Civil Engineering License Exam Review

Geotechnical - Session 2

Geotechnical Engineering

Technical Areas for Geotechnical Engineering Session 2

In this session will review technical areas that overlap between geotechnical and structural engineering. These areas can be the subject of questions in either the breadth or depth portion of the Civil Engineering principles and practices exam. The following subjects will be reviewed:

- Shallow Foundations
- Concrete Mix Design
- Retaining Walls

Shallow Foundations

In Session 1 we reviewed the general bearing capacity and vertical pressure distribution. In this session we will take a closer look at calculating the bearing capacity of the foundation. Lindeburg covers shallow foundations in Chapter 36. The structural design of a reinforced concrete footing is covered in Chapter 55. Let's examine a few example problems that will first examine the methods of calculating the bearing capacity of soils and then the basic steps of completing the structural design of the footing will be covered in a later review session.

Problem G-13

A mat foundation will be used to support a building with dimensions of 80 ft. x 40 ft. and a total load of 5200 tons. The mat is located at a depth of D = 8 ft. below the surface. The soil beneath the mat is a sand with a density of 120 pcf and an average SPT N-value of 18. (Source: Practice Problems for Civil Engineering PE Exam, 8th Edition)

Problem G-13A:

The allowable bearing capacity of the mat is most nearly?

(A) 2.2 tons/sq. ft

(B) 2.5 tons/sq. ft

(C) 2.9 tons/sq. ft

(D) 5.4 tons/sq. ft

Problem G-13B:

The factor of safety against bearing failure is most nearly?

(A) 1.3

(B) 1.9

(C) 2.2

(D) 4.4

Solution G-13A:

If you had more information on the soil, specifically the angle of internal friction, you could use Terzaghi or Meyerhoff equations to determine the ultimate bearing strength. In this case we don't know that piece of information, but we are given the blow count, N, from the SPT. Lindeburg discusses the bearing capacity of sand on Page 36-7. In that section, he relates how to use the blow count to determine the ALLOWABLE bearing pressure, q_a.

$q_a = 0.22 * C_w * C_n * N$ (Eq. 36.23) , where C_w is a correction factor for shallow water tables and C_n is a correction factor based on the overburden. The problem does not provide information on the location of the water table, so it is fair to assume it is not shallow and therefore C_w is = 1.0. As Lindeburg points out, it is common practice to assess the correction to N at the bottom of the footing and a depth B below the footing.

At the base of the mat foundation p(overburden) = $\gamma * D_f$ = 120 pcf * 8 ft / (2000 lb / ton) = 0.48 tsf. For this value of overburden pressure the correction factor, $C_n = 1.21$.

At a depth of D_f + B below the ground surface, the overburden pressure is

$p_{(overburden)} = \gamma\ (D_f + B)$ = 120 pcf * (8 ft. + 40 ft) / (2000 lb/ton) = 2.88 tsf. For this value of overburden pressure the correction factor, $C_n = 0.63$. This factor should be used for design since it gives the lowest N-value. The net allowable bearing capacity is therefore,

$q_a = 0.22 * 0.63 * 18 = 2.49$ tsf. **ANS(B)**

Solution G-13B:

Using Eqn. 36.24(b), p(net, actual) = total load / raft area - γ Df = 5200 tons / (80 ft. x 40 ft.) -120 pcf * 8 ft. / (2000 lb/ ton) = 1.15 tons per sq. ft.

q net / p net, actual = 2.49 tsf / 1.15 tsf = 2.2 , however, the bearing pressure calculated previously already had a factor of safety of 2 included in the calculation. Therefore F.S. = (2)(2.2) = 4.4 **ANS (D)**

Problem G-14

A total force of 1600 kN is to be supported by a square footing that rests directly on a sand. The sand that has a density of 1900 kg / m3 and an angle of internal friction of 38 degrees. Use Terzaghi factors. Answer the following questions. (Source: Practice Problems for Civil Engineering PE Exam, 8th Edition)

Problem G-14A:

If the footing is placed at the surface of the sand layer, the base dimension of the square footing is most nearly?

