```
==========================================================================
ABUTMENT DESIGN:
----------------------------

DESIGN DATA:
------------
Design Method: Load Factor Design
        Dead Load Factor=1.39
        Live Load Factor=1.70
        Earth Pressure Load Factor=1.70

Concrete strength, fc'= 3.50 ksi
Reinforcing,       Fy= 60 ksi

Minimum reinforcing steel ratio, pmin=0.00132 (on gross area)

Bar clearances:  3.00 inches for bars cast above grade
                 2.00 inches for other bars

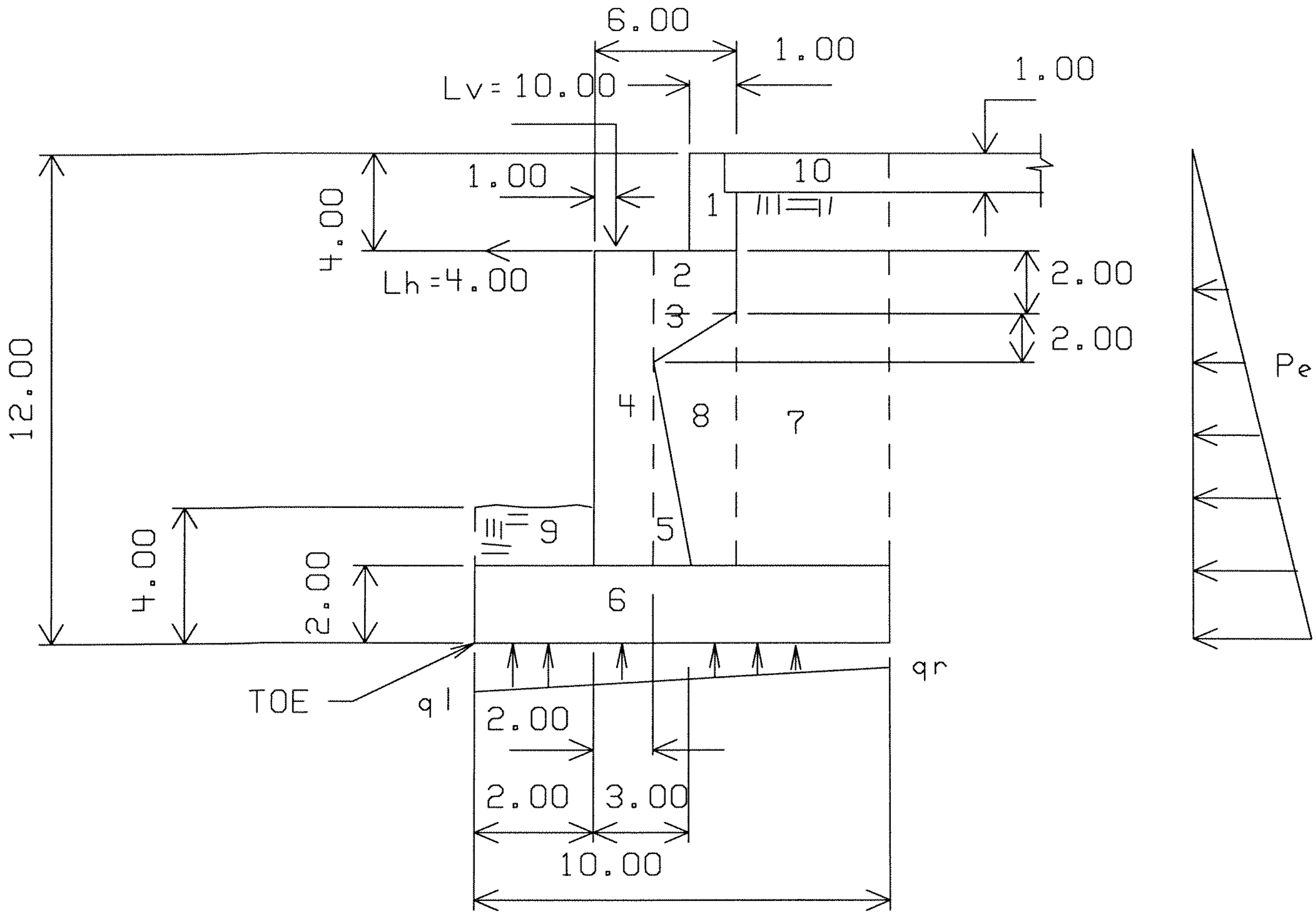
Soil behind wall is unsaturated. Dry earth weight =  .119 kcf
Angle of internal friction= 30.00 degrees

Design for active earth pressure:
Ka=[1-sin(30.00)]/[1+sin(30.00)]= .333
Pa= .333x .119=0.040 kcf

For sliding check of spread footings (see '91 AASHTO Table 5.5.5B):
  Interface:Clean silty or clayey gravel
  Friction factor=  .449
  Adhesion  = 0.000 ksf
```

FIRM:Your Firm JOB NO. SHEET NO: 2
MADE BY:KJH DATE:05-21-2006 CHECKED BY: DATE:
TITLE:Example ABUTMENT calculation

ABUTMENT DESIGN:



STABILITY ANALYSIS:

Item	V	H	arm	Mtoe
1: 1.00 X 4.00 X .15 =	.6		7.50	4.5
2: 4.00 X 2.00 X .15 =	1.2		6.00	7.2
3: 1/2 X 4.00 X 2.00 X.15 =	.6		5.33	3.2
4: 2.00 X 6.00 X .15 =	1.7		3.00	5.3
5: 1/2 X 1.00 X 2.00 X.15 =	.1		4.33	.6
6: 10.00 X 2.00 X .15 =	3.0		5.00	15.0
7: 2.00 X 9.00 X .119 =	2.1		9.00	19.4
8:	1.3		6.39	8.4
9: 2.00 X 2.00 X .119 =	.4		1.00	.4
10: 2.00 X 1.00 X .15 =	.3		9.00	2.7
Lv:	10.0		3.00	30.0
Lh:		4.0	-8.00	-32.0
Pe: 1/2x (11.0)^2 x 0.040 =		2.4	-3.66	-8.8
Ps: 1.00 x.15x .333 x 11.00 =		.5	-5.50	-3.0
TOTALS =	21.6	6.9		53.1

