QUIZ PE-GT

PE Practice Problems – Civil: Geotechnical

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Problem 1. The moist unit weight of a soil is 106 pcf, the water content is 15%, and the specific gravity is 2.70. The porosity of this soil (in percent) is most nearly:

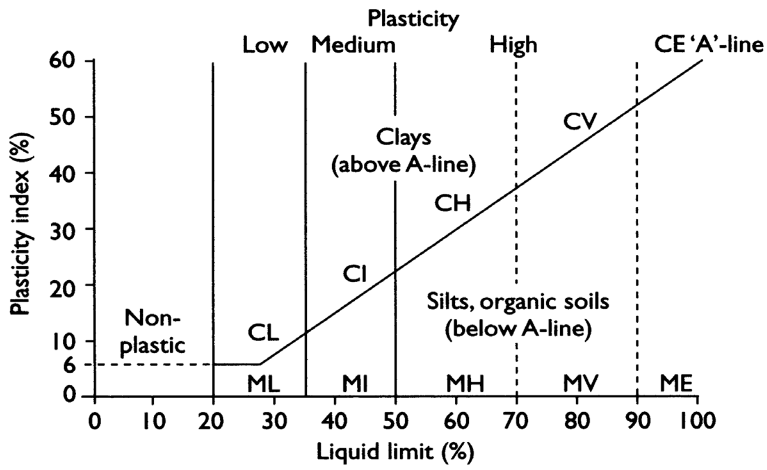
A) 25

B) 33

C) 46

D) 59

Problem 2. Testing revealed that the liquid limit and plastic limit of a soil are 30 and 10%, respectively. A plasticity chart is provided. The soil in question belongs to the category:



A) ML

B) CL

C) MI

D) CI

Problem 3. Which of the following clay minerals contributes most to the activity of a soil?

A) Kaolinite.

B) Halloysite.

C) Illite.

D) Montmorillonite.

Problem 4. The ratio of unconfined compressive strength of an undisturbed sample of soil to that of a remolded sample is known as:

A) Activity.

B) Plasticity.

C) Sensitivity.

D) Thixotropy.

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Problem 5. Which of the following soils is most susceptible to freezing?

A) High-plasticity clay.

B) Saturated sillt.

C) Dry sand.

D) Clean gravel.

Problem 6. The hydraulic conductivity of a sand at a void ratio of 0.55 is 0.02 cm/sec. The hydraulic conductivity (cm/sec) of the same sand at a void ratio of 0.67 is most nearly:

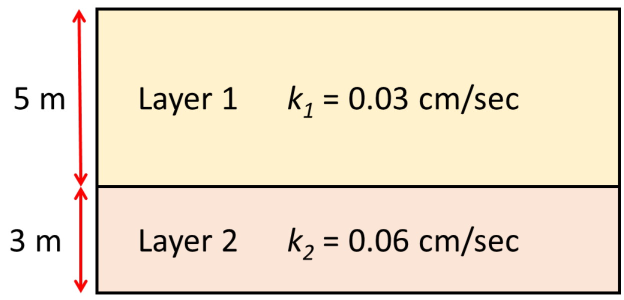
A) 0.029

B) 0.041

C) 0.067

D) 0.088

Problem 7. A soil has the stratigraphy and hydraulic conductivities illustrated below. Assuming the horizontal and vertical hydraulic conductivities for each individual layer to be the same, the ratio of the horizontal equivalent hydraulic conductivity to the vertical equivalent hydraulic conductivity is most nearly:



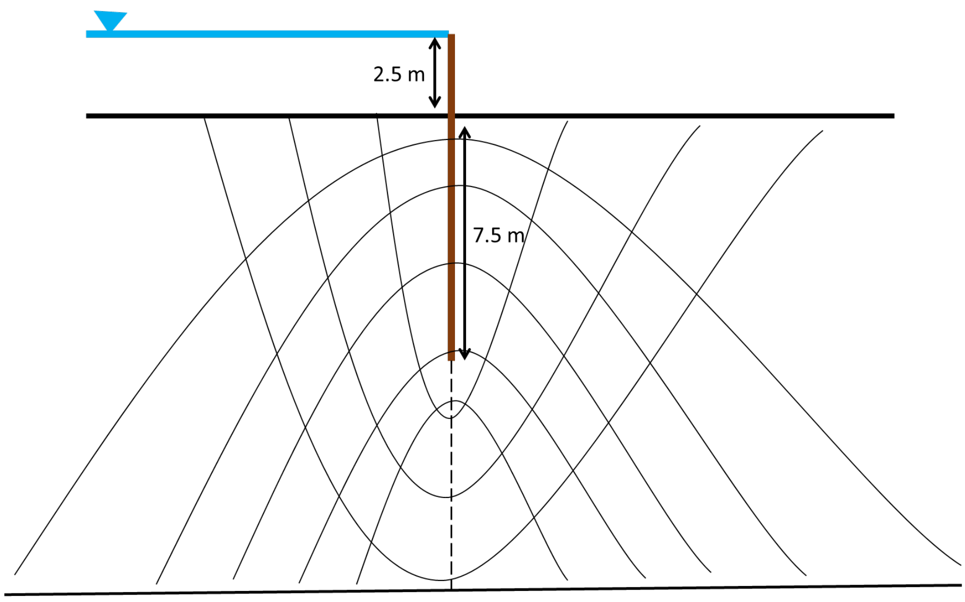
A) 1.1

B) 2.0

C) 3.1

D) 4.0

Problem 8. A deposit of cohesionless soil with a permeability of 3×10^{-3} m/s has a depth of 10 m with an impervious ledge below. A sheet pile wall is driven into this deposit to a depth of 7.5 m. The wall extends above the surface of the soil and a 2.5 m depth of water acts on one side. The flow net for this system is provided. The seepage quantity per meter length of wall (m^3/s/m) is most nearly:



A) 0.0025

B) 0.005

C) 0.0075

D) 0.01

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Problem 9. The dimensions of a soil sampler are given in the following table. The outside clearance ratio (in percent) for this soil sampler is most nearly:

