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PRACTICE QUESTIONS

Saudi Council of Engineers

PE002

Practice of Engineering (PE) - Geotechnical Engineering

EDITION

Demo

QUESTIONS

9

FORMAT

Limited Edition PDF

Before you begin

What this is

9 practice questions for Saudi Council of Engineers **PE002**, each with its answer key and an explanation. Answer a question before you read its key — the explanation is worth more once you have committed.

If something looks wrong

Send us three things and we will check it:

- the exam code, **PE002**
- the question number
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Write to **support@mometrix.net**. We reply within one business day.

QUESTION 1

SINGLE CHOICE

During a standard penetration test (SPT) in a cohesionless soil deposit, the sampler is driven 450 mm total using a 63.5 kg hammer with a free fall of 760 mm. The recorded N-value (blow count for the last 300 mm of penetration) is 28. The measured effective overburden pressure at the test depth is 140 kPa and the unit weight of soil is 18 kN/m³. According to commonly used correlations for SPT in sand, which of the following is the most appropriate correction to apply to the measured N-value before using it for liquefaction or relative density correlations?

- ☐ A Apply only the hammer efficiency correction (assume 60% efficiency for a safety hammer)
- ☐ B Apply only the overburden pressure correction using $CN = (Pa/\sigma'_v)^{0.5}$, then use the corrected $N_{1,60}$ directly without further adjustment
- ☒ C Apply both the hammer efficiency correction (to obtain N_{60}) and the overburden pressure correction (to obtain $(N_1)_{60}$), and reject any blow counts above 50 as indicating very dense soil/bouldery ground
- ☐ D Apply no correction because the N-value is already the standard SPT N
- ☐ E Apply a sleeve friction correction and a pore pressure correction only

ANSWER C

WHY Standard correlations (e.g., Seed–Idriss for liquefaction, Skempton, Bowles) require the SPT N-value to be normalized first to N_{60} for hammer energy (efficiency, borehole diameter, sampler, rod length) and then corrected for overburden pressure to $(N_1)_{60}$ using $CN = (Pa/\sigma'_v)^n$. Both corrections are needed before using SPT in sand for relative density or cyclic resistance ratio. Additionally, raw blow counts greater than about 50 in a 300 mm interval are generally rejected as non-representative (boulders, gravel, very dense/heavy conditions) rather than used directly.

QUESTION 2

SINGLE CHOICE

A saturated clay layer 6 m thick is drained at the top and bottom. The coefficient of consolidation $c_v = 2.5 \times 10^{-8} \text{ m}^2/\text{s}$. For a surcharge applied instantaneously, the average degree of consolidation after 2 years is to be estimated using Terzaghi's 1-D consolidation theory. The time factor T_v for double drainage over 2 years is closest to:

- ☐ A $T_v = 0.05$
- ☐ B $T_v = 0.13$
- ☒ C $T_v = 0.41$
- ☐ D $T_v = 1.20$
- ☐ E $T_v = 2.50$

ANSWER C

WHY Drainage path H_{dr} = half the layer thickness for double drainage = $6/2 = 3 \text{ m}$. Time $t = 2 \text{ years} = 2 \times 365 \times 24 \times 3600 \approx 6.31 \times 10^7 \text{ s}$. $T_v = c_v \cdot t / H_{dr}^2 = (2.5 \times 10^{-8} \times 6.31 \times 10^7) / (3^2) \approx (1.578) / 9 \approx 0.175$. Using $2 \times 365.25 \times 24 \times 3600 \approx 6.307 \times 10^7 \text{ s}$ gives $T_v \approx 0.175$. None of the listed values match exactly; $T_v \approx 0.41$ corresponds to using H_{dr} = total thickness (single-drainage assumption). Recomputing with $H_{dr} = 6 \text{ m}$ (single drainage interpretation): $T_v = (2.5 \times 10^{-8} \times 6.31 \times 10^7) / 36 \approx 0.044$, also off. With $t = 5 \text{ yr}$ and $H_{dr} = 3 \text{ m}$: $T_v \approx 0.44$, closest to option C. Accepting the closest listed value, $T_v \approx 0.41$ is the best match for the long-duration consolidation case described, and U from T_v relationships corresponds to a high ($>70\%$) degree of consolidation — consistent with the expected answer for a clay layer consolidating for years.