Eccentricity, e = 53.1/ 21.6= 2.45 feet right of toe

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FIRM:Your Firm                                  JOB NO.              SHEET NO:  3
MADE BY:KJH  DATE:05-21-2006                    CHECKED BY:          DATE:
TITLE:Example ABUTMENT calculation
==============================================================================
ABUTMENT DESIGN:
------------------------------
e<W/2= 5.000, therefore footing uplifts

Length of pressure triangle=3 x  2.457= 7.373

  21.6 = 1/2 x  7.373 x ql
ql=2 x   21.6/ 7.373 =  5.861 ksf

CHECK OVERTURNING WITHOUT SUPERSTRUCTURE IN PLACE:
--------------------------------------------------
Overturning moment, Mo=    3.02+   8.87=  11.89 k*ft
Righting moment,    Mr=    4.50 +    7.20 +    3.20 +    5.39
                       +     .65 +   15.00 +   19.43 +    8.43
                       +     .47+   2.70 =   67.00 k*ft

Safety factor against overturning,
      SF=Mr/Mo=  67.00/  11.89= 5.631

CHECK SLIDING:
-------------
Available friction at base=  .449x  21.6 k + 0.000x10.00' =   9.72 k

Kp=(1+sin30.00)/(1-sin30.00)= 2.99
Pp =  .119 x  2.99 =    .359 kcf
Available passive pressure in front=1/2x .359 ksfx(4.000 ft)^2  =   2.87 k

Safety factor against sliding (w/o passive pressure)
       =    9.72/   6.9= 1.395
Safety factor against sliding (w/passive pressure)
       =(   9.72+   2.87)/   6.9= 1.808
```

==

ABUTMENT DESIGN:

COMPUTE FACTORED FOOTING PRESSURES FOR FOOTING DESIGN:

For footing design purposes, linear contact pressures are computed based on the factored loads (see AASHTO Standard Spec. 5.14.7).