Parameter	Cutting edge	Sampling tube
Inside diameter (mm)	80	86
Outside diameter (mm)	100	90

A) 5
B) 11
C) 21
D) 30

Problem 10. Commencing from 0.6 m below the ground surface and using a standard penetration test (SPT) split-barrel sampler driven 0.45 m, the blow data provided were obtained in increments of 0.15 m. The *N*-value to be reported on the boring log for the depth of 0.9 m is most nearly:

Procedure	Blow Count
First 0.15-m drive	12
Second 0.15-m drive	16
Third 0.15-m drive	20

A) 20
B) 28
C) 36
D) 48

Problem 11. Suppose that G_s represents the specific gravity of soil particles, w represents the soil water content, and γ_w is the unit weight of water. The equation that represents the zero-air-voids line in a compaction test plot is:

A) $\gamma_d = \dfrac{G_s \gamma_w}{1 + G_s w}$

B) $\gamma_d = \dfrac{G_s \gamma_w}{w}$

C) $\gamma_d = \dfrac{G_s w}{1 + \gamma_w}$

D) $\gamma_d = \dfrac{G_s w}{1 - \gamma_w}$

Problem 12. Which of the following is **not** an assumption in Terzaghi's theory of one-dimensional consolidation?
A) Flow of water in the soil is laminar and Darcy's law is valid.
B) The soil is saturated and homogeneous.
C) The mechanical behavior of the soil is isotropic.
D) The soil particles are compressive.

Problem 13. A sand fill compacted to a bulk density of 18.0 kN/m³ is to be placed on a 3.5-m thick saturated marsh deposit. The depth of the sand fill is to be 2.6 m. If the volume compressibility of the deposit is 6.8×10^{-4} m²/kN, the final settlement of the fill (mm) is most nearly:
A) 55
B) 111
C) 159
D) 205

Problem 14. The time required for 50% consolidation of a 1-in.-thick clay layer, drained at top and bottom, in the laboratory is 4 minutes. The time (days) required for a 60-ft-thick layer of the same clay, under the same pressure increment, to reach 50% consolidation is most nearly:

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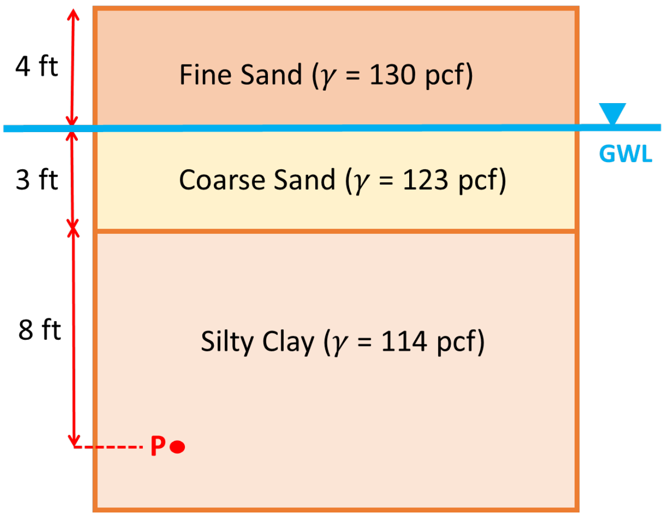
A) 1
B) 2
C) 3
D) 4

Problem 15. A proposed fill is to be placed on the soil profile shown. A consolidation test has been performed on a sample obtained from Point A, and this test indicates that the preconsolidation pressure at that point is 2800 psf. The overconsolidation ratio of the silty clay stratum is most nearly:



A) 1.5
B) 2.0
C) 2.5
D) 3.0

Problem 16. Which of the following triaxial tests is slower to perform?
A) A consolidated-undrained test on clay.
B) A consolidated-drained test on clay.
C) A consolidated-undrained test on sand.
D) A consolidated-drained test on sand.

Problem 17. In the field, the vane shear test is mainly used to determine
A) The undrained shear strength of coarse-grained soils.
B) The drained shear strength of coarse-grained soils.
C) The undrained shear strength of fine-grained soils.
D) The drained shear strength of fine-grained soils.

Problem 18. A saturated specimen of sand with friction angle of 30° was tested under drained conditions in a triaxial apparatus. The sample failed at a deviator stress of 450 kN/m^2. The major principal stress of this soil at failure (kPa) is most nearly:
A) 560
B) 605
C) 675
D) 750

Problem 19. An unconfined cylindrical specimen of clay fails under an axial stress of 241 kPa. The failure plane was inclined at an angle of 60° with the horizontal. The cohesion of this clay (kPa) is most nearly:
A) 8
B) 15
C) 25
D) 35

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Problem 20. The Brazilian disc test is used to establish which of the following mechanical properties of rock?

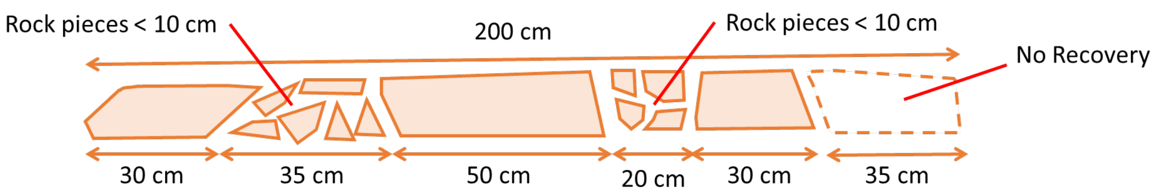
A) Uniaxial compressive strength.

B) Point load index.

C) Angle of internal friction.

D) Tensile strength.

