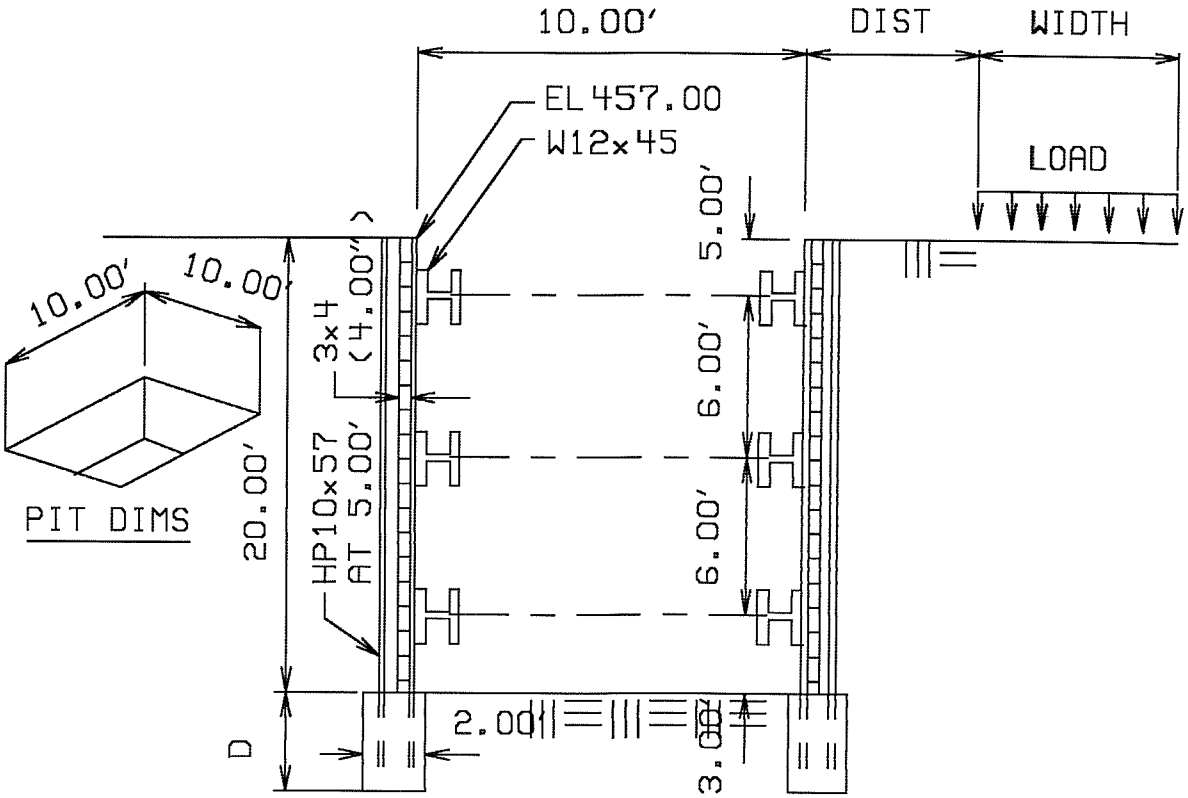
FIRM:DesignCalcs, Inc. JOB NO. SHEET NO: 1
MADE BY:KJH DATE:06-25-2012 CHECKED BY: DATE:
TITLE:Example of DCALC Program EXCAV

==========

BRACED EXCAVATION DESIGN:

BORING NO. 2, BORING SURFACE EL. 457 FT



Design Data:

The program designs braced excavations using a methodology described in the FHWA publication No. FHWA-IF-99-015. The approach is similar in concept to traditional apparent pressure diagrams that were developed by Terzaghi and Peck in the 1940's, but it uses slightly different trapezoidal pressure shapes.

Steel Data:
Design Specification: AISC, 9th Edition (ASD)
Steel Fy=36.00 ksi
Allowable bending stress, Fb=21.60 ksi

Wood Data:
Basic allowable bending stress, Fb,wood = 1.700 ksi
Basic allowable axial stress, Fc,wood = 1.600 ksi
Min. Modulus of elasticity, E_{min} = 690 ksi

3x4 lagging is rough lumber with dimensions 3.0 in x 4.0 in

Expected duration of excavation:More than 6 weeks

BRACED EXCAVATION DESIGN:

SOIL DATA:

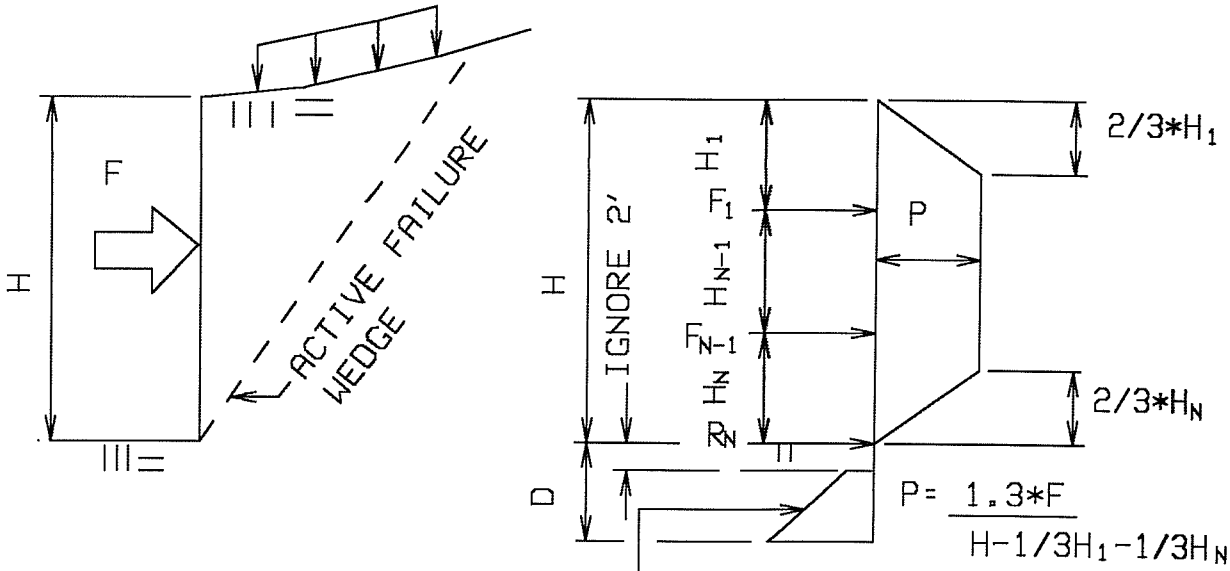
Layer No.	From Elev. (ft)	To Elev. (ft)	Soil Classification (using IDOT terminology)	Qu (tsf)	Dry Wt (pcf)	Sat Wt (pcf)	Phi (deg)
1	457.00	441.50	Clean Medium to Coarse Sand		101	110	25
2	441.50	439.00	Cohesive Soil		121	121	15
3	439.00	436.50	Sandy Gravel		131	133	33
4	436.50	434.00	Clean Medium to Coarse Sand		118	123	28
5	434.00	424.00	Cohesive Soil		132	132	15
6	424.00	421.50	Clean Medium to Coarse Sand		118	123	28
7	421.50	411.50	Cohesive Soil		118	118	15
8	411.50	409.00	Fine Sand		122	126	33
9	409.00	406.50	Clean Medium to Coarse Sand		110	117	28
10	406.50	401.50	Cohesive Soil		129	129	15
11	401.50	399.00	Cohesive Soil		136	136	15
12	399.00	396.50	Cohesive Soil		121	121	15
13	396.50	389.00	Cohesive Soil		129	129	15
14	387.50	385.50	Rock: Limestone		125	125	45

Load. No.	Distance (ft)	Width (ft)	Load
1			.250 ksf (full width)

==========

BRACED EXCAVATION DESIGN:

Description of Design Approach:



1. COMPUTE ACTIVE FORCE, F, USING TRIAL WEDGE METHOD.
2. COMPUTE APPARENT PRESSURE, P, BY APPLYING 1.3*F TO ABOVE AREA
3. COMPUTE PASSIVE TOE PRESSURES BASED ON RANKINE PRESSURES, REDUCING BY 0.75. IGNORE TOP 2'
4. COMPUTE "D" BY EQUATING PASSIVE FORCE TO REQ'D "Rn" REACTION.

STEPS FOR COMPUTING MULTIPLE BRACED PRESSURES

The above design methodolgy has been adopted from the approach described on page 60 of the FHWA publication, "Ground Anchors and Anchored Systems", FHWA-IF-99-015 (*). The publication was written for tie-back systems, using principles that are also applicable to struted systems. (A useful comparison of various proposed trapezoidal diagrams is shown on page 51-55 of this reference.)