Factoring forces and moments from stability analysis:

```
Vfactored = (  .60 +  1.20 +   .60 +  1.79 +   .15 +  3.00 +  2.15
            +  1.31 +   .47 +   .30 +  0.00 ) x 1.39        (Dead loads)
            +  10.00 x 1.70                                  (Live load)
          =  33.25 k/ft
Hfactored = (  .55 +  2.42) x 1.70                           (Earth loads)
            +  4.00 x 1.70                                   (Live load)
          =  11.84 k/ft
Mfactored = (  4.50 +   7.20 +   3.20 +   5.39 +    .65 +  15.00 +  19.43
            +   8.43 +    .47 +   2.70 +   0.00 ) x 1.39    (Dead loads)
            + ( -3.02 +  -8.87) x 1.70                       (Earth loads)
            + ( 30.00 + -32.00) x 1.70                       (Live load)
          =   70.1 k*ft/ft
```

Eccentricity due to factored loads,
e = 70.1/ 33.2= 2.11 feet right of toe

e<W/2= 5.000, therefore footing uplifts

Length of pressure triangle=3 x 2.110= 6.331

33.2 = 1/2 x 6.331 x ql
Factored ql=2 x 33.2/ 6.331 = 10.503 ksf

COMPUTE FACTORED FOOTING PRESSURES FOR BEARING CAPCITY FAILURE CHECK:

Customarily, service load pressures (see previous sheet) have been checked against allowable bearing pressures. With the introduction of LF/LRFD design approaches, a check of factored pressure compared to ultimate bearing capacity is also required (see AASHTO Standard Spec. 5.14.6.1 and LRFD Art. 10.6.2.2.4).

To check against bearing capacity failure, a uniform contact pressure acting over an effective width equal to "B - 2*e" is computed using the factored loads.

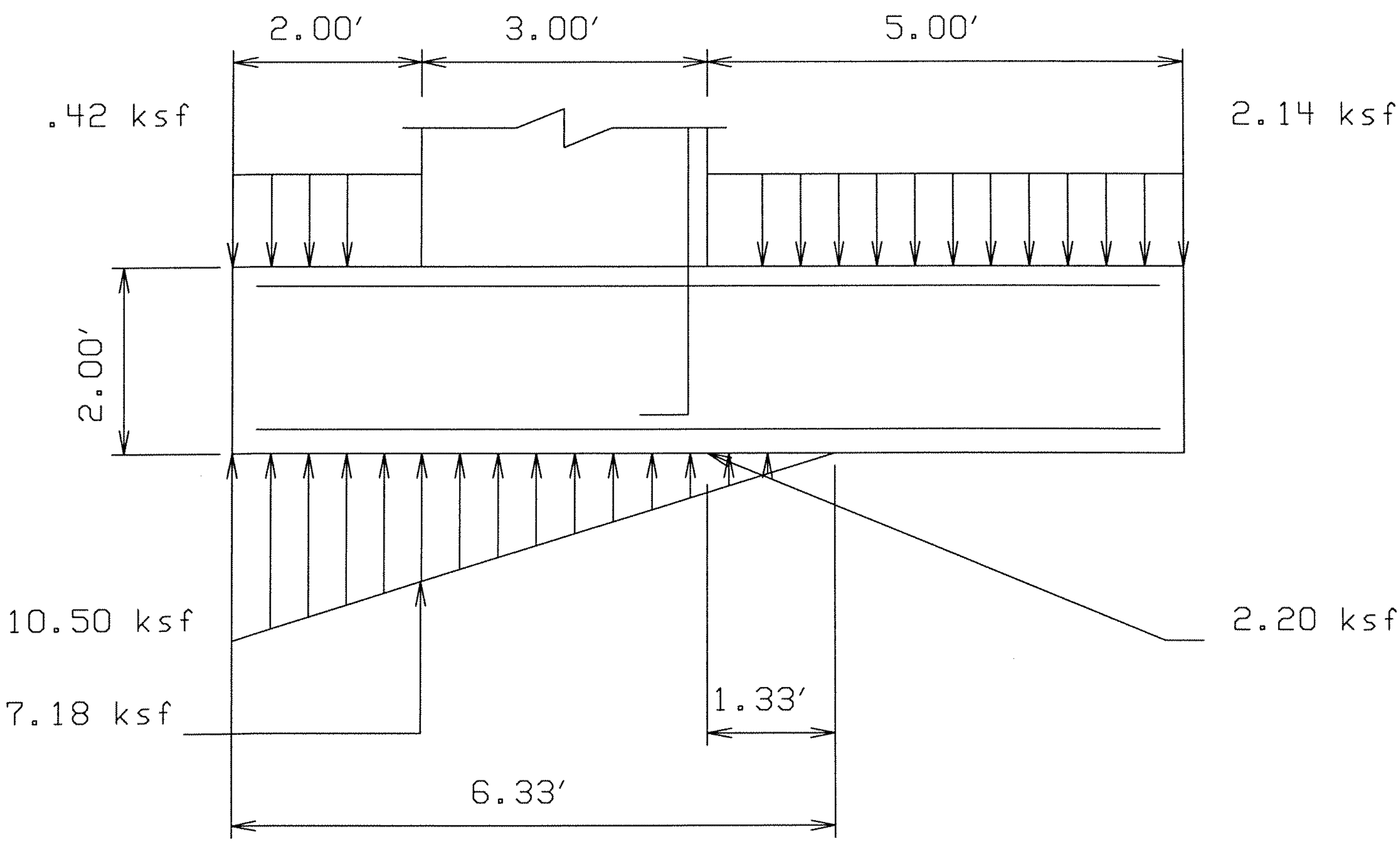
Footing width, B= 7.37 ft
Eccentricity to center of footing, e = 7.37 ft/2 - 2.11 ft = 1.57 ft
Effective contact width, B - 2*e = 7.37 ft - 2* 1.57 ft = 4.22 ft

Uniform factored pressure, q_{max} = 33.2 k/ft/ 4.22 ft = 7.87 ksf