Problem 21. A 200-cm borehole log of rock is illustrated below. The rock quality designation (in percent) of this rock sample is most nearly:



A) 55

B) 65

C) 75

D) 85

Problem 22. A point load test was carried out on a 70-mm-diameter cross section cylindrical limestone core. The sample withstood a load of 15 kN. The point load index (MPa), modified by the size correction factor, is most nearly:

A) 1.2

B) 2.4

C) 3.6

D) 4.8

Problem 23. The critical hydraulic gradient of a sand deposit with porosity of 35% and specific gravity of 2.71 is most nearly:

A) 0.881

B) 1.11

C) 1.37

D) 1.52

Problem 24. A plate load test was conducted on a sandy soil in which the bearing plate was 2 ft × 2 ft. The ultimate load per unit area for the test was found to be 7000 lb/ft^2. Using a factor of safety of 3.5, the maximum allowable bearing pressure (lb/ft^2) for a footing of size 4 ft × 4 ft is most nearly:

A) 3200

B) 4000

C) 4800

D) 5600

Problem 25. In the following table, the end-bearing and skin frictional resistances of two pile foundations are provided. Which of the following is true?

Pile	End-bearing resistance (kN)	Skin frictional resistance (kN)
Pile 1	400	200
Pile 2	400	1200

A) Both piles are end-bearing piles.

B) Pile 1 is an end-bearing pile and Pile 2 is a friction pile.

C) Pile 1 is a friction pile and Pile 2 is an end-bearing pile.

D) Both piles are frictional piles.

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Problem 26. A cylindrical timber pile of 18 in. diameter is driven to a depth of 36 ft into homogeneous normally consolidated clay. The skin frictional stress is 430 psf, and the end-bearing resistance is 12.1 kips. The allowable pile load capacity (kips) with a factor of safety of 2.0 is most nearly:

A) 20

B) 43

C) 60

D) 83

Problem 27. A group of nine piles in a 3 × 3 configuration was found to have a group load capacity of 5760 kN. The capacity of each individual pile was found to be 800 kN. The efficiency factor of this pile configuration is most nearly:

A) 0.6

B) 0.7

C) 0.8

D) 0.9

Problem 28. Let σ_h, σ_v, σ_h' and σ_v' represent the total horizontal stress, total vertical stress, effective horizontal stress, and effective vertical stress in a soil mass. The at-rest coefficient of earth pressure is given by:

A) $\frac{\sigma_h}{\sigma_v}$

B) $\frac{\sigma_h'}{\sigma_v'}$

C) $\frac{\sigma_v}{\sigma_h}$

D) $\frac{\sigma_v'}{\sigma_h'}$

Problem 29. In Rankine active earth pressure theory, doubling the height of a frictionless retaining wall will cause the maximum lateral earth force to increase by a factor of:

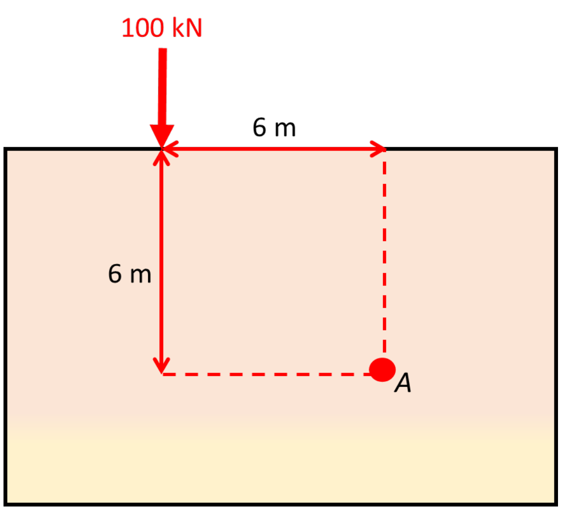
A) 2

B) 4

C) 8

D) 16

Problem 30. A point load of 100-kN intensity is imparted on a homogeneous normally consolidated soil. Use the Boussinesq point load formula. The vertical stress (Pa) in point A, which is in the same vertical plane as the point load, is most nearly:



A) 80

B) 133

C) 188

D) 234

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Problems 31 to 40 are slightly more advanced than the preceding ones.

Problem 31. Regarding Skempton's pore pressure parameters, which of the following statements is true?

A) Coefficient *B* equals zero for fully saturated soil.

B) Coefficient *B* equals unity for dry soil.

C) Coefficient *A* can be negative for overconsolidated clays.

D) Coefficient *A* cannot be greater than unity.

Problem 32. A square foundation is 1.8 m × 1.8 m in plan. The soil supporting the foundation has a friction angle of 23° and a cohesion of 18 kN/m^3. The unit weight of soil is 16.2 kN/m^3. The depth of the foundation is 1.6 m and it is assumed that general shear failure occurs in the soil. The allowable gross load (kN/m^2) on the foundation with a factor of safety of 3.0 is most nearly:

A) 280

B) 390

C) 500

D) 620

Problem 33. Reconsider the previous problem. If the elastic modulus and Poisson's ratio of the clay layer in which the foundation is embedded are 50 × 10^3 kPa and 0.4, and the influence factor of the footing is 1.75, the elastic settlement of the footing (mm) will be most nearly:

A) 23

B) 30

C) 45

D) 60

Problem 34. A pressuremeter test was performed on a soil. At a pressure of 4000 psf, the volume of the pressuremeter was measured to be 13 in.^{3} The pressure is slightly increased by 900 psf and the volume increase was measured to be 0.22 in.^{3}. The failure pressure was found to be 8500 psf. Poisson's ratio of the soil is known to be 0.3. A table indicating the types of soil according to the ratio of pressuremeter modulus to failure pressure is provided. The soil in question is most likely a:

Soil type	Pressuremeter Modulus/Failure Pressure
Clay	> 16
Silt	> 14
Sand	> 12
Gravel	> 10

A) Clay.

B) Silt.

C) Sand.

D) Gravel.

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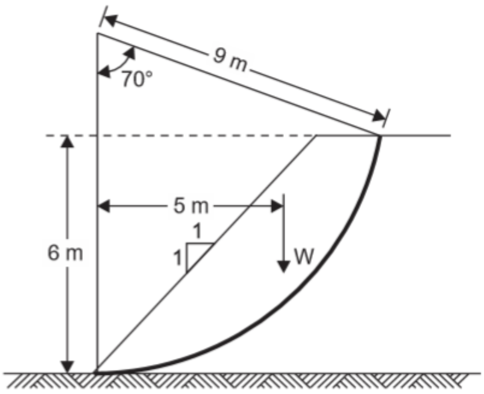
Problem 35. The following figure shows the details of an embankment made of cohesive soil with friction angle ϕ = 0 and cohesion c' = 32 kN/m^2. The unit weight of the soil is 19.0 kN/m^3. The weight of the sliding mass is 350 kN acting at an eccentricity of 5.0 m from the center of rotation. The central angle is 70º. The factor of safety against sliding is most nearly:



A) 1.2

B) 1.4

C) 1.8

D) 2.2

Problem 36. Which of the following slope analysis methods does **not** consider interslice forces, be they normal or shear forces?

