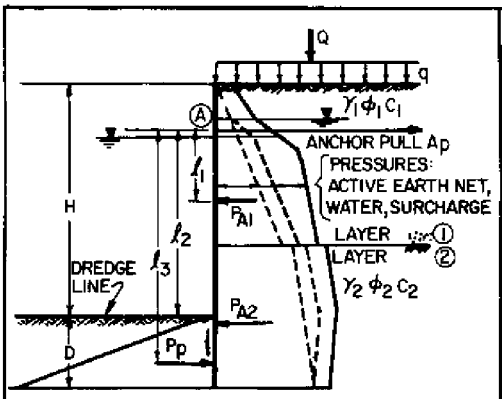
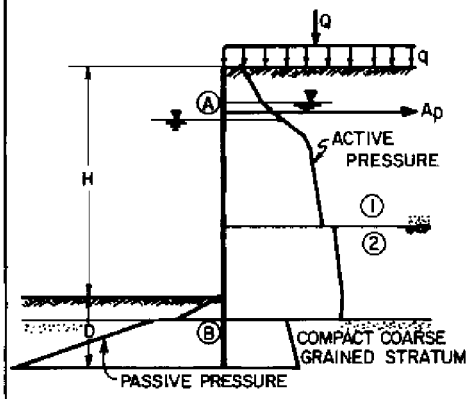


FREE EARTH SUPPORT – GENERAL CASE

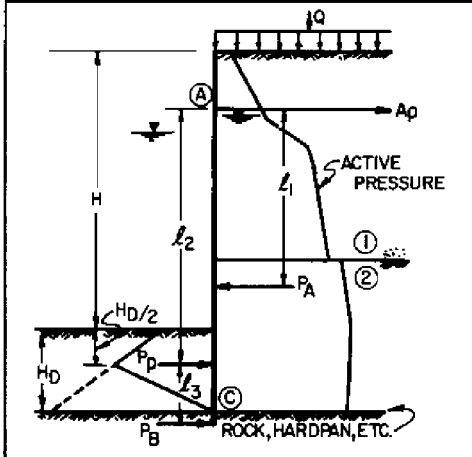
1. COMPUTE PRESSURES BY METHODS OF FIGURES 2 TO 7 PASSIVE PRESSURES FOR CLEAN COARSE GRAIN SOILS INCLUDE WALL FRICTION (δ). TABLE I. FOR ACTIVE OR PASSIVE PRESSURES IN ALL OTHER SOIL TYPES, IGNORE WALL FRICTION.
2. DEPTH OF PENETRATION REQUIRED: TAKE MOMENTS ABOUT POINT (A) AND SOLVE FOR D: $P_{A1}\ell_1 + P_{A2}\ell_2 = \frac{Pp}{F_S}\ell_3$
   F_S = 2 TO 3 FOR COARSE GRAINED SOILS
   F_S = 1.5 TO 2 FOR FINE GRAINED SOILS
3. ANCHOR PULL: $Ap = \left[P_{A1} + P_{A2} - Pp/F_S\right] d$, d=ANCHOR SPACING
4. MAXIMUM BENDING MOMENT (M_{MAX}) IN SHEETING COMPUTED BY THE FREE EARTH SUPPORT METHOD AND APPLYING P_{A1}, P_{A2}, Pp/F_S AND Ap. FOR SHEETING IN SAND APPLY MOMENT REDUCTION FOR FLEXIBILITY OF FIGURE 19.
5. INCRESE PENETRATION COMPUTED (D) BY 20% TO ALLOW FOR DREDGING, SCOUR, ETC.



PENETRATION IN COMPACT COARSE GRAINED STRATUM

DESIGN STEPS 1, 2, AND 3 SAME AS ABOVE EARTH SUPPORT.

