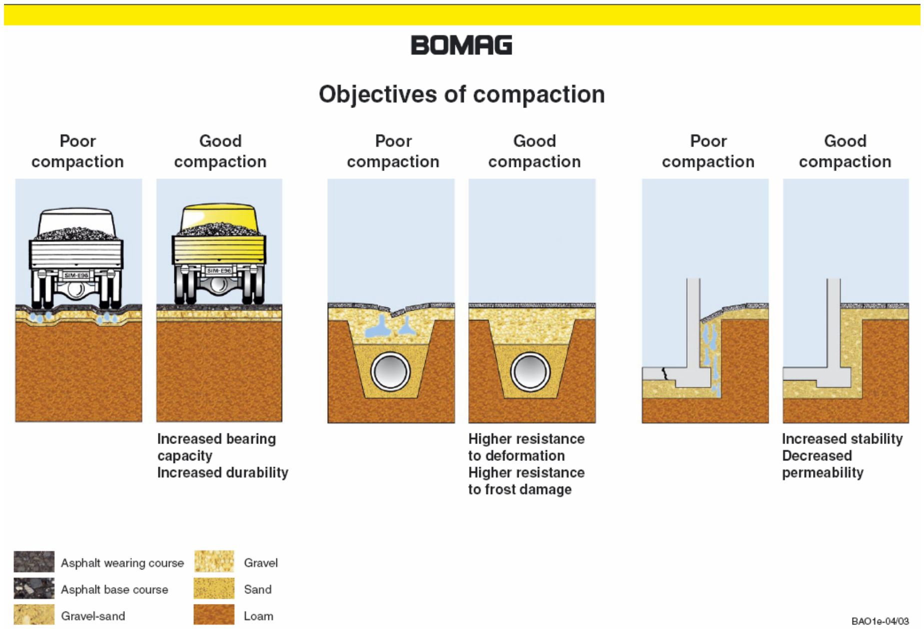
Compaction

Asphalt, Roads, Trench Restoration





Goal of Compaction

- Place loose soil in the field and compact it to make soil strong as possible
  - Maximum shear strength
  - Very little settlement

  - Find soil lowest e_{min} ……highest dry unit weight

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Soil compaction

Fine aggregate: Clay, Silt	Coarse aggregate: Sand, Gravel	Rockfill: Cobbles, Boulders
Application primarily for • dam construction • embankments for road, rail track and airport construction • trenches and backfills • sanitary landfill construction	**Application** primarily for • embankments subbases and bases for road, rail track and airport construction • foundations for buildings • trenches and backfills	**Application** primarily for • dam construction • embankments for road, rail track and airport construction • foundations for buildings
Clay < 0,002mm Silt 0,002-0,06mm	Sand 0,06 - 2 mm Gravel 2 - 60 mm	Cobbles > 60 mm Boulders > 100 mm
Compactability • difficult to compact due to cohesion • compaction effect depends strongly on water content • material needs high compaction energy	**Compactability** • depends on grading • too much compaction may be detrimental	**Compactability** • layer thickness should be three times thicker than max. particle size • material needs high compaction energy
Compaction equipment primarily • heavy and medium size single drum rollers (smooth and padfoot drum) • trench compactors and heavy plates	**Compaction equipment** • vibratory tandem rollers and single drum rollers (smooth drum) • heavy and medium size plates	**Compaction equipment** primarily • heavy single drum rollers • heavy plates

