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QUESTION

What is determined in the Proctor test?

ANSWER

The compaction curve is determined correlating dry unit weight, moisture content, and the energy used in compaction.

QUESTION

Why does compaction increase soil strength?

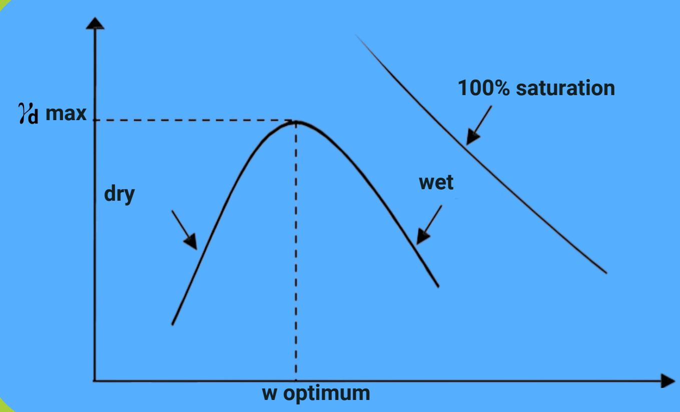
ANSWER

Compaction increases soil strength because it reduces the volume of voids, bringing the particles closer together and improving interlock between them. This intensifies frictional forces and, in cohesive soils, increases apparent cohesion. The particles become rearranged into a denser, more stable structure, which allows better stress distribution and lowers the soil's deformability. Additionally, the decrease in porosity reduces permeability, controlling water flow and preventing conditions that could weaken the soil.

QUESTION

Draw a compaction curve and identify the dry side, the wet side, and the 100% saturation curve

ANSWER



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QUESTION

Why is it difficult to compact soil on the dry side of the optimum of the compaction curve?

ANSWER

On the dry side, water forms menisci that hinder the movement of soil particles and prevent volume reduction. As moisture content increases, these menisci disappear, which facilitates particle slippage and allows higher dry densities to be achieved.

QUESTION

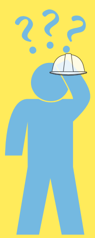
What are the two main factors that affect compaction?

ANSWER

The compaction energy and the soil's moisture content.

QUESTION

Why is it difficult to compact soil on the wet side of the optimum of the compaction curve?



ANSWER

On the wet side, water forms a continuous phase with air trapped in occluded bubbles. In this state, compression can only occur by expelling water, since the air bubbles cannot escape. Expelling water is much more difficult, which explains why it is hard to achieve higher dry densities in this condition.

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QUESTION

What are the steps in field compaction?

Selection of the borrow area, transporting the soil, spreading the soil, adjusting the soil's moisture content, and then performing the compaction itself.

ANSWER

QUESTION

What is the difference between compaction and consolidation?

Compaction is the mechanical action of reducing soil volume by expelling air from the voids, whereas consolidation is the process of expelling water from the voids.

ANSWER

QUESTION

Explain the field phenomenon of "rubbery soil".

It occurs when compaction is attempted at a very high moisture content. The combination of trapped air bubbles and excess water causes the soil to compress temporarily during compaction but then spring back to its original state once the pressure is removed, behaving like rubber.

ANSWER

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QUESTION

How does compaction energy influence the compaction curve?

ANSWER

When the soil's moisture is below the optimum, increasing the compaction energy will raise the dry density achieved. However, when the moisture content is above the optimum, applying more compactive effort has little to no effect on increasing dry density, because the excess water prevents further air expulsion from the voids.

QUESTION

What is soil compaction?

ANSWER

It is a mechanical process in which compactive energy is applied to soil to expel air from the soil's voids, thereby increasing the soil's density.

QUESTION

What is the degree of compaction?

ANSWER

The degree of compaction is the ratio of a soil's dry unit weight in the field to its maximum dry unit weight obtained in the laboratory compaction test. This ratio is expressed as a percentage.

