Geotechnical Engineering–I

BSc Civil Engineering – 4th Semester

Lecture # 11

2-Mar-2015

by

Dr. Muhammad Irfan

Assistant Professor

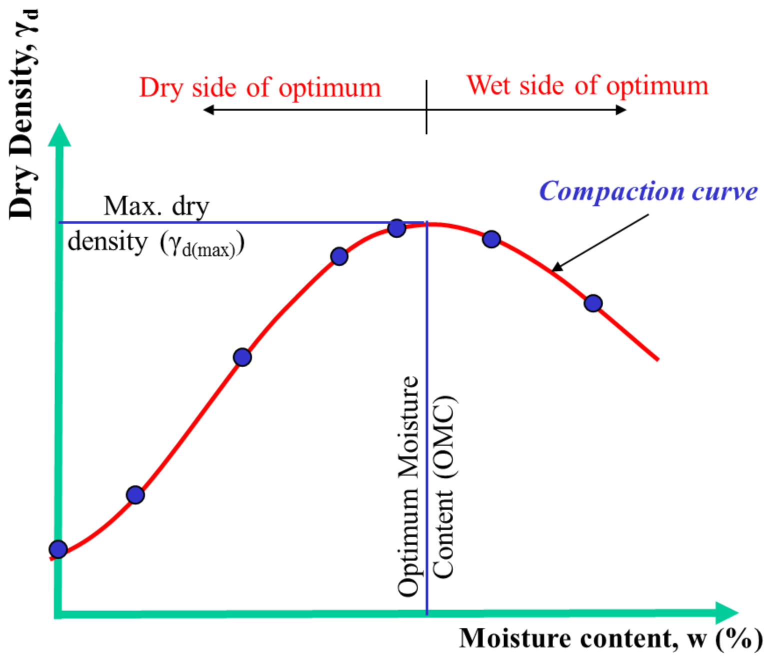
Civil Engg. Dept. – UET Lahore

Email: mirfan1@msn.com

Lecture Handouts: https://groups.google.com/d/forum/geotec-1

SOIL COMPACTION – LABORATORY EVALUATION

Ultimate goal → to obtain *compaction curve* of soil



Test Procedure → Standard Proctor Test

(ASTM ASTM D-698 or AASHTO T-99)

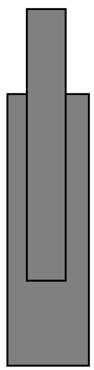
STANDARD PROCTOR TEST

(ASTM D-698 or AASHTO T-99)

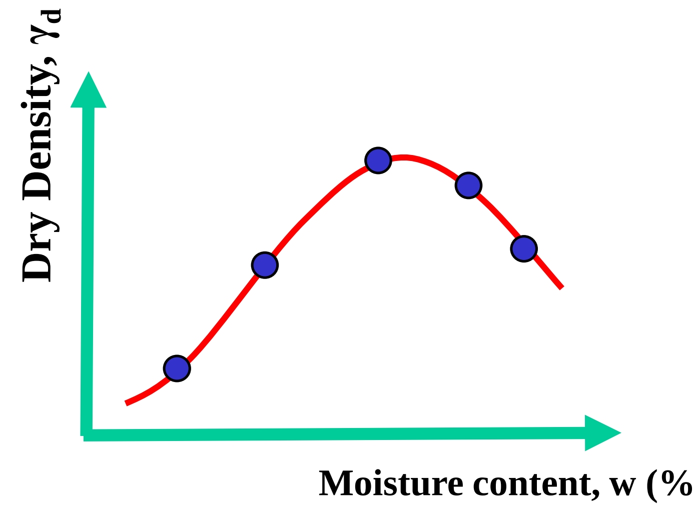
Ultimate goal → to obtain *compaction curve* of soil.