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Field Compaction Equipment

Vibratory Smooth Wheel Rollers

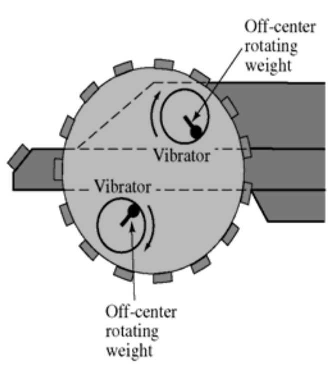

Figure 4.12 Principles of vibratory rollers

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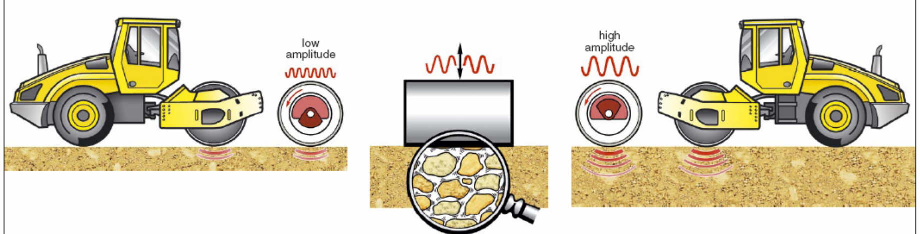
Vibratory compaction single drum rollers with circular exciter system



Application
- thin layers
- granular materials
- granular bases
- overlay compaction on thick granular layers

Compaction principle
static pressure and dynamic energy

Key parameters
- static linear load
- vibrating mass
- amplitude
- frequency

Application
- thick layers
- granular and cohesive materials
- cement bound materials
- subbases
- embankments
- dams

Gravel-sand

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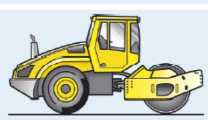
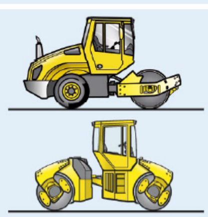
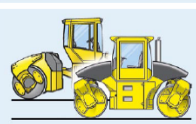
Application guidelines - vibratory rollers

application	roller	static linear pressure kg/cm	amplitude mm	frequency Hz	rolling speed km/h
earthworks dams (rocks, loam)		≥ 30	≥ 1,5	28 - 35	1 - 2,5
granular bases, subbases (gravel, gravel-sand, sand)		≥ 10	≥ 0,4	28 - 60	2 - 4
asphalt base course		10 - 30	0,35 - 0,9	30 - 60	2 - 4
asphalt wearing course			≤ 0,5	40 - 60	2 - 6

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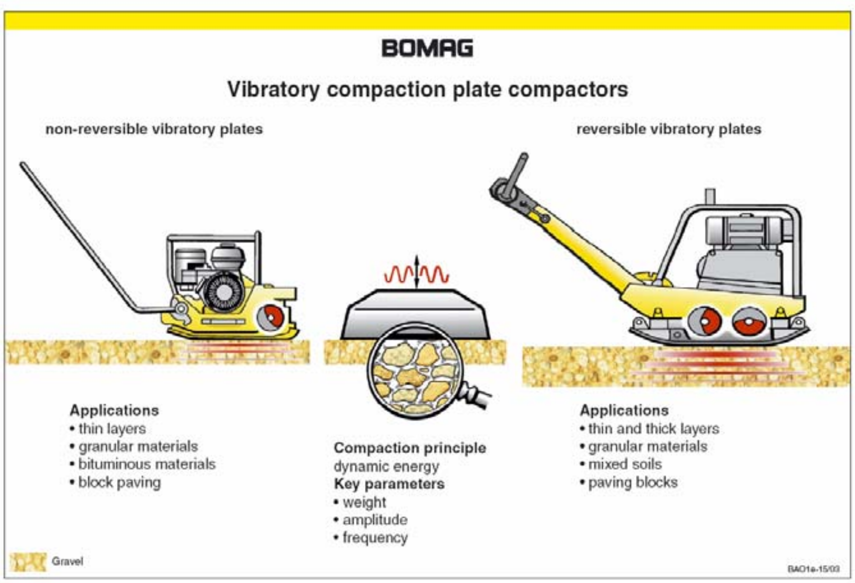
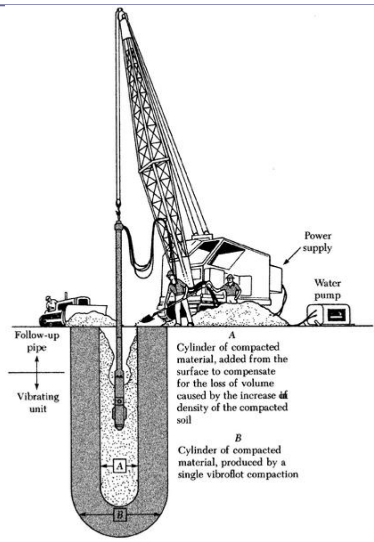
Field Compaction Equipment