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QUESTION

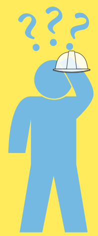
How is compaction control carried out in the field?

ANSWER

Field compaction is controlled by conducting in-situ tests to determine the soil's in-place bulk unit weight and moisture content after compaction. From these, the dry unit weight and the achieved degree of compaction can be calculated and compared to the specified values.

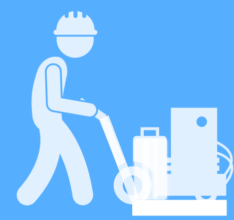
QUESTION

What equipment is recommended for compacting fine-grained soils?



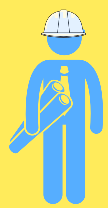
ANSWER

Sheepsfoot roller



QUESTION

What are the most common field tests for compaction control?



ANSWER

For determining in-place bulk density: the sand cone test and the drive-cylinder method. For determining moisture content: the Speedy moisture test, the method of burning a soil and ethanol mixture, or the pan-drying method. Although the oven-drying method is the most accurate for moisture determination, it is too time-consuming to be practical in the field.

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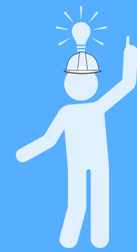
QUESTION

Which standardized tests can be used to determine the compaction curve?

ANSWER

Dynamic compaction tests (Proctor test at three standard energy levels) and static compaction tests (using a press to apply pressure to soil samples)

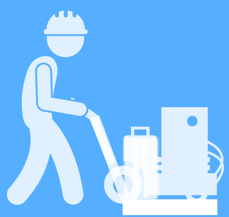


QUESTION

How do experimental embankments help in a project?

ANSWER

They assist in selecting the compaction equipment to use, determining the layer thicknesses, and deciding the number of passes required to reach the desired degree of compaction.

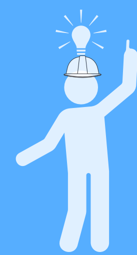


QUESTION

What are the compaction energies of the Proctor test?

ANSWER

The Proctor compaction test has three standardized energy levels: standard (normal), intermediate, and modified.



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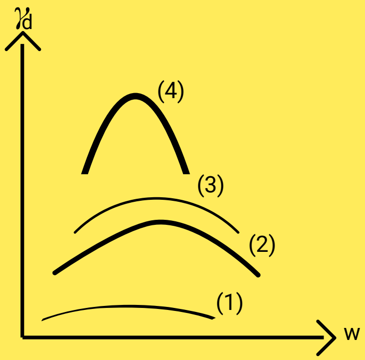
QUESTION

The compaction curves in the figure were obtained with the same compaction energy. What are the likely soil types for each curve?

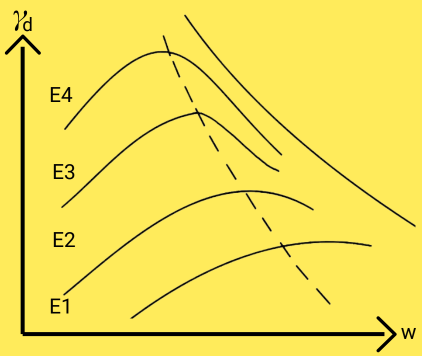


1-Sand
2-Clayey sand
3-Sandy clay
4-Plastic clay

ANSWER

QUESTION

Given compaction curves of the same soil with different compaction energies, which curve corresponds to the highest compaction energy?



E4

ANSWER

QUESTION

What is the name of the test that uses soil samples in a 1000 cm³ mold, compacted in 3 layers with 21 blows per layer from a 4.5 kg hammer dropped from 45.7 cm?

Intermediate Proctor test.

ANSWER

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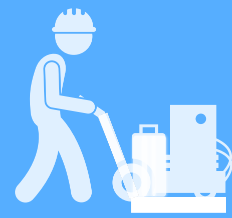
QUESTION

What is the name of the test that uses soil samples in a 2300 cm³ mold, compacted in 5 layers with 12 blows per layer from a 4.5 kg hammer dropped from 45.7 cm?