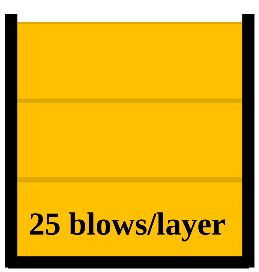
→ *OMC* & $\gamma_{d(max)}$

5.5 lb



Drop height = 12 in

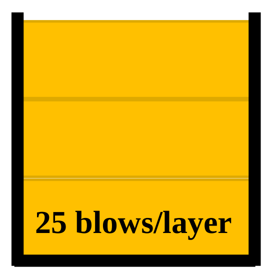




w_1

$\gamma_{b(1)}$ **= W/V** ⇨ $\gamma_d = \dfrac{\gamma_b}{(1+w)}$

Repeat the test by adding more water →



w_2 ($w_2 > w_1$)

$\gamma_{b(2)}$

→ Repeat the same procedure by adding more and more water every time.

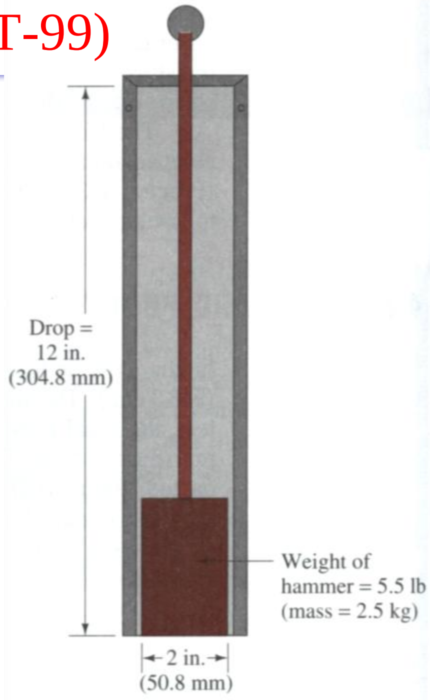
STANDARD PROCTOR TEST

(ASTM D-698 or AASHTO T-99)

Developed by *R.R. Proctor (1933)*

Equipment

- Volume of mold = *1/30 ft³* (943.3 cm³)
- Diameter of mold = *4 in* (101.6 mm)
- Weight of hammer = *5.5 lb* (2.45 kg)
- Drop height = *12 in* (305 mm)
- Soil compacted in *3 layers*
- *25 blows per layer*

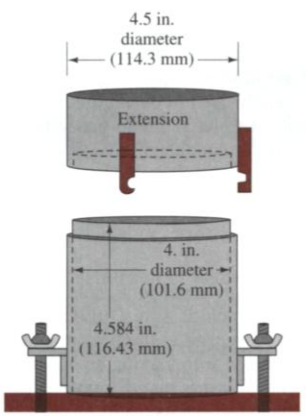


Compaction Energy, E

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

$$E = \frac{2.495\,kg(9.81\,m/s^2)\times(0.3048\,m)\times(25\,blows/layer)\times(3\ layers)}{0.944\times10^{-3}\ m^3}$$

