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Continuing Education Course #117
Mechanically Stabilized Earth Structures
Part 3

The student shall calculate the factors of safety with respect to External Stability using Equations 1-18 as noted on Pages 2-5. This applies to questions 1-20.

Design a 30-ft tall MSE wall with the following geometry and loading conditions.

- Level toe with 2-ft embedment depth below final grade
- Level backfill, $\beta=0$ -degrees

- Live load traffic surcharge of $q=250$ -lb/ft²

Soil Properties for the Reinforced, Retained and Foundation are

- $\Phi'=30$ -deg
- $c'=0$ -lb/ft²
- $\gamma=120$ -lb/ft³

1. Determine Active Earth Pressure Coefficient $K_{a \text{ ext}}$ based on Rankine Earth Pressure?

- a. 0.333
- b. 0.361
- c. 0.300
- d. 0.249

2. Calculate driving force due to soil pressure F_1 .

- a. 12,000 lb/ft
- b. 15,500 lb/ft
- c. 18,000 lb/ft
- d. 18,500 lb/ft

3. Calculate driving force due to traffic surcharge pressure F_2 .

- a. 2,000 lb/ft
- b. 2,500 lb/ft
- c. 3,000 lb/ft
- d. 4,500 lb/ft

4. Calculate the minimum reinforcement length based on FHWA criteria?

- a. 21-ft
- b. 18-ft
- c. 30-ft
- d. 24-ft

5. Calculate resisting force due to wall V_1 ?

- a. 50,500 lb/ft
- b. 60,250 lb/ft
- c. 75,600 lb/ft
- d. 80,600 lb/ft

6. Calculate resisting force due to surcharge V_2 ?

- a. 4,000 lb/ft
- b. 5,250 lb/ft
- c. 6,250 lb/ft
- d. 6,500 lb/ft

7. Calculate the resisting moment M_R using Equation 7?

- a. 793,800 lb-ft
- b. 794,600 lb-ft
- c. 739,850 lb-ft
- d. 800,790 lb-ft

8. Calculate the driving moment M_D using Equation 7?

- a. 271,500 lb-ft
- b. 360,220 lb-ft
- c. 217,500 lb-ft
- d. 210,350 lb-ft

9. What is the factor of safety for overturning, FS_{OT} ?

- a. 2.65
- b. 3.65
- c. 3.80
- d. 4.13

10. Calculate the resisting force F_R using Equation 8?

- a. 43,648 lb
- b. 46,643 lb
- c. 47,225 lb
- d. 64,843 lb

11. Calculate the driving force F_D using Equation 8?

- a. 18,500 lb
- b. 22,500 lb
- c. 20,500 lb
- d. 22,000 lb

12. What is the factor of safety for external sliding, FS_{SL} ?

- a. 1.55
- b. 2.13
- c. 2.31
- d. 2.55

13. Calculate the resultant of vertical forces using Equation 9?

- a. 80,850 lb/ft
- b. 75,600 lb/ft
- c. 60,250 lb/ft
- d. 50,500 lb/ft

14. Calculate the resisting moment for bearing capacity M_{RBC} using Equation 10?

- a. 848,925 lb-ft
- b. 794,600 lb-ft
- c. 739,850 lb-ft
- d. 800,790 lb-ft

15. Calculate the eccentricity using Equation 11?

- a. 1.39-ft
- b. 1.56-ft
- c. 2.29-ft
- d. 2.69-ft

16. Calculate effective foundation width B' using Equation 12?

- a. 21.00-ft
- b. 18.31-ft
- c. 15.62-ft
- d. 12.93-ft

17. Calculate the vertical overburden stress, σ'_v , using Equation 13?

- a. 5,176 lb/ft²
- b. 2,225 lb/ft²
- c. 5,576 lb/ft²
- d. 7,651 lb/ft²

18. Calculated bearing capacity factors using Equations 14-16?

- a. $N_c = 30.14$
- b. $N_q = 18.40$
- c. $N_\gamma = 22.40$
- d. all of the above

19. Calculate the ultimate bearing capacity, q_{ult} , using Equation 17?

- a. 12,000 lb/ft²
- b. 15,625 lb/ft²
- c. 20,995 lb/ft²
- d. 22,275 lb/ft²

20. What is the factor of safety for bearing capacity, FS_{BC} ?

- a. 2.54
- b. 4.06
- c. 5.40
- d. 6.04

The student shall calculate the factors of safety with respect to Internal Stability using Equations 19-33 as noted on Pages 6-16 for reinforcement layer #7. This applies to questions 21-36.