A) Ordinary method of slices.

B) Janbu's simplified method.

C) Spencer's method.

D) Morgenstern-Price method.

Problem 37. A 60-ft long pile is to be built in a deposit of normally consolidated clay. The loads acting on the pile are listed below. With a factor of safety of 2.0, the allowable load on this pile (kips) is most nearly:

Loading	Magnitude
End-bearing resistance	20 kips
Skin friction	90 kips
Downdrag	10 kips

A) 50

B) 60

C) 110

D) 120

Problem 38. A reinforced concrete pile weighing 45 kN (including helmet and dolly) is driven by a drop hammer weighing 30 kN with an effective fall of 0.8 m. The average penetration per blow is 16 mm. The total temporary elastic compression of the pile, pile cap and soil may be taken as 19 mm. The coefficient of restitution is 0.32. Use Hiley's formula with a factor of safety of 1.5. The allowable load (kN) for the pile is most nearly:

A) 190

B) 230

C) 290

D) 360

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Problem 39. Some correlations make use of an averaged earth pressure coefficient given by $\overline{K} = (K_o + K_a + K_p)/3$, where K_o is the at-rest lateral pressure coefficient, K_a is the Rankine active earth pressure coefficient, and K_p is the Rankine passive earth pressure coefficient. Use the Jaky formula to compute K_o. The averaged earth pressure coefficient for a normally consolidated soil with friction angle of 30° is most nearly:

A) 1.0

B) 1.3

C) 1.9

D) 2.5

Problem 40. The Geological Strength Index (GSI) system was originally conceived for use with which of the following rock failure criteria?

A) Mohr-Coulomb failure criterion.

B) Griffith failure criterion.

C) Tresca failure criterion.

D) Hoek-Brown failure criterion.

► SOLUTIONS

P.1 ■ Solution

The dry unit weight of the soil, γ_d, is

$$\gamma_d = \frac{\gamma}{1+w} = \frac{106}{1+0.15} = 92.2 \text{ pcf}$$

The void ratio, in turn, can be determined as

$$\gamma_d = \frac{G_s\gamma_w}{1+e} \rightarrow e = \frac{G_s\gamma_w}{\gamma_d} - 1$$

$$\therefore e = \frac{2.70\times 63}{92.2} - 1 = 0.845$$

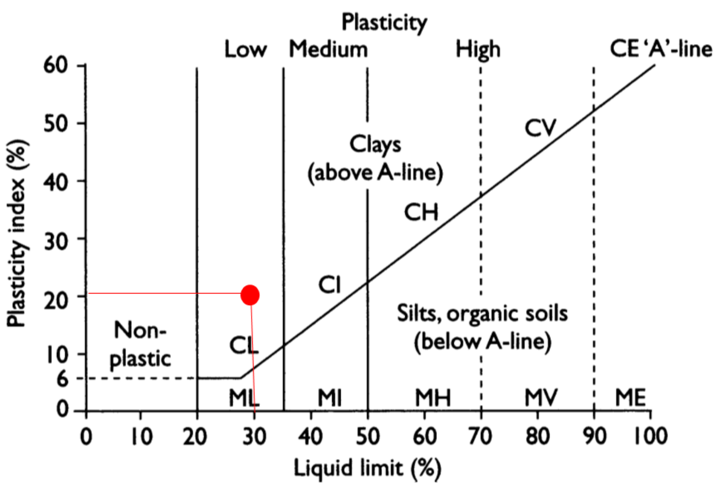
Lastly, the porosity is found as

$$n = \frac{e}{1+e} = \frac{0.845}{1+0.845} = \boxed{45.8\%}$$

► The correct answer is **C**.

P.2 ■ Solution

The liquid limit is 30% and the plasticity index is 30 – 10 = 20%. Mapping these two quantities onto the chart, we conclude that the soil belongs in category CL, as shown. (In the original Casagrande chart, *C* defines an 'inorganic clay', while *L* stands for 'low plasticity'.)



► The correct answer is **B**.

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P.3 ■ Solution

Activity is defined as the ratio of plasticity index to the clay fraction of a soil. Activity values less than 0.75 are considered low, values between 0.75 and 1.25 are considered normal, and values greater than 1.25 indicate clays of high activity. Kaolinite, halloysite, and allophane are of low activity; illite is of medium, or normal, activity; montmorillonite is of high activity. Indeed, sodium montmorillonite may have an activity as high as 7.0.

► The correct answer is **D**.

P.4 ■ Solution

The ratio of unconfined compressive strength of a soil in its natural state to that of a remolded soil is known as *sensitivity*. A clay with sensitivity greater than 2.0 to 4.0 is said to be *medium sensitive*, while a soil with sensitivity between 4.0 and 8.0 is said to be *very sensitive*. Clays with sensitivity greater than 8.0 enter the range of values of the so-called *quick clays*.

► The correct answer is **C**.

P.5 ■ Solution

Frost susceptibility is smallest for clean gravels and clean sands, on the one hand, and for high-plasticity clays on the other. The most frost-susceptible soils are silts. The reason is that frost heave requires the soil to have the ability to lift water by capillary action and let the water flow through its voids. Clean gravels and clean sands have high hydraulic conductivity but little ability for capillary action; in other words, it is easy for the water to move, but the water has no energy to go anywhere. High-plasticity clays, in contrast, have a very high ability for capillary action but a very low hydraulic conductivity; in other words, the water has plenty of energy, but it is very hard to move through the clay. Silts optimize the two requirements of capillary potential and hence are some of the most frost-susceptible soils.

► The correct answer is **B**.