(The designer will need to check "q_{max}" against the reduced "q_{ult}" specific to geotechnical information at this location.)

FIRM:Your Firm JOB NO. SHEET NO: 5
MADE BY:KJH DATE:05-21-2006 CHECKED BY: DATE:
TITLE:Example ABUTMENT calculation

ABUTMENT DESIGN:



FOOTING DESIGN DATA:

Minimum reinforcement ratio=0.0013 (on gross area)
Fy= 60.00 ksi, fc'=3.50 ksi
Allowable shear= 0.85 * 2 (3500)$^{.5}$ =100 psi

d = 12 x 2.00 - (3.00 + 0.5) in= 20.50 in (bottom bars)
= 12 x 2.00 - (2.00 + 0.5) in= 21.50 in (top bars)

LOADS ON TOP OF FOOTING:

Load on toe,
(Neglect overburden on toe, due to possibility of erosion)
Dead load footing= 2.00 x 0.15 = .30 ksf
Factored dead load footing = 1.39 x .30 ksf = .42 ksf

Load on heel,
=(12.00 - 2.00 - 1.00)x .119 kcf + 1.00*.15 + .30 ksf= 1.52 ksf
Factored load on heel = 1.39 x 1.52 ksf = 2.14 ksf

ABUTMENT DESIGN:

TOE DESIGN:

Factored MdlU= .42 x $(2.00)^2$ /2= .84 k*ft/ft

Critical section for shear at 2.00 ft- 20.50in/12= .29 ft from toe
Factored VdlU= .42 x .29= .12 k/ft

Compute factored toe moment and shear due to factored footing pressures:
MqU= 7.18x$(2.00)^2$ /2 + 1/3x(10.50 - 7.18)x$(2.00)^2$ =18.79 k*ft

At critical shear section, q= 10.50 - .29 x 10.50/ 6.33=10.01 k
VqU= 10.01 x .29 +1/2x(10.50 - 10.01)x .29= 2.99 k

Total factored shear, Vu= 2.99 - .12 = 2.87 k
Shear stress= 2.87/(12x 20.50) x 1000= 11 psi < 100 psi (OK)

Factored moment, Mu= 18.79 - .84 = 17.95 k*ft

By trial and error, compression block depth, a= .32 in

As=12*M/(0.9*Fy(d-a/2))
=12 x 17.9/(0.9 x 60 (20.50 - .32/2))
= .19 in^2 /ft

Check a:
a=AsxFy/(0.85 x Fc x b)
= .19 x 60.00/(0.85 x 3.50 x 12)
= .32 in (checks)

Mininum reinforcement,
Amin=200/60000 x 20.50 x 12 = .81 in^2 /ft
or = 1.33 x .19 = .26 in^2 /ft
but not less than, 0.0013 x 24.00 x 12 = .38 in^2 /ft

Toe reinforcement req'd= .38 sq.in./ft Bot.