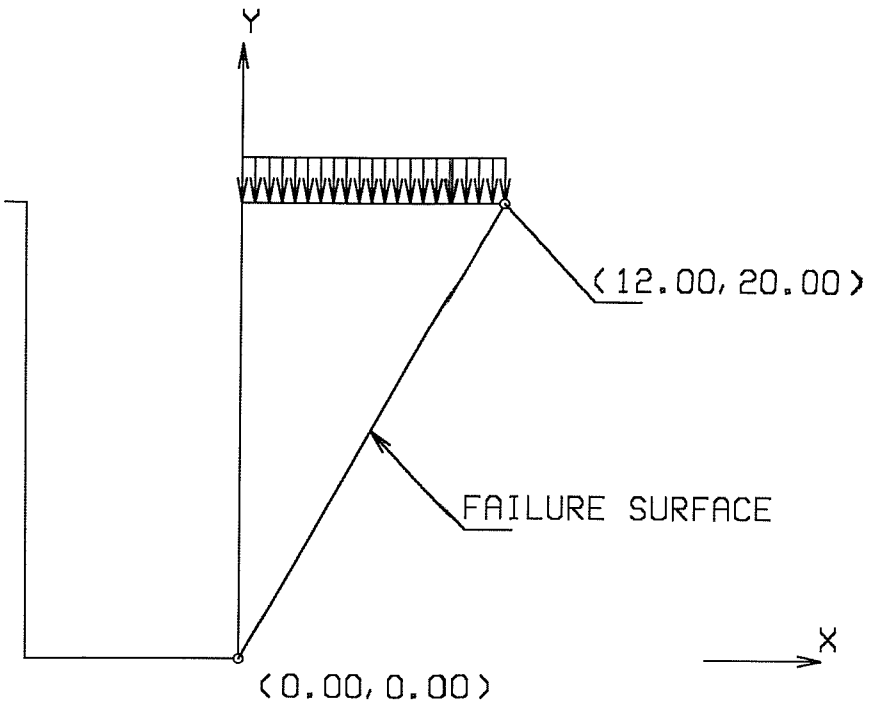
Struted braced excavations are typically installed using bracing that is precut to fit the trench. Before the struts are installed, the sheeting will deflect inward due to active forces. The struts will need to be forced and shimmed into placed, pushing the sheeting back somewhat. This forcing action causes an increase in pressures behind the sheeting, localized around the struts, as shown in the above diagrams. Note that these are empirical rules, and are not claimed to be exact.

This program uses the methodology described on p. 60, "5.2.7 Loading Diagrams for Stratified Soil Profiles".

==========

BRACED EXCAVATION DESIGN:

Trial Wedge Solution for Active Failure:



The above diagram shows the active failure plane, based on 100 iterations using the trial wedge method.