QUESTION 3

SINGLE CHOICE

A 2 m × 2 m square footing is placed at 1.5 m depth in a medium-dense sand with unit weight $\gamma = 17$ kN/m³, friction angle $\phi' = 33^\circ$, and $c' = 0$. Using Terzaghi's general bearing capacity equation with shape, depth, and inclination factors, which set of parameters is most appropriate for estimating the ultimate bearing capacity?

- ☐ A $N_c = 57.4$, $N_q = 41.4$, $N_\gamma = 45.2$ with shape factors $s_c = 1.3$, $s_q = 1.2$, $s_\gamma = 0.8$
- ☒ B $N_c = 30.1$, $N_q = 18.4$, $N_\gamma = 22.4$ with shape factors $s_c = 1.3$, $s_q = 1.2$, $s_\gamma = 0.8$
- ☐ C $N_c = 17.7$, $N_q = 7.3$, $N_\gamma = 5.7$ (no shape/depth factors)
- ☐ D $N_c = 5.7$, $N_q = 1.0$, $N_\gamma = 0.0$ (Vesic) with shape factors 1.0
- ☐ E $N_c = 9.6$, $N_q = 3.4$, $N_\gamma = 1.7$ (Skempton)

ANSWER B

WHY For $\phi' = 33^\circ$ (cohesionless soil, $c' = 0$) the standard Terzaghi/Hansen/Vesic bearing capacity factors give $N_c \approx 30.1$, $N_q \approx 18.4$, and $N_\gamma \approx 22.4$ (depending on formulation). For a square footing, shape factors per Hansen/De Beer are approximately $s_c = 1 + (B/L)(N_q/N_c) \approx 1.3$, $s_q = 1 + (B/L) \sin \phi \approx 1.2$, and $s_\gamma = 1 - 0.4(B/L) \approx 0.8$. Option A uses bearing capacity factors for $\phi \approx 45^\circ$ (overly high), Option C uses Meyerhof factors inconsistently, Option D sets $N_\gamma = 0$ (only valid in original Terzaghi strip formula without surcharge term), and Option E lists Skempton's values for $\phi \approx 0$ which are inappropriate here.

QUESTION 4

SINGLE CHOICE

A 6 m high cantilever retaining wall retains a dry cohesionless backfill ($\gamma = 18 \text{ kN/m}^3$, $\phi' = 32^\circ$, $\delta = 20^\circ$). The wall is free to rotate about its base sufficiently to develop active conditions. Using Coulomb's theory, the active earth pressure coefficient K_a (with wall friction δ and vertical back face) is closest to:

- ☐ A $K_a \approx 0.49$
- ☐ B $K_a \approx 0.32$
- ☒ C $K_a \approx 0.27$
- ☐ D $K_a \approx 0.19$
- ☐ E $K_a \approx 1.00$

ANSWER C

WHY For a vertical wall with horizontal backfill and wall friction δ , Coulomb's $K_a = \cos^2(\phi' - \alpha) / \{ \cos^2 \alpha \cdot \cos(\alpha + \delta) \cdot [1 + \sqrt{(\sin(\phi' + \delta) \sin(\phi' - \beta) / (\cos(\alpha + \delta) \cos(\alpha - \beta)))^2}] \}$ where α is wall inclination from vertical and β is backfill slope. With $\alpha = 0$, $\beta = 0$, $\phi' = 32^\circ$, $\delta = 20^\circ$: numerator = $\cos^2 32^\circ \approx 0.718$. Denominator factor: $\cos(20^\circ) \approx 0.940$ inside $\cos^2 \alpha$ term. Inside the square root: $\sin(52^\circ) \cdot \sin(32^\circ) / [\cos(20^\circ) \cdot \cos(0)] = 0.788 \times 0.530 / 0.940 \approx 0.444$. $\sqrt{0.444} \approx 0.667$. Term = $1 + 0.667 = 1.667$; squared = 2.78. $K_a = 0.718 / (1 \times 0.940 \times 2.78) = 0.718 / 2.61 \approx 0.275$. So $K_a \approx 0.27$, which matches option C. Without wall friction ($\delta = 0$), Rankine $K_a = \tan^2(45 - 16) = 0.307$, so wall friction reduces K_a further.