(A) 1.8 m square

(B) 2.4 m square

(C) 2.7 m square

(D) 3.4 m square

Problem G-14B:

If the footing is placed at a depth of 1.5 meters below the surface, the footing base dimension is most nearly?

(A) 1.0 m square

(B) 1.1 m square

(C) 1.3 m square

(D) 1.8 m square

Solution G-14A:

The general net bearing pressure equation for a sand is given in Eqn. 36.10a.

$q_{net} = 0.5 * B * \rho * g * N_\gamma + \rho * g * D_f * (Nq - 1)$

For Φ = 38 degrees and using Table 36.2, $N_q \approx$. 65 and $N_\gamma \approx 77$. Note that you must use curvilinear interpolation for these tables. That is covered in Ch.12 of Lindeburg.

$D_f = 0$ since the footing rests on the sand.

therefore, q_{net} =[0.5 * B * 1900 kg/m^3 * 9.81 m/s^2 * (0.85*77) + 0 (since Df = 0)] (1 kPa / 1000 Pa)

q_{net} = 609.96 B kPa

The design capacity using F.S. = 2.0 and Eqn. 36.4, q (allowable) = q_{net} / F.S. --> q_{net} = F.S. * q (allowable) = (2) (1600 kN / (B x B)) or $q_{net} = 3200 / B^2$

Equating the two formulas --> B = 1.75 meters **ANS. (A)**

Solution G-14B:

The general net bearing pressure equation for a sand is given in Eqn. 36.10a.

q net = 0.5 * B * **ρ** * g * N_γ + **ρ** * g * D_f * (Nq - 1)

For Φ = 38 degrees and using Table 36.2, $N_q \approx 65$ and $N_\gamma \approx 77$. Note that you must use curvilinear interpolation for these tables. That is covered in Ch.12 of Lindeburg.

therefore, q net = [0.5 * B * 1900 kg/m^3 * 9.81 m/s^2 * (0.85*77) + 1900 kg/m^3 * 9.81 m/s^2 * 1.5 meters * (65 - 1)] (1 kPa / 1000 Pa)

q net = 609.96 (B) kPa + 1789.34 kPa.

The design capacity is the same as Part A. Setting the two equations equal to each other, you have a cubic equation. Using trial and error (You expect it to be smaller than Part A so you only have three values to try at the most), B is found to be 1.14 m. **ANS. (B)**

Problem G-15

A 2m x 2m square spread footing is designed to support an axial column total load of 600 kN and a moment of 150 KN-m about one axis. The footing is placed 1 meter into a sandy soil with a density of 2000 kg / cubic meters and an angle of internal friction of 30 degrees. Answer the following questions. (Source: Practice Problems for Civil Engineering PE Exam, 8th Edition)

Problem G-15A:

The eccentricity of the resultant load is most nearly?

(A) 0.10 m

(B) 0.25 m

(C) 0.50 m

(D) 1.3 m

Problem G-15B:

The equivalent width of footing to be used for footing design is most nearly?

(A) 1.3 m

(B) 1.5 m

(C) 1.8 m

(D) 2.0 m

Problem G-15C:
Using the Meyerhof theory, the value of the bearing capacity factor, N_γ, to be used in calculating the bearing capacity is most nearly?

(A) 16

(B) 22

(C) 27

(D) 35

Problem G-15D:
The value of the shape factor for N_γ to be used in calculating the bearing capacity is most nearly?

(A) 0.85

(B) 0.88

(C) 0.90

(D) 1.00

Problem G-15E:
The value of the net bearing capacity is most nearly?

(A) 100 kPa

(B) 340 kPa

(C) 544 kPa

(D) 1300 kPa

Problem G-15F:
The maximum soil pressure on the bottom of the footing is most nearly?

(A) 55 kPa

(B) 90 kPa

(C) 200 kPa

(D) 260 kPa

Problem G-15G:
The factor of safety against bearing failure is most nearly?

(A) 1.9

(B) 2.1

(C) 2.7

(D) 3.0

Solution G-15A:
The eccentricity, **ε**, is given by Eq. 36.18. The equation defines the eccentricity about each axis of the footing with one axis having length B and the other length L. In this case a moment occurs on only one axis and the footing is square, so the distinction is not important.

