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## NCEES

# NCEES PE Civil: Geotechnical

*NCEES - PE Civil Engineering - Geotechnical 2024*

**Question 1:**
A geotechnical engineer is conducting a groundwater exploration program using a combination of piezometers and observation wells. The groundwater flow direction is determined to be towards a nearby river. If the hydraulic gradient is measured at 0.05 and the hydraulic conductivity of the soil is 10 m/day, what is the estimated seepage velocity of the groundwater in the soil?
A. 0.5 m/day
B. 2 m/day
C. 5 m/day
D. 10 m/day

**Answer:** A

**Explanation:** The seepage velocity (v) can be calculated using Darcy's law: $v = K \cdot i$, where $K$ is the hydraulic conductivity and $i$ is the hydraulic gradient. Thus, $v = 10\,\mathrm{m/day} \cdot 0.05 = 0.5\,\mathrm{m/day}$.

**Question 2:**
During a site investigation, a soil sample is retrieved from a depth of 10 m below ground level. The soil is classified as silty

sand (SM) based on the Unified Soil Classification System (USCS). If the sample has a moisture content of 12%, what is the specific gravity of the solids if the dry density of the soil is 18 kN/m³?

A. 1.65

B. 1.70

C. 1.75

D. 1.80

**Answer:** D

**Explanation:** The specific gravity (G) can be calculated using the formula $G = \frac{\gamma_d}{\gamma_w}$, where $\gamma_d$ is the dry density, and $\gamma_w$ is the unit weight of water (approximately 9.81 kN/m³). Thus, $G = \frac{18\,\mathrm{kN/m^3}}{9.81\,\mathrm{kN/m^3}} \approx 1.83$.

**Question 3:**

A laboratory consolidation test is performed on a clay sample, and the results indicate an initial void ratio of 1.2. After applying a vertical stress of 100 kPa, the void ratio decreases to 0.9. What is the coefficient of volume change (mv) for this clay if the applied stress is uniform and the test duration is sufficient for primary consolidation?

A. 0.003

B. 0.02

C. 0.03
D. 0.05

**Answer:** A

**Explanation:** The coefficient of volume change can be calculated using the formula $m_v = \frac{e_0 - e}{\Delta\sigma}$, where $e_0$ is the initial void ratio, $e$ is the final void ratio, and $\Delta\sigma$ is the change in stress. Thus, $m_v = \frac{1.2 - 0.9}{100} = 0.003$.

**Question 4:**
A site has been found to have contaminated soil containing heavy metals. During a geotechnical assessment, the engineer decides to perform a series of chemical tests to determine the leachability of the contaminants. Which of the following tests is most effective in assessing the potential for contaminants to migrate through groundwater?
A. pH test
B. Toxicity Characteristic Leaching Procedure (TCLP)
C. Standard Proctor Test
D. Atterberg Limits Test

**Answer:** B

**Explanation:** The Toxicity Characteristic Leaching Procedure

(TCLP) is designed specifically to evaluate the leachability of contaminants from soil into groundwater, making it the most relevant test for this scenario.

**Question 5:**

A geotechnical engineer is evaluating the electrical resistivity of a clay soil to assess its suitability for a buried pipeline installation. If the resistivity of the soil is found to be 50 ohm-m, what can be inferred about the soil's ion concentration and potential for corrosion of the pipeline?

A. High ion concentration, low corrosion potential
B. Low ion concentration, high corrosion potential
C. High ion concentration, high corrosion potential
D. Low ion concentration, low corrosion potential

**Answer:** C

**Explanation:** A low electrical resistivity value (50 ohm-m) indicates a high concentration of ions in the soil, which can lead to increased corrosion potential for buried pipelines.

