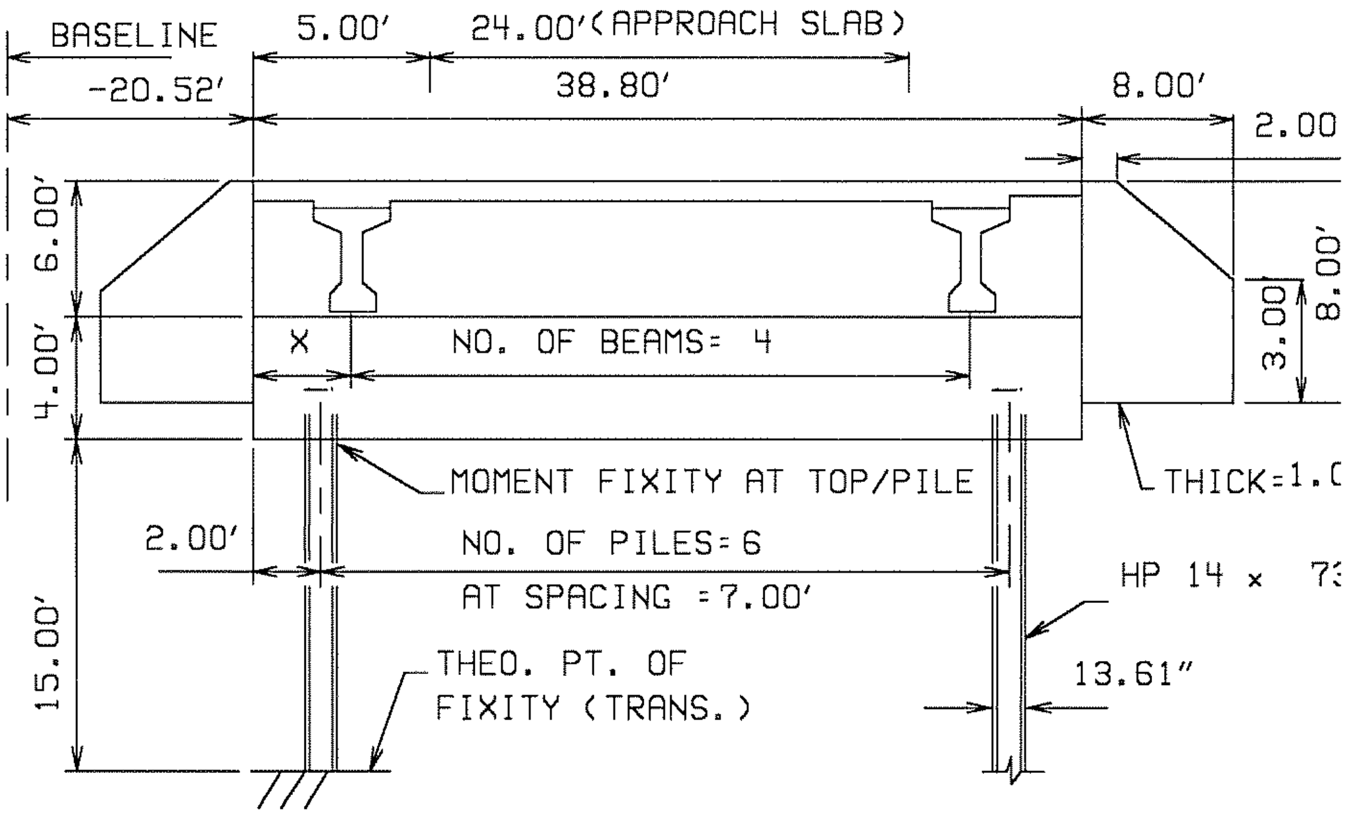
FIRM:DesignCalcs, Inc                              JOB NO.1234567890  SHEET NO:  1
MADE BY:KJH  DATE:03-28-2014                       CHECKED BY:        DATE:
TITLE:Example INTEGRAL abument calculation

INTEGRAL ABUTMENT DESIGN:




ELEVATION LOOKING UPSTATION

DESIGN DATA:

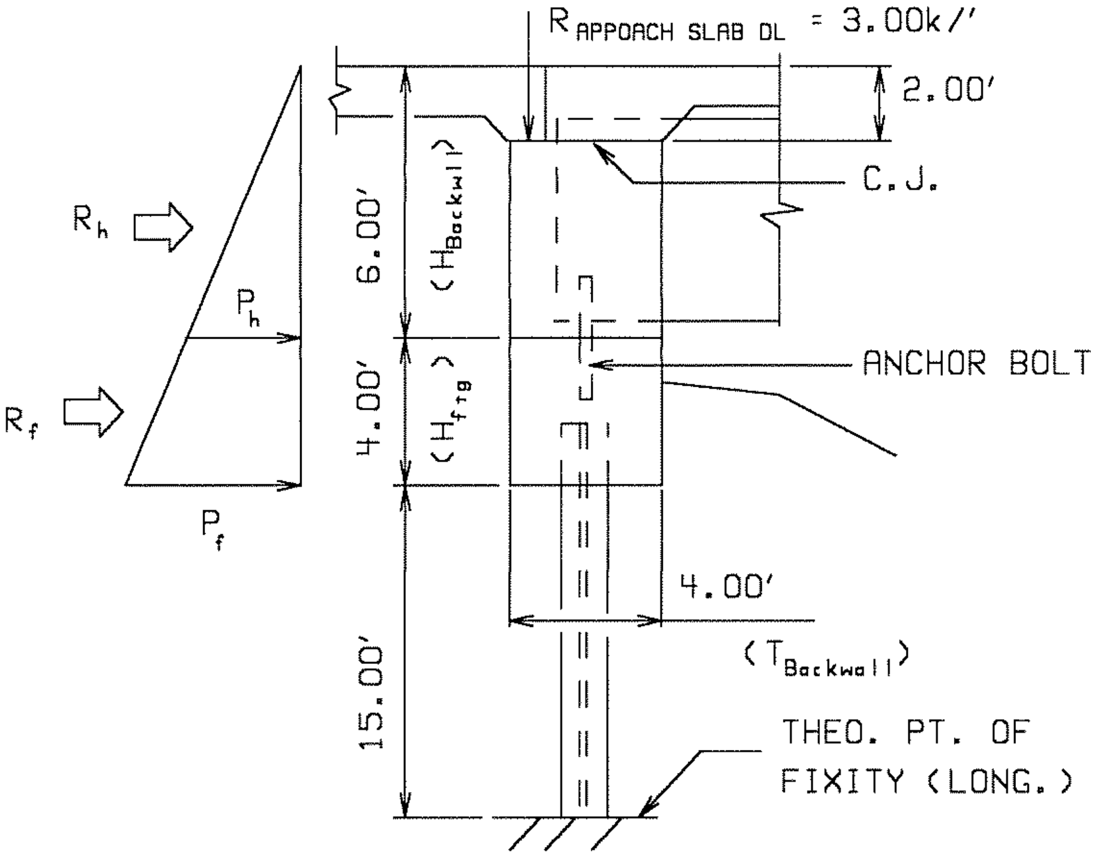
Design Method: 2012 AASHTO LRFD Specification
Concrete strength, fc'= 4.00 ksi
Concrete Modulus of Rupture,
$fr = 0.37 * (fc')^{.5}$ (LRFD 5.4.2.6)
$= 0.37 * (4.000)^{.5} = .740$ ksi

Reinforcing, Fy= 60 ksi

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

Passive earth pressure coefficient, Kp = 4.000
At-rest earth pressure coefficient, Ko = .500
Backfill unit weight, γ = 145 pcf

INTEGRAL ABUTMENT DESIGN:




SECTION THRU ABUTMENT

Description of Analysis Approach:

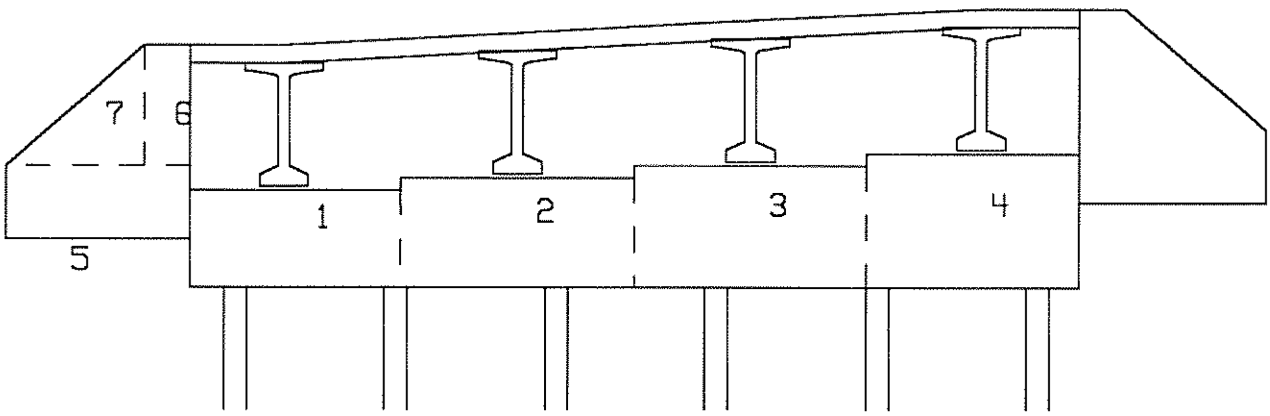
This program analyzes integral abutments by modeling an abutment as a pile bent. For vertical loading, the pile bent consists of of a cap beam supported by piles. For horizontal loading due to passive earth pressure, the cap beam is analyzed as a continuous beam, supported laterally by the bridge beams. Similarly, the backwall is analyzed as a continuous beam subject to passive earth pressure, laterally supported by the bridge beams.