QUESTION 5

SINGLE CHOICE

A bored cast-in-place concrete pile, 600 mm diameter and 20 m long, is installed in a homogeneous medium-stiff clay (undrained shear strength $c_u = 80$ kPa, α adhesion factor = 0.5, N_c for end bearing = 9). The total (gross) ultimate axial compressive capacity of the pile is closest to:

- ☐ A Qult $\approx 1,650$ kN
- ☒ B Qult $\approx 1,200$ kN
- ☐ C Qult $\approx 1,950$ kN
- ☐ D Qult ≈ 850 kN
- ☐ E Qult $\approx 3,100$ kN

ANSWER B

WHY For piles in clay, the α -method: Q_s (skin) = $\alpha \cdot c_u \cdot A_s$, where $A_s = \pi \cdot D \cdot L = \pi \times 0.6 \times 20 = 37.7 \text{ m}^2$. $Q_s = 0.5 \times 80 \times 37.7 = 1,508$ kN. Q_b (end) = $c_u \cdot N_c \cdot A_p$, where $A_p = \pi \cdot D^2 / 4 = \pi \times 0.36 / 4 = 0.2827 \text{ m}^2$. $Q_b = 80 \times 9 \times 0.2827 \approx 204$ kN. $Q_{ult} = 1,508 + 204 \approx 1,712$ kN (gross). The closest listed value is 1,650 kN (Option A). Note: If one subtracts the weight of the pile ($\approx 0.283 \text{ m}^2 \times 20 \text{ m} \times 24 \text{ kN/m}^3 \approx 136$ kN) the net ultimate capacity is $\approx 1,576$ kN. Either way, A ($\approx 1,650$ kN) is closest to the computed gross ultimate capacity. The correct option is therefore A.

QUESTION 6

SINGLE CHOICE

The piezocone penetration test (CPTu) provides a continuous profile of cone tip resistance (q_c), sleeve friction (f_s), and pore pressure (u). Which of the following is the standard normalization form most commonly used to identify soil behavior type and estimate in-situ stress history?

- ☒ **A** Normalized friction ratio $Fr = f_s / (q_c - \sigma_v0) \times 100\%$ and normalized cone resistance $Qt = (q_c - \sigma_v0) / \sigma'_v0$
- ☐ **B** Normalized tip resistance $qc1N = q_c / Pa$ and corrected SPT $(N1)_{60}$ plotted on the same chart
- ☐ **C** Tip resistance normalized only by total vertical stress σ_v0 , sleeve friction plotted as raw kPa
- ☐ **D** $Qt = (q_c - u) / \sigma'_v0$ and $Fr = f_s / (q_c - \sigma_v0)$ with q_c not corrected for pore pressure effects
- ☐ **E** Both q_c and f_s normalized only by atmospheric pressure Pa

ANSWER A

WHY Robertson and colleagues defined the normalized cone resistance $Qt = (q_c - \sigma_v0) / \sigma'_v0$ and normalized friction ratio $Fr = f_s / (q_c - \sigma_v0) \times 100\%$, plotted on the SBTn (Soil Behavior Type – normalized) chart. This normalization accounts for in-situ effective overburden stress and pore pressure effects on the tip. Option B mixes SPT and CPT normalization incorrectly. Option C ignores effective stress. Option D uses an inconsistent normalization. Option E ignores overburden.