**Question 6:**

In a thermal conductivity test on a saturated sand sample, the thermal conductivity is measured at 1.5 W/m·K. If the temperature gradient across the sample is 10 K over a

thickness of 0.5 m, what is the heat flux through the sample?
A. 10 W/m²
B. 15 W/m²
C. 20 W/m²
D. 30 W/m²

**Answer:** D

**Explanation:** The heat flux (q) can be calculated using Fourier's law: $q = k \cdot \frac{\Delta T}{L}$, where $k$ is thermal conductivity, $\Delta T$ is the temperature difference, and $L$ is the thickness. Thus, $q = 1.5 \cdot \frac{10}{0.5} = 30\,\mathrm{W/m^2}$.

**Question 7:**
During a laboratory test, a soil sample exhibits a plasticity index of 18 and a liquid limit of 40. What is the soil's classification based on the Unified Soil Classification System (USCS)?
A. CL
B. CH
C. ML
D. MH

**Answer:** A

**Explanation:** Based on the plasticity index (PI) and liquid limit

(LL), the soil is classified as CL (Clay of Low Plasticity) since it falls within the range for clay with a liquid limit greater than 20 and a plasticity index less than 25.

**Question 8:**

A geotechnical investigation reveals that a site contains a layer of compacted fill overlying soft clay. The engineer needs to calculate the effective stress at a depth of 5 m below the fill. If the fill has a unit weight of 18 kN/m$^3$ and the water table is at 2 m depth, what is the effective stress at the 5 m depth?

A. 2.30 kPa

B. 5.0 kPa

C. 60.5 kPa

D. 14.0 kPa

**Answer:** C

**Explanation:** The effective stress ($\sigma'$) can be calculated as $\sigma' = \sigma - u$, where $\sigma$ is total stress and $u$ is pore water pressure. Total stress at 5 m is $18 \cdot 5 = 90\,\mathrm{kPa}$, and pore water pressure at 3 m (5 m - 2 m) is $9.81 \cdot 3 = 29.43\,\mathrm{kPa}$. Thus, $\sigma' = 90 - 29.43 = 60.57\,\mathrm{kPa}$.

**Question 9:**

In performing a consolidation test, a soil specimen is subjected to a series of loading increments. If the final void ratio after consolidation is 0.5 and the initial void ratio was 1.0, what is the coefficient of consolidation (Cv) if the test duration was 24 hours and the drainage path length was 0.1 m?

A. 0.01 $m^2$/yr

B. 0.1 $m^2$/yr

C. 0.5 $m^2$/yr

D. 1.0 $m^2$/yr

**Answer:** C

**Explanation:** The coefficient of consolidation can be estimated using $C_v = \frac{t \cdot d^2}{H}$, where $t$ is time in seconds, $d$ is drainage path length, and $H$ is the change in void ratio. Thus, converting 24 hours to seconds and substituting gives $C_v \approx 0.5\,\mathrm{m}^2/\mathrm{yr}$.

**Question 10:**

A soil sample has a moisture content of 15% and a specific gravity of solids of 2.68. If the sample's bulk density is measured at 19 kN/$m^3$, what is the degree of saturation of the soil?

A. 30%

B. 40%

C. 50%

D. 60%

**Answer:** B

**Explanation:** The degree of saturation (S) can be calculated using the equation $S = \frac{w \cdot G}{\gamma_w}$, where $w$ is moisture content, $G$ is specific gravity, and $\gamma_w$ is the unit weight of water. Thus, $S = \frac{0.15 \cdot 2.68}{9.81} \approx 0.41$ or 41%.



**Question 11:**

A geotechnical engineer is evaluating the thermal response of a subsurface environment due to a newly proposed geothermal heating system. If the ground temperature at a depth of 5 m is measured at 15°C and the rate of increase is 2°C per 100 m depth, what would be the expected ground temperature at 20 m depth?

A. 17°C
B. 19°C
C. 20°C
D. 22°C

**Answer:** B

**Explanation:** The expected ground temperature can be calculated as $T = T_0 + \left(\frac{d}{100} \cdot \text{rate of increase}\right)$, where $T_0$

is the temperature at 5 m, $d$ is the depth (15 m additional), and the rate of increase is 2°C per 100 m. Thus, $T = 15 + (15/100 \cdot 2) = 19^{\circ}C$.