P.6 ■ Solution

The hydraulic conductivity of sandy soils can be estimated with the Kozeny-Carman equation,

$$k = \frac{1}{C_s S_s^2 T^2} \frac{\gamma_w}{\eta} \frac{e^3}{1+e}$$

which means that, if everything else is held constant, the hydraulic conductivity must follow the proportion $k \propto e^3/(1+e)$. Accordingly, the hydraulic conductivity when the void ratio changes from 0.55 to 0.67 follows as

$$\frac{k_2}{k_1} = \frac{e_2^3/(1+e_2)}{e_1^3/(1+e_1)} \rightarrow k_2 = k_1 \frac{e_2^3/(1+e_2)}{e_1^3/(1+e_1)}$$

$$\therefore k_2 = 0.02 \times \frac{0.67^3/(1+0.67)}{0.55^3/(1+0.55)} = \boxed{0.067 \text{ cm/s}}$$

► The correct answer is **C**.

P.7 ■ Solution

The equivalent hydraulic conductivity in the horizontal (i.e., the *x*-) direction is

$$k_{x,\text{eq}} = \frac{1}{H_0}\left(z_1 k_{x,1} + z_2 k_{x,2}\right)$$

$$\therefore k_{x,\text{eq}} = \frac{1}{(3+5)} \times (5 \times 0.03 + 3 \times 0.06) = 0.0413 \text{ cm/s}$$

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while, in the vertical direction (that is, the z-) direction, we have

$$k_{z,\mathrm{eq}} = \frac{H_o}{\frac{z_1}{k_{z,1}} + \frac{z_2}{k_{z,2}}}$$

$$\therefore k_{z,\mathrm{eq}} = \frac{(5+3)}{\frac{5}{0.03} + \frac{3}{0.06}} = 0.0369 \text{ cm/s}$$

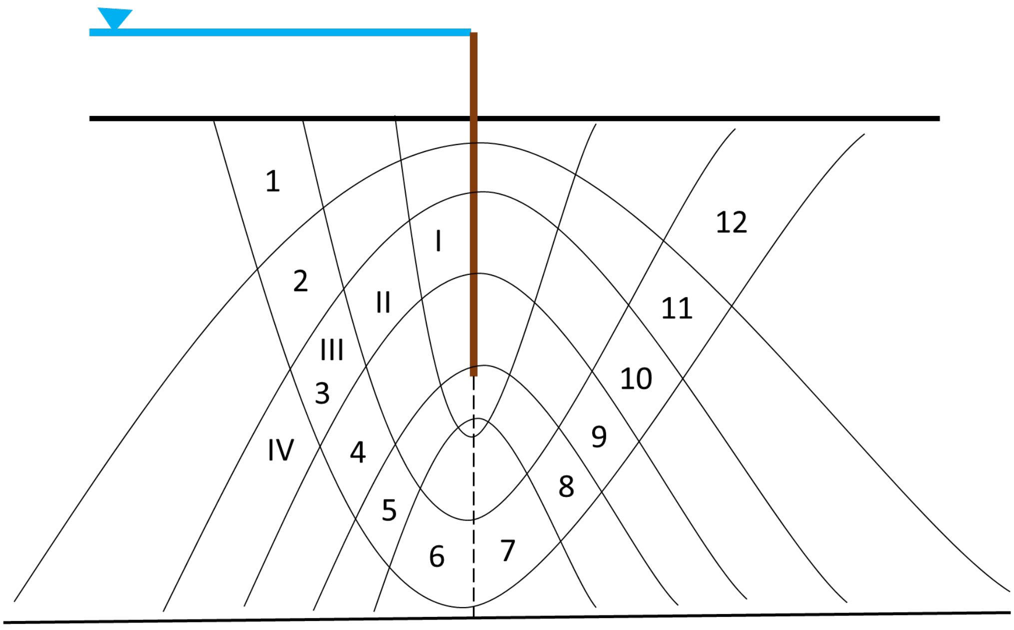
Ratio $k_{x,\mathrm{eq}}/k_{z,\mathrm{eq}}$ follows as

$$\frac{k_{x,\mathrm{eq}}}{k_{z,\mathrm{eq}}} = \frac{0.0413}{0.0369} = \boxed{1.12}$$

► The correct answer is **A**.

P.8 ■ Solution

Refer to the figure below.



The number of flow channels, counted in roman numerals above, is $N_f = 4$, while the number of equipotential drops, counted in Hindu-Arabic numerals, is $N_d = 12$. The quantity of seepage per meter length of wall is then

$$q = k \times H \times \frac{N_f}{N_d} = (3\times10^{-3}) \times 2.5 \times \frac{4}{12} = \boxed{0.0025 \text{ m}^3/\text{s/m}}$$

► The correct answer is **A**.

P.9 ■ Solution

The outside clearance ratio is the difference in outside diameter of the cutting edge and the sampler to the outside diameter of the sampler. Accordingly, we have

$$C = \frac{\text{Outside diameter of the cutting edge} - \text{Outside diameter of the sampling tube}}{\text{Outside diameter of the sampling tube}} = \frac{100-90}{90} = \boxed{11.1\%}$$

► The correct answer is **B**.

P.10 ■ Solution

The N-value is obtained by counting the number of blows needed to drive the sampler for 0.3 m after a 0.15 m seating drive. Accordingly, the N-value is given by the sum of blow counts for the final two sets of 0.15 m increments; that is,

$$N = N_{\text{2nd-0.15}} + N_{\text{3rd-0.15}} = 16 + 20 = \boxed{36}$$

► The correct answer is **C**.

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P.11 ■ Solution

We know that the dry unit weight of soil can be stated as

$$\gamma_d = \frac{G_s}{1+e}\gamma_w$$

However, the void ratio is given by $e = wG_s/S$, with the result that

$$\gamma_d = \frac{G_s}{1+e}\gamma_w \rightarrow \gamma_d = \frac{G_s}{1+wG_s/S}\gamma_w$$

For a fully saturated soil, S = 1 and the equation above becomes

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

The latter equation describes the zero-air-voids curve in the water content-dry unit weight plane.

► The correct answer is **A**.