ε = M / P = 150 kN*m / 600 kN = 0.25 meter **ANS. (B)**

Solution G-12B:
As shown in Eqn. 36.19 the footing width to be used for analysis of bearing capacity is reduced by twice the eccentricity from the original width. B' = B - 2*ε = 2 m - (2) (0.25m) = 1.5 m (x 2 meters). **ANS. (B)**

Solution G-15C:
The Meyerhoff factor can be read from Table 36.3, for Φ = 30 degrees, N_Υ = 15.7 **ANS. (A)**

Solution G-15D:
The shape factor for N_Υ is found by interpolation from Table 36.5 and using the <u>effective width to account for the moment</u>. For B'/L = 1.5 m / 2.0 m = 0.75, the shape factor is 0.875. **ANS. (B)**

Solution G-15E:
The net bearing capacity is given by Eq. 36.10. (No shape factor was found for N_q, nor does Lindeburg provide such a reference, the problem would probably guide you to use one if necessary to get their solution).

$q_{net} = 0.5 * B' * \rho * g * N_\Upsilon + \rho * g * D_f * (Nq - 1)$

From Table 36.3, Nq = 18.4 for Φ = 30 degrees

$= (0.5) (1.5 \text{ m}) (2000 \text{ kg} / \text{m}^3 * 9.81 \text{ m/s}^2) (15.7 * 0.875) + (2000 \text{ kg} / \text{m}^3 * 9.81 \text{ m/s}^2) (1 \text{ m}) (18.4 - 1)$

= 202,147 Pa + 341,388 Pa = 543,535 Pa ≅ 544 kPa **ANS. (C)**

Solution G-15F:

The maximum pressure beneath the footing is given by Eq. 36.20. p(max) = (P/BL) (1 + 6*ε/B) The actual footing size is used to determine the pressure using statics.

p(max) = (600 kN / (2m x 2m)) (1 + 6 * 0.25 m / 2 m) = 262.5 kPa **ANS. (D)**

Solution G-15G:

Factor of safety against bearing capacity failure is determined by dividing the net bearing capacity by the maximum contact pressure.

F.S. = q net / p(max) = 544 kPa / 262.5 kPa = 2.1 **ANS. (B)**

Concrete Proportioning, Mixing, and Placing

Concrete proportioning, mixing, and placing is covered in Chapter 49 of Lindeburg. In general concrete can be proportioned by weight or volume. Since this subject matter can be either on the Structural breadth or depth exam and the depth exam for Geotechnical it increases the odds of seeing a problem related to concrete proportioning or "mixing."

Problem G-16

A 1:1.6:2.6 (by weight) mixture of cement, sand, and coarse aggregate is produced with the following specifications.

cement:	specific gravity = 3.15
	94 lb. per sack
sand:	specific gravity = 2.62 SSD
coarse aggregate:	specific gravity = 2.65 SSD
water:	5.8 gal per sack cement
entrained air:	3%

Answer the following questions. (Source: 101 Solved Civil Engineering Problems, 3rd edition)

Problem G-16A

The cement required to produce 1 cubic yard of concrete (by weight) is most nearly?

(A) 94 lb

(B) 253 lb

(C) 671 lb

(D) 703 lb

Problem G-16B

If the sand absorbs 1.6% moisture and the coarse aggregate has 3.2% excess moisture (based on SSD conditions), the weight of water needed to produce 1 cu. yd. of concrete is most nearly?

(A) 348

(B) 295

(C) 310

(D) 387

Solution G-16A:

First the yield of the mix must be determined to determine the amount of yield per sack of cement. This is determined by calculating the volume of each component for one sack of cement.

In general the volume of a component is equal to

V = (94 lb. x proportion) / (62.4 pcf x specific gravity of component)

Cement: V = (94 lb. x 1) / (62.4 pcf x 3.15) = 0.48 cu. ft. / sack

Fine aggregate: V = (94 lb. x 1.6) / (62.4 pcf x 2.62) = 0.92 cu. ft. / sack

Coarse aggregate: V = (94 lb. x 2.6) / (62.4 pcf x 2.65) = 1.48 cu. ft. / sack

Water: V = 5.8 gal / 7.48 gal / cu.ft. = 0.78 cu.ft. / sack

The yield volume is the sum of these volumes divided by (1 - 0.03) since 3% air will be added.

