FIRM:Your Firm   JOB NO.   SHEET NO: 1
MADE BY:YOU DATE:05-20-2010   CHECKED BY: DATE:
TITLE:Testing Tiewall, 2 anchors temporary in clay

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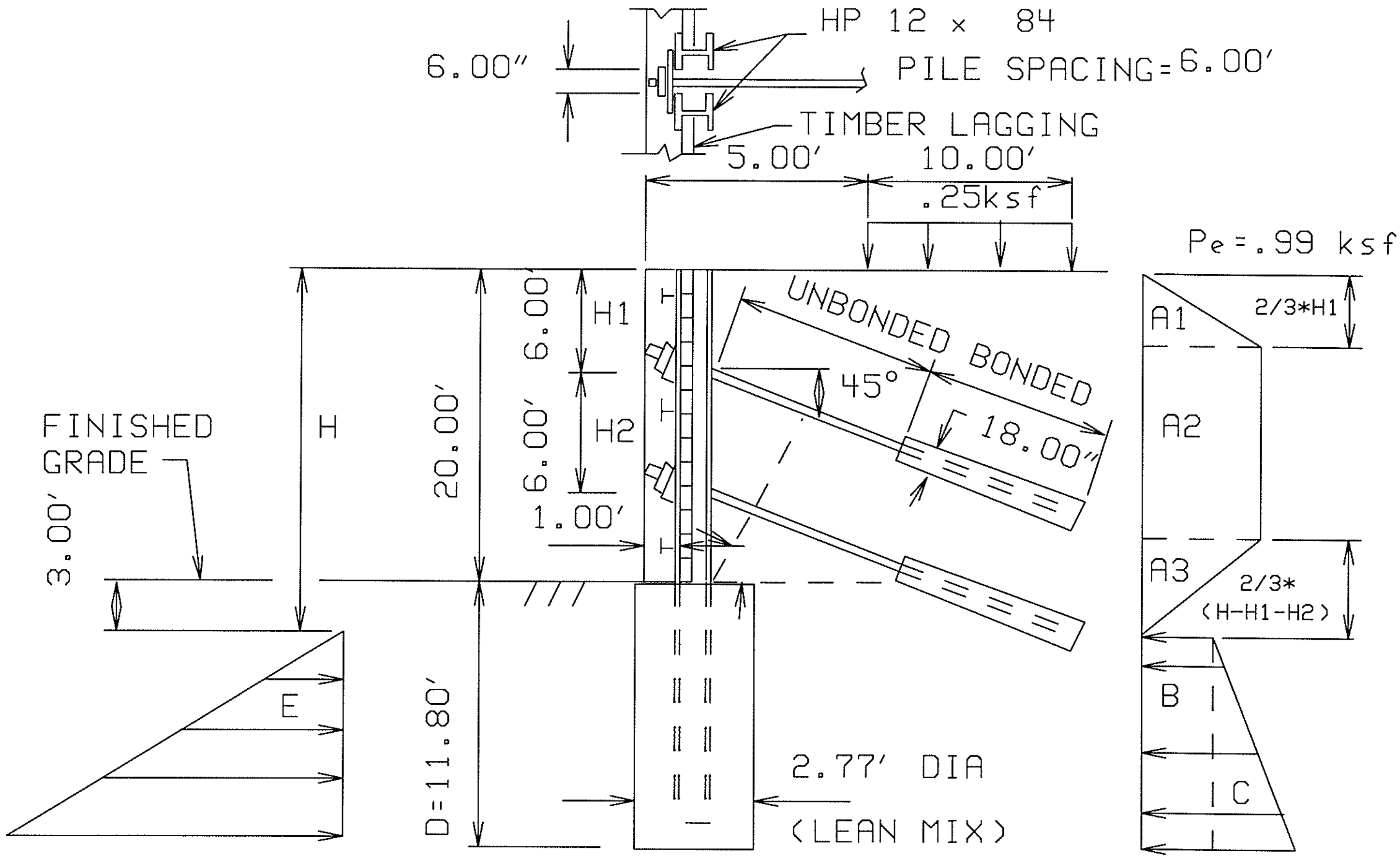
GROUND ANCHORED WALL DESIGN:



DESIGN METHODOLOGY:

Design References:

1. FHWA Publication,"Ground Anchors and Anchored Systems", Pub. No. FHWA-IF-99-015 by Sabatini, Pass and Bachus, 1999
2. US Army Corps of Engineers Pub.,"State of the Practice in the Design of Tall, Stiff Tieback Retaining Walls" by Trom and Ebeling, 2001
3. AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007

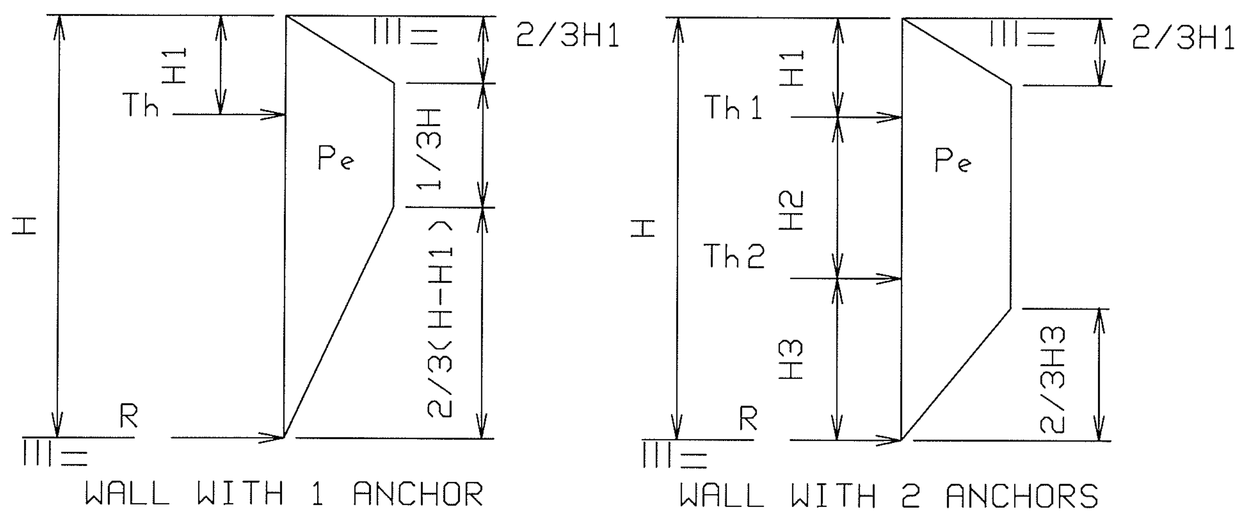
Program Description:

This program is for the purpose of designing soldier pile walls that are anchored by one or two levels of post-tensioned ground anchor ties. This type of wall is constructed in "cut" situations, where the wall is built from the top-down (earth is progressively removed from the front of the wall as timber lagging is slipped between the pile flanges).

The design of this type of wall differs from tieback walls in fill. The designer specifies an an active post-tensioned force that creates a complex pressure distribution behind the wall. Pressures behind these types of walls have been confirmed to be higher near the top and generally uniform, compared to classical earth pressure theories used for other types of walls(see AASHTO LRFD,C3.11.5.7).

