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Solutions to Sample Exam questions – by Professor Ian Smith
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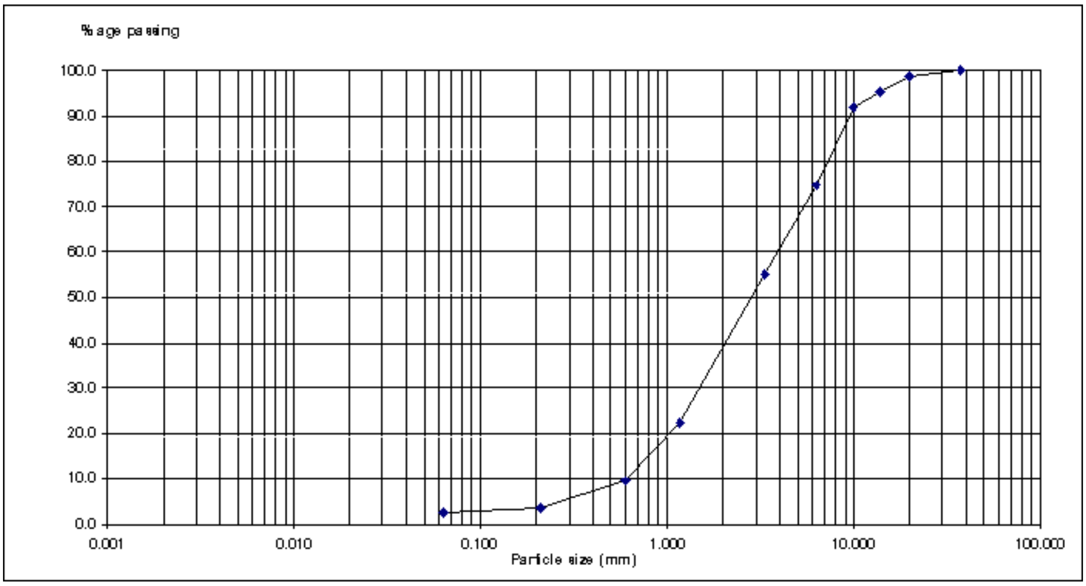
The sample exam questions are provided in a separate downloadable file.

Q1. (a)

Sieve (mm)	Mass (g)	% retained	% passing
37.5	0	0.0	100.0
20.0	2	1.2	98.8
14.0	5.4	3.3	95.5
10.0	6.2	3.7	91.8
6.3	28.3	17.1	74.7
3.35	32.5	19.6	55.0
1.18	54	32.6	22.4
0.60	21	12.7	9.7
0.212	10.2	6.2	3.5
0.063	1.6	1.0	2.5
pan	4.2	2.5	



(10 marks)

(b)

From PSD:

$D_{60} = 4$
$D_{10} = 0.64$

$$C_u = D_{60}/D_{10} = 4/0.64 = \underline{\underline{6.25}}$$

(2 marks)

(c)

(i) $\rho_b = \frac{M}{V} = \frac{2.035 \times 10^{-3}}{1.05 \times 10^{-3}} = \underline{\underline{1.938 \text{ Mg/m}^3}}$

(ii) $w = \frac{\textit{mass of water}}{\textit{mass of dry soil}} = \frac{2.035 - 1.85}{1.85} = \underline{\underline{10\%}}$

(iii) $\rho_d = \frac{\rho_b \times 100}{100 + w} = \frac{193.8}{110} = \underline{\underline{1.762 \text{Mg/m}^3}}$

(iv) $\rho_d = \frac{\rho_w G_s}{1 + e}$ (N.B. ρ_w = density of water = 1 Mg/m^3)

$\Rightarrow 1.762 = \frac{2.70}{1 + e}$

$e = 1.53 - 1 = \underline{\underline{0.53}}$

(v) $\rho_b = \frac{G_s + eS_r}{1 + e}$

$1.938 = \frac{2.70 + 0.53S_r}{1.53}$

$0.53S_r = (1.938 \text{ x } 1.53) - 2.7$

$Sr = \frac{0.265}{0.53} = 0.50 \equiv 50\%$

(13 marks)

(Total 25 marks)

Q2.

(a)
(i) Consider two 30 m x 4 m rectangles meeting over point A:

m = b / z = 4 / 3 = 1.33

n = l / z = 30 / 3 = 10

From chart, I_σ = 0.222

=> applied stress = 2 x 0.222 x 40 = 17.8 kPa

(ii) Consider four 15 m x 4 m rectangles meeting over point A:

m = b / z = 4 / 3 = 1.33

n = l / z = 15 / 3 = 5

From chart, I_σ = 0.222

=> applied stress = 4 x 0.222 x 40 = 35.5 kPa

(15 marks)

(b) $$\rho_i = \frac{pB\left(1-\nu^2\right)N_p}{E} = \frac{40 \times 8 \times 0.75 \times 0.94}{5 \times 10^6} = 45.1\text{mm}$$

(5 marks)

(Total 20 marks)

Q3.

