Civil

Discipline-Specific Review for the FE/EIT Exam

Third Edition

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Professional Publications, Inc. • Belmont, California

Practice Problems

SURVEYING

Problems 1 and 2 are based on the following information.

Earthwork quantities for a section of roadway indicate a transition from fill to cut. The following areas are scaled from the print cross sections.

station (m)	cut area (m^2)	fill area (m^2)
20+00	–	173.21
20+10.50	–	43.56
20+21.50	14.32	9.63
20+28.45	64.73	–
20+40	187.42	–

In the region where there is a transition from fill to cut, the fill area and cut area are both triangular in shape on the road cross section.

Problem 1

The total volume of fill required for this section of road is most nearly

(A) 1430 m^3
(B) 1450 m^3
(C) 1730 m^3
(D) 1780 m^3

Solution

Earthwork volumes for fill areas and cut areas can be calculated using the average end area formula. Since the cut and fill areas are triangular in shape as given in the problem statement, earthwork volumes in the transition region from fill to cut can be calculated from the formula that gives the volume of a pyramid.

For sta 20+00 to 20+10.50,

$$\begin{aligned} L &= 10.50 \text{ m} - 0 \text{ m} \\ &= 10.50 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{fill volume} &= L\left(\frac{A_1 + A_2}{2}\right) \\ &= (10.50 \text{ m})\left(\frac{173.21 \text{ m}^2 + 43.56 \text{ m}^2}{2}\right) \\ &= 1138.0 \text{ m}^3 \end{aligned}$$

For sta 20+10.50 to 20+21.50,

$$\begin{aligned} L &= 21.50 \text{ m} - 10.50 \text{ m} \\ &= 11.00 \text{ m} \end{aligned}$$

(This is the transition from fill to cut, so use the formula for pyramid volume to calculate cut area.)

$$\begin{aligned} \text{fill volume} &= L\left(\frac{A_1 + A_2}{2}\right) \\ &= (11.00 \text{ m})\left(\frac{43.56 \text{ m}^2 + 9.63 \text{ m}^2}{2}\right) \\ &= 292.5 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{cut volume} &= h\left(\frac{\text{area of base}}{3}\right) \\ &= (11.00 \text{ m})\left(\frac{14.32 \text{ m}^2}{3}\right) \\ &= 52.5 \text{ m}^3 \end{aligned}$$

For sta 20+21.50 to 20+28.45,

$$\begin{aligned} L &= 28.45 \text{ m} - 21.50 \text{ m} \\ &= 6.95 \text{ m} \end{aligned}$$

(This is the transition from fill to cut, so use the formula for pyramid volume to calculate fill area.)

$$\begin{aligned} \text{fill volume} &= h\left(\frac{\text{area of base}}{3}\right) \\ &= (6.95 \text{ m})\left(\frac{9.63 \text{ m}^2}{3}\right) \\ &= 22.3 \text{ m}^3 \end{aligned}$$

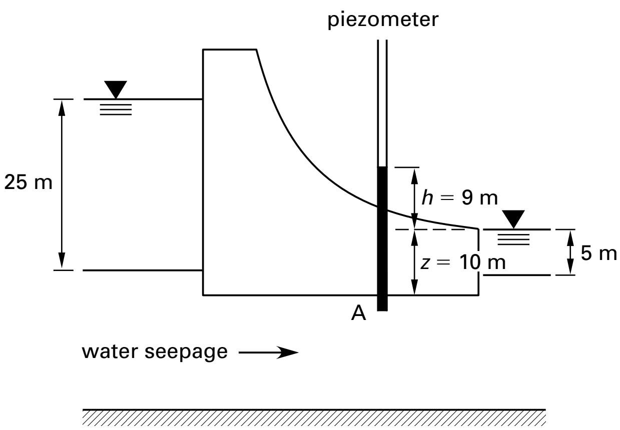
$$\begin{aligned} \text{cut volume} &= L\left(\frac{A_1 + A_2}{2}\right) \\ &= (6.95 \text{ m})\left(\frac{14.32 \text{ m}^2 + 64.73 \text{ m}^2}{2}\right) \\ &= 274.7 \text{ m}^3 \end{aligned}$$

14. Water flows through a 30.0 cm inside diameter pipe at an initial velocity of 1.9 m/min. The pipe diameter subsequently reduces to 15.0 cm before discharging into an open channel. The discharge velocity is most nearly

(A) 3.8 m/min
(B) 7.5 m/min
(C) 8.6 m/min
(D) 9.3 m/min

Problems 15–17 are based on the following information and illustration.

An impervious dam on pervious soil above an impervious rock layer has piezometric data as shown.



15. The total pressure head above atmospheric at point A is most nearly

(A) 9 m
(B) 10 m
(C) 20 m
(D) 30 m

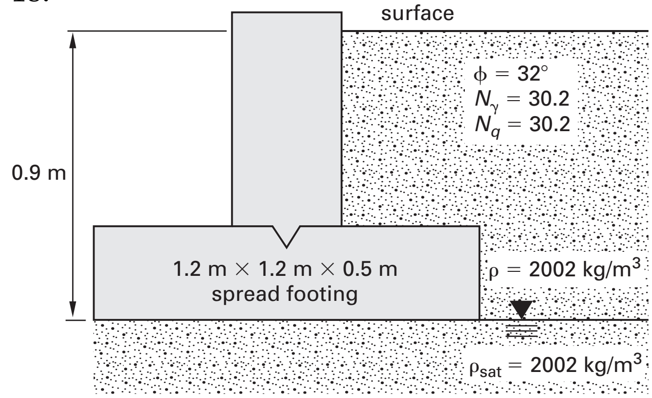
16. The total pressure head above the tailwater at point A is most nearly

(A) 9 m
(B) 10 m
(C) 14 m
(D) 15 m

17. The uplift pressure at point A is most nearly

(A) 10 kPa
(B) 30 kPa
(C) 70 kPa
(D) 190 kPa

18.