Follow the design example on Pages 6-13 to calculate internal factors of safety for sliding, overstress and pullout using the given parameters:

- $LTDS=3,274\text{-lb/ft}$
- $K_{aint} = 0.271$
- $F^* = 0.700$
- $L=14\text{-ft}$
- $Z = 7.5\text{-ft}$
- $q=250\text{-lb/ft}^2$

No slopes or footing loads:

- $\sigma_2 = 0\text{-psf}$
- $\Delta\sigma_H = 0\text{-psf}$ and
- $\Delta\sigma_V = 0\text{-psf}$

Soil Properties are:

- $\Phi' = 35\text{-deg}$
- $c' = 0\text{-lb/ft}^2$
- $\gamma = 125\text{-lb/ft}^3$
- $\rho = 29.256\text{-deg}$
- $K_{aext} = 0.361$
- $\gamma_r = 110\text{-lb/ft}^3$

21. Calculate the vertical stress for geosynthetic layer #7 located at a depth of 7.5-ft, from the top of wall use Equation 23?

- a. $\sigma_v(7) = 1,888 \text{ lb/ft}^2$
- b. $\sigma_v(7) = 1,188 \text{ lb/ft}^2$
- c. $\sigma_v(7) = 1,818 \text{ lb/ft}^2$
- d. $\sigma_v(7) = 2,188 \text{ lb/ft}^2$

22. Calculate the horizontal stress for geosynthetic layer #7 located at a depth of 7.5-ft, from the top of wall use Equation 24?

- a. $\sigma_h(7) = 233 \text{ lb/ft}^2$
- b. $\sigma_h(7) = 333 \text{ lb/ft}^2$
- c. $\sigma_h(7) = 231 \text{ lb/ft}^2$
- d. $\sigma_h(7) = 322 \text{ lb/ft}^2$

23. Calculate the maximum tension T_{max} for reinforcement layer #7 using Equation 25. Vertical spacing S_v between reinforcement layers is 2.0-ft.

- a. $T_{max}(7) = 644 \text{ lb/ft}$
- b. $T_{max}(7) = 600 \text{ lb/ft}$
- c. $T_{max}(7) = 322 \text{ lb/ft}$
- d. $T_{max}(7) = 161 \text{ lb/ft}$

24. Calculate the Factor of Safety for Reinforcement Overstress for reinforcement layer #(7) using Equation 26.

- a. $FS_{OS}(7) = 6.12$
- b. $FS_{OS}(7) = 6.09$
- c. $FS_{OS}(7) = 5.09$
- d. $FS_{OS}(7) = 4.23$

25. Determine the active zone L_a for each reinforcement layer for reinforcement layer #7 using Equation 29.

- a. $L_a(7) = 7.49$
- b. $L_a(7) = 7.05$
- c. $L_a(7) = 6.51$
- d. $L_a(7) = 6.15$

26. Determine the actual design embedment length for L_e for reinforcement layer #7 using Equation 30.

- a. $L_e(7) = 5.35$
- b. $L_e(7) = 6.15$
- c. $L_e(7) = 6.51$
- d. $L_e(7) = 7.49$

27. Determine the Factor of Safety for Pullout for reinforcement layer #7 using Equation 31.

- a. $F_{SpO}(7) = 17.35$
- b. $F_{SpO}(7) = 15.37$
- c. $F_{SpO}(7) = 13.75$
- d. $F_{SpO}(7) = 12.43$

28. Determine the Factor of Safety for Internal Sliding for reinforcement layer #7 using Equation 32. Need to first calculate $F_1(7)$, $F_2(7)$ and $V_1(7)$ similar to sample problem on Page 9.

