EWCE 341

Principles of Soil Mechanics

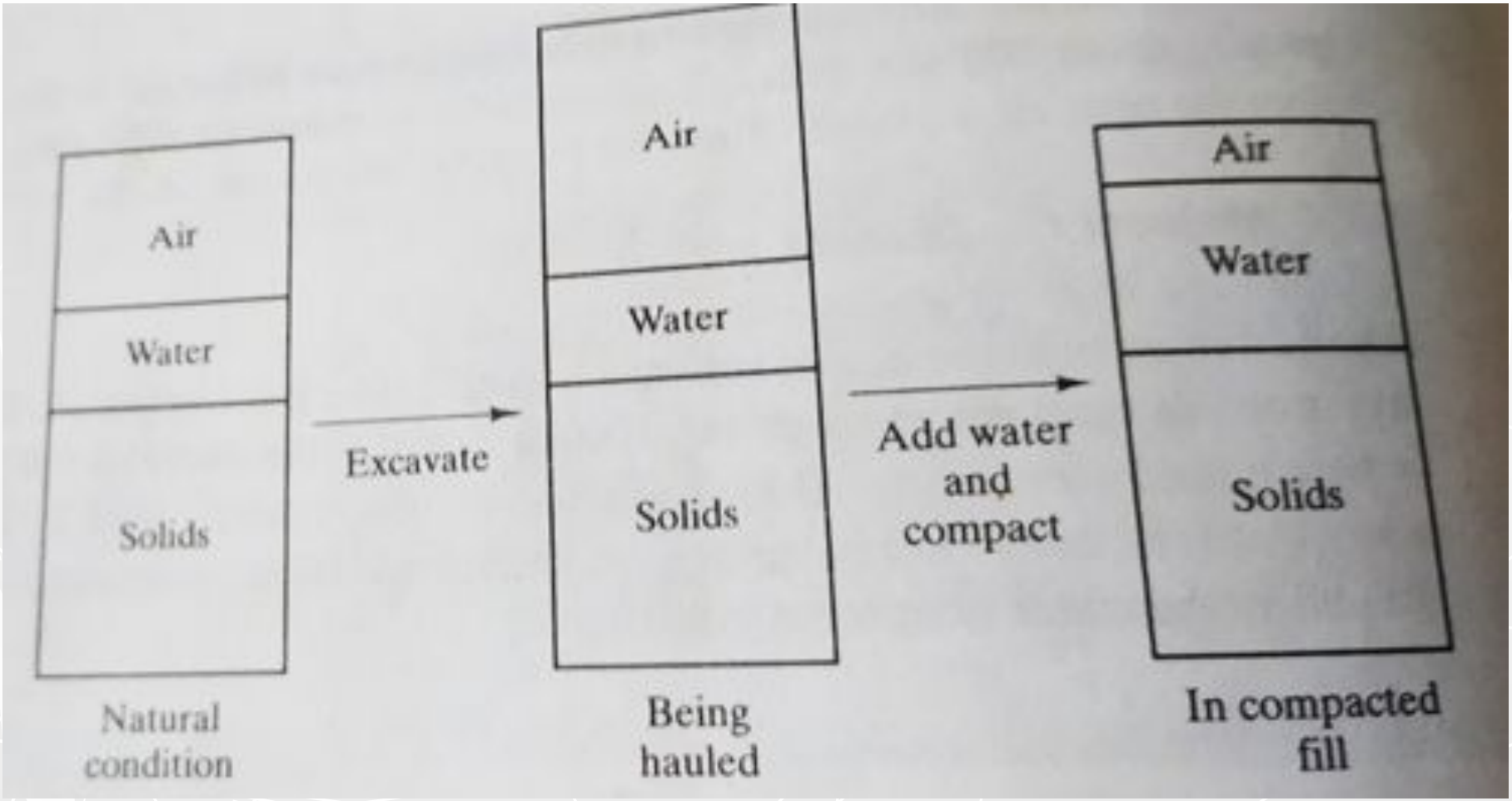
What is soil Compaction?

- **Use of equipment** to **compress soil** into **smaller volume**, thus increasing its dry unit weight and improving its engineering properties.

- Solids and water are virtually **incompressible**, so compaction produces a **reduction in volume of air**.

Definition of soil Compaction

- Pressing the soil particles close each other **by mechanical methods.**
- During compaction, **air is expelled from the voids** in the soil mass and **moisture content is fixed**.



Phase Diagram showing the changes in soil as it moves from its natural location to a compaction fill

Purpose of soil Compaction:

- Improve **engineering properties** of soils.
- Increase **shear strength** of soil.
- Increase **stability** and **bearing capacity**.
- Reduce **compressibility**.
- Reduce the **permeability**.