**Question 12:**
A soil layer is identified as a well-graded gravel (GW) with a high degree of angularity. How would this angularity affect the soil's shear strength parameters compared to a rounded gravel of the same grading?

A. Higher cohesion and lower friction angle
B. Lower cohesion and higher friction angle
C. Higher cohesion and higher friction angle
D. Lower cohesion and lower friction angle

**Answer:** C

**Explanation:** Angular particles have interlocking characteristics that increase both cohesion and friction angle, leading to improved shear strength compared to rounded particles.

**Question: 1088**

While utilizing the split-barrel sampling method, an engineer notices that the sample retrieved is excessively compacted. What could be a likely cause of this phenomenon?

A. Insufficient hammer weight
B. Incorrect borehole size
C. Poor soil cohesion
D. Excessive drilling speed

Answer: D

Explanation: Excessive drilling speed can lead to over-compaction of the soil sample during the split-barrel sampling process. This can alter the sample's characteristics and affect the interpretation of results.

**Question: 1089**

What is the primary advantage of using helical screw piles in areas with limited access and where noise pollution must be minimized during installation?

A. Their ability to transfer load immediately
B. The low noise and vibration levels during installation
C. The speed of installation
D. Their environmental footprint

Answer: B

Explanation: Helical screw piles are installed with minimal noise and vibration, making them ideal for locations where access is constrained and noise pollution is a concern, while also providing immediate load capacity.

**Question: 1090**

While analyzing data from an inclinometer in a landslide-prone area, you observe sudden and unusual lateral movements. What is the most immediate course of action to take?

A. Increase monitoring frequency and wait for further data
B. Implement a slope stabilization plan without delay
C. Conduct a detailed geological survey of the site
D. Notify the local authorities and evacuate the area

Answer: D

Explanation: Notifying local authorities and evacuating the area is critical in response to sudden and unusual lateral movements, as this may indicate an imminent landslide or significant risk to public safety.

**Question: 1091**

During the field operation of split-barrel sampling, which aspect is crucial to ensure that the sampler is vertical and achieves accurate penetration?

A. Manual adjustments by personnel
B. Using a plumb line
C. Calibrating the hammer weight
D. Pre-drilling the sampling location

Answer: B

Explanation: Using a plumb line ensures that the sampler is vertical, which is crucial for accurate penetration and reliable sample retrieval.

**Question: 1092**

A construction project requires the use of auger cast piles in an area with significant groundwater fluctuations. What is the most critical design consideration to mitigate potential issues related to these fluctuations?

A. Selecting a more robust pile material
B. Designing for buoyancy effects
C. Increasing the pile diameter
D. Implementing a deep excavation strategy

Answer: B

Explanation: Designing for buoyancy effects is crucial in areas with fluctuating groundwater levels, as it ensures that the piles remain stable and do not experience uplift forces due to changes in water levels.



**Question: 1093**

In a construction project involving the use of piezometers, a reading shows an unexpected drop in pore water pressure after installation. What is the most likely explanation for this observation?

A. The piezometer was installed incorrectly
B. There has been an increase in soil suction
C. The water table has lowered due to nearby dewatering activities
D. The surrounding soil has consolidated significantly

Answer: C

Explanation: A drop in pore water pressure is likely due to a lowering of the water table, which can occur as a result of nearby dewatering activities, affecting the readings from the piezometer.

**Question: 1094**

A geotechnical investigation indicates that a site has a shallow groundwater table and loose sands. What is the most critical consideration when selecting an exploration technique?

A. The method's ability to handle saturated conditions
B. The potential for soil liquefaction
C. The depth of exploration required
D. The need for geophysical surveys

Answer: A

Explanation: The exploration technique must effectively manage saturated conditions to prevent issues like collapse or inaccurate sampling, especially in loose sands.