P.12 ■ Solution

One of the main assumptions of Terzaghi's theory of consolidation is that the soil particles and pore water are incompressible, and any volume change of soil is merely due to changes in void ratio.

► The correct answer is **D**.

P.13 ■ Solution

The increment in pressure on top of the marsh deposit is

$$\Delta\sigma = \gamma h = 18.0 \times 2.6 = 46.8 \text{ kPa}$$

The final settlement of the marsh deposit is estimated as

$$\rho = m_v H_o \Delta\sigma = \left(6.8\times 10^{-4}\right)\times 3.5 \times 46.8 = \boxed{111 \text{ mm}}$$

► The correct answer is **B**.

P.14 ■ Solution

The rate of consolidation is assessed by means of time factors

$$T_{50} = \frac{c_{v,\text{lab}} t_{\text{lab}}}{H_{\text{dr,lab}}^2} = \frac{c_{v,\text{field}} t_{\text{field}}}{H_{\text{dr,field}}^2}$$

Since the soil is the same in the laboratory and field, we have $c_{v,lab} = c_{v,field}$ and the relation above simplifies to

$$\frac{\cancel{c_{v,\text{lab}}} t_{\text{lab}}}{H_{\text{dr,lab}}^2} = \frac{\cancel{c_{v,\text{field}}} t_{\text{field}}}{H_{\text{dr,field}}^2} \rightarrow t_{\text{field}} = \frac{H_{\text{dr,field}}^2}{H_{\text{dr,lab}}^2}\times t_{\text{lab}}$$

$$\therefore t_{\text{field}} = \frac{60/2}{\left[(1/12)/2\right]}\times(4\times 60) = 172{,}800 \text{ s} = \boxed{2 \text{ days}}$$

Note that we have divided the layer thickness by 2 because the soils are drained at both ends.

► The correct answer is **B**.

P.15 ■ Solution

At point A, the effective stress is

$$\sigma_A' = \Sigma\gamma H - u$$

$$\therefore \sigma_A' = 4\times 130 + 3\times 123 + 8\times 114 - (3+8)\times 62.4 = 1{,}115 \text{ psf}$$

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The preconsolidation pressure at the point in question is σ_0' = 2800 psf. The overconsolidation ratio is then

$$OCR = \frac{\sigma_0'}{\sigma_A'} = \frac{2,800}{1,115} = \boxed{2.51}$$

► The correct answer is **C**.

P.16 ■ Solution

In the consolidated-drained test, drainage of the specimen is permitted under a specified confining pressure until consolidation is complete. This implies that consolidated-drained tests are generally slower than consolidated-undrained tests. Further, given the inherently low permeability of clay, a CD test on this type of soil would be much slower than an equivalent procedure on sand.

► The correct answer is **B**.

P.17 ■ Solution

Experience has shown that the vane test, which has been available since the 1920s, can be reliably used to estimate the shear strength of soft-sensitive clays on the field. Since the test is relatively quick, lasting about 10 minutes, the data can be associated with the undrained state.

► The correct answer is **C**.

P.18 ■ Solution

For the test in question, the friction angle is associated to the principal stresses by the expression

$$\sin\phi' = \frac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3}$$

Substituting the deviator stress $\sigma_1 - \sigma_3$ = 450 kN/m^2 and the friction angle ϕ' = 30° gives

$$\sin 30^\circ = \frac{450}{\sigma_1 + \sigma_3} \rightarrow \sigma_1 + \sigma_3 = 900\text{ kN/m}^2\text{ (I)}$$

However, we also know that

$$\sigma_1 - \sigma_3 = 450\text{ kN/m}^2\text{ (II)}$$

Summing equations (I) and (II), we obtain

$$(\sigma_1 + \sigma_3) + (\sigma_1 - \sigma_3) = 900 + 450$$
$$\therefore 2\sigma_1 = 1350$$
$$\therefore \boxed{\sigma_1 = 675\text{ kPa}}$$

► The correct answer is **C**.

P.19 ■ Solution

Given the inclination of the failure plane α = 60°, the angle of internal friction for this clay is found as

$$\alpha = 45^\circ + \frac{\phi}{2} \rightarrow 60^\circ = 45^\circ + \frac{\phi}{2}$$
$$\therefore \phi = 30^\circ$$

The principal stresses, the cohesion and the friction angle are related to each other by the expression

$$\sigma_1 = \sigma_3 \tan^2\left(45^\circ + \frac{\phi'}{2}\right) + 2c\tan\left(45^\circ + \frac{\phi'}{2}\right)$$

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However, σ_3 = 0 for an unconfined compression test. Thus, substituting and solving for the cohesion *c*, we get

$$120 = \cancel{\sigma_3 \tan^2\left(45^\circ + \frac{\phi'}{2}\right)} + 2 \times c \times \tan\left(45^\circ + \frac{30^\circ}{2}\right)$$

$$\therefore c = \frac{120}{2\tan\left(45^\circ + \frac{30^\circ}{2}\right)} = \boxed{34.6 \text{ kPa}}$$

▶ The correct answer is **D**.

P.20 ■ Solution

The Brazilian disc test was originally conceived to evaluate the tensile strength of concrete, but has since gained acceptance as a reliable indicator of the tensile strength of various types of rock.

▶ The correct answer is **D**.

P.21 ■ Solution

The RQD is given by the ratio

$$RQD = \frac{\Sigma \text{Length of core pieces} > 10 \text{ cm}}{\text{Total length of core run}}$$

$$\therefore RQD = \frac{30 + 50 + 30}{200} = \boxed{55\%}$$

▶ The correct answer is **A**.

P.22 ■ Solution

The uncorrected point load index is simply the ratio of the applied load to the squared diameter of the specimen,

$$I_s = \frac{P}{D^2} = \frac{15 \times 10^3}{0.07^2} = 3.06 \text{ MPa}$$

The corrected index is obtained if we multiply I_s by $(D/50)^{0.45}$; that is,

$$I_{s(50)} = I_s \times \left(\frac{D}{50}\right)^{0.45} = 3.06 \times \left(\frac{70}{50}\right)^{0.45} = \boxed{3.56 \text{ MPa}}$$

▶ The correct answer is **C**.