Requirements of soil compaction in Engineering works:

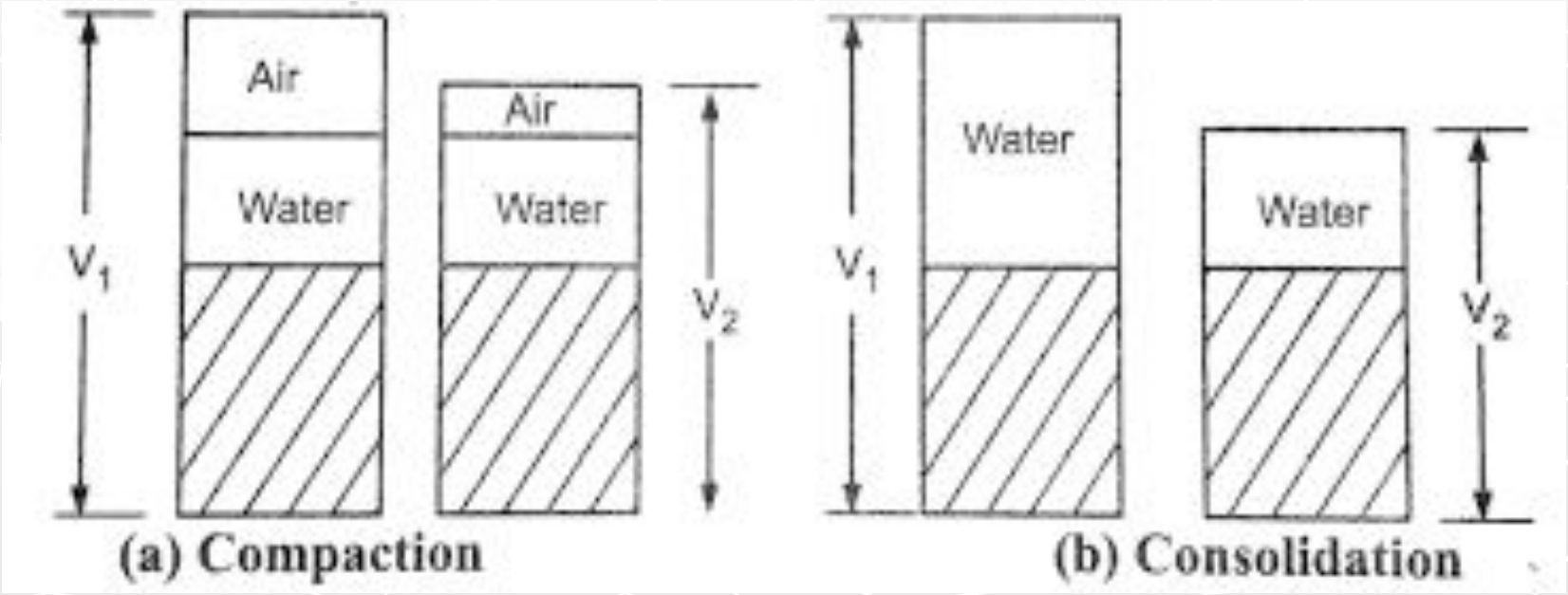


- Earth dam
- Canal embankment
- Highways, railways and runways
- Many other engineering applications.

Differences between consolidation and compaction of soils:

- Both the processes caused the **reduction of volume** in the soil mass.
- **Consolidation**: **Gradual process** of reduction of volume under **sustained static loading**.

Compaction: **Rapid process** of reduction of volume by **mechanical methods** like rolling, tamping, vibration etc.



- **Consolidation**: Causes a reduction of volume of **saturated soils/partially saturated soils** due to **squeezing out of water** from the soils.

Compaction: Volume of **limited saturated soils** decreases due to **expulsion of air** from the voids at **unaltered water content**.

- **Consolidation**: Process **occurs in nature** when saturated soil deposits are subjected to **static loads**, caused by the weight of buildings and other structures.

Compaction: **Artificial process** which is done to increase the density (unit weight) of the soils **to improve its properties** before it put into any use.

Ensuring Proper Compaction of Fill:

- Civil Engineers have to **include criteria for placement and compaction of fill** in the plans and specifications.

- Contractors are then **obliged to satisfy the criteria** while implementing projects.

History of development of compaction of fill:

- Early fill were used **without any special effort to compact** the fill.
- Some engineers **recognized the importance** of compaction in 19th century.
- **Animals were used as compaction equipment** on some project, a team of 115 goats used to compact an earth dam.