GROUND ANCHORED WALL DESIGN:

DESIGN METHODOLOGY (CONT'D):



The above diagrams show the apparent earth pressure distributions that are typically used for this type of wall design for a wall in cohesionless soil. For permanent walls that are located in clay, the same diagrams are used based on a "k_a" based on the drained friction angle (Ref. 3 Art. 3.11.5.7.2)

The maximum ordinate, p_e of the pressure diagram is computed as follows:

For walls with one anchor level,

$$p_e = Ka * \gamma * H \qquad \text{(AASHTO LRFD Eq. 3.11.5.7.1-1)}$$

For walls with two anchor levels,

$$p_e = \frac{Ka * \gamma * H^2}{1.5H - 0.5H1 - 0.5*H3} \qquad \text{(AASHTO LRFD Eq. 3.11.5.7.1-2)}$$

ADDITIONAL CHECKS REQUIRED BY DESIGNER OUTSIDE SCOPE OF THIS PROGRAM:

1. Steel stress in tie rod or strands
2. Timber lagging design
3. Concrete facing design
4. Basal stability (bottom heave)
5. External stability (rotational failure of system)
6. Wall and ground movements (for discussion, see Ref. 1, p. 119)

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GROUND ANCHORED WALL DESIGN:

DESIGN DATA:

Allowable stress in steel pile, Fb= 21.60 ksi

Estimated Average Tieback Ultimate Bond Stress = 15 psi

Ult. Bond Stress Per Ft = 3.14*(18.00 in. dia.)* 12 in/ft * 15 psi/1000
= 10.18 k/ft

Soil properties above finished grade:
Soil type:Stiff clay
Soil weight= .120 kcf, Internal angle of friction= 25.000 degrees

$$Ka1 = \frac{1 - Sin(25.000)}{1 + Sin(25.000)} = .4058$$

Soil properties below finished grade:
Soil type:Stiff clay
Soil weight= .120 kcf, Internal angle of friction= 25.000 degrees

$$Ka2 = \frac{1 - Sin(25.000)}{1 + Sin(25.000)} = .4058$$

Kp2= 1/Ka2 = 1/ .4058 = 2.464

COMPUTE PRESSURES ABOVE FINISHED GRADE:

Apparent earth pressure due to post-tensioned grouted anchors:

$p_e = Ka1 * \gamma * H$
$= .41 * .12 * 23.00 = .991$ ksf

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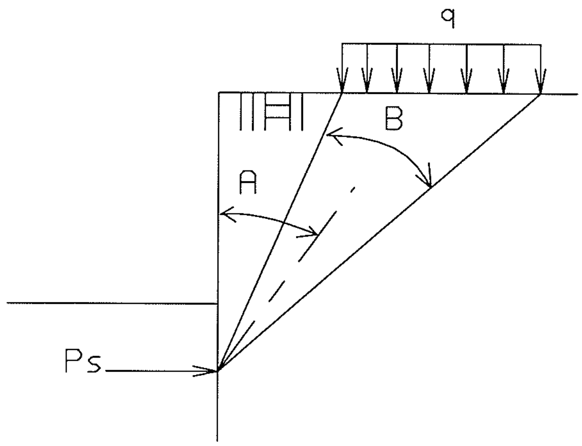
GROUND ANCHORED WALL DESIGN:

STRIP LOADING PRESSURES:

Strip loading pressures are computed using the 1990 AREA specification formula (pages 8-20-4 and 8-20-11 of AREA "Manual for Railway Engineering"),

$$Ps = \frac{2q}{3.14} [(B + \sin B)*(\sin A)^2 + (B - \sin B)*(\cos A)^2]$$



Strip Loading Table

Y (ft)	A (degrees)	B (degrees)	Ps (ksf)	V (k/ft)	M (k*ft/ft)
0	0.000	0.000	0.000	0.00	0.00
2	75.302	14.207	0.073	0.07	0.07
4	63.204	23.728	.104	.25	.40
6	54.002	28.393	.102	.46	1.11
8	46.966	29.922	0.088	.65	2.21
10	41.438	29.745	0.072	.81	3.67
12	36.980	28.720	0.058	.94	5.42
14	33.314	27.321	0.046	1.05	7.41
16	30.253	25.798	0.037	1.13	9.58
18	27.665	24.281	0.030	1.20	11.91
20	25.453	22.834	0.024	1.25	14.36
22	23.546	21.483	0.019	1.30	16.92

Where V and M are the shear and moment taken at Y due to strip loading only.