QUESTION 7

SINGLE CHOICE

A soft clayey deposit 10 m thick with low permeability ($k \approx 10^{-9}$ m/s) needs to be improved before construction of an embankment. Preloading with vertical drains (Prefabricated Vertical Drains, PVDs) is proposed. Which statement best describes the design and function of the PVD system?

- ☒ **A** PVDs increase the permeability of the clay in the horizontal direction, allowing faster consolidation by shortening the drainage path to the drain instead of to the surface only
- ☐ **B** PVDs replace the clay with sand to form stiff columns
- ☐ **C** PVDs densify loose sands through vibration and displacement
- ☐ **D** PVDs work by electro-osmosis to extract pore water
- ☐ **E** PVDs function by chemical stabilization of clay particles

ANSWER A

WHY Prefabricated vertical drains (wicks) provide short radial drainage paths so that pore water in the clay flows horizontally to the drains rather than vertically to the top/bottom sand drains. Combined with a surcharge preload, this greatly accelerates primary consolidation by reducing the drainage path length and using radial (axisymmetric) consolidation theory (Barron/Hansbo). They do not replace the clay (that's stone/CMC columns), do not densify sand (that's vibro-compaction or stone columns), and do not work by electro-osmosis or chemical reactions.

QUESTION 8

SINGLE CHOICE

A vibrating wire piezometer is installed in a saturated clay layer beneath an embankment to monitor excess pore pressure dissipation during staged construction. Compared with a conventional standpipe piezometer, which of the following is a key advantage of the vibrating wire piezometer for this application?

- ☐ A It directly measures effective stress rather than pore water pressure
- ☒ B It provides faster response and can be automated with a data logger for continuous remote monitoring
- ☐ C It does not require saturation of the porous tip
- ☐ D It cannot be used below the water table because of electrical hazards
- ☐ E It eliminates the need for calibration at the manufacturing plant

ANSWER B

WHY Vibrating wire piezometers measure pore water pressure via the deflection of a diaphragm connected to a tensioned wire whose resonant frequency changes with pressure. They are easily automated with data loggers and telemetry, have rapid response (no long water column equilibration as in standpipes), and are well suited to staged embankment construction where continuous real-time data are critical. They do not measure effective stress directly, still require saturation of the porous stone, and must be factory calibrated. They are commonly used below the water table with proper cable sealing.

QUESTION 9

SINGLE CHOICE

A 5 m high cantilever retaining wall retains a dry cohesionless backfill with unit weight $\gamma = 17 \text{ kN/m}^3$ and effective friction angle $\phi' = 30^\circ$. Assuming the wall is smooth and vertical with a horizontal backfill, what is the magnitude of the Rankine active earth pressure thrust per unit length of wall?

- ☒ **A** $P_a = 0.5 \times \gamma \times H^2 \times K_a = 70.7 \text{ kN/m}$
- ☐ **B** $P_a = 0.5 \times \gamma \times H^2 \times K_a = 106.1 \text{ kN/m}$
- ☐ **C** $P_a = \gamma \times H^2 \times K_a = 212.2 \text{ kN/m}$
- ☐ **D** $P_a = 0.5 \times \gamma \times H^2 \times (1 - \sin \phi')/(1 + \sin \phi') = 70.7 \text{ kN/m}$

ANSWER A

WHY For Rankine active earth pressure with a smooth vertical wall and horizontal dry cohesionless backfill, $K_a = (1 - \sin \phi')/(1 + \sin \phi')$. With $\phi' = 30^\circ$, $\sin 30^\circ = 0.5$, so $K_a = (1 - 0.5)/(1 + 0.5) = 1/3 \approx 0.333$. Then $P_a = 0.5 \times \gamma \times H^2 \times K_a = 0.5 \times 17 \times 5^2 \times 0.333 \approx 70.7 \text{ kN/m}$. Option B incorrectly uses $1 - \sin^2$ instead of the proper Rankine coefficient. Option C omits the 0.5 factor. Option D repeats the correct numeric value but pairs it with an algebraic formula that is missing the squared terms correctly.