==

ABUTMENT DESIGN:

HEEL DESIGN:

Factored MdlU=1/2x 2.14x(5.00)^2 = 26.77 k*ft

Factored VdlU= 2.14x 5.00=10.71 k/ft

Factored heel moment and shear due to factored footing pressures:
MqU=1/6x 2.20x(1.33)^2 = .6 k*ft
VqU=1/2x 2.20x 1.33= 1.47 k

VUtot=10.71 - 1.47 = 9.23 k
Shear stress= 9.23/(12x 21.50) x 1000= 35 psi < 100 psi (OK)

Factored moment, Mu = .65 - 26.77 = -26.12 k*ft

By trial and error, compression block depth, a= .45 in

As=12*M/(0.9*Fy(d-a/2))
=12 x 26.1/(0.9 x 60 (21.50 - .45/2))
= .27 in^2 /ft

Check a:
a=AsxFy/(0.85 x Fc x b)
= .27 x 60.00/(0.85 x 3.50 x 12)
= .45 in (checks)

Mininum reinforcement,
Amin=200/60000 x 21.50 x 12 = .86 in^2 /ft
or = 1.33 x .27 = .36 in^2 /ft
but not less than, 0.0013 x 24.00 x 12 = .38 in^2 /ft

Heel reinforcement req'd= .38 sq.in./ft Top

ABUTMENT DESIGN:

HEEL DESIGN (Cont'd):

ALTERNATE LOADING CASE:

Calculate reinforcement required for moment due to loads above the footing only. This condition will correspond roughly to when the abutment is backfilled without superstructure or with little or no live load.
Use an arbitrary reduced load factor, LF=1.3:

Alternate Mu = -1.3 x 1/2 x (1.52 ksf) x (5.00)^2 = -24.86 k*ft

By trial and error, compression block depth, a= .43 in

As=12*M/(0.9*Fy(d-a/2))