- Then **heavy rollers began to be used**; initially these rollers were pulled by a teams of **horses,** but by 1920 the horses being replaced with the **tractors**.

- During 20th century, development of enhanced the **capabilities of compaction equipment**.

- Now, a **wide varieties of effective equipment** is available.

Incidental Compaction:

- **All of equipment that drives over the fill**, from pickup trucks to loaded scrapers, **contribute to the compaction**.

- As an civil engineer, generally you **can not rely on** this incidental compaction because:

-Most construction equipment is **intentionally designed to have low contact pressure** between the tires or tracts and soils. Such pressures are too low to produce the required compaction in normal-thickness lifts.

-**Incidental traffics usually follows common routes**, so their compactive effort is not **uniformly distributed across the fill**. Thus some areas may receive sufficient compaction, while other receive virtually none.

Necessity of Specialized Compaction Equipment:

- Necessary to use specialized compaction equipment specifically designed for this task.

- Such equipment is **much more efficient and effective**.

Methods used by the Compaction Equipment for compaction:

Pressure:

- **Contact pressure** between the equipment and the ground is probably the **most important factor** in resulting compaction of under lying soils.
- A typical **smooth drum roller** has contact pressure of about 3500 kPa (500lb/sq inch), which is far greater than the track mounted equipment (83 kPa or 12 lb/sq inch)



Impact:

- Some equipment **imparts a series of blows** to the soils, such as by dropping a weight.
- This **adds a dynamic component** to the Compactive efforts.



Vibration:

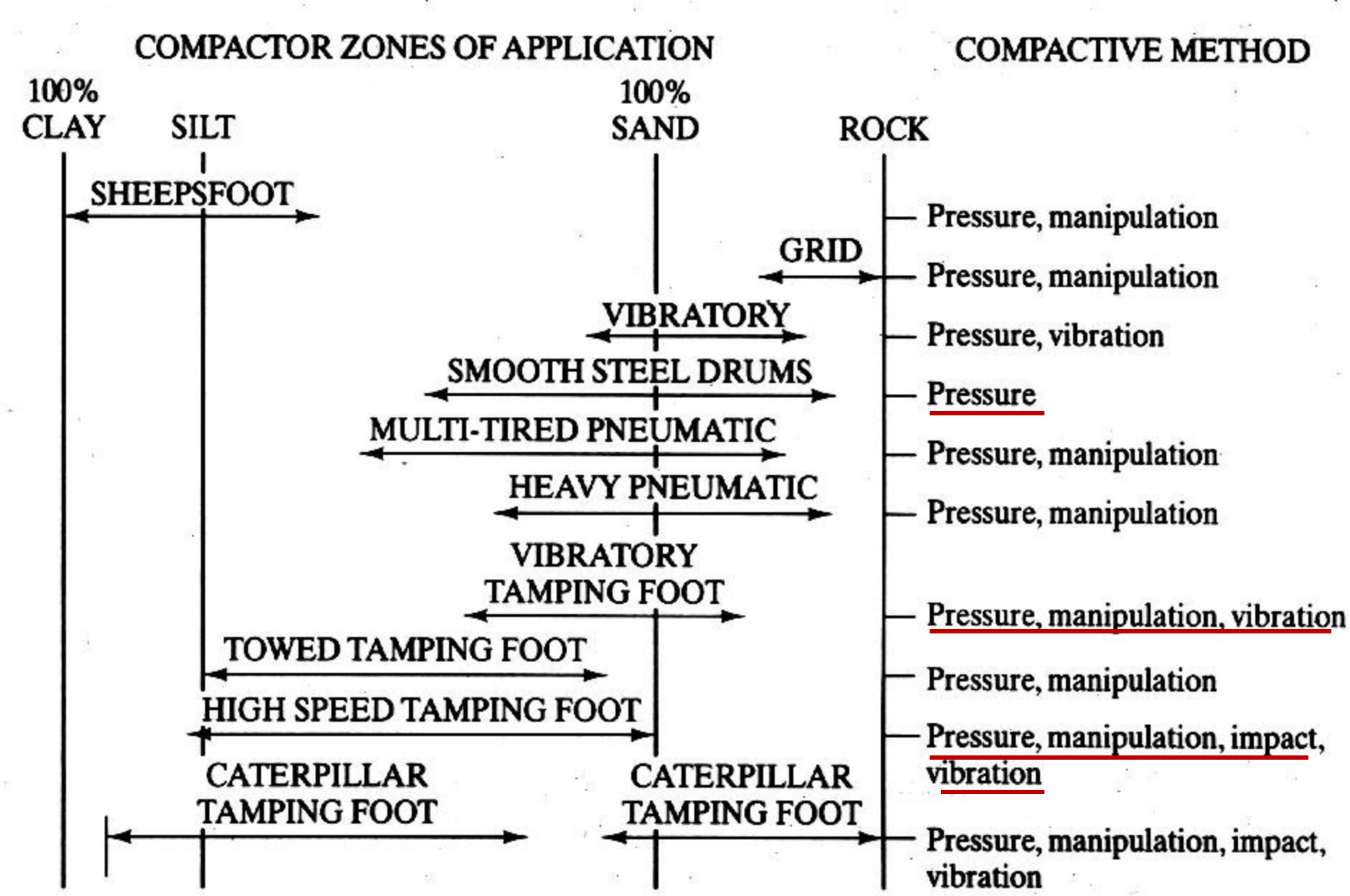
- Vibratory compaction equipment utilizes eccentric weighs or some other device to **induce strong vibrations** in to the soils, which can **enhance the compaction**.
- Vibrations typically have a **frequency of 1000-3500 cycles per minutes.**