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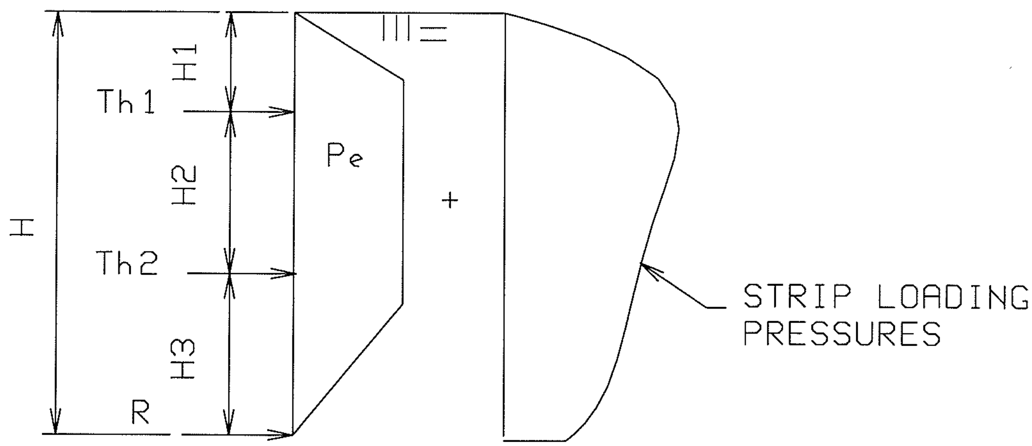
GROUND ANCHORED WALL DESIGN:

Due to the complexity of the strip loading, the pile has been analyzed as a continuous beam, as shown below.



CONTINUOUS BEAM ANAYSIS

The following results were calculated:
Horizontal components of tie force reactions:
Th1 = 48.80 k

Th2 = 62.16 k

R = 13.11 k

Solving for tie forces on 45 degree angle,
T1 = 48.80 k/Cos(45.00) = 69.01 k
T2 = 62.16 k/Cos(45.00) = 87.91 k

The unbonded portion must extend 5' beyond the active failure wedge, but not less than 10' min.
Upper Tie Req'd Unbonded length = 10.00 ft
Lower Tie Req'd Unbonded length = 10.00 ft

Using a safety factor of 2 against bond failure,
Upper Req'd Bond Length = 2*(69.01 k)/(10.18 k/ft) = 13.56 ft< 40' max. (OK)
Lower Req'd Bond Length = 2*(87.91 k)/(10.18 k/ft) = 17.27 ft< 40' max. (OK)
The total required tendon lengths are,
Upper Req'd Tendon Length = 10.00 ft (unbonded) + 13.56 ft (bonded) = 23.56 ft (tota
Lower Req'd Tendon Length = 10.00 ft (unbonded) + 17.27 ft (bonded) = 27.27 ft (tota

Maximum moment in pile= 58.43 k*ft

COMPUTE BENDING STRESS IN PILE:

For HP 12 x 84 , S= 104.39 in^3 ea. pile (calculated - may vary from tables)
fb=12* 58.43/(2* 104.39) = 3.36 ksi < 21.60 ksi (OK)

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GROUND ANCHORED WALL DESIGN:

COMPUTE REQUIRED DEPTH OF EMBEDMENT FOR LATERAL LOADS:

The soldier pile must be embedded to develop passive resistance to carry the lateral load, R, and the active pressure acting over the soldier pile width. A safety factor of 1.5 is required (see Ref. 1, page A-11)

Consider 3.00 ft below finished grade as ineffective in providing passive pressure (see AASHTO Standard Specification Fig. 5.6.2A).