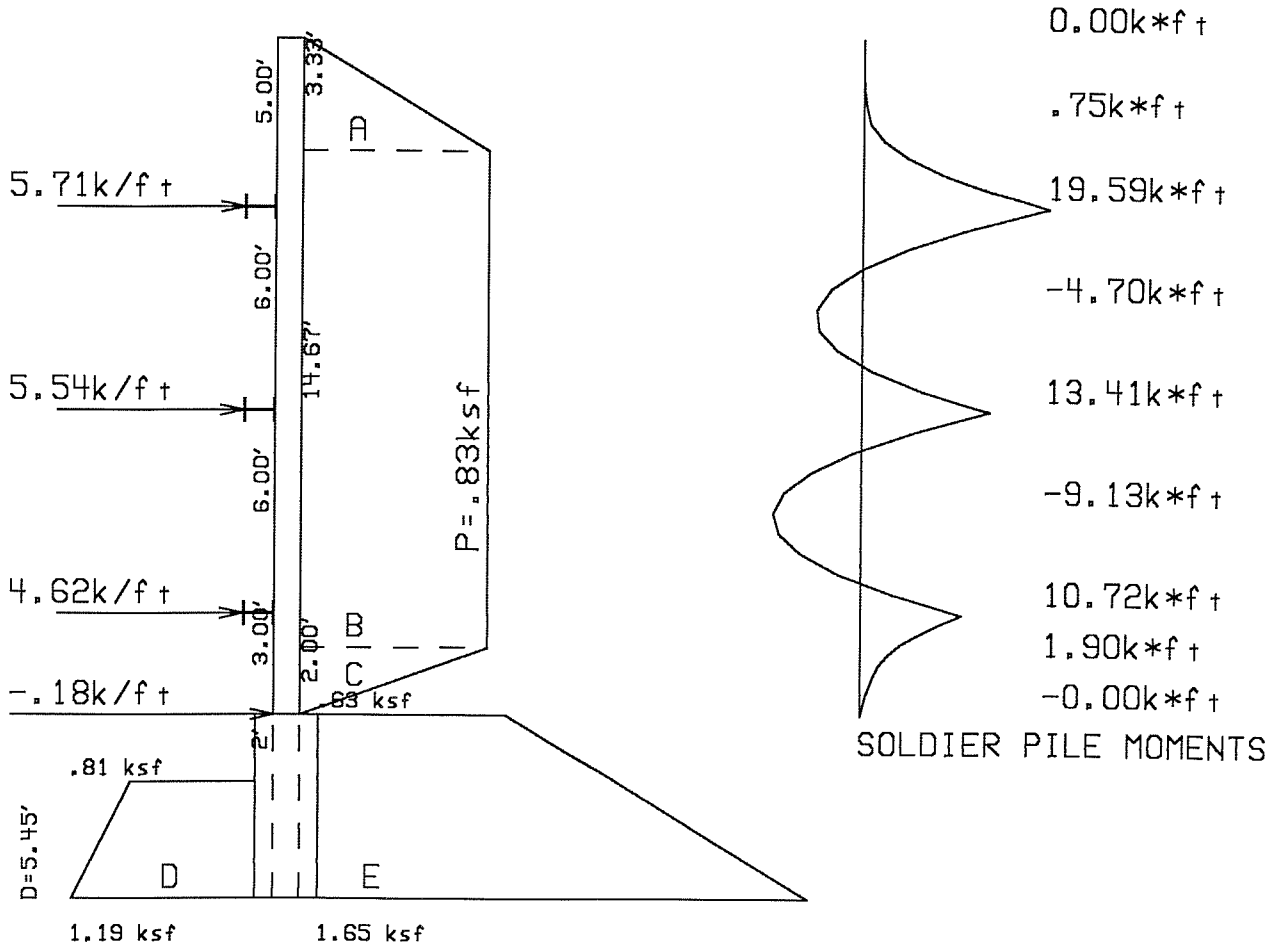
Force = 11.018 k/ft

Apparent pressure, P=1.3* 11.018/(20.00 - 1/3* 5.00 - 1/3* 3.00)
= .826 ksf

==========

BRACED EXCAVATION DESIGN:

Structural Analysis:



The above forces and moments were computed by finite element analysis, modeling the vertical member as a continuous beam on hinged supports, located at the braces and bottom of the excavation (model does not include the portion below the trench).

BRACED EXCAVATION DESIGN:

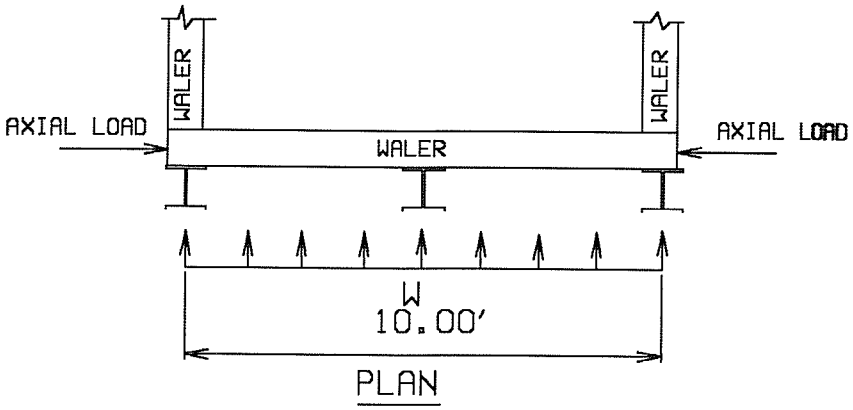
Check Soldier Pile (HP10x57):

Maximum pile bending moment = 19.59 k*ft
fb = 12*(19.59)/ 57.99 in^3 = 4.05 ksi< Fb = 21.60 ksi (OK)

Check Wood Lagging:

Maximum pressure on wood lagging, p = .826 ksf
Soil arching reduces moment to $M=1/12*w*l^2$
M =1/12* (.826 ksf)*(5.000 ft)^2 = 1.72 k*ft/ft
fb=12*(1.72)/ 32.00 in^3 = .65 ksi < Fb = 1.70 ksi (OK)

Check Walers (W12x45):



