Unit 22

Construction Materials

Unit 22 Objectives

Provide an understanding of basic material properties

- Moisture/density relationship of soils and aggregate
- Compaction
- Specific gravity
- Gradation (sieve analysis)

Introduction to Materials

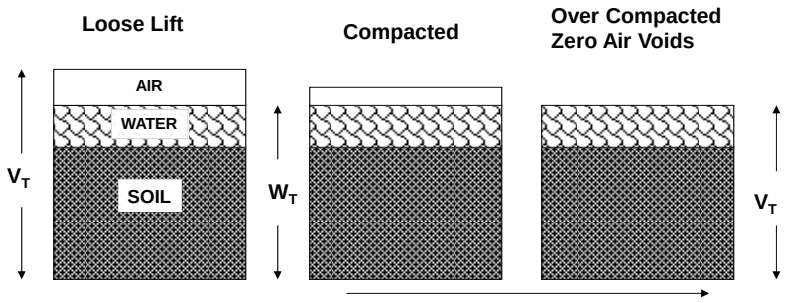
- Moisture vs density
- Soils
- Aggregate

Wet

Near Optimum

-3% Optimum

What happens when a soil is compacted?



Only the volume of voids decreases (i.e., individual soil particles get closer to each other).

Therefore, dry density is a measure of how close the soil particles are to each other.

Does weight of soil and water change?

How do wet and dry density change?

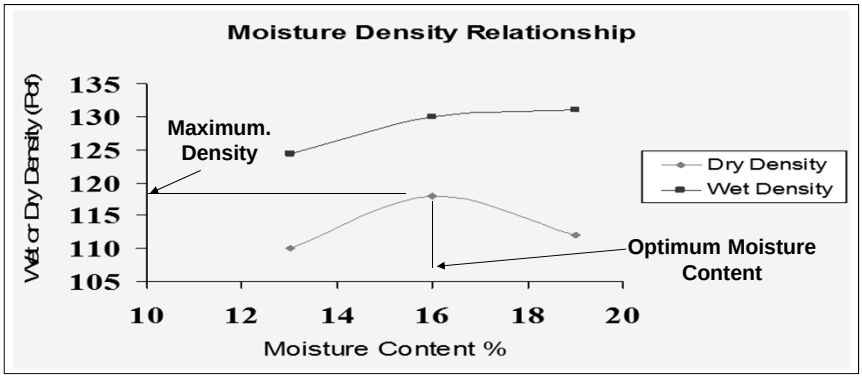
How does percent saturation change?

Does total volume change?

Does the moisture content change?

What happens at 0 air voids

Moisture Density Relationship Graphed



Learn and remember terms *Maximum Density* and *Optimum Moisture Content*

This relationship does not hold or is weakly observed for clean sands and gravels.

What it means

- Moisture density tests establish the moisture-density relationship for a specific soil.
- The moisture content of the soil when being compacted is a major factor in determining how much compactive effort will be required to reach spec density.

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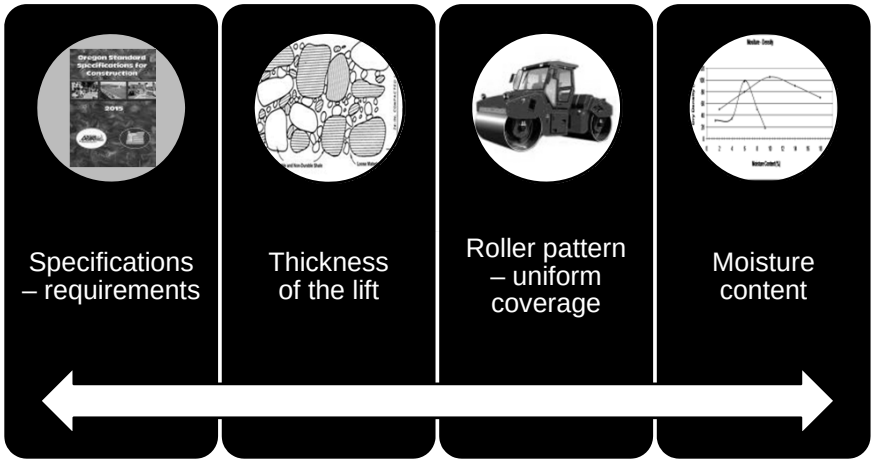
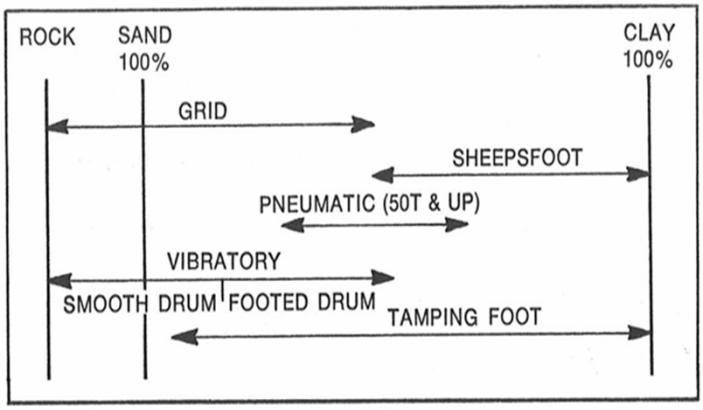
Importance of Compaction

- The density or degree of compaction of soil and aggregate has a significant influence on the stability and durability roadways
- Low density subgrade, subbase, base or embankment will lead to excessive deflection under load and / or long term settlement.