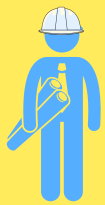
Standard Proctor.



ANSWER

QUESTION

Which soil properties can be improved by compaction?



Hydraulic conductivity, compressibility, and strength.

ANSWER

QUESTION

What equipment is most recommended for compacting a granular soil in the field?

Vibratory rollers.

ANSWER

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QUESTION

In what situation are pneumatic hand tampers recommended for compaction in the field?

ANSWER

They are used for compacting along walls or in spaces that are difficult for larger rollers to reach.

QUESTION

Why is soil compaction performed at all?

ANSWER

Compaction increases the soil's unit weight by removing air from the voids. By bringing the grains closer together, friction between particles increases, producing a denser and more stable soil structure. This leads to better load distribution and reduces the soil's deformability, which is beneficial for construction stability.

QUESTION

Why does an embankment compacted on the dry side of optimum have high strength but low stability?

ANSWER

In a soil compacted on the dry side of the curve, most of the pore water forms thin menisci that create an apparent cohesion, bonding the particles together through suction (like a temporary cement). However, this strength is not permanent. If the soil becomes more saturated (for example, due to rainfall), the menisci vanish, and the apparent cohesion is greatly reduced or lost entirely—thus the initially high strength drops, leading to lower long-term stability.

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QUESTION

Regarding sample preparation, name two common variations of the compaction test.

ANSWER

Conducting the test without reusing previously compacted material, not pre-drying the soil before compaction, or using soil that contains gravel. (Any two of these variations are commonly used.)

QUESTION

The maximum dry unit weight from an embankment's compaction curve is 19.5 kN/m³. In the field (at the same compaction energy), the soil's natural bulk unit weight is 15 kN/m³ at 12.3% moisture. What is the degree of compaction of this embankment?

ANSWER

$$\gamma_d = \frac{\gamma}{1 + w}$$

$$\gamma_d = \frac{15\ \text{kN/m}^3}{(1 + 0.123)} = 13.36\ \text{kN/m}^3$$

$$CD = \frac{\gamma_{d\,(field)}}{\gamma_{d\,(max)}} \times 100$$

$$CD = \frac{13.36}{19.5} \times 100 = \mathbf{68.5\%}$$

QUESTION

Which compaction test is generally used as a reference for compacting the upper (higher-quality) layers of pavements?

ANSWER

Modified Proctor test.

QUESTION

What is the moisture content of a soil with a maximum dry unit weight of 19 kN/m³ and a natural unit weight of 21.66 kN/m³?

ANSWER

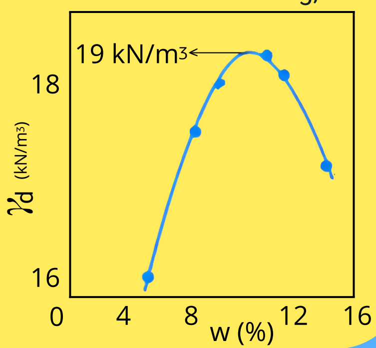
$$\gamma_d = \frac{\gamma}{1 + w}$$

$$19 \text{ kN/m}^3 = \frac{21.66 \text{ kN/m}^3}{(1 + w)}$$

w = **14%**

QUESTION

A soil sample was subjected to a sand cone test with the following results: the mass of the wet soil is 3.007 kg, the hole volume is 0.0014426 m³, and the moisture content is 10.2%. Using the results from the Standard Proctor test, represented in the compaction curve, determine the degree of compaction of this soil.