Top Waler force, W = 5.708 k/ft
Reaction from pile on waler = 5.708 k/ft * 5.000 ft = 28.542 k
M=14.27 k * 5.00 ' = 71.35 k*ft
fb = 12* 71.35/ 56.65 in^3 = 15.11 ksi
Axial load, P = 5.708 k/ft * (10.000 ft)/2 = 28.54 k
fa = 28.54 k/12.91 in^2 = 2.21 ksi
fb + fa = 2.21 + 15.11 = 17.326 ksi < Fb=21.60 ksi (OK)

Middle Waler force, W = 5.536 k/ft
Reaction from pile on waler = 5.536 k/ft * 5.000 ft = 27.682 k
M=13.84 k * 5.00 ' = 69.20 k*ft
fb = 12* 69.20/ 56.65 in^3 = 14.66 ksi
Axial load, P = 5.536 k/ft * (10.000 ft)/2 = 27.68 k
fa = 27.68 k/12.91 in^2 = 2.14 ksi
fb + fa = 2.14 + 14.66 = 16.804 ksi < Fb=21.60 ksi (OK)

Lower Waler force, W = 4.618 k/ft
Reaction from pile on waler = 4.618 k/ft * 5.000 ft = 23.092 k
M=11.55 k * 5.00 ' = 57.73 k*ft
fb = 12* 57.73/ 56.65 in^3 = 12.23 ksi
Axial load, P = 4.618 k/ft * (10.000 ft)/2 = 23.09 k
fa = 23.09 k/12.91 in^2 = 1.79 ksi
fb + fa = 1.79 + 12.23 = 14.018 ksi < Fb=21.60 ksi (OK)

BRACED EXCAVATION DESIGN:

Bottom Embeddment:

Bottom force (against earth at bottom trench) = -.179 k/ft
Required depth of embeddedment, D= 5.45 ft

Detailed calcuation:
Ignore the passive resistance of top 2' of earth at bottom of trench.
Passive pressure will effective over a width = 5.00 ft

Passive pressure at 2' below bot/trench:
In soil layer 4, φ=28.00 degrees. Kp = $\tan(45+\varphi/2)^2$ = 2.770
Effective stress on trench side, σ_{vv}' = .291 ksf
Water pressure on trench side, σ_{vw} = 0.000 ksf
Pp = (σ_{vv}' + c/tan(φ))* Kp - c/tan(φ) + σ_{vw}
= (.291 ksf + 0.000/tan(28.00))*2.770 - 0.000/tan(28.00)+ 0.000 ksf
= .806 ksf

Passive pressure at 5.45' below bot/trench:
In soil layer 5, φ=15.00 degrees. Kp = $\tan(45+\varphi/2)^2$ = 1.698
Effective stress on trench side, σ_{vv}' = .702 ksf
Water pressure on trench side, σ_{vw} = 0.000 ksf
Pp = (σ_{vv}' + c/tan(φ))* Kp - c/tan(φ) + σ_{vw}
= (.702 ksf + 0.000/tan(15.00))*1.698 - 0.000/tan(15.00)+ 0.000 ksf
= 1.193 ksf

Passive force=0.75 reduction* 5.000'*(.806 ksf + 1.193 ksf)/2
*(5.45' - 2') = 12.37 k

Active pressure at bot/trench:
In soil layer 3, φ=33.00 degrees. Ka = $\tan(45-\varphi/2)^2$ = .295
Effective stress behind trench wall, σ_{vv}' = 2.132 ksf
Water pressure behind trench wall, σ_{vw} = 0.000 ksf
Pa = (σ_{vv}' + c/tan(φ))* Ka - c/tan(φ) + σ_{vw}
= (2.132 ksf + 0.000/tan(33.00))* .295 - 0.000/tan(33.00) + 0.000 ksf
= .629 ksf

Active pressure at 5.45' below bot/trench:
In soil layer 5, φ=15.00 degrees. Ka = $\tan(45-\varphi/2)^2$ = .589
Effective stress behind trench wall, σ_{vv}' = 2.808 ksf
Water pressure behind trench wall, σ_{vw} = 0.000 ksf
Pa = (σ_{vv}' + c/tan(φ))* Ka - c/tan(φ) + σ_{vw}
= (2.808 ksf + 0.000/tan(15.00))* .589 - 0.000/tan(15.00) + 0.000 ksf
= 1.653 ksf

Active force= 2.000 ft*(.629 ksf + 1.653 ksf)/2*(5.45')= 12.094 k

Net Resistance = 12.37 k - 12.09 k = .27 k > -.18 k Req'd (OK)