So V(yield) = (0.48 + 0.92 + 1.48 + 0.78)(cu. ft.) / (0.97) = 3.77 cu. ft. = 0.140 cu.yd / sack

Therefore for 1 cu. yd. of concrete, (1 cu. yd. / 0.140 cu.yd. / sack) (94 lb. / sack) = 671 lb of cement is required.

(or 7.14 sacks per 1 cu. yd.)

ANS (C).

Solution G-16B:

Extending the work in Problem G-13A, the weight of the other components at the SSD condition can be determined as well. Then the effect of the excess water and water absorption can be determined.

So for 1 cu. yd. of concrete at SSD condition for all aggregate:

fine aggregate = 7.14 sacks x 1.6 x 94 lb / sack = 1074 lbs

coarse aggregate = 7.14 sacks x 2.6 x 94 lb / sack = 1746 lbs

water = 7.14 sacks x 0.78 cu.ft / sack x 62.4 lb/cu. ft. = 348 lbs

Now, let's examine the impact of the variance from SSD for the coarse and fine aggregate.

Water absorbed by sand = (0.016) (1074 lb.) = -17.18 lbs

Excess water in coarse aggregate = (0.032) (1746 lb.) = 55.87 lb

Adjustment to water required is 55.87 lb - 17.18 lb = 38.69 lb (less water is required due to excess in coarse aggregate)

Weight of water required = 348 lb. - 39 lb. = 309 lb. **ANS (C)**

Problem G-17

A concrete mixture uses the following materials:

cement:	34 sacks, specific gravity = 3.15, 94 pounds per sack
fine aggregate:	6500 pounds (dry basis), specific gravity = 2.67, -2% moisture absorption from SSD
gravel:	11,500 pounds (dry basis), specific gravity = 2.64, +1.5% moisture excess from SSD
water:	142 gal (as delivered)
entrained air:	4%

Answer the following questions. (Source: 101 Solved Civil Engineering Problems, 3rd Edition)

Problem G-17A:

The concrete yield in cubic yards is most nearly?

(A) 2.3

(B) 5.6

(C) 4.2

(D) 5.1

Problem G-17B:

The water-cement ratio in gallons per sack of cement is most nearly?

(A) 4.3

(B) 2.3

(C) 5.8

(C) 6.2

Solution G-17A:
Calculate the volume based on SSD density then adjust based on actual water content of aggregate.

Cement: weight = 34 sacks * 94 lb./sack = 3196 lbs. V = 3196 lbs. / (3.15 * 62.4 pcf) = 16.3 cu. ft.

Fine aggregate: V = 6500 lb. / (2.67 * 62.4 pcf) = 39.0 cu. ft. Water deficit = (0.02 * 6500 lb) = 130 lb.

Gravel: V = 11,500 lb / (2.64 * 62.4 pcf) = 69.8 cu. ft. Excess water = 0.015 * 11,500 lb. = 172.5 lb.

Water: V = 142 gal / 7.48 gal/cu.ft. = 19.0 cu. ft.

Correction from aggregate deviations = (-130 lb. + 172.5 lb) / 62.4 pcf = 0.7 cu. ft.

Total Volume of Water = 19 cu.ft. + 0.7 cu. ft. = 19.7 cu. ft.

Concrete yield = (16.3 cu. ft. + 39.0 cu. ft. + 69.8 cu. ft. + 19.7 cu. ft.) / (1 - 0.04) = 150.8 cu. ft. = 5.6 cu. yd.

ANS (B)

Solution G-17B:
Water-Cement Ratio = (19.7 cu. ft.) (7.48 gallons / cu. ft.) x (1 / 34 sacks) = 4.3 gal / sack **ANS (A)**

Retaining Walls

In Session 1, we examined a sample problem that looked at determining the lateral pressures associated with a retaining wall. Now we will take a closer look at the stability analysis of a retaining wall. Later, after a quick review of flexural and shear design of reinforced concrete, we will look at the structural design of the retaining wall itself.