The 1.2 m × 1.2 m footing shown is 0.9 m below the sand's surface. Assuming the water table is at the base of the footing, the allowable bearing pressure with a factor of safety of 3 is most nearly

(A) 240 kPa
(B) 360 kPa
(C) 600 kPa
(D) 790 kPa

Problems 19–21 are based on the following information.

An undisturbed sample of clay has a weight of 29 kg, a dry weight of 26 kg, and a total volume of 0.014 m^3. Clay solids have a specific gravity of 2.65.

19. What is most nearly the water content of the sample?

(A) 1.2%
(B) 4.3%
(C) 12%
(D) 81%

20. The degree of saturation is most nearly

(A) 19%
(B) 24%
(C) 62%
(D) 75%

21. The void ratio is most nearly

(A) 0.2
(B) 0.3
(C) 0.4
(D) 0.7

10. The pump power equation is

$$\begin{aligned} P &= Q\gamma\frac{h}{\eta} = Q\rho g\frac{h}{\eta} \\ &= \left(0.25\ \frac{\text{m}^3}{\text{s}}\right)\left(1000\ \frac{\text{kg}}{\text{m}^3}\right)\left(9.81\ \frac{\text{m}}{\text{s}^2}\right) \\ &\quad \times \left(\frac{100\ \text{m}}{0.75}\right)\left(\frac{1\ \text{kW}}{1000\ \text{W}}\right) \\ &= 327\ \text{kW} \quad (330\ \text{kW}) \end{aligned}$$

The answer is A.

11. The total watershed area is

$$\begin{aligned} A &= 80\,000\ \text{m}^2 + 20\,000\ \text{m}^2 + 15\,000\ \text{m}^2 \\ &= 115\,000\ \text{m}^2 \end{aligned}$$

Determine the weighted runoff coefficient for the total area.

$$\begin{aligned} C &= \frac{(80\,000\ \text{m}^2)(0.85) + (20\,000\ \text{m}^2)(0.75) + (15\,000\ \text{m}^2)(0.20)}{115\,000\ \text{m}^2} \\ &= 0.748 \end{aligned}$$

The rational formula is

$$Q = CIA$$

The peak runoff is

$$\begin{aligned} Q &= CIA \\ &= (0.748)\left(80\ \frac{\text{mm}}{\text{h}}\right)(115\,000\ \text{m}^2) \\ &\quad \times \left(\frac{1\ \text{m}}{1000\ \text{mm}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) \\ &= 1.9\ \text{m}^3/\text{s} \end{aligned}$$

The answer is C.

12. The pipe area is

$$\begin{aligned} A &= \frac{Q}{\text{v}} = \frac{1.92\ \frac{\text{m}^3}{\text{s}}}{10\ \frac{\text{m}}{\text{s}}} \\ &= 0.192\ \text{m}^2 \\ A &= \frac{\pi d^2}{4} \\ d &= \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{(4)(0.192\ \text{m}^2)}{\pi}} \\ &= 0.49\ \text{m} \quad (0.50\ \text{m}) \end{aligned}$$

The answer is A.

13. The capillary rise in liquids is

$$\begin{aligned} h &= \frac{4\sigma\cos\beta}{\gamma d} \\ &= \frac{(4)\left(0.0696\ \frac{\text{N}}{\text{m}}\right)\cos 0°}{\left(9.730\ \frac{\text{kN}}{\text{m}^3}\right)\left(1000\ \frac{\text{N}}{\text{kN}}\right)(0.0038\ \text{m})} \\ &= 7.53\ \text{mm} \quad (7.5\ \text{mm}) \end{aligned}$$

The answer is C.

14. The continuity equation for one-dimensional flow is

$$A_1\text{v}_1 = A_2\text{v}_2$$

Solve for A_1 and A_2.

$$\begin{aligned} A_1 &= \frac{\pi d_1^2}{4} = \frac{\pi(0.3\ \text{m})^2}{4} \\ &= 0.071\ \text{m}^2 \\ A_2 &= \frac{\pi d_2^2}{4} = \frac{\pi(0.15\ \text{m})^2}{4} \\ &= 0.018\ \text{m}^2 \end{aligned}$$

Since the volumetric flow in the pipe stream is continuous, solve for the water velocity at the discharge point.

$$\begin{aligned} \text{v}_2 &= \frac{A_1\text{v}_1}{A_2} = \frac{(0.071\ \text{m}^2)\left(1.9\ \frac{\text{m}}{\text{min}}\right)}{0.018\ \text{m}^2} \\ &= 7.49\ \text{m/min} \quad (7.5\ \text{m/min}) \end{aligned}$$

The answer is B.

15. The pressure head (length of water in the standpipe), h_p, at point A is

$$\begin{aligned} h_p &= h + z = 9\ \text{m} + 10\ \text{m} \\ &= 19\ \text{m} \quad (20\ \text{m}) \end{aligned}$$

The answer is C.

16. The total head above the tailwater is

$$h_t = h = 9\ \text{m}$$

The answer is A.

17. The uplift pressure, p, at point A is

$$\begin{aligned} p &= h_p\gamma_w = h_p\rho_w g \\ &= (19\ \text{m})\left(1000\ \frac{\text{kg}}{\text{m}^3}\right)\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)\left(\frac{1\ \text{kPa}}{1000\ \text{Pa}}\right) \\ &= 186\ \text{kPa} \quad (190\ \text{kPa}) \end{aligned}$$

The answer is D.