Manipulation/kneading:

- Compaction equipment that **imparts some shearing forces to the soils** can also contribute to better compaction.
- This **action is called kneading** or manipulation.
- Excessive manipulation, such as in **an overlay wet fill**, can be detrimental.
- When such fills are **simply being moved around with no compaction occurring**, condition that called **pumping**.





Soil types best suited for various kinds of compaction equipment (Adapted from Caterpillar,1993).

- Also called **tamping rollers**, have rectangular-shaped **lugs, or "feet**,"(150mm – 250mm).

- Type of Soils: **Heavy clay and silty clay**.

- Compactive Method: **Pressure and manipulation**

Sheep foot Rollers



Grid Rollers





Type of soils: **Gravels and Gravely soils**.

Compactive method: **Pressure and Manipulation**

Vibratory Rollers



- Surface compaction of granular soils is mainly conducted using vibratory rollers.
- Type of Soils: **Sandy soils**.
- Compactive Method: **Pressure and vibration**

Smooth Steel Drum Roller





- Surface compaction of granular soils.
- Type of Soils: **Silt, Sands and Gravel**
- Compactive Method: **Pressure**

Multi-Tired Pneumatic Rollers



- Use air to create the required inflation pressure which goes from 200 to 1000 kN/sq.m.
- Type of Soils: **Silt, Sands and Gravel**
- Compactive Method: **Pressure and Manipulation**

Heavy Pneumatic Roller



- Type of Soils: **Sands and Sandy Gravel**
- Compactive Method: **Pressure and Manipulation**

Vibratory Tamping Foot Roller



- Type of Soils: **Silty Sands and Sand**
- Compactive Method: **Pressure, Manipulation and Vibration**

Towed Tamping Foot Roller



- Type of Soils: **Silts to sands**
- Compactive Method: **Pressure, Manipulation**

High Speed Tamping Foot Roller



- Type of Soils: **Silts to sands**
- Compactive Method: **Pressure, Manipulation, impact, Vibration**

Caterpillar Tamping Foot Roller



- Type of Soils: **All Types of Soils**
- Compactive Method: **Pressure, Manipulation, impact, Vibration**

Compaction Improves engineering properties of fill:

Compaction is one of the **most important parts** of earthwork construction.

Compaction **improves the engineering properties** in many ways:

Increase Shear strength,

- **Reduces the potential for slope stability problems**, such as landslides,
- **Enhances the fill capacity for supporting loads**, such as foundations.

Decrease the compressibility

- Reduces the potential for excessive settlement.

Decrease hydraulic conductivity

- **Inhibits the flow of water through the soils**; may be desirable, depending on situation.

Decrease void ratio

- **Reduces the amount of water can be held in soils**;
- Helps in maintaining the **desirable strength parameters**.

Increase erosion resistance

- Helps to maintain the **ground surface in a serviceable condition**.

Soil Compaction

Why dry unit weight ($\gamma_d = \frac{W_s}{V}$) of soils is an important parameter for soil compaction?

- Nearly all **compaction specifications are based on** achieving a certain value of dry unit weight.
- Geotechnical Engineers **measure the unit weight of soils in the field to verify the contractors compliance** with the specification.
- **Dry unit weight** is an **indicators of soils quality**, **easy to measure** and **correlate** with desirable engineering properties.
- **Engineering properties** ie. Favorable strength, compressibility, erosion control etc **to be obtained when dry unit weight criteria has been achieved.**

Cylindrical Rollers:



Rollers function admirably while utilizing surface dressings to create an even smoother and flatter surface.

Thanks