4. COMPUTE MAXIMUM BENDING MOMENT (M_{MAX}) IN SHEETING BY FREE EARTH SUPPORT METHOD APPLYING P_A, Pp/F_S AND Ap.
5. COMPUTE ρ ACCORDING TO FIGURE 19. IF $\rho \geq 20$, M_{DESIGN} IS COMPUTED FOR THE SPAN (A)(B) ASSUMING SIMPLE SUPPORT AT POINT (B)
   IF $\rho < 20$ OBTAIN MOMENT REDUCTION FOR FLEXIBILITY FROM FIGURE 19.
6. INCREASE PENETRATION COMPUTED (D) BY 20% TO ALLOW FOR DREDGING, SCOUR, ETC.



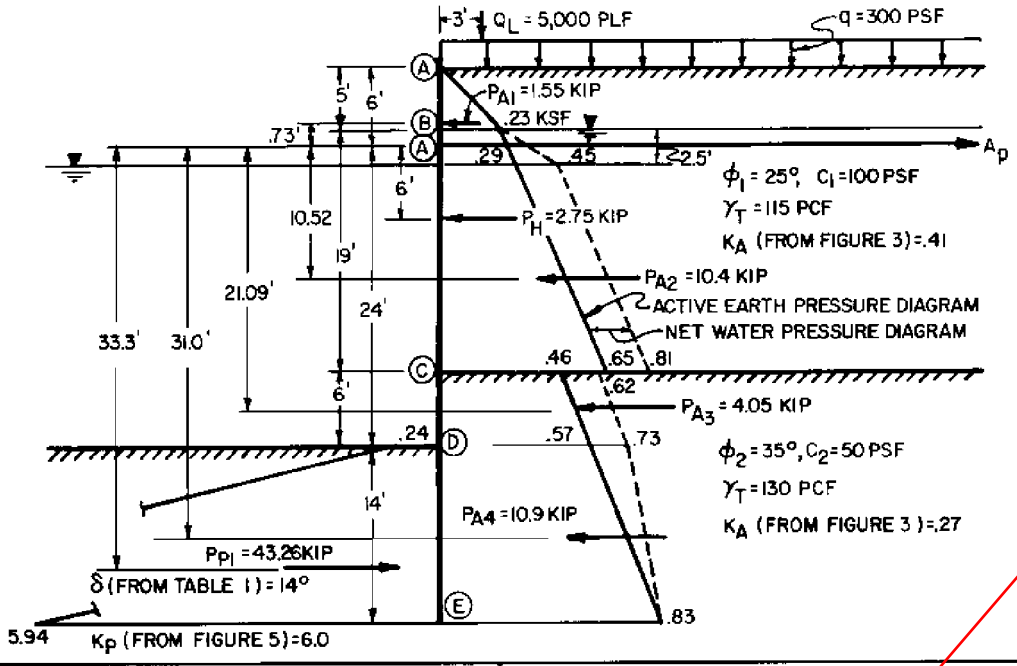
PENETRATION TO TOP OF HARD UNYIELDING STRATUM

1. COMPUTE PRESSURES AS ABOVE, EXCEPT THAT PASSIVE PRESSURE DECREASES TO ZERO AT TOP OF HARD STRATUM.
2. PENETRATION IN HARD STRATUM:
   TAKE MOMENTS ABOUT POINT (A) AND SOLVE FOR P_B:
   $$P_A\ell_1 - \frac{Pp}{F_S}\ell_2 = \frac{P_B}{F_S}(\ell_2+\ell_3)$$
   ESTIMATE IF REACTION P_B CAN BE PROVIDED BY SHALLOW PENETRATION IN HARD STRATUM.
3. ANCHOR PULL: $Ap = \left[P_A - \frac{Pp}{F_S} - \frac{P_B}{F_S}\right] d$
4. MAXIMUM BENDING MOMENT IN SHEETING COMPUTED BY APPLYING P_A, Pp AND Ap TO SPAN (A)-(C) ASSUMING SIMPLE SUPPORT AT (C). NO REDUCTION FOR FLEXIBILITY.

