Quality Check During Field Compaction

Introduction:

When we create infrastructures like roads, highways, airports, and buildings, field compaction of soils plays an important role in the construction process. Field Compaction is a process that tries to enhance the mechanical qualities of soil, such as strength, stability, and resistance to water penetration, while at the same instant increasing soil density. We need to implement effective quality control methods which are needed for field compaction in order to ensure that the project site is compacted to the correct level. Compaction irregularities can result in structural failures, higher maintenance costs, etc.

Understanding Field Compaction

When it comes to field compaction, a range of special tools and machines aimed at compacting soil layers are usually utilized.

a. Soil compaction can be carried out by vibratory rollers: This type of roller compacts the soil by shaking it and increasing its density. The compaction densities they achieve are remarkably high and work well in granular soils.

Vibratory Roller

Smooth Wheel Roller

b. Smooth-wheel rollers with static pressure on their surface can compact soil by the dead weight and rolling movement. Suitable for cohesive soils, finishing layers.

c. Padfoot Rollers have foot or pad features that penetrate into the soil and compress it firmly to yield a smooth finish. They are often valuable in the compaction of wet clay soils where deep compaction depth is required.

d. Instead of steel wheels to crush soil, Pneumatic rollers use rubber tyres.

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210040023- Aryan Patni

Padfoot Roller

Pneumatic roller

The factors affecting field compression are:

1. Soil Type: Granular soils such as gravel and sand get compacted more easily than cohesive soils like silt and clay.
2. Moisture content: It is acknowledged that for the attainment of maximum compaction density, the presence of optimal moisture content is crucial.
3. Density of soil: It is found that loose soils typically necessitate more passes of compaction equipment to reach the desired density, in contrast to soils that are moderately dense.
4. Compaction energy: The amount of energy that is applied to the soil during the compaction process influences its effectiveness of compaction.
5. Layer thickness: When it comes to layer thickness, it is most effective to carry out compaction in thin layers.
6. Compaction method: The results produced by different compaction methods, including static or vibratory compaction, vary based on the conditions of soil.

Specification of Field Compaction

A compacted field dry unit weight of 90% to 95% of the maximum dry unit weight established in the laboratory by either the standard or modified Proctor test is what most earthwork specifications call for the contractor to accomplish.

$$R(\%) = \frac{\gamma_{d(\text{field})}}{\gamma_{d(\text{max—lab})}} \times 100$$

It can also be related to Relative Density as-

$$R = \frac{R_0}{1 - D_r(1 - R_0)}$$

Where,

$$R_0 = \frac{\gamma_{d(\min)}}{\gamma_{d(\max)}}$$

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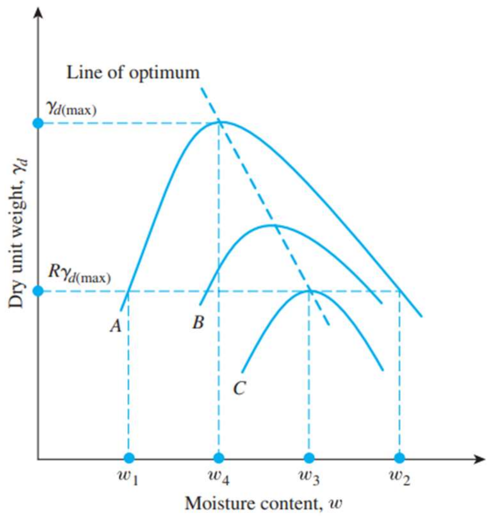

Most economical compaction condition

Let curve A represent the conditions of maximum compactive effort that can be obtained from the existing equipment, W = W4 is the optimum moisture content for curve A.
It can be seen from compaction curve C, the required Yd(field) can be achieved with a lower compactive effort at a moisture content W=W3. Now we can see from Figure that the most economical moisture content is between w3 and w4, which is represented by Curve B

Determination of Field Unit Weight of Compaction

- Sand Cone Method- The sand cone method is a widely used technique for determining the in-place density of compacted soil in the field. This method is particularly suitable for granular soils and provides a quick and relatively simple way to assess the compaction quality. The sand cone method relies on the principle of volume displacement to calculate the in-place density of soil. It involves filling a test hole excavated in the compacted soil with a known volume of dry sand and measuring the volume of sand required to fill the hole. The difference in volume before and after sand placement, along with the mass of sand used, allows for the determination of the in-place density of the soil.

$$\gamma_d = \frac{\text{Dry weight of the soil excavated from the hole}}{\text{Volume of the hole}}$$

And, Volume of hole can be calculated using the unit weight of sand and the weight of sand poured in hole.

Rubber Balloon Method - This method is comparable to the above, the only distinction is that the volume of the hole is calculated by inserting a rubber balloon that is filled with water from a calibrated vessel into it, allowing the volume to be read directly.

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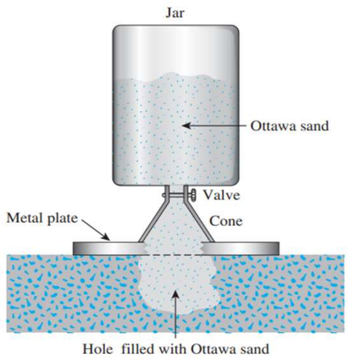
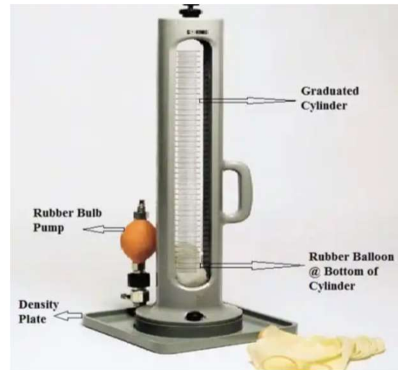


Sand Cone Method



Rubber Balloon Method

Test to Check Soil Compaction

Standard Proctor Test- The standard proctor test, also called the Proctor compaction test, is used to determine the optimal moisture content for compacting a soil. This test helps determine the maximum dry density, or the densest a specific soil can be packed, at a specific moisture content. The Proctor compaction test is performed by compacting moist soil into a mold of a specific size in three or five layers, each with a different moisture content. The weight of the compacted soil and the mold is measured after each layer is compacted. The moisture content of the soil is then determined by drying a sample of the soil in an oven and measuring the weight loss. The dry density of the soil is then calculated for each layer. The dry density and the moisture content for each layer are plotted on a graph. The peak of the curve represents the optimal moisture content, and the corresponding dry density is the maximum dry density.