=12 x 24.8/(0.9 x 60 (21.50 - .43/2))
= .25 in^2 /ft

Check a:
a=AsxFy/(0.85 x Fc x b)
= .25 x 60.00/(0.85 x 3.50 x 12)
= .43 in (checks)

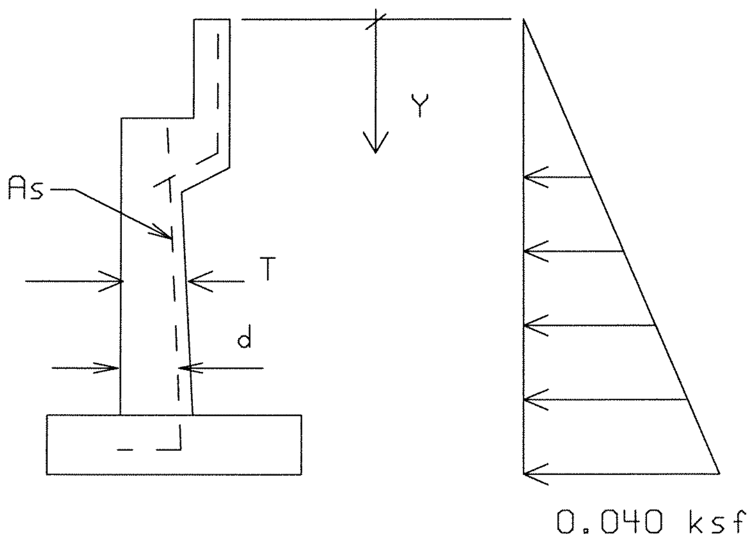
Mininum reinforcement,
Amin=200/60000 x 21.50 x 12 = .86 in^2 /ft
or = 1.33 x .25 = .34 in^2 /ft
but not less than, 0.0013 x 24.00 x 12 = .38 in^2 /ft

| Heel reinforcement req'd= .38 sq.in./ft Top |

FIRM:Your Firm JOB NO. SHEET NO: 9
MADE BY:KJH DATE:05-21-2006 CHECKED BY: DATE:
TITLE:Example ABUTMENT calculation

ABUTMENT DESIGN:

STEM DESIGN - BACK FACE BARS:



Load factor for stem design=1.70
Distance from center of bars to back face = 2.00 + 0.5 in.= 2.50 in

					Reinforcement in back face (sq. in/ft)				
y (ft)	M (k*ft)	Mu (k*ft)	t (in)	d (in)	As,req'd	4/3xAs Min.	Min ratio 200/Fy	Min. ratio 0.0013	Use As
0.0	0.0	0.0	12.00	9.50	0.00	0.00	.37	.19	.19
1.0	0.0	0.0	12.00	9.50	0.00	0.00	.37	.19	.19
2.0	0.0	.0	12.00	9.50	0.00	0.00	.37	.19	.19
3.0	.1	.3	12.00	9.50	0.00	0.00	.37	.19	.19
4.0	.4	.7	12.00	9.50	0.01	0.02	.37	.19	.19
5.0	.8	1.4	72.00	69.50	0.00	0.00	2.77	1.14	1.14
6.0	1.4	2.4	72.00	69.50	0.00	0.01	2.77	1.14	1.14
7.0	2.2	3.8	48.00	45.50	0.01	.02	1.82	.76	.76
8.0	3.4	5.8	24.00	21.50	0.06	0.07	.86	.38	.38
9.0	4.8	8.2	30.00	27.50	0.06	0.08	1.10	.47	.47
10.0	6.6	11.3	36.00	33.50	0.07	.10	1.34	.57	.57