$$\boxed{E = 592.7\,kJ/m^3\ (12{,}375\ ft\cdot lb/ft^3)}$$

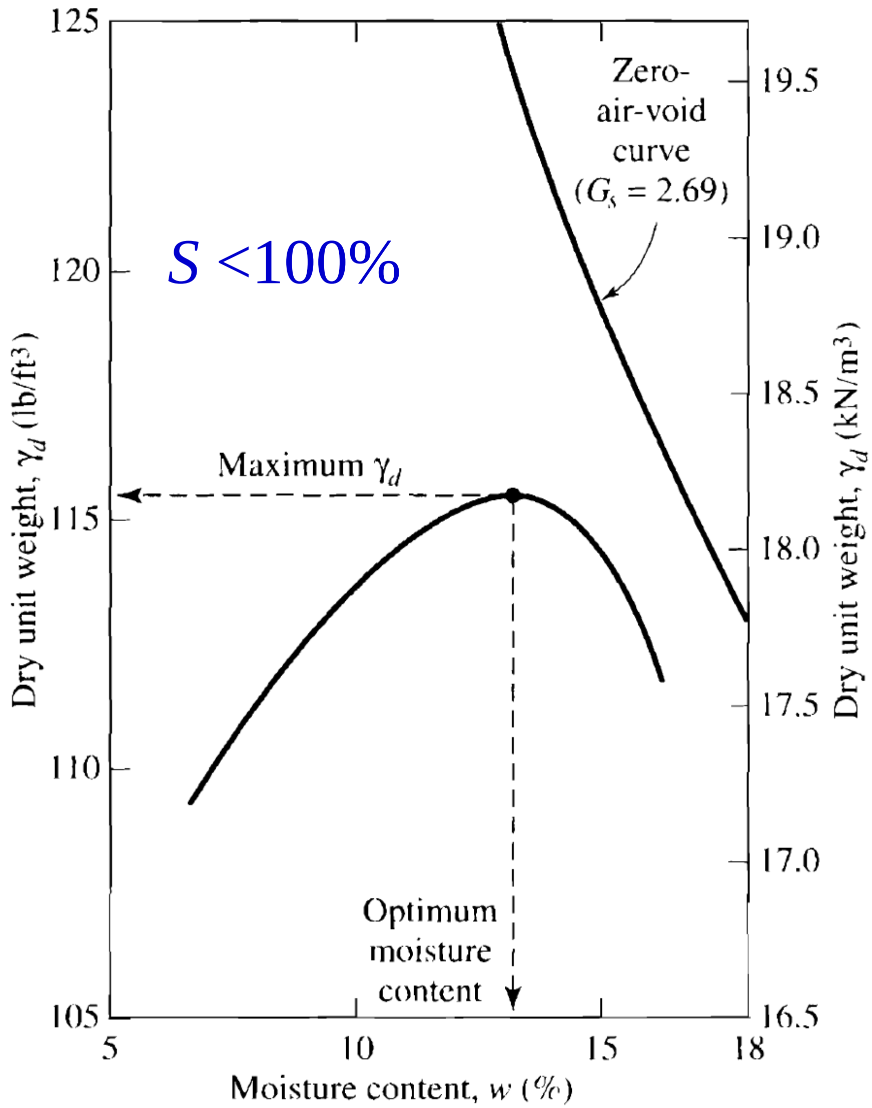


ZERO AIR VOID (ZAV) CURVE

- Corresponds to *100% saturation*.
- Compaction curve always lie on the *left of ZAVC*.
  - because *S > 100% is not possible*