Field Compaction Equipment

Soil Compaction Equipment

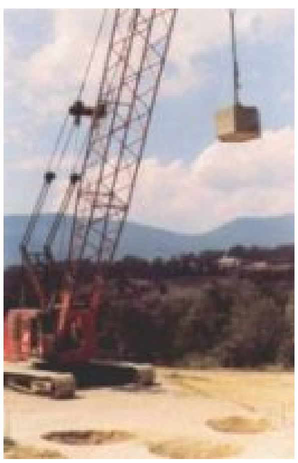


Field Compaction Equipment



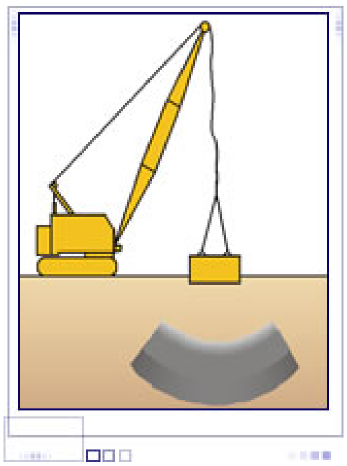
- Vibroflotation unit
- Vibrate loose sand deposits

Field Compaction Equipment



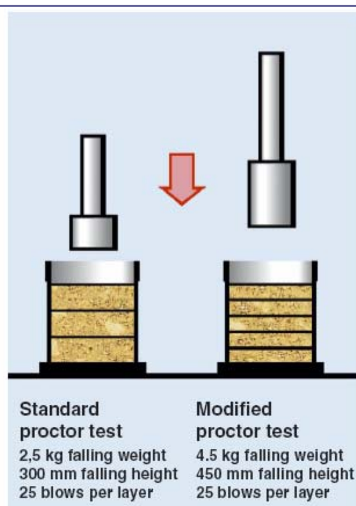
- Drop weight 10 to 20 feet at close centres
- Makes craters
- Loss fill and sand

Field Compaction Equipment

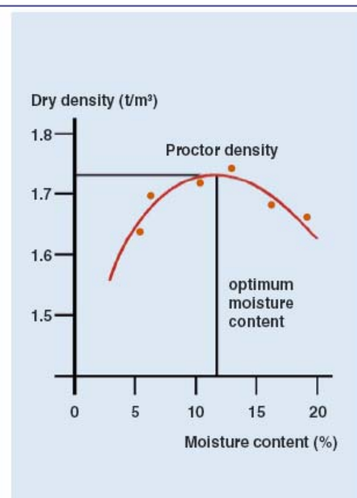


General Soil Type	Most Likely Fill Class	Most Likely AASHTO Soil Type	Degree of Saturation	Suitability for D.D.C.
Pervious deposit in the grain size range of boulders to sand with 0% passing the #200 sieve Coarse portion of Zone 1*	Building Rubble Boulders Broken Concrete	A-1-a A-1-b A-3	High or Low	Excellent
Pervious deposits containing not more than 35% silt Fine portion of Zone 1*	Decomposed Landfills	A-1-6 A-2-4 A-2-5	High Low	Good Excellent
Semi-Pervious soil deposits, generally silty soils containing some sand but less than 25% clay with P1<8 Zone 3*	Clay Fill Mine Spoil	A-6 A-7-5 A-7-6 A-2-6	High Low	Not Recommended Fair-minor improvements. Water content should be less than plastic limit
Miscellaneous fill including paper, organic deposits, metal and wood	Recent Municipal Landfill	None	Low	Fair-long term settlement anticipated due to decomposition. Limit use to embankments
Highly organic deposits peat-organic silts		None	High	Not recommended unless sufficient granular fill added and energy applied to mix granular with organic