Problem G-18

Given the following conditions, answer the following questions:

A reinforced concrete wall is used to support a 14 ft. cut in sandy soil. The backfill is level, but a surcharge of 500 psf is present for a considerable distance behind the wall. Factors of safety of 1.5 against sliding and overturning are required. Passive pressure is to be disregarded. (Source: Practice Problems for the Civil Engineering PE Exam, 3rd Edition)

Soil dry specific weight = 130 pcf

Angle of internal friction = 35 degrees

coefficient of friction against concrete - 0.5

allowable soil pressure = 4500 psf

frost line = 4 ft. below grade

Base length, B = 11.5 ft.

Base thickness, d = 1.75 ft.

Stem thickness at base = 1.75 ft. , at top = 1 ft.

Stem height above base = 18 ft.

Heel extension past back of stem = 6.5 ft.

Problem G-18A:
The surcharge is equivalent to what thickness of backfill soil?

(A) 2 ft

(B) 3 ft

(C) 4 ft

(D) 5 ft

Problem G-18B:
What is the horizontal reaction due to the surcharge?

(A) 2400 lb/ft

(B) 2700 lb/ft

(C) 3500 lb/ft

(D) 3900 lb/ft

Problem G-18C:
The active soil resultant is most nearly?

(A) 5700 lb/ft

(B) 6800 lb/ft

(C) 7500 lb/ft

(D) 8300 lb/ft

Problem G-18D:
What is the total overturning moment, taken about the heel, per foot of wall?

(A) 120,000 ft-lb

(B) 140,000 ft-lb

(C) 160,000 ft-lb

(D) 190,000 ft-lb

Problem G-18E:
What is the maximum vertical pressure at the toe?

(A) 4000 psf

(B) 4500 psf

(C) 5000 psf

(D) 5500 psf

Problem G-18F:
What is the minimum vertical pressure at the heel?

(A) 600 psf

(B) 1300 psf

(C) 2400 psf

(D) 2700 psf

Problem G-18G:
What is the factor of safety against sliding without a key?

(A) 1.3

(B) 1.4

(C) 1.6

(D) 1.8

Problem G-18H:
What is the factor of safety against sliding if a key, 1.75 ft. wide and 1 ft. deep is used?

(A) 1.4

(B) 1.6

(C) 1.7

(D) 2.1

Problem G-18I:
What is the factor of safety against overturning?

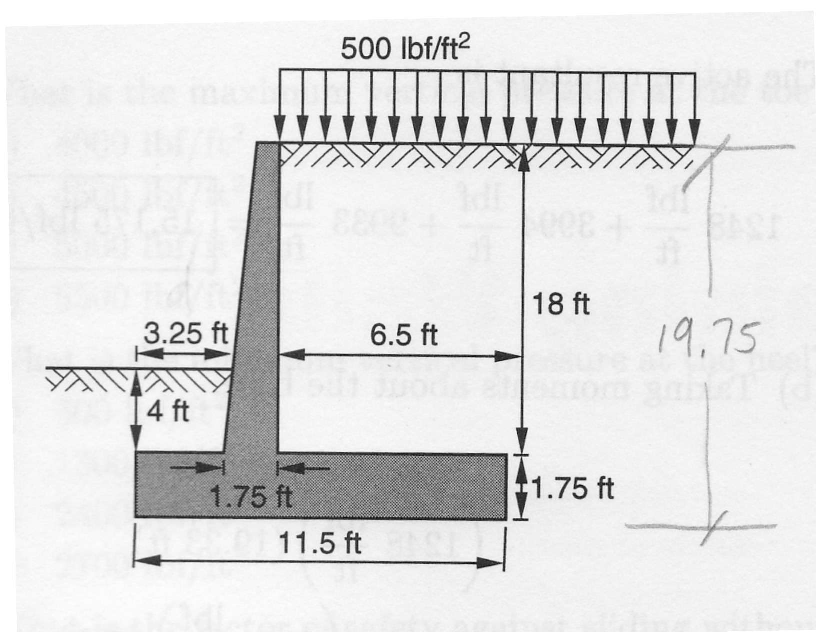
(A) 1.5

(B) 1.8

(C) 1.7

(D) 2.6

Solution G-18A:
First draw out the geometry of the wall in order to make sure the calculations use the appropriate distances for any moments or force locations.