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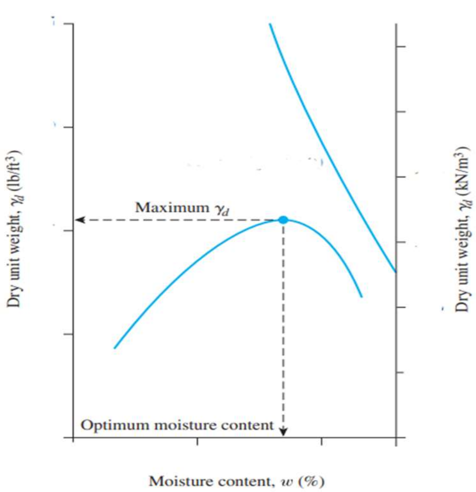

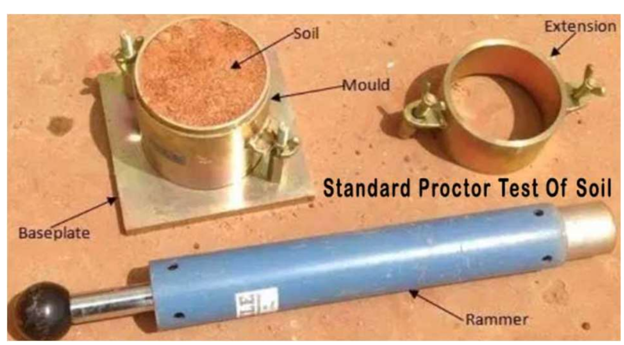

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Modified Proctor test –It is kind of a standard Proctor test designed to simulate higher compaction energy conditions. It's often used for soils expected to experience heavy traffic or significant loads.

Feature	Standard Proctor Test	Modified Proctor Test
Compaction Hammer Weight	2.5 kg	4.5 kg
Drop Height	30 cm	45 cm
Compactive Effort per Layer	62.4 kJ/m³	270 kJ/m³
Number of Layers	3	5
Optimal Moisture Content (Generally)	Higher	Lower
Maximum Dry Density	Lower	Higher
Applications	Foundations, Building Pads, Lightly Trafficked Areas	Pavements, Dams, Heavily Trafficked Areas

Quality Control Measures

To control quality during field compaction, we need to do inspections before, during, and after compacting. These inspections help us check and assess the compaction process. We want to make sure that the built elements are the right density and are uniform. This is important for meeting the compaction requirements.

Pre-compaction Inspection:

A pre-compaction inspection is carried out to evaluate the soil conditions and confirm the compaction equipment specifications prior to starting compaction operations.

- Visual inspection and testing techniques like the Proctor compaction test or moisture content determination are used to assess the kind of soil and its moisture content.
- To make sure that the compaction equipment meets project requirements, its kind, size, and compaction energy are checked.

During Compaction:

To make sure that the predetermined compaction criteria are fulfilled, the compaction process must be continuously monitored

- Tools like the nuclear density gauge, sand cone test, or dynamic cone penetrometer are used to check density of compaction. These tests quickly show the compaction density achieved and help change the compaction effort as needed.
- In order to obtain constant density throughout the project area, uniformity of compaction is assured by checking several areas throughout the site and altering compaction operations as necessary.

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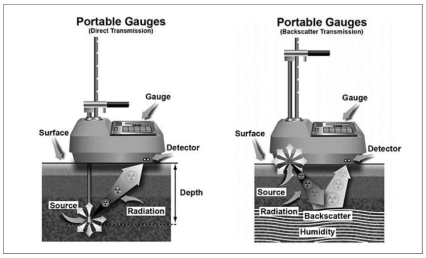

Post-compaction Inspection Following the completion of compaction operations, a post-compaction examination is carried out to confirm the compaction density attained. and evaluate the consistency of the compaction.

- The same techniques used for compaction are used for final density testing, which verify that the requirements for compaction have been fulfilled.
- Visual inspections are carried out to determine whether areas need more compaction or rework. The integrity of the built elements is ensured by swiftly addressing and documenting any problems.

Detailed records of pre-, during, and post-compaction checks give a clear picture of the compaction process. They also help plan future quality checks and audits.
Despite the importance of quality control during field compaction, several challenges may arise during the compaction process.

Common Challenges

- Variability in Soil Conditions: It may be difficult to achieve uniform compaction throughout the project site due to significant variations in soil qualities as moisture content, composition, and density.
- Equipment Malfunctions: The quality and uniformity of compaction operations might be impacted by mechanical malfunctions or incorrect calibration of the equipment, which can produce less than ideal outcomes.
- Environmental Factors: Achieving the required compaction density can be difficult when dealing with unfavourable weather circumstances like rain, strong winds, or extremely high temperatures, which can interfere with compaction processes and alter soil behaviour.

Strategies for Overcoming Challenges

Carefully examine the site conditions to understand the soil and identify any potential issues before starting the compaction work. This allows you to plan ahead and take appropriate actions to address soil variations and ensure even compaction throughout the area.

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