P.23 ■ Solution

The void ratio of the sand deposit is

$$e = \frac{n}{1-n} = \frac{0.35}{1-0.35} = 0.538$$

The critical hydraulic gradient follows as

$$i_c = \frac{G_s - 1}{1+e} = \frac{2.71 - 1}{1 + 0.538} = \boxed{1.11}$$

▶ The correct answer is **B**.

P.24 ■ Solution

The ultimate bearing capacity of the footing can be obtained with the ratio

$$\frac{q_{u,\text{footing}}}{q_{u,\text{plate}}} = \frac{B_{\text{footing}}}{B_{\text{plate}}} \rightarrow q_{u,\text{footing}} = q_{u,\text{plate}} \times \frac{B_{\text{footing}}}{B_{\text{plate}}}$$

$$\therefore q_{u,\text{footing}} = 7000 \times \frac{4.0}{2.0} = 14,000 \text{ lb/ft}^2$$

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Applying the factor of safety, the maximum allowable load is found as

$$FS = \frac{q_{u,\text{footing}}}{q_{\text{allow,footing}}} \rightarrow q_{\text{allow,footing}} = \frac{q_{u,\text{footing}}}{FS}$$

$$\therefore q_{\text{allow,footing}} = \frac{14,000}{3.5} = \boxed{4000 \text{ lb/ft}^2}$$

► The correct answer is **B**.

P.25 ■ Solution

From inspection, we surmise that Pile 1 is an end-bearing pile (because the end-bearing resistance is greater than the skin frictional resistance) and Pile 2 is a friction pile (because the opposite is true).

► The correct answer is **B**.

P.26 ■ Solution

The ultimate load is given by the sum of the frictional resistance Q_f and the end-bearing resistance Q_b,

$$Q_{\text{ult}} = Q_f + Q_b$$

Given the skin frictional stress f_s = 430 psf, the skin friction resistance is given by

$$Q_f = f_s \times \pi DL = 430 \times \left[\pi \times (18/12) \times 36\right] = 72.9 \text{ kips}$$

The end-bearing resistance, in turn, is Q_b = 12.1 kips. The ultimate load is then $Q_{\text{ult}} = Q_f + Q_b$ = 72.9 + 12.1 = 85 kips. Applying the factor of safety, the allowable load becomes

$$Q_{\text{allow}} = \frac{Q_{\text{ult}}}{FS} = \frac{85}{2.0} = \boxed{42.5 \text{ kips}}$$

► The correct answer is **B**.

P.27 ■ Solution

The efficiency factor is the ratio of the load capacity of the pile group to the total load capacity of the piles acting as single piles; that is,

$$\eta = \frac{(Q_{\text{ult}})_g}{nQ_{\text{ult}}} = \frac{5,760}{9 \times 800} = \boxed{0.8}$$

► The correct answer is **C**.

P.28 ■ Solution

The at-rest earth pressure coefficient is defined as the ratio of the horizontal effective stress to the vertical effective stress. In mathematical terms,

$$K_o = \frac{\sigma_h'}{\sigma_v'}$$

► The correct answer is **B**.

P.29 ■ Solution

The lateral earth force is the area of the lateral stress diagram, which, for the Rankine active state, is

$$P_a = \int_0^H K_a \gamma' z dz = \frac{1}{2} K_a \gamma' H_o^2$$

Accordingly, increasing the height from H_o to $2H_o$ gives

$$P_a' = \frac{1}{2} K_a \gamma \times (2H_o)^2 = 4 \times \frac{1}{2} K_a \gamma H_o^2 = 4P_a$$

► The correct answer is **B**.

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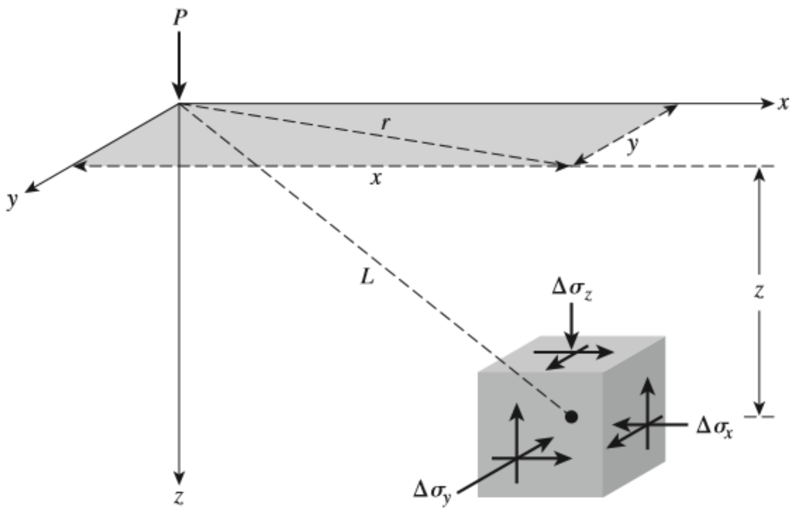
P.30 ■ Solution

Consider the following schematic.



The vertical stress, as per the Boussinesq formulation, is given by

$$\Delta\sigma_z = \frac{3P}{2\pi z^2} \times \frac{1}{\left[\left(r/z\right)^2 + 1\right]^{5/2}}$$

Substituting the load intensity P = 100 × 10³ N, the vertical distance z = 6 m, and the horizontal distance r = 6 m, we obtain

$$\Delta\sigma_z = \frac{3\times\left(100\times10^3\right)}{2\pi\times6^2} \times \frac{1}{\left[\left(6/6\right)^2 + 1\right]^{5/2}} = \boxed{234\ \text{Pa}}$$

► The correct answer is **D**.

P.31 ■ Solution

Indeed, coefficient B can be as low as −0.5 for some overconsolidated clays. Statements A and B have been swapped – that is, B = 1.0 for fully saturated soil and B = 0 for dry soil. Finally, Statement D is also false because A can be as high as 3.0 or 4.0 in the case of some loose sands.

► The correct answer is **C**.