**Question: 1095**

A rock mass with a Rock Mass Rating (RMR) of 40 is encountered during a tunneling project. The RMR indicates which of the following about the rock mass?

A. Favorable conditions for tunneling
B. Poor rock conditions requiring careful excavation
C. Excellent conditions for construction
D. No need for support systems

Answer: B

Explanation: An RMR of 40 indicates poor rock conditions, suggesting that careful excavation techniques and potential support systems will be necessary.

**Question: 1096**

During a construction project in a seismic zone, the engineer decides to use aggregate piers to improve ground conditions. Which of the following is a critical design factor to consider regarding the performance of the aggregate piers?

A. The color of the aggregate
B. The density of the surrounding soil
C. The moisture content during installation
D. The spacing between piers and their depth

Answer: D

Explanation: The spacing and depth of aggregate piers are critical design factors influencing their ability to transfer loads effectively and enhance overall stability during seismic events.

**Question: 1097**

In a planning study for a new commercial development, the engineer encounters a report indicating a nearby landslide history. What is the most critical factor to consider when evaluating the site for construction?

A. The slope stability and drainage conditions

B. The soil type in the area
C. The proximity to urban infrastructure
D. The local flora and fauna

Answer: A

Explanation: Slope stability and drainage conditions are vital to prevent future landslides, especially in areas with a history of such events.

**Question: 1098**

During the design of a cofferdam, engineers must assess potential environmental impacts. Which of the following impacts is most critical to evaluate in the context of aquatic ecosystems?

A. Visual obstruction to boat traffic
B. Increased noise levels during construction
C. Changes in sediment transport patterns
D. Soil compaction in adjacent areas

Answer: C

Explanation: Changes in sediment transport patterns can significantly affect aquatic ecosystems, making it critical to assess this impact during the cofferdam design process.

**Question: 1099**

During a fill placement operation, the engineer discovers that the underlying subgrade has a high plasticity index. What is the most effective strategy to ensure stability during compaction of the fill?

A. Allow for natural drainage of the subgrade
B. Compact the fill aggressively
C. Stabilize the subgrade with lime or cement
D. Increase the fill material moisture content

Answer: C

Explanation: Stabilizing the subgrade with lime or cement enhances its load-bearing capacity, reducing the risk of instability during the compaction of the fill material.

**Question: 1100**

In a vane shear test conducted in a soft clay layer, the results show a shear strength that is significantly lower than expected based on previous studies. What should the engineer's next step be?

A. Rely on conservative design values
B. Investigate the possibility of soil improvement techniques
C. Reassess the project scope to avoid the area
D. Conduct additional tests to confirm the results

Answer: D

Explanation: Conducting additional tests is essential to verify the results and ensure accurate design decisions are made based on reliable data.

**Question: 1101**

In a soil sampling program aimed at characterizing a saturated clay layer, which aspect of handling and storage is most crucial to preserving the integrity of the samples prior to laboratory testing?

A. Storing samples in ambient air conditions
B. Keeping samples submerged in water
C. Sealing samples in airtight containers

D. Placing samples in a frost-free environment

Answer: C

Explanation: Sealing samples in airtight containers is crucial to prevent moisture loss and contamination. This practice helps maintain the original water content and soil structure, which are essential for accurate laboratory testing.

**Question: 1102**

A geotechnical engineer is tasked with assessing the risk of frost heave in a newly constructed roadway. The soil profile shows a mix of clay and silt. What immediate action should be taken to evaluate frost susceptibility?

A. Conduct a visual inspection
B. Perform a frost susceptibility test
C. Assume all soils are frost-susceptible
D. Implement a rapid construction schedule

Answer: B

Explanation: Performing a frost susceptibility test provides quantitative data on the soil's behavior under freezing conditions, allowing for informed decisions regarding design and construction practices to mitigate frost heave risks.