Proctor Test



Proctor test



Proctor curve

Standard Proctor Test

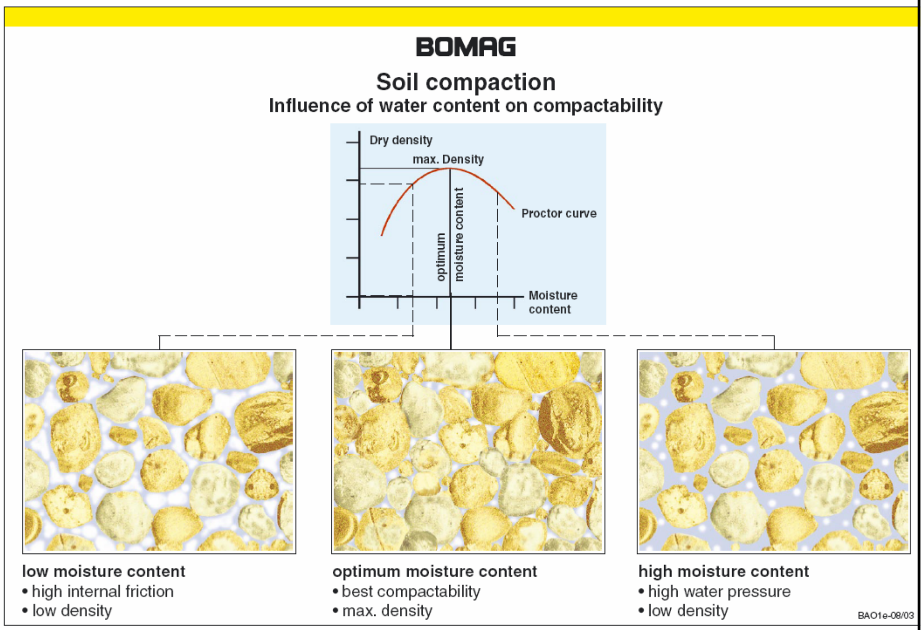
Table 4.2 Specifications for standard Proctor test (Based on ASTM Test Designation 698)

Item	Method A	Method B	Method C
Diameter of mold	101.6 mm	101.6 mm	152.4 mm
Volume of mold	943.3 cm^3	943.3 cm^3	2124 cm^3
Weight of hammer	24.4 N	24.4 N	24.4 N
Height of hammer drop	304.8 mm	304.8 mm	304.8 mm
Number of hammer blows per layer of soil	25	25	56
Number of layers of compaction	3	3	3
Energy of compaction	591.3 kN-m/m^3	591.3 kN-m/m^3	591.3 kN-m/m^3
Soil to be used	Portion passing No. 4 (4.57 mm) sieve. May be used if 20% *or less* by weight of material is retained on No. 4 sieve.	Portion passing 9.5-mm sieve. May be used if soil retained on No. 4 sieve *is more* than 20%, and 20% *or less* by weight is retained on 9.5-mm sieve.	Portion passing 19-mm sieve. May be used if *more than* 20% by weight of material is retained on 9.5-mm sieve, and *less than* 30% by weight is retained on 19-mm sieve.

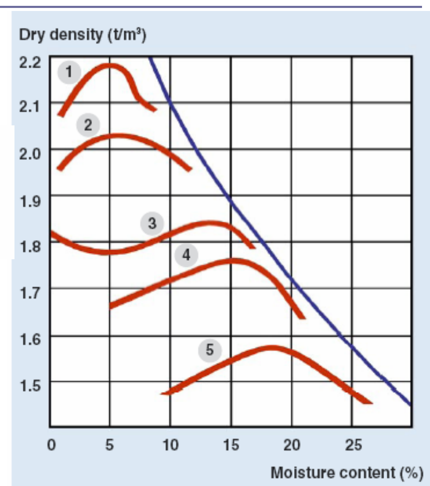
Modified Proctor Test

Table 4.3 Specifications for modified Proctor test (Based on ASTM Test Designation 1557)