$$\gamma_d = \frac{G_s\,\gamma_w}{1+e}; \qquad e = \frac{w\,G_s}{s}$$

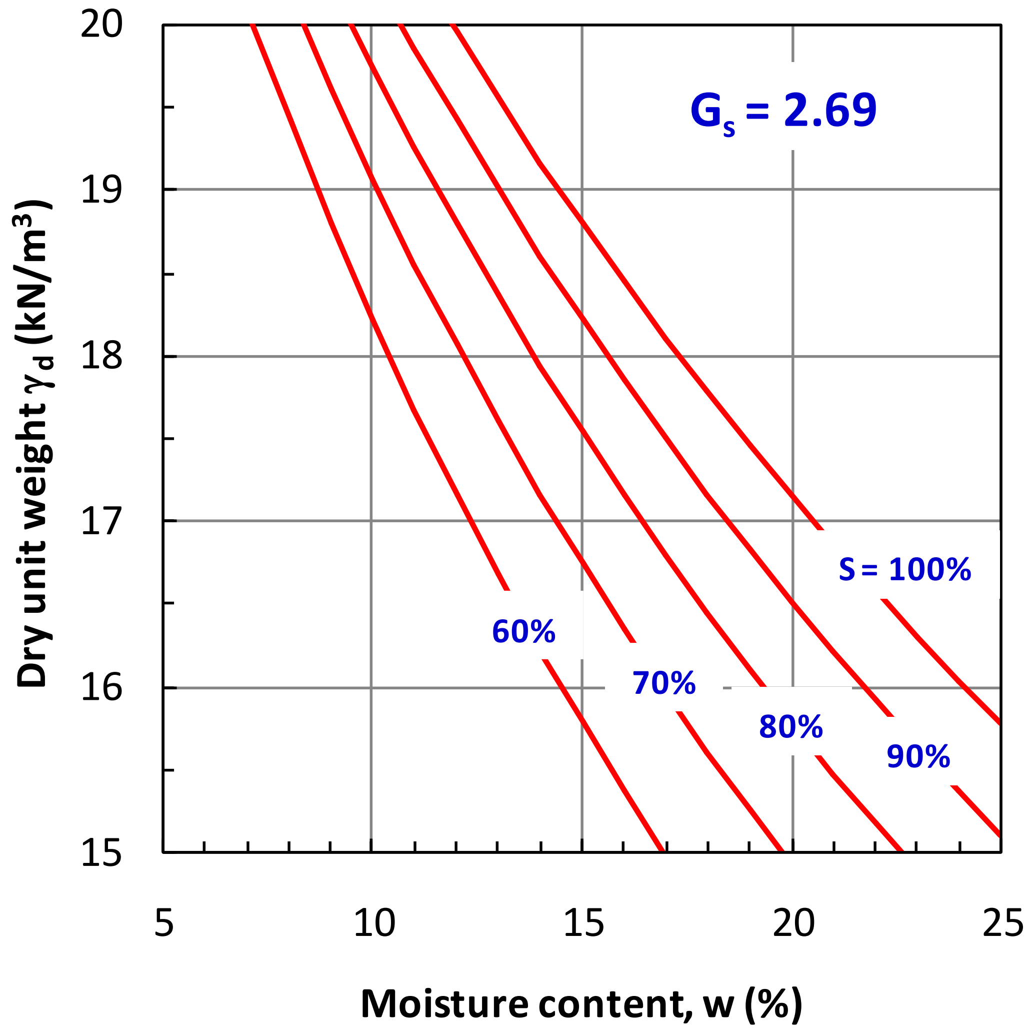
$$\gamma_d = \frac{G_s\,\gamma_w}{1+\frac{w\,G_s}{s}}$$



ZERO AIR VOID (ZAV) CURVE

- Also known as *full saturation curve*.
- Similar curves can be drawn for various degrees of saturation.