The 2012 AASHTO Specification has no load factor for passive pressure. This program assumes that at-rest earth pressure exist when the bridge is backfilled immediately after construction. However, as the bridge expands, the earth pressure will increase from at-rest toward passive, depending on the amount of movement. In this respect, passive earth pressure is a direct consequence of temperature, which uses $\gamma_{TU}$ = 1.20.

The user has entered the following load factor to be applied to passive pressure: $\gamma_{PASSIVE}$ =1.20

FIRM:DesignCalcs, Inc. JOB NO.1234567890 SHEET NO: 3
MADE BY:KJH DATE:03-28-2014 CHECKED BY: DATE:
TITLE:Example INTEGRAL abument calculation

INTEGRAL ABUTMENT DESIGN:




Cap Beam Dead Loads (DC1):

| Item No. | Xbegin (ft) | Length (ft) | Beam Seat Elev. | Bot/Cap Elev. | Depth (ft) | Thickness (ft) | Weight (k/ft) |
|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 9.21 | 109.72 | 104.20 | 4.00 | 4.00 | 2.400 |
| 2 | 9.21 | 10.17 | 109.72 | 104.20 | 4.51 | 4.00 | 2.705 |
| 3 | 19.37 | 10.11 | 109.72 | 104.20 | 5.01 | 4.00 | 3.009 |
| 4 | 29.49 | 9.31 | 109.72 | 104.20 | 5.51 | 4.00 | 3.308 |

Wingwall Dead Load (DC1):

| Item No. | Height (ft) | Length (ft) | Thickness (ft) | Weight (k) | Arm (ft) | Moment (k*ft) |
|---|---|---|---|---|---|---|
| 5 | 3.00 | 8.00 | 1.00 | 3.60 | 4.00 | 14.40 |
| 6 | 5.00 | 2.00 | 1.00 | 1.50 | 1.00 | 1.50 |
| 7 | 5.00 | 6.00 | 1.00 | 2.25 | 5.00 | 11.25 |
| | | | Total = | 7.35 k | M = | 27.15 k*ft |

## INTEGRAL ABUTMENT DESIGN:

### LOADS FROM SUPERSTRUCTURE:

### VERTICAL SUPERSTRUCTURE REACTIONS (UNFACTORED):

| Bm No. | X (ft) | DC1 (k) | DC2 (k) | DW (k) | LL (k) | WS (k) | WL (k) | BR (k) | TU (k) | EQ (k) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.1 | 119.76 | 12.90 | 6.20 | 0.00 | -26.97 | -2.37 | 0.00 | 0.00 | 0.00 |
| 2 | 14.3 | 119.76 | 12.90 | 6.20 | 79.68 | -16.24 | -.79 | 0.00 | 0.00 | 0.00 |
| 3 | 24.5 | 119.76 | 12.90 | 6.20 | 84.32 | -5.51 | .79 | 0.00 | 0.00 | 0.00 |
| 4 | 34.5 | 119.76 | 12.90 | 6.20 | 77.80 | 5.10 | 2.36 | 0.00 | 0.00 | 0.00 |

### Addition Vertical Dead Loads from Diaphragm And Approach Slab:

Diaphragm Unit Weight = ( 6.00' -  8.50 inch deck/12)* 4.00'*.15
                      =  3.17 k/ft

| Bm No. | X (ft) | DC1 from super (k) | Diaphragm Trib. L | Diaphragm Wt | Approach Slab Trib. L | Approach Slab Wt | Total DC1 k |
|---|---|---|---|---|---|---|---|
| 1 | 4.1 | 119.76 | 5.08 | 16.14 | 9.21 | 27.62 | 163.53 |
| 2 | 14.3 | 119.76 | 10.17 | 32.28 | 10.17 | 30.50 | 182.54 |
| 3 | 24.5 | 119.76 | 10.11 | 32.11 | 9.63 | 28.88 | 180.75 |
| 4 | 34.5 | 119.76 | 9.31 | 29.56 | 0.00 | 0.00 | 149.32 |

INTEGRAL ABUTMENT DESIGN:

LOADS FROM SUPERSTRUCTURE (Cont'd):

NORMAL SUPERSTRUCTURE REACTIONS (UNFACTORED):

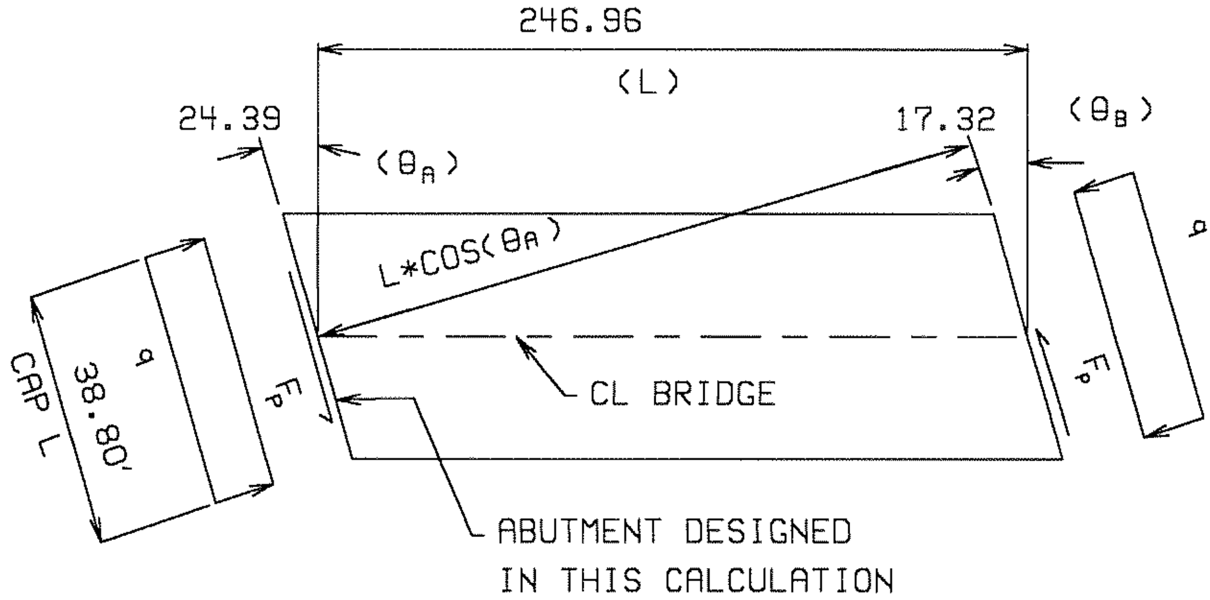
| Bm No. | X (ft) | DC1 (k) | DC2 (k) | DW (k) | LL (k) | WS (k) | WL (k) | BR (k) | TU (k) | EQ (k) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.1 | 0.00 | 0.00 | 0.00 | 0.00 | -2.70 | -.64 | 8.20 | 0.00 | 0.00 |
| 2 | 14.3 | 0.00 | 0.00 | 0.00 | 0.00 | -2.70 | -.64 | 8.20 | 0.00 | 0.00 |
| 3 | 24.5 | 0.00 | 0.00 | 0.00 | 0.00 | -2.70 | -.64 | 8.20 | 0.00 | 0.00 |
| 4 | 34.5 | 0.00 | 0.00 | 0.00 | 0.00 | -2.70 | -.64 | 8.20 | 0.00 | 0.00 |

TRANSVERSE SUPERSTRUCTURE REACTIONS (UNFACTORED):

| Bm No. | X (ft) | DC1 (k) | DC2 (k) | DW (k) | LL (k) | WS (k) | WL (k) | BR (k) | TU (k) | EQ (k) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.1 | 0.00 | 0.00 | 0.00 | 0.00 | 5.95 | 1.41 | 3.72 | 0.00 | 0.00 |
| 2 | 14.3 | 0.00 | 0.00 | 0.00 | 0.00 | 5.95 | 1.41 | 3.72 | 0.00 | 0.00 |
| 3 | 24.5 | 0.00 | 0.00 | 0.00 | 0.00 | 5.95 | 1.41 | 3.72 | 0.00 | 0.00 |
| 4 | 34.5 | 0.00 | 0.00 | 0.00 | 0.00 | 5.95 | 1.41 | 3.72 | 0.00 | 0.00 |

## INTEGRAL ABUTMENT DESIGN:

### LATERAL BUTTRESS FORCE (EH):




For bridges with skews, the entire superstructure tends to rotate because the lateral earth pressure forces at each abutment are not concentric. The magnitude of lateral earth pressure is dependent on the direction and amount of movement, which can change.