- a. $FS_{SL}(7) = 4.10$
- b. $FS_{SL}(7) = 3.98$
- c. $FS_{SL}(7) = 2.54$
- d. $FS_{SL}(7) = 1.91$

The student shall calculate the factors of safety with respect to Facing Stability using Equations 34-41 as noted on Pages 14-16 for reinforcement layer #7. This applies to questions 28-36.

Follow the design example on Pages 14-16 to calculate factors of safety for connection using the given parameters:

- $T_{conn} = 2,585\text{-lb/ft} + N \tan 31^\circ$
- $\gamma_{block} = 112\text{-lb/ft}^3$
- $RF_D = 1.10$
- $RF_{CR} = 1.45$
- $Z = 7.5\text{-ft}$
- $T_{lot}(7) = 7,200\text{-lb/ft}$
- $T_{max}(7) = 644\text{-lb/ft}$ previously calculated when determining FS_{OS} .

29. Calculate the normal load at the connection for reinforcement layer #7 using Equation 35.

- a. $N_{(7)} = 980 \text{ lb/ft}$
- b. $N_{(7)} = 786 \text{ lb/ft}$
- c. $N_{(7)} = 840 \text{ lb/ft}^2$
- d. $N_{(7)} = 480 \text{ lb/ft}$
30. Calculate the connection capacity for reinforcement layer #7 using Equation 34.
- a. $T_{\text{conn}(7)} = 3,090 \text{ lb/ft}$
- b. $T_{\text{conn}(7)} = 1,786 \text{ lb/ft}$
- c. $T_{\text{conn}(7)} = 2,840 \text{ lb/ft}$
- d. $T_{\text{conn}(7)} = 3,480 \text{ lb/ft}$
31. Calculate the CR_u for reinforcement layer #7 using Equation 36.
- a. $CR_u (7) = 0.5039$
- b. $CR_u (7) = 0.4478$
- c. $CR_u (7) = 0.4291$
- d. $CR_u (7) = 0.3917$
32. Calculate the CR_s for reinforcement layer #7 using Equation 37.
- a. $CR_s (7) = 0.5039$
- b. $CR_s (7) = 0.4478$
- c. $CR_s (7) = 0.4291$
- d. $CR_s (7) = 0.3917$
33. Calculate the connection capacity based of reinforcement rupture or break, $T_{AC(\text{rup})}$ for reinforcement layer #7 using Equation 38.
- a. $T_{ac(\text{rup})} (7) = 2,275 \text{ lb/ft}$
- b. $T_{ac(\text{rup})} (7) = 2,022 \text{ lb/ft}$
- c. $T_{ac(\text{rup})} (7) = 1,937 \text{ lb/ft}$
- d. $T_{ac(\text{rup})} (7) = 1,768 \text{ lb/ft}$
34. Calculate the connection capacity based of reinforcement pullout, $T_{ac(\text{po})}$ for reinforcement layer #7 using Equation 39.
- a. $T_{ac(\text{po})} (7) = 3,628 \text{ lb/ft}$
- b. $T_{ac(\text{po})} (7) = 3,224 \text{ lb/ft}$
- c. $T_{ac(\text{po})} (7) = 3,090 \text{ lb/ft}$
- d. $T_{ac(\text{po})} (7) = 2,821 \text{ lb/ft}$
35. Determine the Factor of Safety for connection based on reinforcement rupture for reinforcement layer #7 using Equation 40.
- a. $FS_{\text{rup}(7)} = 3.01$
- b. $FS_{\text{rup}(7)} = 2.59$
- c. $FS_{\text{rup}(7)} = 2.09$
- d. $FS_{\text{rup}(7)} = 1.69$

36. Determine the Factor of Safety for connection based on reinforcement pullout for reinforcement layer #7 using Equation 41.

- a. $FS_{po(7)} = 4.80$
- b. $FS_{po(7)} = 4.14$
- c. $FS_{po(7)} = 3.01$
- d. $FS_{po(7)} = 2.69$

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