$$\gamma_d = \frac{G_s\,\gamma_w}{1+\dfrac{w\,G_s}{S}}$$

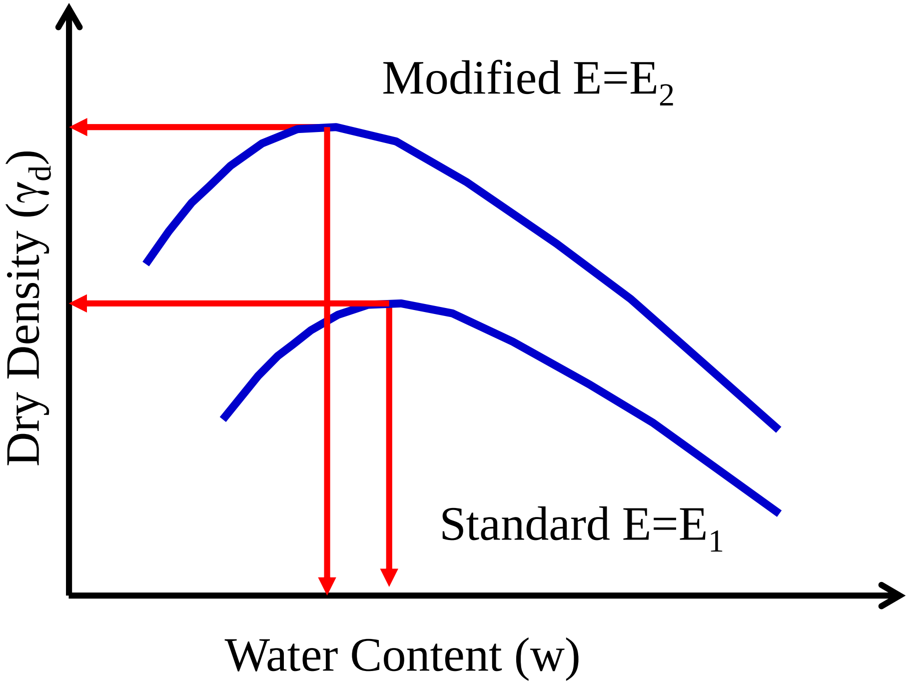


MODIFIED PROCTOR TEST

- Developed during *World War II* by *U.S. Army Corps of Engineers*
  - to represent compaction required at airfields to support *heavy aircrafts*.

Equipment

- Volume of mold = *1/30* ft^3
- Diameter of mold = *4 in*
- Weight of hammer = *10 lb*
- Drop height = *18 in*
- Soil compacted in *5 layers*
- *25 blows per layer*



STANDARD vs MODIFIED PROCTOR TEST

	Standard Proctor Test	**Modified Proctor Test**
Mold size (ft^3)	1/30	1/30
Height of drop (inch)	12	18
Hammer weight (lb)	5.5	10
No. of layers	3	5
No. of blows per layer	25	25
Energy ($ft.lb/ft^3$)	12,375	56,250