The eccentricity of the earth forces creates a couple acting on the the entire bridge:

M = q*(Cap L)*sin(θ)*L (Eq. A)

This couple is resisted by a corresponding couple acting perpendicular to both abutment pile bents, each with force "Fp":

M = Fp*cos(θ)*L (Eq. B)

Equating the above equations "A" and "B" leads to,

Fp = q * (Cap L) * tan(θ)

where,

q = at-rest earth pressure force
= 1/2 * $\gamma_e$ * $K_o$ * $H^2$
= 1/2 * .145 kcf * .50 * ( 4.00 + 6.00)$^2$
= 3.62 k/ft

Cap L = Abutment Length = 38.80 ft

θ = 24.39 degrees

--> Fp = ( 3.62)*( 38.80)*tan( 24.39) = 63.8 k

## INTEGRAL ABUTMENT DESIGN:

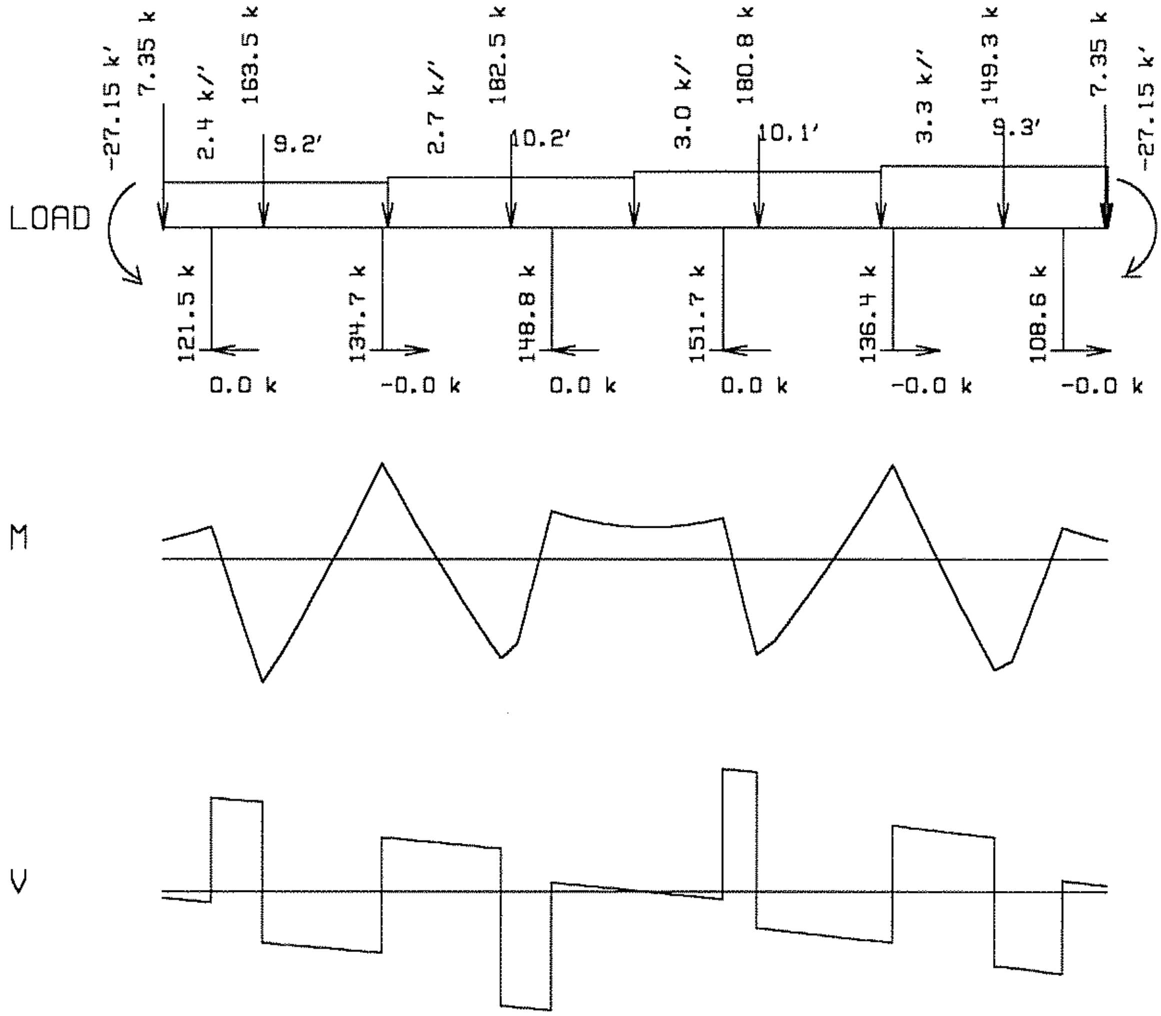
LOAD FACTORS FOR LOADING CASES (Refer to LRFD Table 3.4.1-1):

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SERVICE I | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| STRENGTH I MAX | 1.25 | 1.25 | 1.50 | 1.75 | 1.75 | 1.35 | 0.00 | 0.00 | 1.75 | .50 | 0.00 |
| STRENGTH I MIN | .90 | .90 | .65 | 1.75 | 1.75 | .90 | 0.00 | 0.00 | 1.75 | .50 | 0.00 |
| STRENGTH II MAX | 1.25 | 1.25 | 1.50 | 0.00 | 0.00 | 1.35 | 1.00 | 0.00 | 0.00 | .50 | 0.00 |
| STRENGTH II MIN | .90 | .90 | .65 | 0.00 | 0.00 | .90 | 1.00 | 0.00 | 0.00 | .50 | 0.00 |
| STRENGTH V MAX | 1.25 | 1.25 | 1.50 | 1.35 | 1.35 | 1.35 | .40 | 1.00 | 1.35 | .50 | 0.00 |
| STRENGTH V MIN | .90 | .90 | .65 | 1.35 | 1.35 | .90 | .40 | 1.00 | 1.35 | .50 | 0.00 |
| EXTREME I MAX | 1.25 | 1.25 | 1.50 | 0.00 | 0.00 | 1.35 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| EXTREME I MIN | .90 | .90 | .65 | 0.00 | 0.00 | .90 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |

FIRM:DesignCalcs, Inc. JOB NO.1234567890 SHEET NO: 8
MADE BY:KJH DATE:03-28-2014 CHECKED BY: DATE:
TITLE:Example INTEGRAL abument calculation

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE DC1

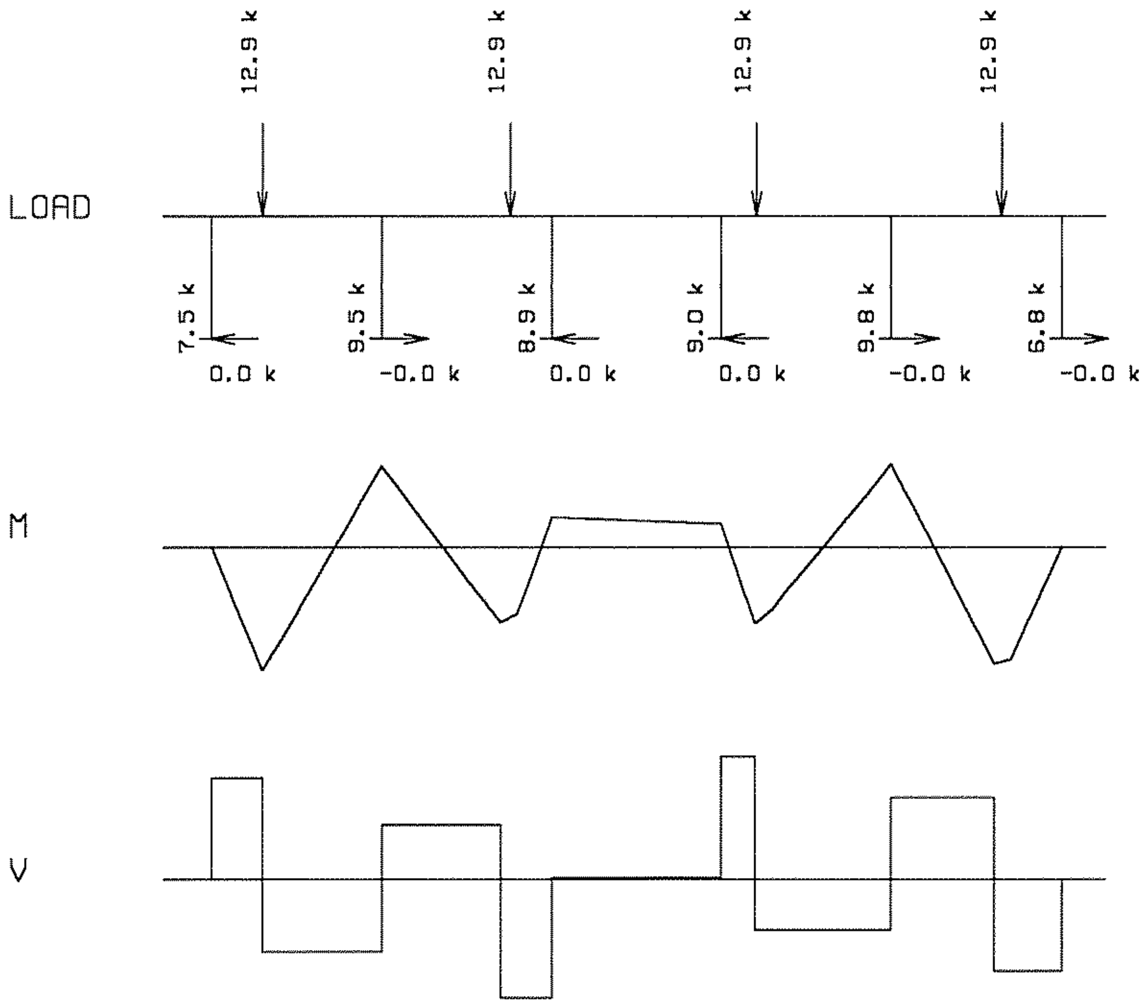



| CAP BEAM X (ft) | Vleft (k) | Vright (k) | M (k*ft) | PILE Axial (k) | Moment (k*ft) at Top | at Bot. | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -7.35 | -7.35 | -27.15 | | | | |
| 1.00 | -9.75 | -9.75 | -35.70 | | | | |
| 2.00 | -12.15 | 109.36 | -46.65 | 121.51 | 0.07 | .12 | 0.01 |
| 5.50 | -62.57 | -62.57 | 95.80 | | | | |
| 9.00 | -70.97 | 63.69 | -137.89 | 134.66 | -.65 | -.25 | -0.06 |
| 12.50 | 54.29 | 54.29 | 68.84 | | | | |
| 16.00 | -137.72 | 11.12 | -69.60 | 148.84 | .15 | .15 | 0.02 |
| 19.50 | 1.62 | 1.62 | -46.59 | | | | |
| 23.00 | -8.91 | 142.81 | -59.36 | 151.72 | .65 | .40 | 0.07 |
| 26.50 | -48.48 | -48.48 | 52.39 | | | | |
| 30.00 | -59.16 | 77.23 | -135.75 | 136.39 | -.46 | -.15 | -0.04 |
| 33.50 | 65.65 | 65.65 | 114.20 | | | | |
| 37.00 | -95.26 | 13.31 | -46.53 | 108.56 | -0.07 | 0.03 | -0.00 |
| 37.90 | 10.33 | 10.33 | -35.10 | | | | |
| 38.80 | 7.35 | 7.35 | -27.15 | | | | |