ANSWER

$$\rho = \frac{\text{soil mass}}{\text{volume}} = \frac{3.007}{0.0014426} = 2084.4 \text{ kg/m}^3$$

$$\gamma = \rho \times g = \frac{2084.4 \times 10}{1000} = 20.84 \text{ kN/m}^3$$

$$\gamma_d = \frac{\gamma}{1 + w} = \frac{20.84}{(1 + 0.102)} = 18.91 \text{ kN/m}^3$$

$$CD = \frac{\gamma_{d\,(field)}}{\gamma_{d\,(max)}} \times 100 = \frac{18.91}{19}$$

CD = **99.55%**

QUESTION

Determine the moisture content of a Proctor Normal test sample given: the mass of container + wet soil is 111.58 g, the mass of container + dry soil is 103.70 g, and the mass of the container alone is 37.88 g.

ANSWER

$$w = \frac{m_w - m_s}{m_s} \times 100$$

$$w = \frac{111.58 - 103.70}{103.70 - 37.88} \times 100$$

w = **12%**

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QUESTION

Which equation is used to plot the equal-saturation (constant degree of saturation) curves on a compaction chart?

ANSWER

$$\gamma_d = \frac{\gamma_s \times S \times \gamma_w}{(S \times \gamma_w) + (\gamma_s \times w)}$$

γ_d → dry unit weight

γ_s → specific gravity of solids

γ_w → unit weight of water

S → degree of saturation

w → water content

QUESTION

If the specifications require a 98% degree of compaction in the field, what should the dry unit weight of the soil be in the field, given that the maximum dry unit weight from the lab (Proctor) is 17.64 kN/m³?

ANSWER

$$CD = \frac{\gamma_{d\,(field)}}{\gamma_{d\,(max)}} \times 100$$

$$98 = \frac{\gamma_{d\,(field)}}{17.64\ kN/m^3} \times 100$$

$\gamma_{d\,(field)}$ **= 17.29 kN/m³**

QUESTION

What moisture content corresponds to a dry unit weight of 15.9 kN/m³ on the 90% saturation curve (consider Gs = 2.70)?

ANSWER

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

$$15.90\ kN/m^3 = \frac{1}{\frac{1}{2.70} + \frac{w}{0.90}}$$

w = 5.33%

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QUESTION

An embankment requires a minimum 95% degree of compaction and a ±1.5% moisture tolerance. Laboratory tests found a max dry density of 15.6 kN/m³ at an optimum moisture of 22.5%. Within what moisture range can the soil be compacted, and what is the minimum dry unit weight required in the field?

ANSWER

$$CD = \frac{\gamma_{d\,(field)}}{\gamma_{d\,(max)}} \times 100$$

$$95 = \frac{\gamma_{d\,(field)}}{15.60\ kN/m^3} \times 100$$

$\gamma_{d\,(field)}$ **= 14.82 kN/m³**

w = **21% - 24%**

QUESTION

What equation is used to determine the energy applied in dynamic compaction tests?

ANSWER

$$E = \frac{P \times H \times N \times n}{V}$$

E → compaction energy per unit volume
P → hammer weight
H → drop height
N → number of blows per layer
n → number of layers
V → volume of the soil specimen

QUESTION

For a field compaction, it was specified that 98% compaction is required. In the lab the soil's max dry density is 15.4 kN/m³ at an optimum moisture of 22.8%. In the field, a dry density of 15 kN/m³ was achieved at 20.6% moisture. The allowable moisture deviation is ±1.5%. Can this compacted layer be accepted?

ANSWER

$$CD = \frac{\gamma_{d\,(field)}}{\gamma_{d\,(max)}} \times 100$$

$$CD = \frac{15\ kN/m^3}{15.4\ kN/m^3} \times 100 = 97.4\%$$ ***(Not OK)***

$$\Delta w = w_{(field)} - w_{(otm)}$$

$$\Delta w = 20.6 - 22.8 = 2.2\%$$ ***(Not OK)***

The compacted layer cannot be accepted. Both the achieved compaction and the moisture content fall outside the specified requirements.

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