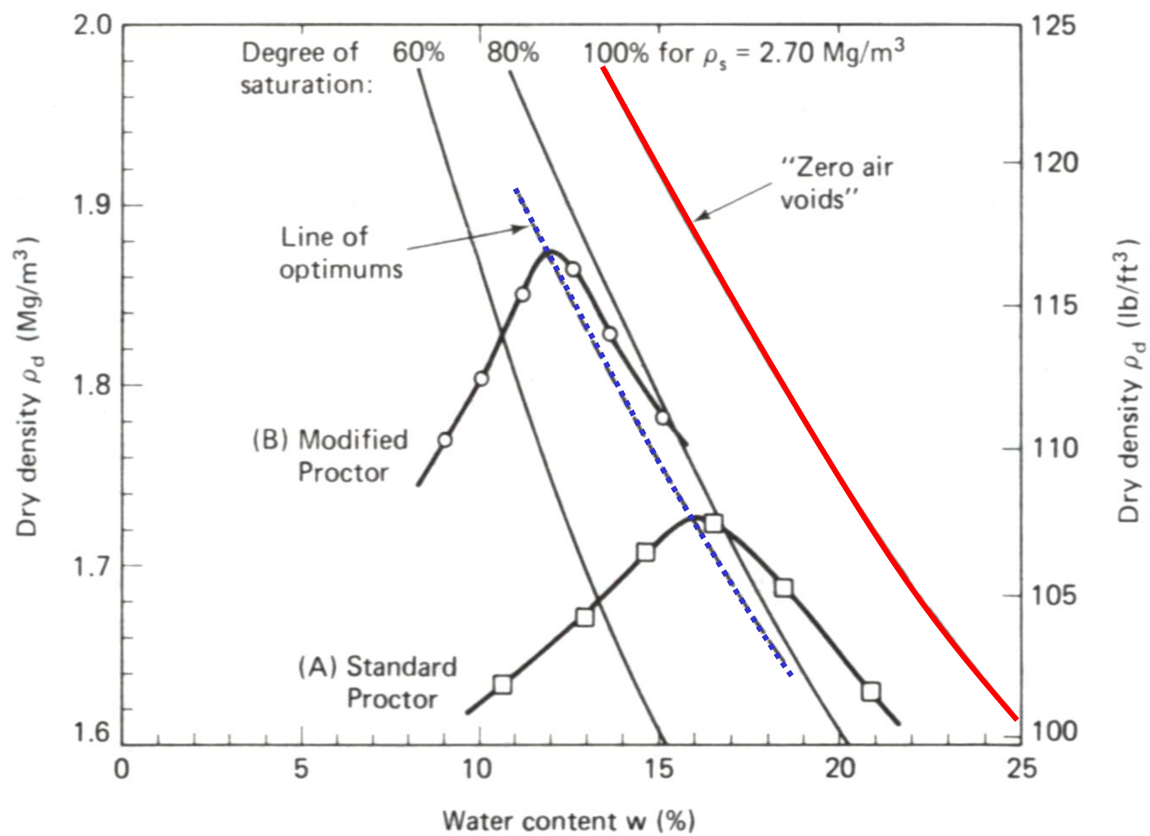
STANDARD vs MODIFIED PROCTOR TEST

Zero Air Voids Curve

The curve represents the fully saturated condition (S = 100 %).

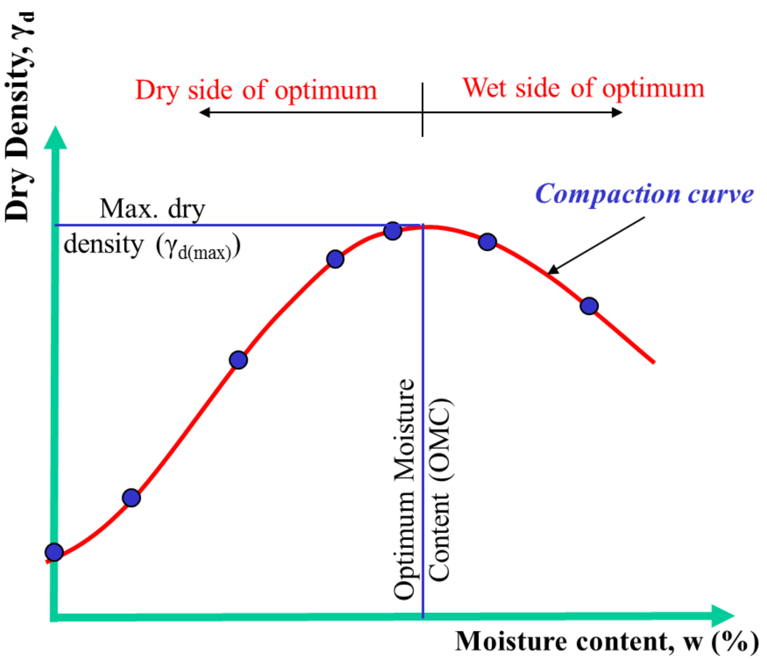
Line of Optimums

A line drawn through the peak points of several compaction curves at different compactive efforts for the same soil will be almost parallel to a 100 % saturation curve.



COMPACTION – Notes

- *OMC* is typically *slightly less* than the *plastic limit* (ASTM suggestion).
- *Typical values* of *OMC* are between *10% and 20%*, with an outside maximum range of about 5% to 40%.
- Typical values of $\gamma_{d(max)}$ are around *1.6 to 2.0 Mg/m³* with the maximum range from about 1.3 to 2.4 Mg/m^3.