Item	Method A	Method B	Method C
Diameter of mold	101.6 mm	101.6 mm	152.4 mm
Volume of mold	943.3 cm^3	943.3 cm^3	2124 cm^3
Weight of hammer	44.5 N	44.5 N	44.5 N
Height of hammer drop	457.2 mm	457.2 mm	457.2 mm
Number of hammer blows per layer of soil	25	25	56
Number of layers of compaction	5	5	5
Energy of compaction	2696 kN-m/m^3	2696 kN-m/m^3	2696 kN-m/m^3
Soil to be used	Portion passing No. 4 (4.57 mm) sieve. May be used if 20% *or less* by weight of material is retained on No. 4 sieve.	Portion passing 9.5-mm sieve. May be used if soil retained on No. 4 sieve *is more* than 20%, and 20% *or less* by weight is retained on 9.5-mm sieve.	Portion passing 19-mm sieve. May be used if *more than* 20% by weight of material is retained on 9.5-mm sieve, and *less than* 30% by weight is retained on 19-mm sieve.



1 sandy gravel
2 Gravel - sand
3 uniform sand
4 sandy silt
5 heavy clay



Proctor curves of
different soil types

Impact of No. Blows

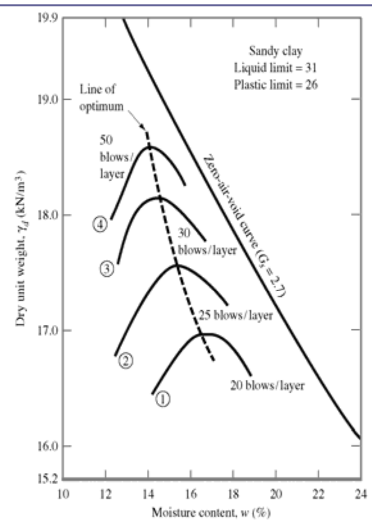


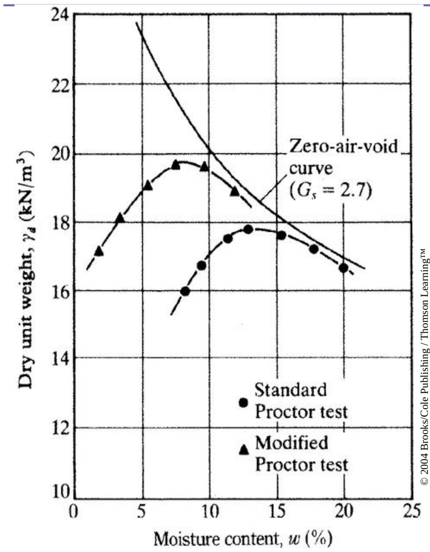
Figure 4.6 Effect of compaction energy on the compaction of a sandy c

Impact of No. Blows

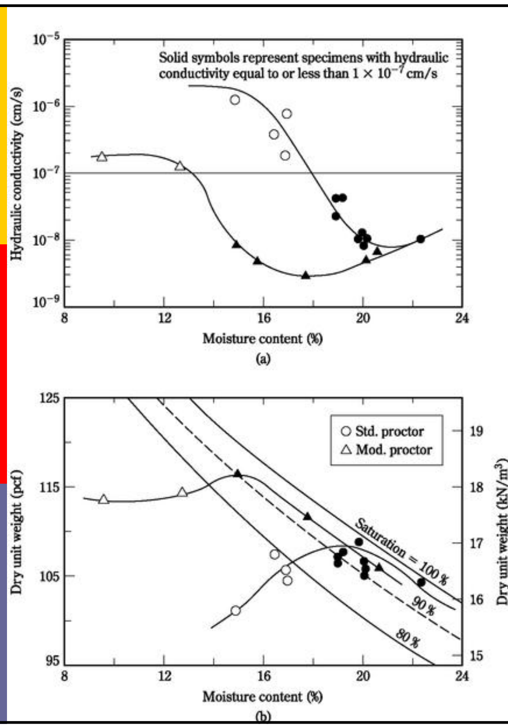
Table 4.1 Compaction energy for tests shown in Figure 4.6

Curve number in Figure 4.6	Number of blows/layer	Compaction energy (kN-m/m^3)
1	20	473.0
2	25	591.3
3	30	709.6
4	50	1182.6