P.32 ■ Solution

This is a straightforward application of the Terzaghi bearing capacity formula

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$$

where, with ϕ' = 23°, we have N_c = 21.75, N_q = 10.23 and N_γ = 6.00 (see, for example, Table 3.1 of Das's *Principles of Foundation Engineering*, 2007), with the result that

$$q_u = 1.3\times18\times21.75 + \left(1.6\times16.2\right)\times10.23 + 0.4\times16.2\times1.8\times6.00$$

$$\therefore q_u = 844\ \text{kN/m}^2$$

Applying the factor of safety, we obtain

$$q_b = \frac{q_u}{FS} = \frac{844}{3.0} = \boxed{281\ \text{kN/m}^2}$$

► The correct answer is **A**.

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P.33 ■ Solution

The settlement can be estimated with the relation

$$\rho_s = q_u B \frac{1-\nu^2}{E_s} I_F = 844 \times 1.8 \times \frac{1-0.4^2}{50 \times 10^3} \times 1.75 = 0.0447 = \boxed{44.7 \text{ mm}}$$

▶ The correct answer is **C**.

P.34 ■ Solution

The pressuremeter modulus is given by

$$E_{pm} = 2(1+\nu)V \frac{\Delta p}{\Delta V}$$

where ν = 0.3 is Poisson's ratio, V = 12 in.^{3} is the volume of the pressuremeter at a pressure p, Δp = 900 psf is the pressure increment, and ΔV = 0.22 in.^{3} is the volume increment. Substituting these data, we obtain

$$E_{pm} = 2 \times (1+0.3) \times 12 \times \frac{900}{0.22} = 127{,}600$$

The ratio of pressuremeter modulus to failure pressure is 127,600/8500 = 15.0. With reference to the table, we conclude that the soil in question is a silt.

▶ The correct answer is **B**.

P.35 ■ Solution

The sliding moment is given by

$$M_S = \text{Sliding mass } \times \text{ Eccentricity} = 350 \times 5.0 = 1750 \text{ kN} \cdot \text{m}$$

The restoring moment, in turn, follows as

$$M_R = c \times r^2 \times \theta = 32 \times 9^2 \times \left(\frac{70 \times \pi}{180}\right) = 3170 \text{ kN} \cdot \text{m}$$

The factor of safety is the ratio of these quantities,

$$FS = \frac{M_R}{M_S} = \frac{3170}{1750} = \boxed{1.81}$$

▶ The correct answer is **C**.

P.36 ■ Solution

The main simplification in the OMS is that there are no interslice forces between slices. Janbu's simplified method, in turn, considers normal interslice forces, but no shear forces. Lastly, the Spencer and Morgenstern-Price methods consider both normal and shear interslice forces.

▶ The correct answer is **A**.

P.37 ■ Solution

The ultimate upward load imparted on the pile is given by

$$q_{\text{ult}} = \text{End bearing} + \text{Skin friction} - \text{Downdrag} = 20 + 90 - 10 = 100 \text{ kips}$$

Applying the factor of safety, the allowable load is found as

$$q_{\text{allow}} = \frac{q_{\text{ult}}}{FS} = \frac{100}{2.0} = \boxed{50 \text{ kips}}$$

▶ The correct answer is **A**.

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P.38 ■ Solution

As per the Hiley formula, the ultimate load is

$$Q_{\text{ult}} = \eta_b \frac{W \times H}{S + \dfrac{C}{2}}$$

where W = 30 kN is the weight of the hammer, H = 0.9 m is the effective fall, S = 0.015 m is the average penetration per blow, C = 0.018 m is the temporary compression of the pile, pile cap and soil. Lastly, η_b is the efficiency factor, which is given by

$$\eta_b = \frac{W + e^2 P}{W + P}$$

in which W = 30 kN, P = 45 kN, and e = 0.32 is the coefficient of restitution, so that

$$\eta_b = \frac{30 + 0.32^2 \times 45}{30 + 45} = 0.461$$

Substituting the pertaining variables in the equation for Q_{ult}, we obtain

$$Q_{\text{ult}} = 0.461 \times \frac{30 \times 0.8}{0.016 + 0.019/2} = 434 \text{ kN}$$

Applying the factor of safety, the allowable load becomes

$$Q_{\text{allow}} = \frac{Q_{\text{ult}}}{FS} = \frac{434}{1.5} = \boxed{289 \text{ kN}}$$

► The correct answer is **C**.

P.39 ■ Solution

The at-rest lateral pressure coefficient can be estimated with the Jaky formula

$$K_o = 1 - \sin\phi' = 1 - \sin 30^\circ = 0.5$$

The Rankine active earth pressure coefficient is

$$K_a = \tan^2\left(45^\circ - \frac{\phi'}{2}\right) = \tan^2\left(45^\circ - \frac{30^\circ}{2}\right) = 0.333$$

The Rankine passive earth pressure coefficient is

$$K_p = \tan^2\left(45^\circ + \frac{\phi'}{2}\right) = \tan^2\left(45^\circ + \frac{30^\circ}{2}\right) = 3.0$$

The averaged coefficient is then

$$\bar{K} = \frac{0.5 + 0.333 + 3.0}{3} = \boxed{1.28}$$

► The correct answer is **B**.

P.40 ■ Solution

The GSI was developed by Hoek and his collaborators for use with the Hoek-Brown failure criterion. One of the inherent advantages of the GSI is its ease of use, as this parameter requires no mechanical testing and can be obtained by visual inspection alone.

► The correct answer is **D**.

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▸ ANSWER SUMMARY

1	**C**	21	**A**
2	**B**	22	**C**
3	**D**	23	**B**
4	**C**	24	**B**
5	**B**	25	**B**
6	**C**	26	**B**
7	**A**	27	**C**
8	**A**	28	**B**
9	**B**	29	**B**
10	**C**	30	**D**
11	**A**	31	**C**
12	**D**	32	**A**
13	**B**	33	**C**
14	**B**	34	**B**
15	**C**	35	**C**
16	**B**	36	**A**
17	**C**	37	**A**
18	**C**	38	**C**
19	**D**	39	**B**
20	**D**	40	**D**

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