Now, to convert the surcharge load into an equivalent depth of backfill, you simply divide the applied surcharge by the unit weight of the backfill. Therefore d,equiv = 500 psf / 130 pcf = 3.85 ft. **ANS (C)**

Solution G-18B:
Since we don't have sloping backfill, inclined active-side wall face, or a given friction angle between the soil and wall face; we do not want to use the full Coulomb equation given in Equation 37.5. Using the Rankine equation, the active pressure coefficient, k_a, can be found using Equation 37.7.

k_a = (1 - sin(35)) / (1 + sin(35)) = 0.27

Using equation 37.31, the active component of the surcharge pressure can be found.

p_q = k_a * q = 0.27 * 500 psf = 135 psf

The surcharge reaction is found by multiplying the active component of the surcharge pressure by the height of the wall.

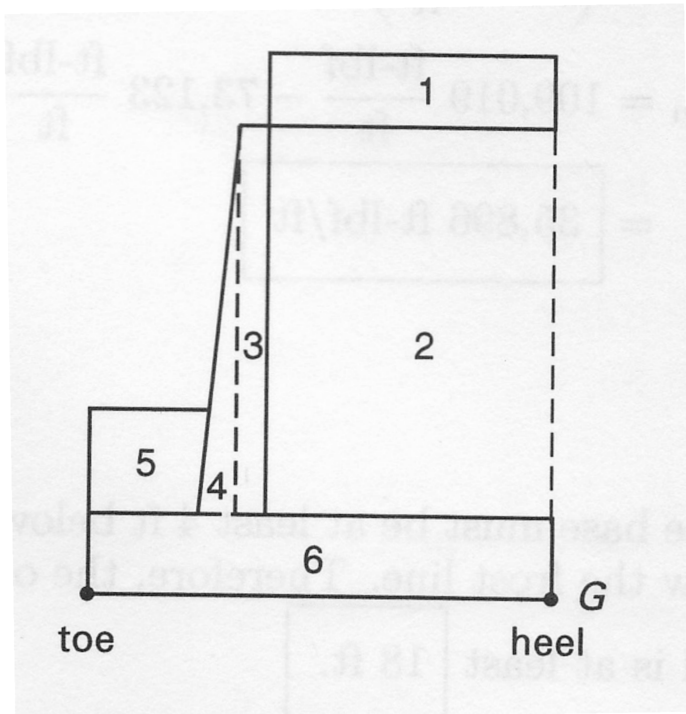
R(surcharge) = p_q * H = 135 psf / ft of wall * 19.75 ft. = 2666 psf / ft of wall. **ANS(B)**

Solution G-18C:
The active resultant of the backfill can be found using Eqn. 37.10(b).

Ra = 0.5 * k_a * ϒ * H^2 = 0.5 * 0.27 * 130 psf * $(19.75 \text{ ft})^2$ = 6846 lb / ft **ANS(B)**

Since the soil above the heel is horizontal, R_a, is horizontal and there is no vertical component.

Solution G-18D:
First break up the wall, backfill, and surcharge into convenient areas.



Now the moment of each area about point G can be calculated.

i	area (sq. ft.)	Y (pcf)	Wi - lb per ft	dist from G (ft)	Moment - G (ft-lb / ft)
1	25.03	130	3254	3.25	10,575
2	117	130	15,210	3.25	49,433
3	18	150	2700	7.00	18,900
4	6.75	150	1013	7.75	7851
5	13	130	1690	9.875	16,689
6	20.13	150	3020	5.75	17,365
Totals			26,887		120,813

The moment per foot of wall is therefore:

M(about G) = 120,813 ft-lb / ft. + 2666 lb/ft * (19.75 ft / 2) + 6846 lb/ft * (1.75 ft. + 18 ft.) / 3

M(about G) = 120,813 ft-lb / ft + 71,936 ft-lb / ft = 192,209 ft-lb / ft **ANS(D)**

Solution G-18E:
From Part D we found the total vertical force is 26,887 lb. So to determine the moment arm of the force for the calculated moment, we simply divide the moment by the force.

so Xr = (192,209 ft-lb / ft) / (26,887 lb / ft) = 7.15 ft. (from G, i.e. heel)

Using Eqn. 37.52 the eccentricity, **ε** = | 0.5 * 11.5 ft - 7.15 ft | = 1.40 ft.