Shear at base of stem=1/2x(10.0)^2 x0.040= 2.00 k
Vu=1.70 x 2.00= 3.40 k

fv= 3.40/(12x33.50)x1000= 8 psi < fv,allowable=100 psi (OK)

FIRM:Your Firm　　　　　　　　　　JOB NO.　　　　　SHEET NO: 10
MADE BY:KJH DATE:05-21-2006　　　CHECKED BY:　　　DATE:
TITLE:Example ABUTMENT calculation

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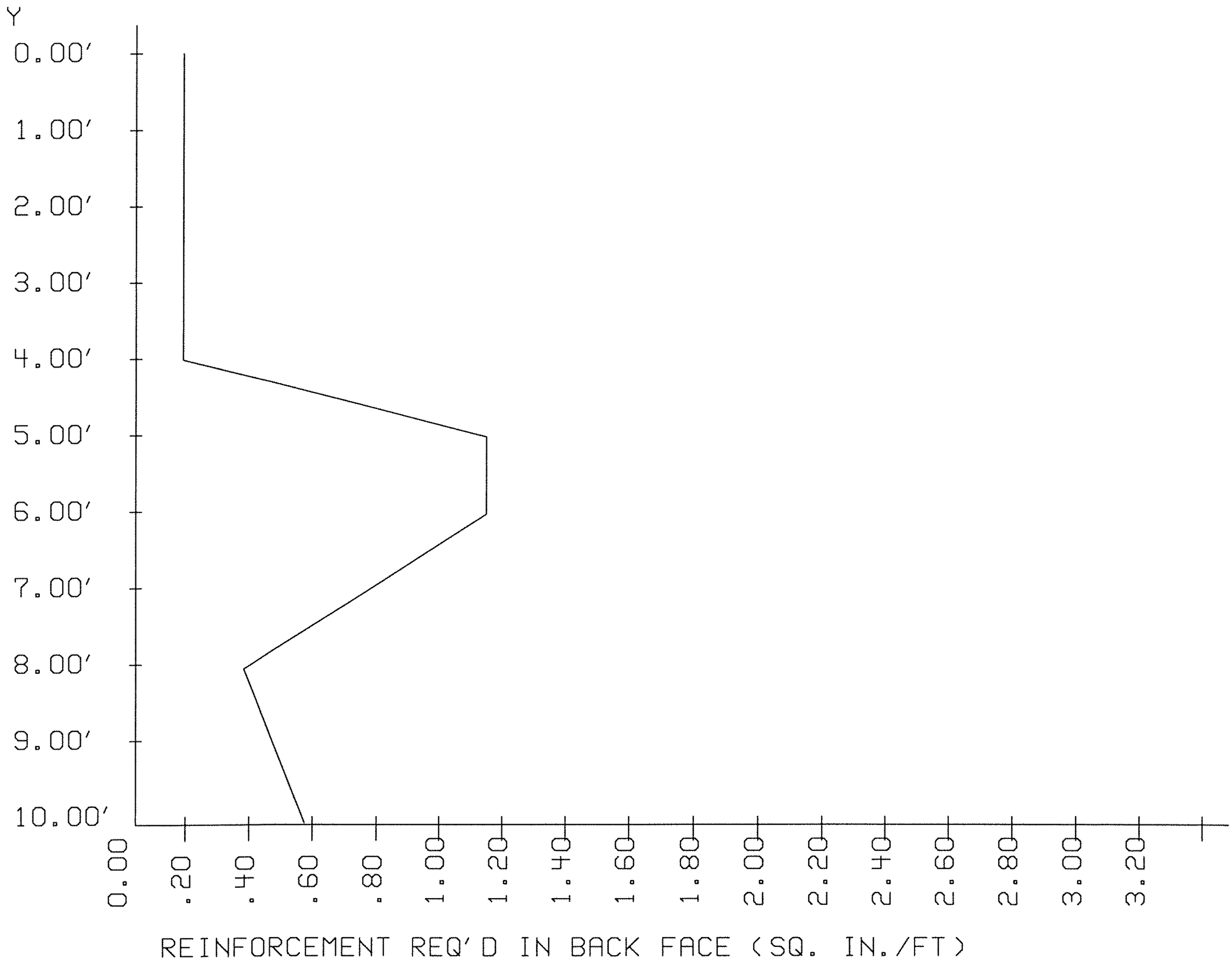
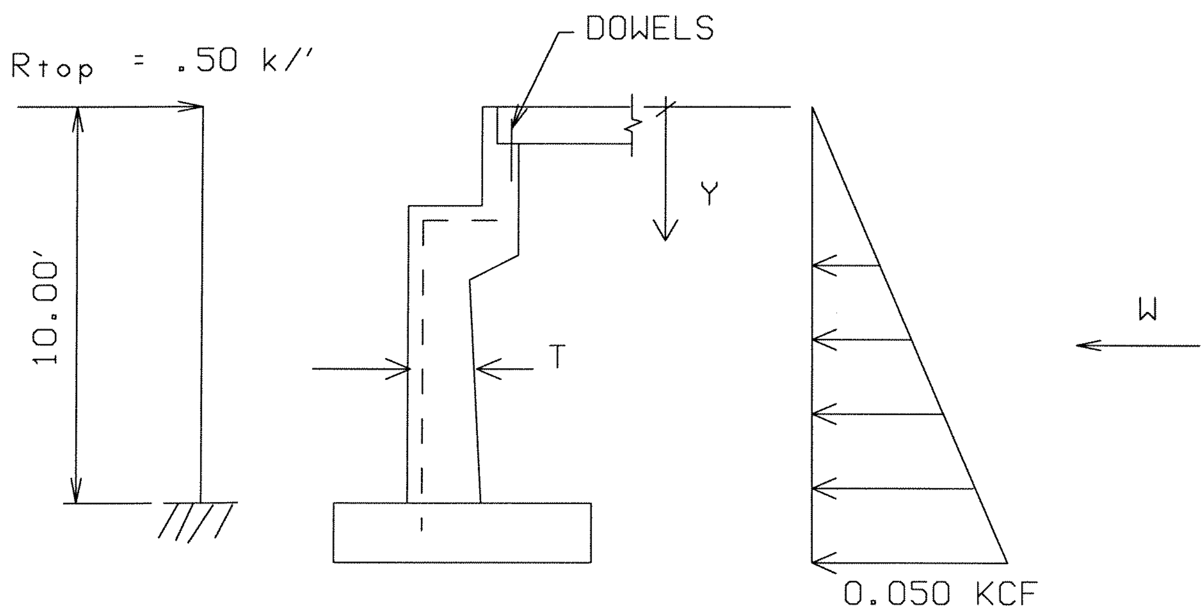
ABUTMENT DESIGN:

STEM DESIGN - BACK FACE BARS:



ABUTMENT DESIGN:

STEM DESIGN - FRONT FACE BARS:



With time, creep and settlement in the fill will cause the abutment to act as a pinned-fixed structure. Pressures will tend to increase towards the at-rest state. Arbitrarily design for 125% of active pressure: 125%* 0.040 kcf=0.050 kcf

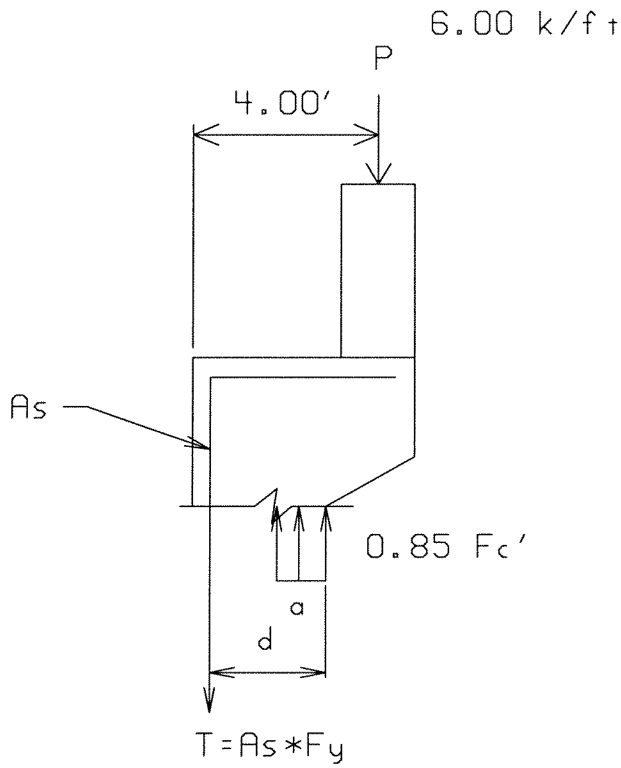
Load factor for stem design=1.70
Distance from center of bars to front face = 2.00 + 0.5 in.= 2.50 in

					Reinforcement in front face (sq. in/ft)				
y (ft)	M (k*ft)	Mu (k*ft)	t (in)	d (in)	As,req'd	4/3xAs Min.	Min ratio 200/Fy	Min. ratio 0.0013(*)	Use As*
0.0	0.0	0.0	12.00	9.50	0.00	0.00	.37	(*)	0.00
1.0	.4	.8	12.00	9.50	0.01	0.02	.37	(*)	0.02
2.0	.9	1.5	12.00	9.50	.03	0.04	.37	(*)	0.04
3.0	1.2	2.1	12.00	9.50	0.05	0.06	.37	(*)	0.06
4.0	1.4	2.4	12.00	9.50	0.05	0.07	.37	(*)	0.07