PRACTICE PROBLEM #1

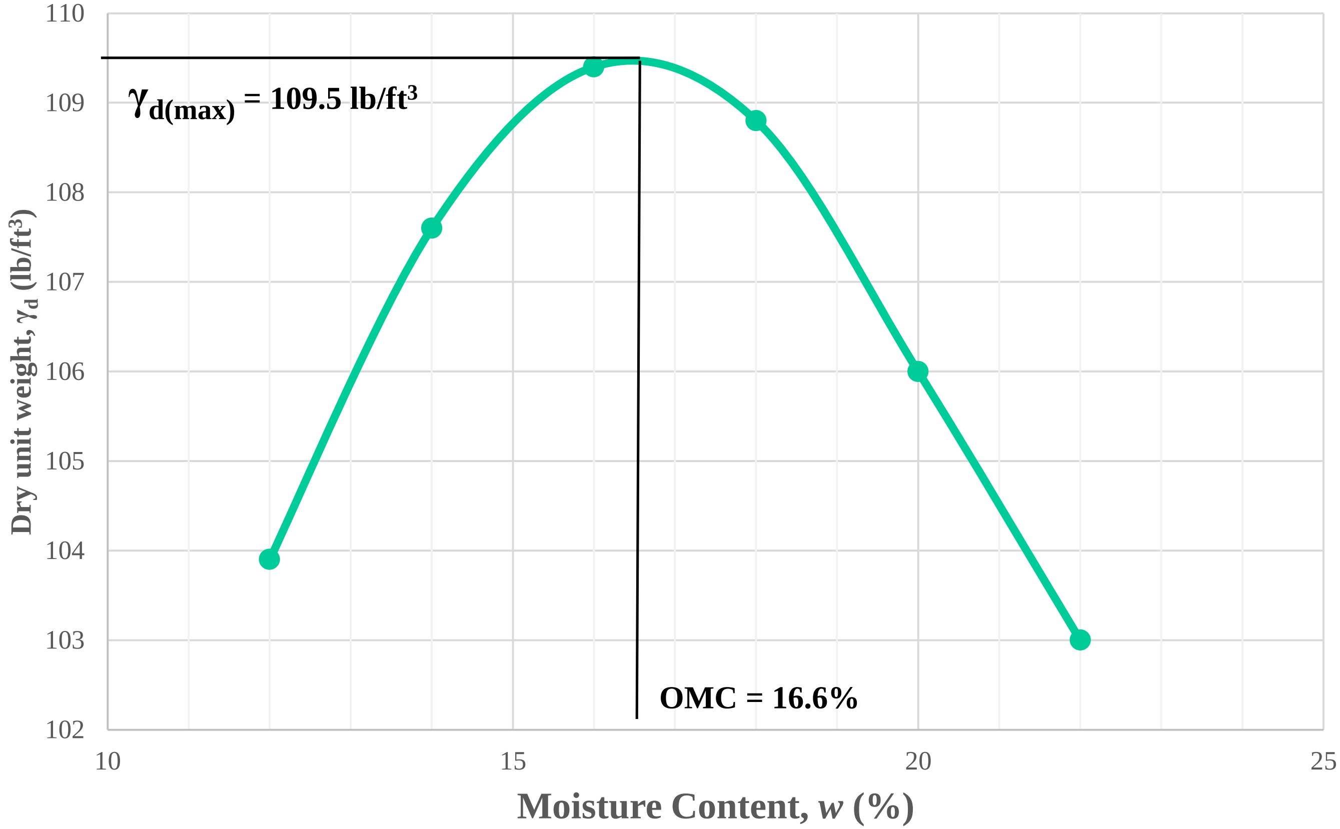
The laboratory test for a standard proctor is shown below. Determine the optimum water content and maximum dry density. If G_s of the soil is **2.70**, draw the ZAV curve.

Volume of Proctor Mold (ft^3)	Weight of wet soil in the mold (lb)	Water Content (%)
1/30	3.88	12
1/30	4.09	14
1/30	4.23	16
1/30	4.28	18
1/30	4.24	20
1/30	4.19	22

PRACTICE PROBLEM #1

Volume of Proctor Mold (ft^3)	Weight of wet soil in the mold (lb)	Wet Unit Weight (lb/ft^3)	Water Content (%)	Dry Unit Weight (lb/ft^3)
1/30	3.88	116.4	12	103.9
1/30	4.09	122.7	14	107.6
1/30	4.23	126.9	16	109.4
1/30	4.28	128.4	18	108.8
1/30	4.24	127.2	20	106.0
1/30	4.19	125.7	22	103.0

PRACTICE PROBLEM #1



CONCLUDED