B/6 = 11.5 ft / 6 = 1.9 ft., so the above resultant is within the middle third of the footing and is acceptable.

The maximum pressure at the toe, p(max,toe), can be found using Equation 37.54.

p(max,toe) = ((Σ Wi + Ra,v) / B) x (1 ± (6**ε** / B))

p(max, toe) = ((26,887 lb / ft) / 11.5 ft.) x (1 + (6 * 1.40 ft / 11.5 ft.)) = 4046 psf **ANS (A)**

Solution G-18F:
The minimum pressure at the toe, p (min, toe) can be found using Equation 37.54.

p(min, toe) = ((26,887 lb / ft) / 11.5 ft.) x (1 - (6 * 1.40 ft / 11.5 ft.)) = 630 psf **ANS (A)**

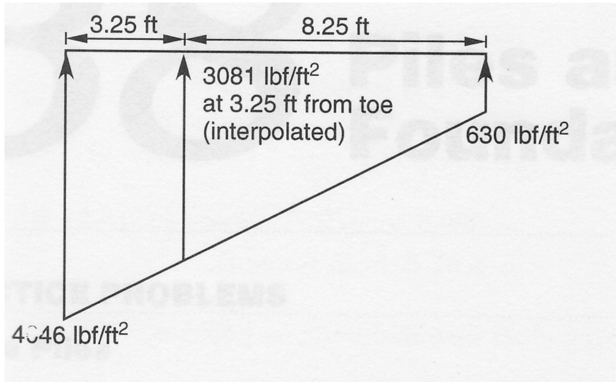
Solution G-18G:
Since there is no key, the friction between concrete and soil resists sliding. This is found using the general frictional force formula of F = Normal force x friction coefficient. More about calculating sliding forces can be found in Lindeburg on page 37-10.

Therefore R_S = 26,887 lb /ft of wall x 0.5 = 13,444 lb / ft of wall

This is compared to the horizontal forces acting on the wall to determine the factor of safety.

F.S. (sliding) = Rs / (R surcharge, horiz. + Ra) = 13,444 lb/ft / (2666 lb/ft + 6846 lb/ft) = 1.41 **ANS(B**).

Solution G-18H:
Using the key dimensions given, the impact of the key is to cause the soil in front of the key to shear. The soil behind the key is still subject to sliding. In order to determine the various components it is useful to draw the vertical pressure diagram for the base. This can be constructed using the answers to Part E and Part F.



The shearing force is found by multiplying the total upward normal force and the coefficient of shearing (internal) friction.

R (s1) = (3.25 ft * 3081 psf + 0.5 * 3.25 ft * (4046 psf - 3081 psf)) (tan 35°)

R (s1) = 11,581 lb * tan 35° = 8109 lb /ft

The sliding friction between the key and the heel is found the same way as before, just adjusting for the total upward vertical force in that area.

R (s2) = (26,887 lb - 11,581 lb) * 0.5 = 7653 lb/ft

F.S. (sliding) = (8109 lb/ft + 7653 lb/ft) / (2666 lb/ft + 6846 lb/ft) = 1.66   **ANS(C)**

Solution G-18I:
First find the moment about the pivot point, in this case the toe. Use a table as was done for finding the moment about the heel.

i	Wi (lbs / ft)	xi from toe (ft)	M (toe) (ft-lb/ft)
1	3254	8.25	26,846
2	15,210	8.25	125,483
3	2700	4.5	12,150
4	1013	3.75	3,799

i	Wi (lbs / ft)	xi from toe (ft)	M (toe) (ft-lb/ft)
5	1690	1.63	2,755
6	3020	5.75	17,365
TOTAL			188,398