FIRM:DesignCalcs, Inc. JOB NO.1234567890 SHEET NO: 9
MADE BY:KJH DATE:03-28-2014 CHECKED BY: DATE:
TITLE:Example INTEGRAL abument calculation

INTEGRAL ABUTMENT DESIGN:

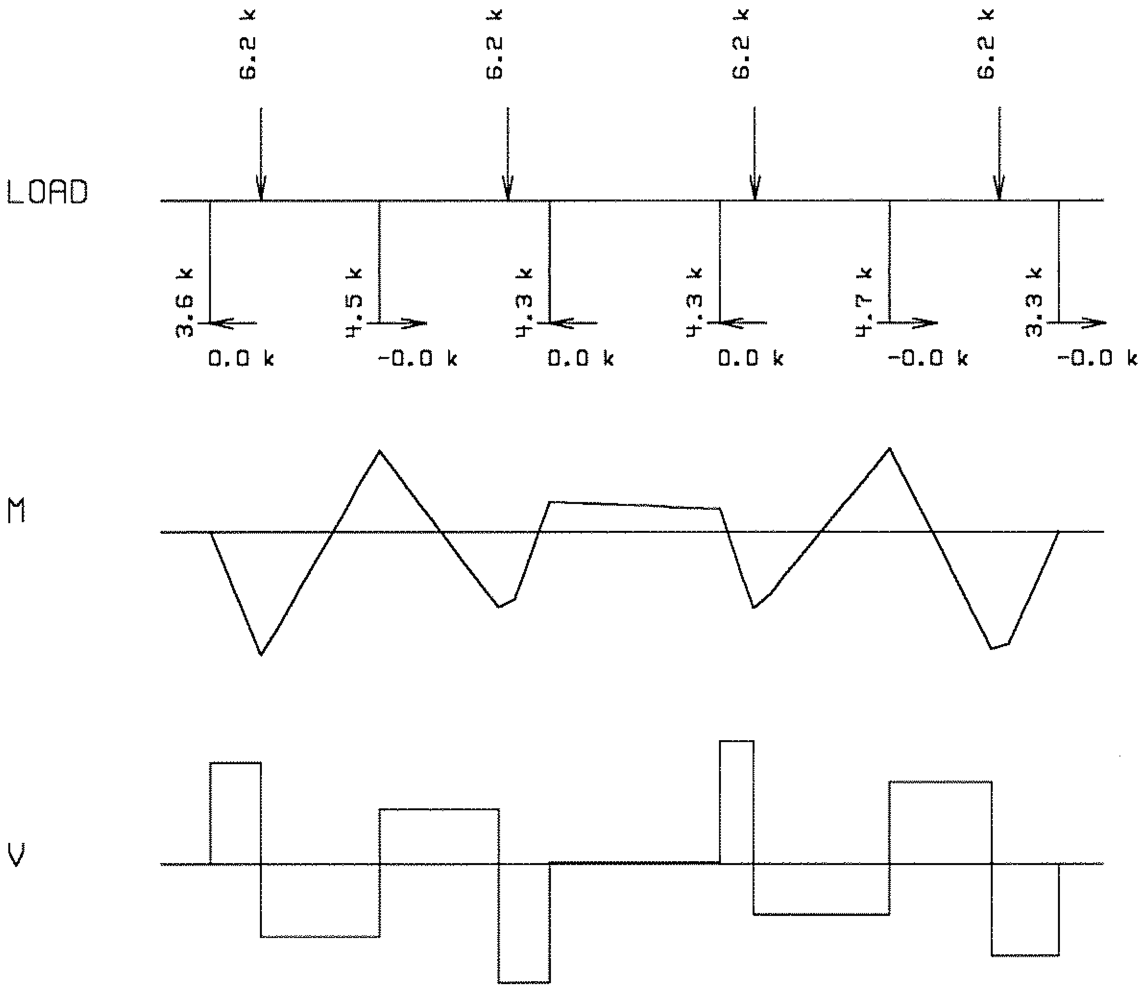
CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE DC2




| CAP BEAM X (ft) | Vleft (k) | Vright (k) | M (k*ft) | PILE Axial (k) | Moment (k*ft) at Top | at Bot. | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 1.00 | 0.00 | 0.00 | 0.00 | | | | |
| 2.00 | 0.00 | 7.51 | 0.00 | 7.51 | 0.00 | 0.01 | 0.00 |
| 5.50 | -5.39 | -5.39 | 8.48 | | | | |
| 9.00 | -5.39 | 4.08 | -10.38 | 9.46 | -0.06 | -0.02 | -0.00 |
| 12.50 | 4.08 | 4.08 | 3.91 | | | | |
| 16.00 | -8.82 | .12 | -3.87 | 8.94 | 0.02 | 0.01 | 0.00 |
| 19.50 | .12 | .12 | -3.41 | | | | |
| 23.00 | .12 | 9.13 | -3.00 | 9.01 | 0.04 | 0.03 | 0.00 |
| 26.50 | -3.77 | -3.77 | 2.57 | | | | |
| 30.00 | -3.77 | 6.08 | -10.63 | 9.85 | -0.02 | -0.00 | -0.00 |
| 33.50 | 6.08 | 6.08 | 10.62 | | | | |
| 37.00 | -6.82 | 0.00 | -0.08 | 6.82 | -0.01 | 0.00 | -0.00 |
| 37.90 | 0.00 | 0.00 | 0.00 | | | | |
| 38.80 | 0.00 | 0.00 | 0.00 | | | | |

INTEGRAL ABUTMENT DESIGN:

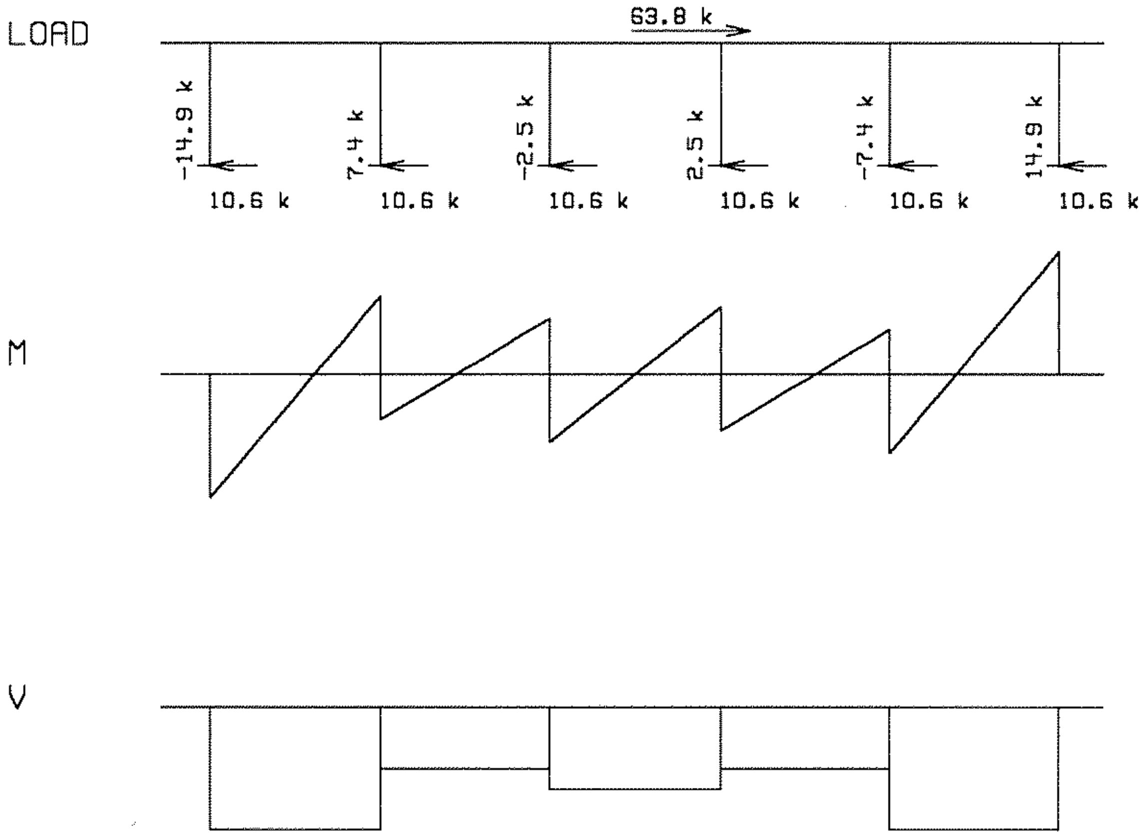
CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE DW




| CAP BEAM X (ft) | Vleft (k) | Vright (k) | M (k*ft) | PILE Axial (k) | Moment (k*ft) at Top | Moment (k*ft) at Bot. | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 1.00 | 0.00 | 0.00 | 0.00 | | | | |
| 2.00 | 0.00 | 3.62 | 0.00 | 3.62 | -0.01 | -0.02 | 0.00 |
| 5.50 | -2.58 | -2.58 | 4.07 | | | | |
| 9.00 | -2.58 | 1.96 | -4.98 | 4.55 | -0.05 | -0.04 | -0.02 |
| 12.50 | 1.96 | 1.96 | 1.88 | | | | |
| 16.00 | -4.24 | 0.05 | -1.85 | 4.30 | -0.01 | -0.02 | 0.00 |
| 19.50 | 0.05 | 0.05 | -1.64 | | | | |
| 23.00 | 0.05 | 4.39 | -1.43 | 4.33 | 0.00 | -0.01 | 0.02 |
| 26.50 | -1.81 | -1.81 | 1.23 | | | | |
| 30.00 | -1.81 | 2.93 | -5.10 | 4.74 | -0.03 | -0.03 | -0.01 |
| 33.50 | 2.93 | 2.93 | 5.11 | | | | |
| 37.00 | -3.27 | 0.00 | -.02 | 3.27 | -0.02 | -0.03 | -0.00 |
| 37.90 | 0.00 | 0.00 | 0.00 | | | | |
| 38.80 | 0.00 | 0.00 | 0.00 | | | | |