Passive pressure infront of the pile tends to fail in a wedge shape that is taken into account as an "effective width" (see Ref. 1, Appendix B) In this case, passive pressures are effective over 6.00 ft (pile spacing).

Active pressures behind the piles are effective over the a width for two piles,
B = 2.77 ft

Depth of embedment required for lateral loads is D = 11.80 ft

Detailed Calculation:

(Refer to figure on first sheet for force indentifications)
Infront of pile at D=11.80 ft below finished grade,
P= 2.464 * .120 kcf * 8.800 ft = 2.602 ksf
--> Force E = 1/2* 8.800 ft * 6.00 ft * 2.602 ksf = 68.69 k

Behind pile at 3.00 ft below finished grade,
P= .406 * .120 kcf * 23.000 ft = 1.120 ksf
<-- Force B = 8.800 ft * 2.77 ft * 1.120 ksf = 27.31 k

Behind pile at D=11.80 ft below finished grade,
P= .406 * (.120 kcf * 23.000 ft + .120 kcf * 8.800 ft)
= 1.549 ksf
<-- Force C = 1/2* 8.800 ft * 2.77 ft * (1.549 ksf - 1.120 ksf) = 5.22 k

R_{Load} = R + Force B + Force C = 13.11 + 27.31 + 5.22 = 45.64 k

SF = Force E/R_{Load} = 68.69 k/ 45.64 k = 1.505> 1.5 (OK)

GROUND ANCHORED WALL DESIGN:

COMPUTE REQUIRED DEPTH OF EMBEDMENT FOR VERTICAL LOADS:

Calculate Total Axial Load (above finished grade loads only):

Vertical anchor force of anchor = 156.92 k * Sin(45.00)	=	110.92 k
Weight of Steel Soldier Piles	=	1.78 k
Weight of Concrete Encasement	=	19.42 k
Weight of Timber Lagging	=	1.75 k
Weight of Concrete Facing	=	18.00 k
Total	=	151.87 k

Depth of embedment required for vertical loads is D = 5.00 ft

Detailed Calculation:

Safety factors to be applied (see Ref. 1, Table 14)
Skin Friction, SF = 2.5 for Clays
End Bearing, SF = 2.5 for Clays

Resistances for augered piles in clay per AASHTO LRFD Art. 10.8:
Skin friction, $q_s = \alpha$ *Su (LRFD Eq. 10.8.3.5.1b-1)
in which α =0/55 for Su/p_a < 1.5 (LRFD Eq. 10.8.3.4.1b-2)
and α =0.55-0.1*(Su/p_a -1.5)
for 1.5 < Su/p_a <2.5 (LRFD Eq. 10.8.3.4.1b-3)
where S_u = undrained shear strength = 2.00 ksf
p_a = atmospheric pressure = 2.12 ksf
Solving, α = .550
q_s = 1.100 ksf

Qskin = (q_s * Area Skin)
Compute Area Skin at 2.00 ft below ineffective zone:
Perimeter of embeded portion = 8.73 ft
Area Skin = 8.73 ft * 2.00 ft = 17.46 s.f.
---> Qskin = 1.10 ksf * 17.46 s.f. = 19.21 k

End bearing, $q_p = N_c * S_u$ < 80 (LRFD Eq. 10.8.3.5.1c-1)
in which N_c = 6*[1 + 0.2*(Z/D)]< 9 (LRFD Eq. 10.8.3.5.1c-2)
where D = diameter of drilled shaft (ft)
Z = penetration of shaft (ft)
Solving, N_c = 6.87
q_p = 13.733 ksf
Qend = q_p *Area End (use punch-out area because of low strength conc)
= 13.73 ksf * 31.30 s.f. = 429.89 k

Qallowable = Qskin/SF + Qend/SF
= 19.21/2.50 + 429.89/2.50 = 179.64 k> 151.87 k (OK)

Governing required Depth of Embedment is D = 11.80 ft