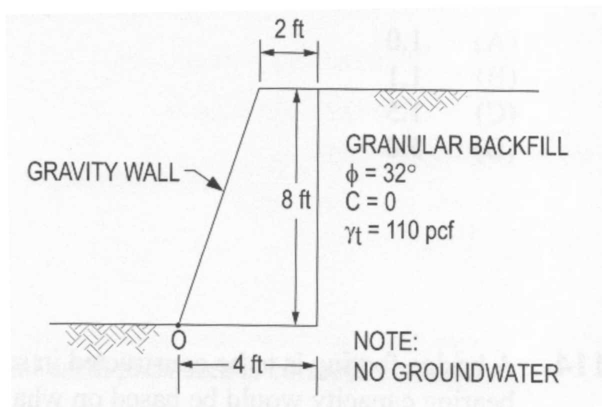
(Key was ignored)

F.S. (overturning) = ((188,398 ft-lb/ft) / ((6846 lb/ft * 19.75 ft / 3) + (2666 lb/ft * 19.75 * 0.5))

F.S. (overturning) = 2.64 **ANS (D)**

Problem G-19

A masonry gravity retaining wall having a unit weight of 150 pcf is shown in the figure. Use the Rankine active earth pressure theory and neglect wall friction. The factor of safety against overturning about the toe at Point 0 is most nearly:



(A) 2.8

(B) 2.5

(C) 2.2

(D) 0.3

Source: NCEES Civil: Construction Sample Questions and Solutions, 2011

Solution G-19

Lindeburg provides the formula for the Rankine active pressure coefficient in equation 37.7:

$k_a = \tan^2 (45^o - \phi/2) = (1 - \sin \phi) / (1 + \sin \phi) = 0.307$

The total active resultant acts H/3 above the base and is, per unit width of wall -

$R_a = 1/2 * k_a * \gamma * H^2 = 0.5 \times 0.307 \times 110$ pcf x (8 ft.)^2 = 1081 lb / ft of wall

M_a = 1081 lb. / ft of wall * (8 ft. / 3) = 2,883 lb ft / ft of wall

Now determine the resisting moment, which is due to the weight of the retaining wall.

The wall can be broken into a triangular portion and rectangular portion.

$W_{\triangle}$ = 0.5 x 2 ft. x 8 ft. x 150 pcf = 1200 lb. / ft. of wall

$W_{\square}$ = 2 ft. x 8 ft. x 150 pcf = 2400 lb. / ft. of wall

$M_{\triangle}$ = 1200 lb. x (2 ft. / 3) = 800 lb. ft. / ft. of wall

$M_{\square}$ = 2400 lb. x 3 ft = 7200 lb. ft. / ft. of wall

M_R = $M_{\triangle}$ + $M_{\square}$ = 8,000 lb. ft. / ft. of wall

Factor of Safety = F.S. = 8,000 / 2,883 = 2.77 --- **ANS (A)** most nearly 2.8

Additional Study Suggestions for Breadth Exam

It is suggested that you closely review Examples 35. 2 and 35.3 of Lindeburg. These examples show how to use phase diagrams to help guide you through the inter-relationships of the various soil properties. Using this in conjunction with Table 35.7 can help solve problems where you need to extend the few quantities given in a problem in order to get to an answer.

I also suggest that you work a couple of borrow /fill type problems that relate to the engineering properties of soils such as Example 35.3 in Lindeburg. This is also a type of problem that could appear on the breadth or depth portions of the exam.

Lastly, you should be familiar with the equations used to determine the bearing capacity. These topics are found in Chapter 36 of Lindeburg.

Additional Topics in Geotechnical Depth Exam

Within Geotechnical engineering the following topics should also be reviewed if you preparing for the geotechnical depth exam.

- stability analysis
- seepage
- consolidation
- pavement design
- deep foundations
- mechanically stabilized earth
- dams
- earthquake fundamentals
- liquefaction

•other Civil Engineering discipline topics listed in table in Session 1 Notes