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE EH

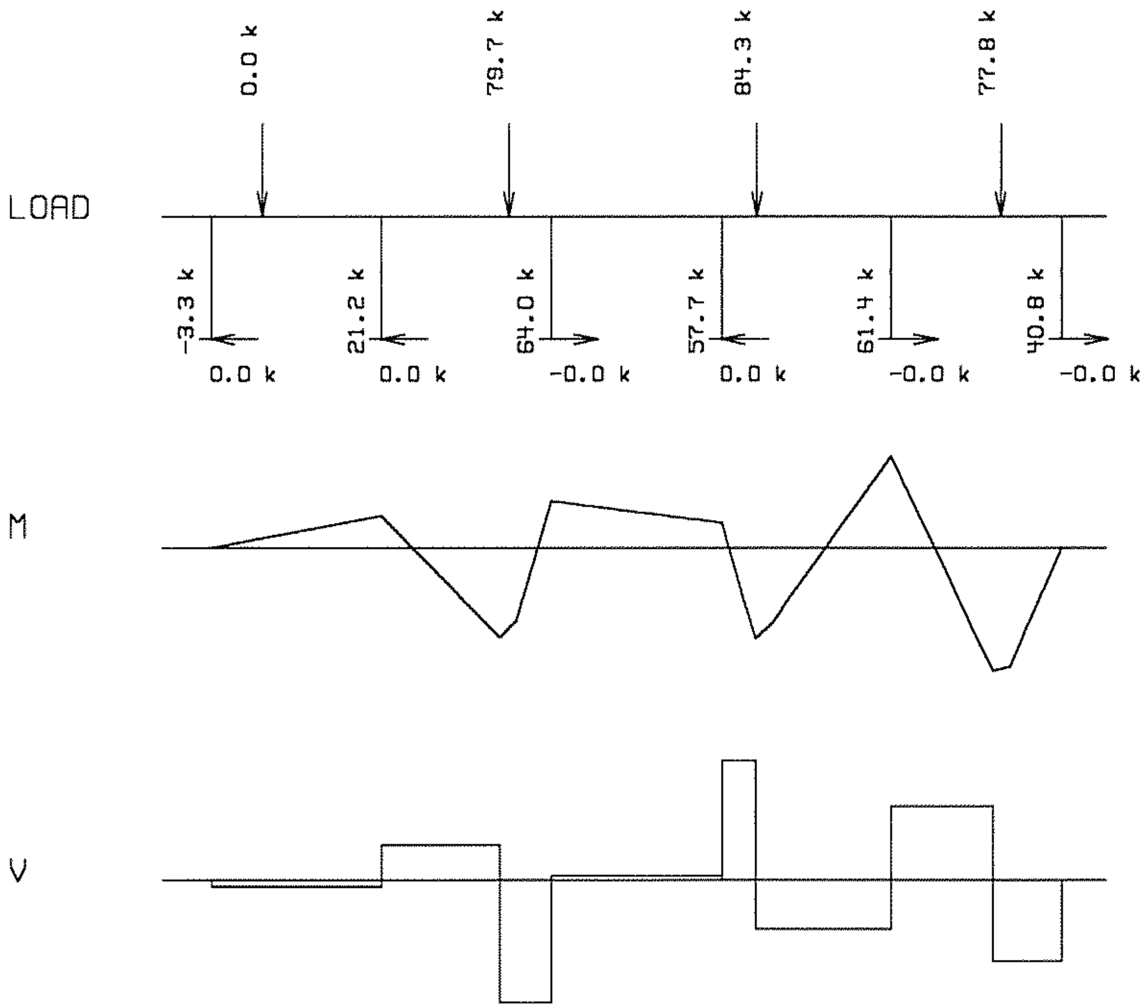



| CAP BEAM | | | | PILE | | | |
|---|---|---|---|---|---|---|---|
| X (ft) | Vleft (k) | Vright (k) | M (k*ft) | Axial (k) | Moment (k*ft) at Top | at Bot. | Shear (k) |
| 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 1.00 | 0.00 | 0.00 | 0.00 | | | | |
| 2.00 | 0.00 | -14.87 | 0.00 | -14.87 | 63.56 | 95.65 | 10.61 |
| 5.50 | -14.87 | -14.87 | 11.51 | | | | |
| 9.00 | -14.87 | -7.47 | -40.54 | 7.41 | 63.81 | 95.77 | 10.64 |
| 12.50 | -7.47 | -7.47 | -2.87 | | | | |
| 16.00 | -7.47 | -9.93 | -29.00 | -2.46 | 63.75 | 95.74 | 10.63 |
| 19.50 | -9.93 | -9.93 | 0.00 | | | | |
| 23.00 | -9.93 | -7.47 | -34.74 | 2.46 | 63.75 | 95.74 | 10.63 |
| 26.50 | -7.47 | -7.47 | 2.87 | | | | |
| 30.00 | -7.47 | -14.87 | -23.26 | -7.41 | 63.81 | 95.77 | 10.64 |
| 33.50 | -14.87 | -14.87 | -11.51 | | | | |
| 37.00 | -14.87 | 0.00 | -63.56 | 14.87 | 63.56 | 95.65 | 10.61 |
| 37.90 | 0.00 | 0.00 | 0.00 | | | | |
| 38.80 | 0.00 | 0.00 | 0.00 | | | | |

FIRM:DesignCalcs, Inc.                JOB NO.1234567890   SHEET NO:  12
MADE BY:KJH   DATE:03-28-2014          CHECKED BY:         DATE:
TITLE:Example INTEGRAL abument calculation

INTEGRAL ABUTMENT DESIGN:

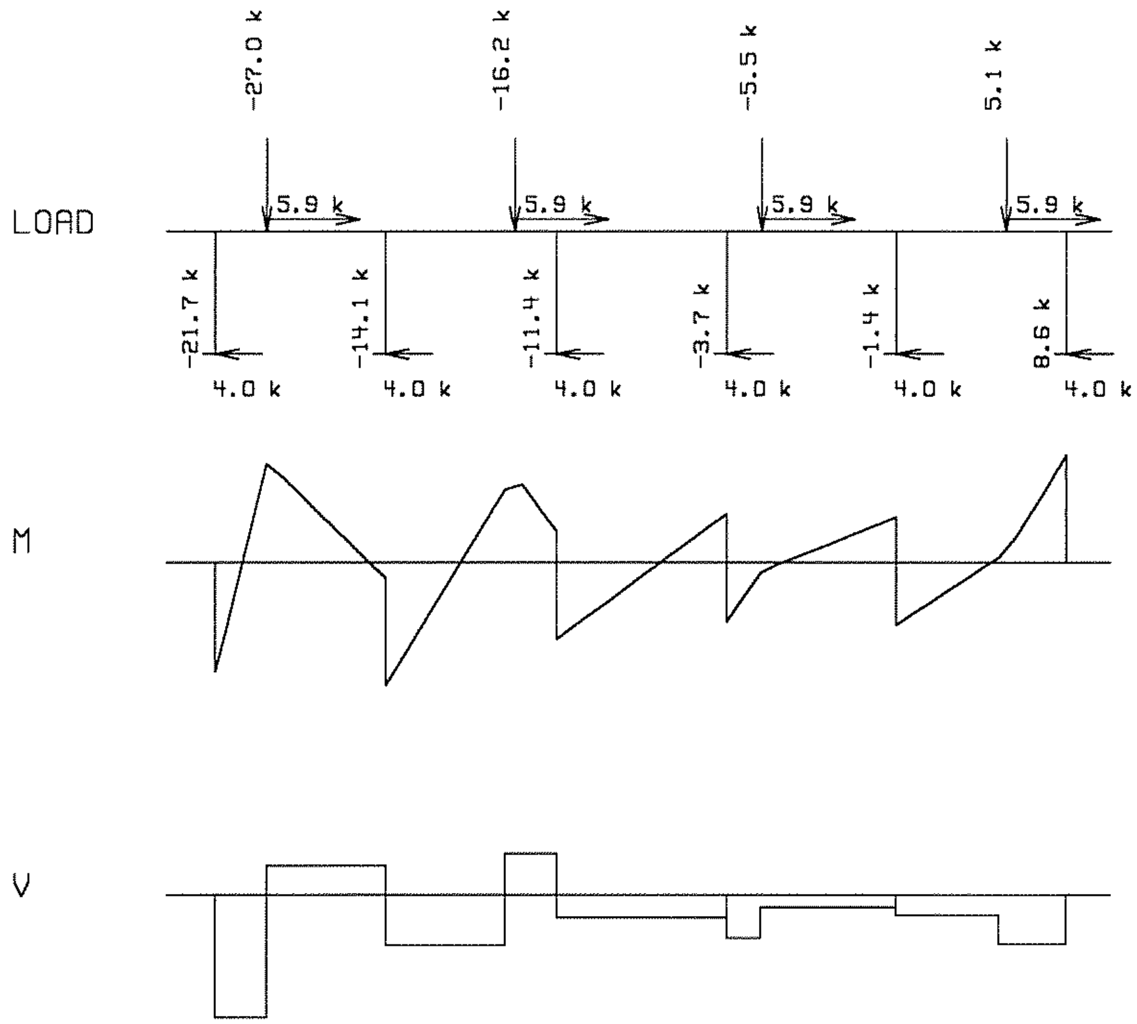
CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE LL