5.0	1.4	2.4	72.00	69.50	0.00	0.01	2.77	(*)	0.01
6.0	1.2	2.0	72.00	69.50	0.00	0.00	2.77	(*)	0.00
7.0	.6	1.0	48.00	45.50	0.00	0.00	1.82	(*)	0.00
8.0	-.2	-.4	24.00	21.50	0.00	0.00	.86	(*)	0.00
9.0	-1.5	-2.6	30.00	27.50	0.00	0.00	1.10	(*)	0.00
10.0	-3.3	-5.6	36.00	33.50	0.00	0.00	1.34	(*)	0.00

(* - NOTE: Designer should evaluate if the 0.0013 minimum ratio applies for this condition.)

ABUTMENT DESIGN:

STEM DESIGN - FRONT FACE BARS:



Design front face bars to resist load on backwall (neglect other forces)
Use load factor = 1.70
P= 1.70 * 6.00 k/ft = 10.20 k/ft
d= 12* 2.00 ft- (2.00 + .5) in = 21.50 in
e= 12* 4.00 ft-(2.00 + .5) in = 45.50 in (measured from P to front bars)
Concrete compression force, Fcomp= P*e/(d-a/2)
Also, Fcomp=0.85*fc'*a*12

By trial and error, a= .61 in
therefore, Fcomp= 10.20 * 45.50 /(21.50 - .61/2)= 21.89 k/ft

Check a= 21.8/(0.85*3.50 ksi*12)= .61 in

Force in steel, T=Fcomp - P= 21.89 - 10.20 = 11.69 k/ft
Using 0.9 strength reduction factor, design for T= 11.69/0.9= 12.99 k/ft

Required area of steel = T/Fy= 12.99/60 = .21 sq. in./per ft.

Mininum reinforcement,
Amin=200/60000 x 21.50 x 12 = .86 in^2 /ft
or = 1.33 x .21 = .28 in^2 /ft
but not less than, 0.0013 x 24.00 x 12 = .38 in^2 /ft

Front face reinforcement req'd= .38 sq. in./ft