Impact of Proctor Method

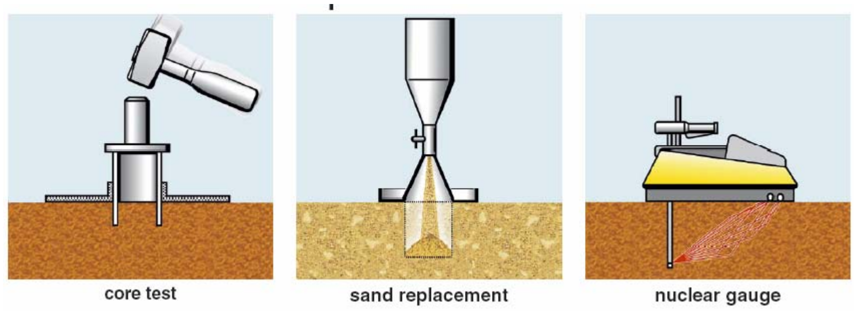


- Increase energy
- increase dry unit weight
- Decrease optimum moisture content



- Influence of compaction on soil hydraulic conductivity

Soil Compaction Measurement



Soil Compaction Measurement

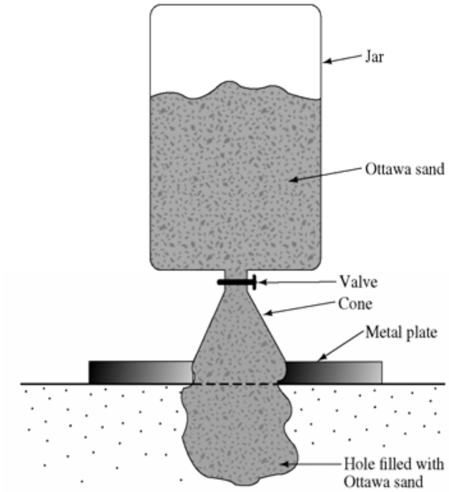
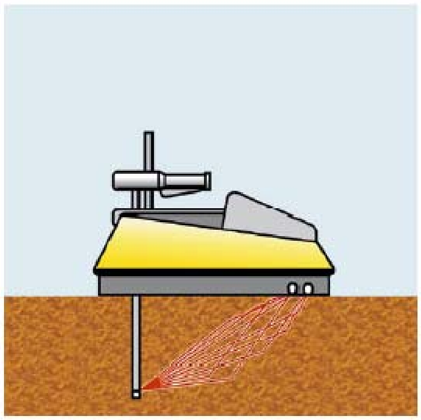


Figure 4.15 Field unit weight by sand cone method

- Use dry sand with known dry density and specific gravity
- Use dry sand to get volume of hole
- Quick and reliable method

Soil Compaction Measurement



nuclear gauge

- Use radioactive material to get moisture content and soil density
- Quick method
- Reliable if calibrated
- Radioactive device therefore special transportation and rules must be followed

Compaction Specification

$$\text{Compaction level (\%)} = \frac{\text{Insitu dry unit weight}}{\text{Max. dry unit weight (Proctor)}} x\,100$$

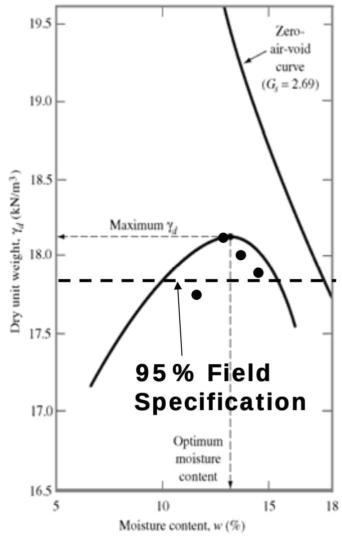
Standard Proctor Specification

- 95 to 100 percent of MDUW

Modified Proctor Specification

- 92 to 98 percent of MDUW

Compaction Specification



- Make sure compacted soil same as Proctor material (grain size distribution analysis)
- Add water to soil if too dry