| CAP BEAM X (ft) | Vleft (k) | Vright (k) | M (k*ft) | PILE Axial (k) | Moment (k*ft) at Top | Moment (k*ft) at Bot. | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 1.00 | 0.00 | 0.00 | 0.00 | | | | |
| 2.00 | 0.00 | -3.32 | 0.00 | -3.32 | 0.01 | 0.02 | 0.00 |
| 5.50 | -3.32 | -3.32 | -11.53 | | | | |
| 9.00 | -3.32 | 17.89 | -23.15 | 21.22 | 0.09 | 0.06 | 0.01 |
| 12.50 | 17.89 | 17.89 | 39.32 | | | | |
| 16.00 | -61.79 | 2.25 | -34.20 | 64.04 | -.15 | -0.05 | -0.01 |
| 19.50 | 2.25 | 2.25 | -26.02 | | | | |
| 23.00 | 2.25 | 59.91 | -18.16 | 57.66 | .32 | .17 | 0.03 |
| 26.50 | -24.41 | -24.41 | 19.08 | | | | |
| 30.00 | -24.41 | 36.98 | -66.36 | 61.39 | -.23 | -.10 | -0.02 |
| 33.50 | 36.98 | 36.98 | 62.97 | | | | |
| 37.00 | -40.82 | 0.00 | -.49 | 40.82 | -.11 | -0.03 | -0.00 |
| 37.90 | 0.00 | 0.00 | 0.00 | | | | |
| 38.80 | 0.00 | 0.00 | 0.00 | | | | |

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE W

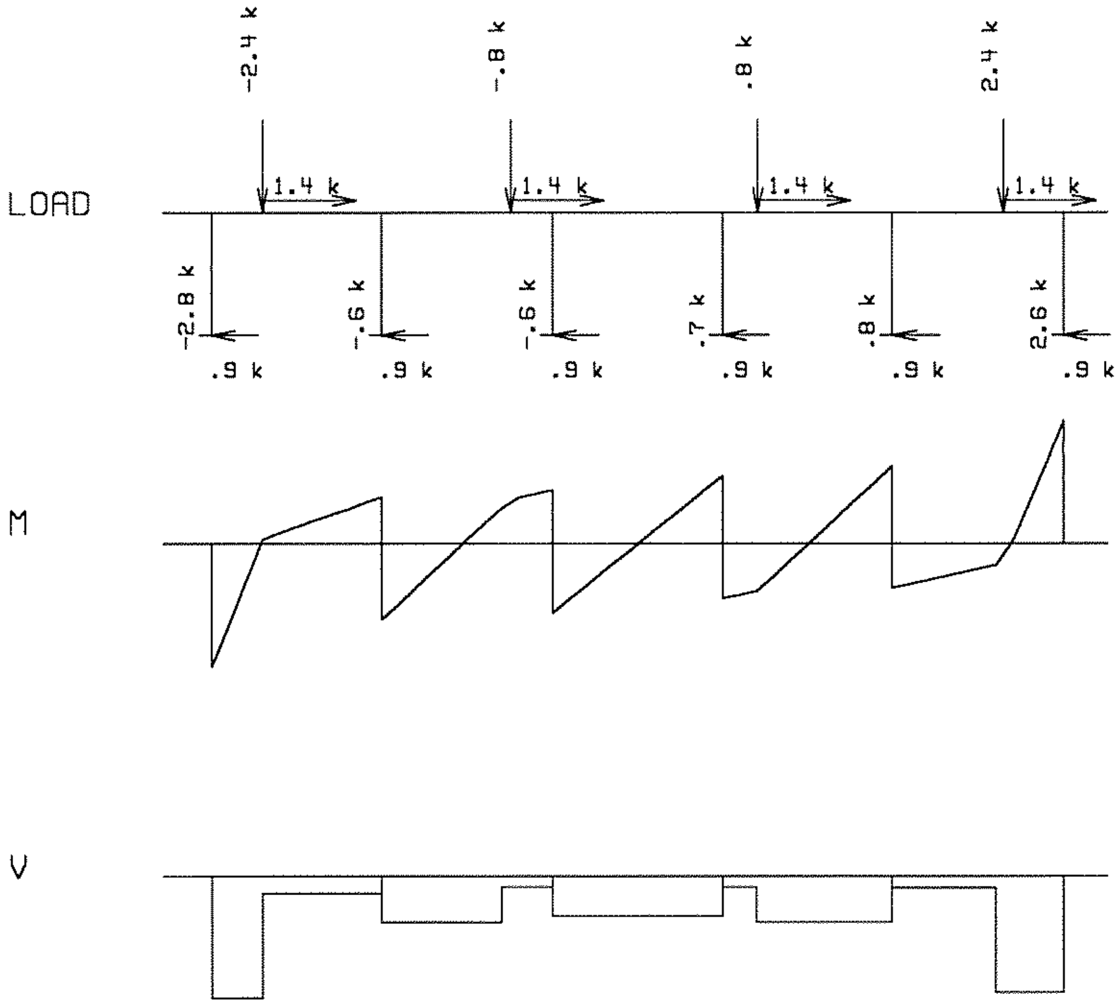



| CAP BEAM X (ft) | Vleft (k) | Vright (k) | M (k*ft) | PILE Axial (k) | Moment (k*ft) at Top | Moment (k*ft) at Bot. | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 1.00 | 0.00 | 0.00 | 0.00 | | | | |
| 2.00 | 0.00 | -21.72 | 0.00 | -21.72 | 23.70 | 35.66 | 3.96 |
| 5.50 | 5.25 | 5.25 | -15.04 | | | | |
| 9.00 | 5.25 | -8.82 | 3.35 | -14.07 | 23.96 | 35.79 | 3.98 |
| 12.50 | -8.82 | -8.82 | -3.78 | | | | |
| 16.00 | 7.42 | -3.94 | -6.89 | -11.37 | 23.71 | 35.67 | 3.96 |
| 19.50 | -3.94 | -3.94 | 3.04 | | | | |
| 23.00 | -3.94 | -7.66 | -10.76 | -3.72 | 23.73 | 35.68 | 3.96 |
| 26.50 | -2.15 | -2.15 | -2.52 | | | | |
| 30.00 | -2.15 | -3.54 | -10.03 | -1.40 | 23.82 | 35.72 | 3.97 |
| 33.50 | -3.54 | -3.54 | 1.32 | | | | |
| 37.00 | -8.65 | 0.00 | -23.74 | 8.65 | 23.67 | 35.64 | 3.95 |
| 37.90 | 0.00 | 0.00 | 0.00 | | | | |
| 38.80 | 0.00 | 0.00 | 0.00 | | | | |

FIRM:DesignCalcs, Inc.                    JOB NO.1234567890   SHEET NO:  14
MADE BY:KJH   DATE:03-28-2014             CHECKED BY:         DATE:
TITLE:Example INTEGRAL abument calculation

INTEGRAL ABUTMENT DESIGN:

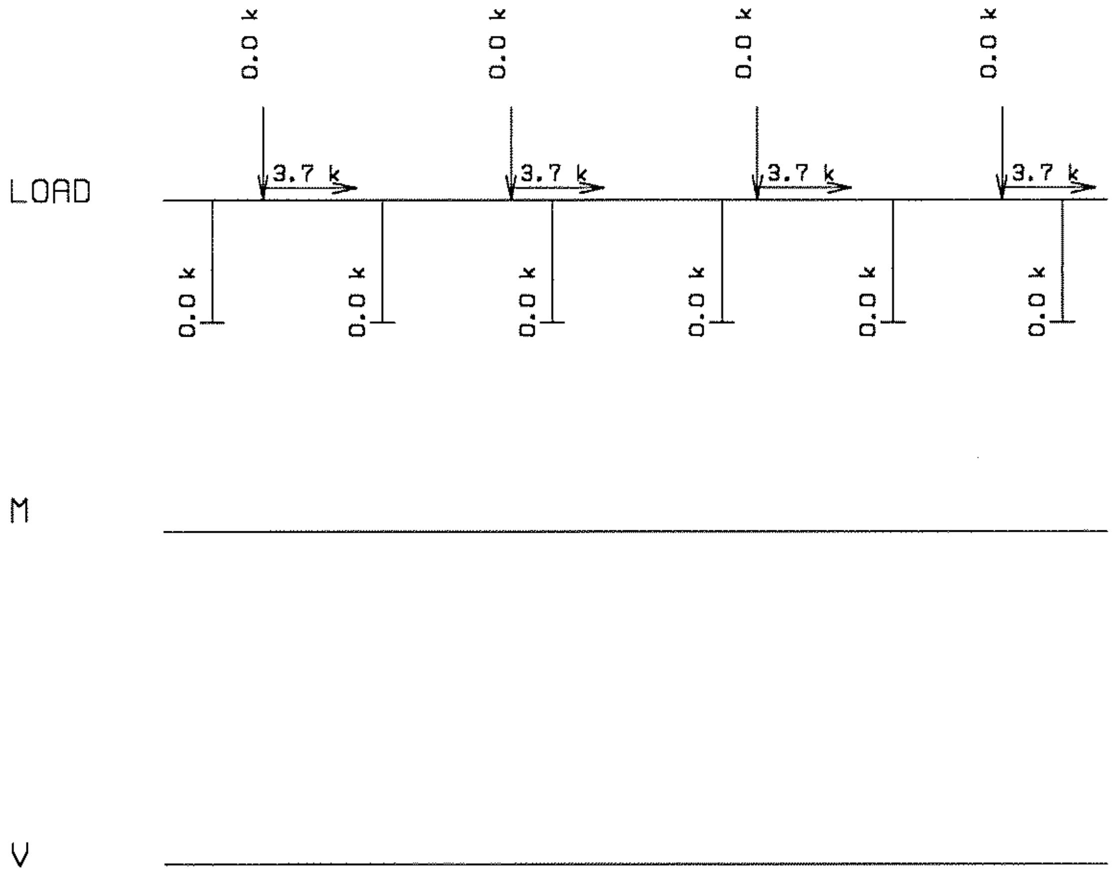
CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE WL