SLIDING

Combination 1:

From Table 5.1: $\gamma_{G;\,unfav}$ = 1.35; $\gamma_{G;\,fav}$ = 1.0; γ_Q = 1.5; $\gamma_{\phi'}$ = 1.0.

Design ϕ = 30° (since partial factor of safety for phi = 1.0.)

From chart, K_a = 0.27

Pressure at base of wall = $K_a \times \gamma \times h$ = 0.27 x 19 x 5 = 25.7 kPa

P_a = 0.5 x 25.7 x 5 = 64.2 kN

Design action, $P_{a;\,d}$ = 64.2 x 1.35 = 86.7 kN

Weight of wall, W = ½(1.7 + 3.0) x 5 x 24 = 282.0 kN

Design weight, W_d = 282 x 1.0 = 282 kN

Resistance to sliding, $R_d = W_d$ x tan 30° (since δ/ϕ = 1.0) = 282 tan 30 = 162.8 kN

Since $R_d > P_{a;\,d}$ limit state requirement is satisfied.

Over design factor = 162.8 / 86.7 = 1.88 **(10 marks)**

Combination 2:

From Table 5.1: : $\gamma_{G;\,fav}$ = 1.0; $\gamma_{G;\,unfav}$ = 1.0; γ_Q = 1.3; $\gamma_{\phi'}$ = 1.25

Design ϕ = 24.8° (since partial factor of safety for phi = 1.25.)

From chart, K_a = 0.34

Pressure at base of wall = $K_a \times \gamma \times h$ = 0.34 x 19 x 5 = 32.3 kPa

P_a = 0.5 x 32.3 x 5.0 = 80.7 kN

Design action, $P_{a;\,d}$ = 80.7 x 1.0 = 80.7 kN

Weight of wall, $W = ½(1.7 + 3.0) \times 5 \times 24 = 282.0$ kN

Design weight, $W_d = 282 \times 1.0 =$ 282 kN

Resistance to sliding, $R_d = W_d \times \tan 24.8°$ (since $\delta/\phi = 1.0$) = 282 tan 24.8 = 130.3 kN

Since $R_d > P_{a;\,d}$ limit state requirement is satisfied.

Over design factor = 130.3 / 80.7 = 1.61 **(5 marks)**

OVERTURNING

Combination 1:

From Table 5.1: $\gamma_{G;\,unfav} = 1.35$; $\gamma_{G;\,fav} = 1.0$; $\gamma_Q = 1.5$; $\gamma_{\phi'} = 1.0$.

Design $\phi = 30°$ (since partial factor of safety for phi = 1.0.)

From chart, $K_a = 0.27$

Consider wall as comprising 2 sections:

Area 1: $W_d = ½ \times 1.3 \times 5 \times 24 \times \gamma_{G;\,fav} = 78.0$ kN
Area 2: $W_d = 1.7 \times 5 \times 24 \times \gamma_{G;\,fav} = 204.0$ kN

Active thrust:

$P_a = 0.5 \times 25.7 \times 5 = 64.2$ kN
Design action, $P_{a;\,d} = 64.2 \times 1.35 =$ 86.7 kN

The effect of the actions is to cause the overturning moment about the toe of the wall. This is resisted by the stabilising moment from the self-weight of the wall.

Action	Magnitude of Action (kN)	Lever arm (m)	Moment (kNm)
Stabilising:			
Area 1	78.0	0.67 x 1.3 = 0.88	68.6
Area 2	204.0	1.3 + (1.7/2) = 2.15	438.6
		Total:	**507.2**
Destabilising:			
P_a	86.7	5/3 = 1.67	144.5
		Total:	**144.5**

Over design factor = 507.2 / 144.5 = 3.51

(10 marks)

Combination 2:

From Table 5.1: : $\gamma_{G;\,fav}$ = 1.0; $\gamma_{G;\,unfav}$ = 1.0; γ_Q = 1.3; $\gamma_{\phi'}$ = 1.25

Design ϕ = 24.8° (since partial factor of safety for phi = 1.25.)

From chart, K_a = 0.34

Weight and Moments of Wall same as Combination 1 (since $\gamma_{G;\,fav}$ = 1.0 for both)

Mstb;d = 507.2 kNm

Active thrust:

Pressure at base of wall = $K_a \times \gamma \times h$ = 0.34 x 19 x 5 = 32.3 kPa
P_a = 0.5 x 32.3 x 5.0 = 80.7 kN
Design action, $P_{a;\,d}$ = 80.7 x 1.0 = 80.7 kN

$M_{dst;d}$ = 80.7 x 1.67 = 134.8 kNm

Over design factor = 507.2 / 134.8 = 3.76

(5 marks)

(Total 30 marks)