FIGURE 18
Design Criteria for Anchored Bulkhead (Free Earth Support)

example in pag. 7.2-93 does not considers PP/FS when computing moments about a

example in pag. 7.2-93 does considers/ this approach for computing AP



ACTIVE EARTH PRESSURE (SEE FIGURE 2)
INCLUDING UNIFORM SURCHARGE q

$\sigma_H = \gamma Z K_A - 2C\sqrt{K_A}$

Ⓐ, $\sigma_H = .30 \times .41 - 2 \times .10\sqrt{.41} = 0$
Ⓑ, $\sigma_H = (.30+5\times.115).41 - 2\times.10\sqrt{.41} = .23$ KSF
Ⓒ, $\sigma_H = (.30+5\times.115+19\times.053).41 - 2\times.10\sqrt{.41} = .65$ KSF
Ⓒ, $\sigma_H = (.30+5\times.115+19\times.053).27 - 2\times.05\sqrt{.27} = .46$ KSF
Ⓓ, $\sigma_H = .46 + 6\times.068\times.27 = .57$ KSF
Ⓔ, $\sigma_H = .46 + (6+14)\times.068\times.27 = .83$ KSF

PRESSURE OF LINE LOAD SURCHARGE
(SEE FIGURE 11)

$m = \frac{X}{H} = \frac{3}{30} = 0.1$

$P_H = 0.55\,Q_L = 0.55\times5 = 2.75$ KIP

LOCATION OF RESULTANT:
$R = .60\,H = .60\times30 = 18'$

NET WATER PRESSURE

$\sigma_W = \gamma_W Z = .0625\times2.5 = .16$ KSF

PASSIVE PRESSURE

$\sigma_H = \gamma Z K_P + 2C\sqrt{K_P}$

Ⓓ, $\sigma_H = 0 + 2\times.05\sqrt{6.0} = .24$ KSF
Ⓔ, $\sigma_H = .068\times14\times6.0 + 2\times.05\sqrt{6.0} = 5.94$ KSF

SAFETY FACTOR AGAINST TOE FAILURE:
TAKE MOMENTS ABOUT Ⓐ

$F_S = \frac{\Sigma \text{ MOMENTS OF PASSIVE FORCES}}{\Sigma \text{ MOMENTS OF ACTIVE FORCES}}$

$= \frac{43.26\times33.3}{1.55\times0.73 + 2.75\times6 + 10.4\times10.52 + 4.05\times21.09 + 10.9\times31.0}$

$= 2.61 > 2.5$

ANCHOR PULL

$A_p = \Sigma P_A - \Sigma P_p / F_S$

$= 1.55 + 2.75 + 10.4 + 4.05 + 10.9 - \frac{43.26}{2.5} = 12.37$ KIPS

MAXIMUM BENDING MOMENT IN SHEETING
POINT OF ZERO SHEAR:

$12.37 - 1.55 - 2.75 - .45X - .022\times\frac{X^2}{2} = 0$

$X = 13.6'$ BELOW OUTSIDE WATER LEVEL

$M_{MAX} = 1.55\times15.7 + 12.37\times15.1 - 2.75\times9.1$
$- .45\times\frac{13.6^2}{2} - .022\times\frac{13.6^2}{2}\times4.52 = 86.9$ FT-KIPS

MOMENT REDUCTION:
ASSUME: f_S = 27,000 PSI, E = 30,000,000 PSI
TRY ZP 32, I = 385.7 IN^4, S = 38.3 IN^3

ρ = (FROM FIGURE 19) = $\frac{(H+D)4}{EI}$

$\rho = \frac{(30\times12+14\times12)^4}{30{,}000{,}000\times385.7} = 6.7\ \frac{IN^2}{LB}$

$\frac{M_{DESIGN}}{M_{MAX}} = .83$; $M_{DESIGN} = .83\times86.9 = 72.1$ FT-KIPS

$f_S = \frac{M}{S} = \frac{72.1\times1000\times12}{38.3} = 22{,}600$ PSI < 27,000

TRY A SMALLER SECTION

No PP/FS/? as suggested in Pag 7.2-88

shouldn't this term be negative?

FIGURE 21
Example of Analysis of Anchored Bulkhead