| CAP BEAM | | | | PILE | | | |
|---|---|---|---|---|---|---|---|
| X (ft) | Vleft (k) | Vright (k) | M (k*ft) | Axial (k) | Moment (k*ft) at Top | at Bot. | Shear (k) |
| 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 1.00 | 0.00 | 0.00 | 0.00 | | | | |
| 2.00 | 0.00 | -2.76 | 0.00 | -2.76 | 5.60 | 8.43 | .94 |
| 5.50 | -.39 | -.39 | -.78 | | | | |
| 9.00 | -.39 | -1.04 | -2.14 | -.65 | 5.64 | 8.45 | .94 |
| 12.50 | -1.04 | -1.04 | -.17 | | | | |
| 16.00 | -.25 | -.90 | -2.46 | -.64 | 5.61 | 8.44 | .94 |
| 19.50 | -.90 | -.90 | 0.02 | | | | |
| 23.00 | -.90 | -.24 | -3.11 | .66 | 5.62 | 8.44 | .94 |
| 26.50 | -1.03 | -1.03 | 0.04 | | | | |
| 30.00 | -1.03 | -.26 | -3.58 | .78 | 5.62 | 8.44 | .94 |
| 33.50 | -.26 | -.26 | 1.14 | | | | |
| 37.00 | -2.62 | 0.00 | -5.62 | 2.62 | 5.60 | 8.43 | .93 |
| 37.90 | 0.00 | 0.00 | 0.00 | | | | |
| 38.80 | 0.00 | 0.00 | 0.00 | | | | |

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VERTICAL ANALYSIS: BASIC LOAD CASE BR




| CAP BEAM X (ft) | Vleft (k) | Vright (k) | M (k*ft) | PILE Axial (k) | Moment (k*ft) at Top | Moment (k*ft) at Bot. | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 1.00 | 0.00 | 0.00 | 0.00 | | | | |
| 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.50 | 0.00 | 0.00 | 0.00 | | | | |
| 9.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12.50 | 0.00 | 0.00 | 0.00 | | | | |
| 16.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19.50 | 0.00 | 0.00 | 0.00 | | | | |
| 23.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26.50 | 0.00 | 0.00 | 0.00 | | | | |
| 30.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33.50 | 0.00 | 0.00 | 0.00 | | | | |
| 37.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 37.90 | 0.00 | 0.00 | 0.00 | | | | |
| 38.80 | 0.00 | 0.00 | 0.00 | | | | |

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD SERVICE I

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SERVICE I | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -7.35 | -7.35 | -27.15 | | | | |
| 1.00 | -9.75 | -9.75 | -35.70 | | | | |
| 2.00 | -12.15 | 102.29 | -46.65 | 114.44 | 63.65 | 95.78 | 10.64 |
| 5.50 | -88.73 | -88.73 | 108.33 | | | | |
| 9.00 | -97.13 | 80.16 | -216.94 | 177.29 | 63.13 | 95.52 | 10.56 |
| 12.50 | 70.75 | 70.75 | 111.08 | | | | |
| 16.00 | -220.04 | 3.62 | -138.52 | 223.66 | 63.76 | 95.83 | 10.65 |
| 19.50 | -5.89 | -5.89 | -77.66 | | | | |
| 23.00 | -16.42 | 208.77 | -116.70 | 225.18 | 64.77 | 96.34 | 10.77 |
| 26.50 | -85.94 | -85.94 | 78.14 | | | | |
| 30.00 | -96.62 | 108.34 | -241.10 | 204.96 | 63.05 | 95.48 | 10.56 |
| 33.50 | 96.76 | 96.76 | 181.40 | | | | |
| 37.00 | -161.05 | 13.31 | -110.69 | 174.35 | 63.34 | 95.62 | 10.60 |
| 37.90 | 10.33 | 10.33 | -35.10 | | | | |
| 38.80 | 7.35 | 7.35 | -27.15 | | | | |

## INTEGRAL ABUTMENT DESIGN:

### CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD STRENGTH I MAX

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STRENGTH I MAX | 1.25 | 1.25 | 1.50 | 1.75 | 1.75 | 1.35 | 0.00 | 0.00 | 1.75 | .50 | 0.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -9.19 | -9.19 | -33.94 | | | | |
| 1.00 | -12.19 | -12.19 | -44.62 | | | | |
| 2.00 | -15.19 | 125.62 | -58.31 | 140.81 | 85.92 | 129.29 | 14.36 |
| 5.50 | -114.71 | -114.71 | 131.81 | | | | |
| 9.00 | -125.21 | 108.89 | -288.05 | 234.10 | 85.32 | 128.99 | 14.26 |
| 12.50 | 97.13 | 97.13 | 158.70 | | | | |
| 16.00 | -307.75 | 4.67 | -193.62 | 312.42 | 86.00 | 129.33 | 14.37 |
| 19.50 | -7.21 | -7.21 | -110.50 | | | | |
| 23.00 | -20.38 | 291.26 | -158.78 | 311.64 | 87.49 | 130.08 | 14.54 |
| 26.50 | -120.83 | -120.83 | 107.81 | | | | |
| 30.00 | -134.18 | 153.16 | -338.16 | 287.34 | 85.07 | 128.86 | 14.25 |
| 33.50 | 138.68 | 138.68 | 258.36 | | | | |
| 37.00 | -224.03 | 16.63 | -144.97 | 240.66 | 85.47 | 129.07 | 14.31 |
| 37.90 | 12.91 | 12.91 | -43.88 | | | | |
| 38.80 | 9.19 | 9.19 | -33.94 | | | | |

## INTEGRAL ABUTMENT DESIGN:

### CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD STRENGTH I MIN

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STRENGTH I MIN | .90 | .90 | .65 | 1.75 | 1.75 | .90 | 0.00 | 0.00 | 1.75 | .50 | 0.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -6.61 | -6.61 | -24.43 | | | | |
| 1.00 | -8.77 | -8.77 | -32.13 | | | | |
| 2.00 | -10.93 | 88.34 | -41.99 | 99.27 | 57.30 | 86.22 | 9.57 |
| 5.50 | -82.04 | -82.04 | 86.68 | | | | |
| 9.00 | -89.60 | 86.86 | -213.69 | 176.46 | 56.91 | 86.03 | 9.52 |
| 12.50 | 78.40 | 78.40 | 132.93 | | | | |
| 16.00 | -249.50 | 5.15 | -153.28 | 254.65 | 57.26 | 86.21 | 9.57 |
| 19.50 | -3.40 | -3.40 | -91.60 | | | | |
| 23.00 | -12.88 | 237.72 | -120.11 | 250.60 | 58.56 | 86.86 | 9.71 |
| 26.50 | -97.64 | -97.64 | 86.23 | | | | |
| 30.00 | -107.25 | 128.21 | -272.12 | 235.46 | 56.55 | 85.85 | 9.49 |
| 33.50 | 117.79 | 117.79 | 215.51 | | | | |
| 37.00 | -178.82 | 11.97 | -100.04 | 190.80 | 56.92 | 86.04 | 9.53 |
| 37.90 | 9.29 | 9.29 | -31.59 | | | | |
| 38.80 | 6.61 | 6.61 | -24.43 | | | | |

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VÉRTICAL ANALYSIS: LIMIT STATE LOAD STRENGTH II MAX

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STRENGTH II MAX | 1.25 | 1.25 | 1.50 | 0.00 | 0.00 | 1.35 | 1.00 | 0.00 | 0.00 | .50 | 0.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -9.19 | -9.19 | -33.94 | | | | |
| 1.00 | -12.19 | -12.19 | -44.62 | | | | |
| 2.00 | -15.19 | 109.72 | -58.31 | 124.91 | 109.59 | 164.91 | 18.31 |
| 5.50 | -103.65 | -103.65 | 136.95 | | | | |
| 9.00 | -114.15 | 68.76 | -244.19 | 182.90 | 109.11 | 164.67 | 18.23 |
| 12.50 | 57.00 | 57.00 | 86.10 | | | | |
| 16.00 | -192.19 | -3.21 | -140.66 | 188.99 | 109.97 | 165.10 | 18.35 |
| 19.50 | -15.09 | -15.09 | -61.93 | | | | |
| 23.00 | -28.25 | 178.76 | -137.77 | 207.01 | 110.66 | 165.45 | 18.45 |
| 26.50 | -80.25 | -80.25 | 71.91 | | | | |
| 30.00 | -93.61 | 84.90 | -232.06 | 178.50 | 109.29 | 164.76 | 18.26 |
| 33.50 | 70.42 | 70.42 | 149.49 | | | | |
| 37.00 | -161.24 | 16.63 | -167.85 | 177.87 | 109.32 | 164.78 | 18.28 |
| 37.90 | 12.91 | 12.91 | -43.88 | | | | |
| 38.80 | 9.19 | 9.19 | -33.94 | | | | |