➔ **Reduced performance**

Proper compaction depends on:





Performing Compaction Testing

Two Test Methods

- Deflection Testing
  ODOT TM158
- Nuclear Density Testing
  - AASHTO T310
  - ODOT TM8

ODOT MATERIALS & INSPECTION

ODOT TM-158 – Deflection Testing

- Required for soil and aggregate materials
- Basically a proof roll operation
- Water or haul truck loaded to Gross Vehicle Weight and driven over the entire compacted area
- No yielding, deflection. Reaction, or pumping of the ground surface
- Must PASS before conducting other compaction tests
- Must be performed by a certified density technician
- 330.43(b-2-c) – "…witnessed by the Engineer…."

T-158 Definitions

- **Deflection or Reaction**
  A movement or deviation of material which returns back to a former or less advanced condition in a localized area directly under the test vehicle tire.
- **Pumping**
  Vertical displacement of the top surface of the compacted layer, not directly under the vehicles tires.
- **Loaded Haul Vehicle**
  Water truck or construction material haul unit (i.e., belly bump, end dump or similar).
- **GVW**
  Gross Vehicle Weight

Pumping Soil

Click on video to start

Pumping Base Rock

Click on video to start

Dealing with Wet Materials

- Wet material is normally suitable, just wet
- Work multiple areas
- Keep lifts thinner than normal
- Aerate the material with equipment
- Mix material with rock
- Route trucking over different areas in the fill or cut
- Provide suggestions, not direction

Inspector Documentation to Include:

- Any problems encountered
- Times technician was on-site
- Areas tested
- ODOT TM 158 Deflection Testing results; witness testing
- Nuclear test results – aggregate applications

Suggestion: Document on General Daily Report

Specific Gravity

Specific Gravity: The ratio of the mass of one substance to the mass of water (both with the same volume).

For example the Specific Gravity of rock is:

$$\frac{\textbf{1 cubic foot of rock}}{\textbf{1 cubic foot of water}} \rightarrow \frac{156.0\frac{lbs}{ft^3}}{62.4\frac{lbs}{ft^3}} = 2.500$$

So the rock is 2.500 times heavier than water.

Why is specific gravity important?

Aggregate quantities listed in the Bid Items are based on an assumed specific gravity

Contractor may use a source that is significantly different from what was used for estimating (think lead versus cinders!).

Differences between assumed and actual can affect quantities used.

HMAC specific gravity is in the Special Provisions.

Specific Gravity Example 1

- The Bid Item (BI) lists 1000 tons of aggregate based on an assumed SG = 2.600
- Contractor's aggregate has an actual SG = 2.700
- Calculate actual tons of the Contractor's aggregate required:

$$\frac{2.700\ (\text{Actual or contractor \#})}{2.600\ (\text{Assumed or agency \#})} = 1.038 * 1000\ tons = 1038\ tons$$

So, 38 additional tons of aggregate are needed to cover the designed volume.

Specific Gravity Example 2

- BI lists 1000 tons at an assumed SG = 2.600
- Contractor's aggregate has an actual SG = 2.500
- Calculate actual tons of the Contractor's aggregate required:

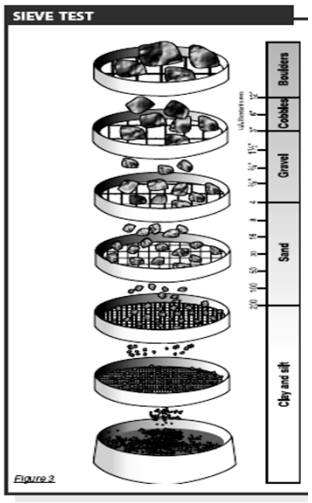
$$\frac{2.500\ (\text{Actual or contractor \#})}{2.600\ (\text{Assumed or agency \#})} = 0.962 * 1000\ tons = 962\ tons$$

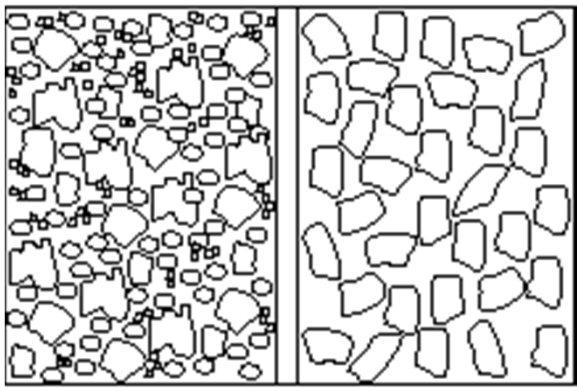
So 38 tons less of aggregate are needed to cover the same volume.

Gradation of Materials

Gradation of Materials (Sieve Analysis)

- Gradation determined by sieve analysis
- Reveals the size makeup of materials from largest to smallest





Well vs. Uniformly Graded

Well-graded materials have an even distribution of particle sizes that provide better load handling properties

Key Inspection Points:

- Witness all deflection tests
- TM158 deflection testing needs to be performed by contractors certified density technician
- Need proper moisture, reasonable lift thickness, and adequate compaction to achieve dense material
- Compaction is critical
- Talk to your QCCS about materials related issues

Unit 22 Review

✓Moisture/density relationship of soils and aggregate

✓Compaction

✓Specific gravity

✓Gradation (sieve analysis)

Specific Gravity

Class Exercise 22-1:

Bid Item 0470 is for 4,200 tons of ACP. Special provisions section 00745.80 shows quantities based on SG = 2.750. The Contractor has selected his aggregate source and has an SG = 2.650.

Calculate the actual quantity of aggregate required on the project.