## INTEGRAL ABUTMENT DESIGN:

### CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD STRENGTH II MIN

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STRENGTH II MIN | .90 | .90 | .65 | 0.00 | 0.00 | .90 | 1.00 | 0.00 | 0.00 | .50 | 0.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -6.61 | -6.61 | -24.43 | | | | |
| 1.00 | -8.77 | -8.77 | -32.13 | | | | |
| 2.00 | -10.93 | 72.43 | -41.99 | 83.37 | 80.97 | 121.84 | 13.53 |
| 5.50 | -70.97 | -70.97 | 91.81 | | | | |
| 9.00 | -78.53 | 46.73 | -169.82 | 125.26 | 80.70 | 121.71 | 13.48 |
| 12.50 | 38.27 | 38.27 | 60.33 | | | | |
| 16.00 | -133.94 | -2.72 | -100.32 | 131.22 | 81.24 | 121.98 | 13.55 |
| 19.50 | -11.28 | -11.28 | -43.04 | | | | |
| 23.00 | -20.75 | 125.21 | -99.09 | 145.97 | 81.73 | 122.23 | 13.61 |
| 26.50 | -57.07 | -57.07 | 50.33 | | | | |
| 30.00 | -66.68 | 59.94 | -166.02 | 126.63 | 80.78 | 121.75 | 13.50 |
| 33.50 | 49.52 | 49.52 | 106.63 | | | | |
| 37.00 | -116.03 | 11.97 | -122.91 | 128.01 | 80.77 | 121.75 | 13.50 |
| 37.90 | 9.29 | 9.29 | -31.59 | | | | |
| 38.80 | 6.61 | 6.61 | -24.43 | | | | |

## INTEGRAL ABUTMENT DESIGN:

### CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD STRENGTH V MAX

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STRENGTH V MAX | 1.25 | 1.25 | 1.50 | 1.35 | 1.35 | 1.35 | .40 | 1.00 | 1.35 | .50 | 0.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -9.19 | -9.19 | -33.94 | | | | |
| 1.00 | -12.19 | -12.19 | -44.62 | | | | |
| 2.00 | -15.19 | 115.51 | -58.31 | 130.69 | 100.99 | 151.97 | 16.88 |
| 5.50 | -111.67 | -111.67 | 129.63 | | | | |
| 9.00 | -122.17 | 97.16 | -279.60 | 219.33 | 100.51 | 151.73 | 16.79 |
| 12.50 | 85.41 | 85.41 | 141.29 | | | | |
| 16.00 | -280.32 | 1.30 | -185.16 | 281.61 | 101.16 | 152.06 | 16.90 |
| 19.50 | -10.59 | -10.59 | -98.86 | | | | |
| 23.00 | -23.75 | 264.00 | -158.94 | 287.74 | 102.48 | 152.72 | 17.05 |
| 26.50 | -112.95 | -112.95 | 99.22 | | | | |
| 30.00 | -126.31 | 136.69 | -319.21 | 263.00 | 100.31 | 151.63 | 16.78 |
| 33.50 | 122.22 | 122.22 | 234.84 | | | | |
| 37.00 | -213.78 | 16.63 | -159.89 | 230.41 | 100.57 | 151.77 | 16.83 |
| 37.90 | 12.91 | 12.91 | -43.88 | | | | |
| 38.80 | 9.19 | 9.19 | -33.94 | | | | |

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD STRENGTH V MIN

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STRENGTH V MIN | .90 | .90 | .65 | 1.35 | 1.35 | .90 | .40 | 1.00 | 1.35 | .50 | 0.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -6.61 | -6.61 | -24.43 | | | | |
| 1.00 | -8.77 | -8.77 | -32.13 | | | | |
| 2.00 | -10.93 | 78.22 | -41.99 | 89.15 | 72.37 | 108.91 | 12.09 |
| 5.50 | -79.00 | -79.00 | 84.49 | | | | |
| 9.00 | -86.56 | 75.14 | -205.23 | 161.69 | 72.09 | 108.77 | 12.05 |
| 12.50 | 66.67 | 66.67 | 115.52 | | | | |
| 16.00 | -222.07 | 1.78 | -144.82 | 223.84 | 72.42 | 108.93 | 12.10 |
| 19.50 | -6.78 | -6.78 | -79.96 | | | | |
| 23.00 | -16.25 | 210.45 | -120.26 | 226.70 | 73.54 | 109.49 | 12.22 |
| 26.50 | -89.77 | -89.77 | 77.64 | | | | |
| 30.00 | -99.38 | 111.74 | -253.17 | 211.12 | 71.80 | 108.62 | 12.02 |
| 33.50 | 101.32 | 101.32 | 191.99 | | | | |
| 37.00 | -168.57 | 11.97 | -114.95 | 180.55 | 72.03 | 108.74 | 12.05 |
| 37.90 | 9.29 | 9.29 | -31.59 | | | | |
| 38.80 | 6.61 | 6.61 | -24.43 | | | | |

## INTEGRAL ABUTMENT DESIGN:

### CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD EXTREME I MAX

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EXTREME I MAX | 1.25 | 1.25 | 1.50 | 0.00 | 0.00 | 1.35 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |

| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -9.19 | -9.19 | -33.94 | | | | |
| 1.00 | -12.19 | -12.19 | -44.62 | | | | |
| 2.00 | -15.19 | 131.43 | -58.31 | 146.62 | 85.89 | 129.25 | 14.35 |
| 5.50 | -108.90 | -108.90 | 151.99 | | | | |
| 9.00 | -119.40 | 77.57 | -247.54 | 196.97 | 85.15 | 128.88 | 14.25 |
| 12.50 | 65.82 | 65.82 | 89.88 | | | | |
| 16.00 | -199.62 | .74 | -133.77 | 200.35 | 86.26 | 129.44 | 14.39 |
| 19.50 | -11.14 | -11.14 | -64.97 | | | | |
| 23.00 | -24.31 | 186.42 | -127.01 | 210.73 | 86.93 | 129.77 | 14.49 |
| 26.50 | -78.11 | -78.11 | 74.43 | | | | |
| 30.00 | -91.46 | 88.44 | -222.03 | 179.90 | 85.48 | 129.04 | 14.29 |
| 33.50 | 73.97 | 73.97 | 148.16 | | | | |
| 37.00 | -152.59 | 16.63 | -144.11 | 169.22 | 85.65 | 129.13 | 14.32 |
| 37.90 | 12.91 | 12.91 | -43.88 | | | | |
| 38.80 | 9.19 | 9.19 | -33.94 | | | | |

INTEGRAL ABUTMENT DESIGN:

CAP BEAM VERTICAL ANALYSIS: LIMIT STATE LOAD EXTREME I MIN

| LIMIT STATE | DC1 | DC2 | DW | LL | LS | EH | WS | WL | BR | TU | EQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EXTREME I MIN | .90 | .90 | .65 | 0.00 | 0.00 | .90 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |

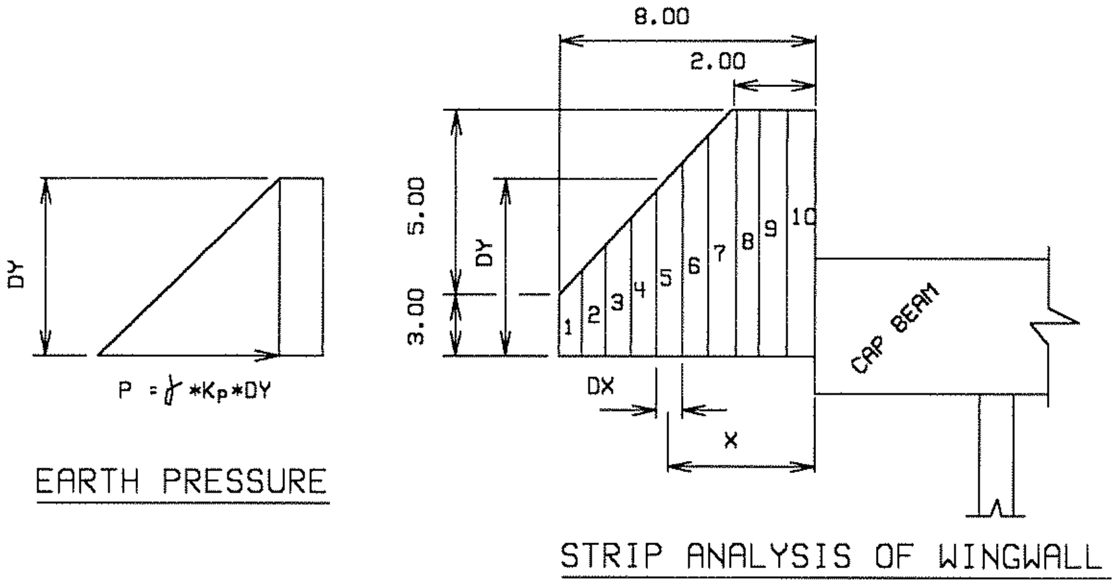
| CAP BEAM X (ft) | Vu,left (k) | Vu,right (k) | Mu (k*ft) | PILE Axial (k) | Moment (k*ft) At Top | Moment (k*ft) At Bot | Shear (k) |
|---|---|---|---|---|---|---|---|
| 0.00 | -6.61 | -6.61 | -24.43 | | | | |
| 1.00 | -8.77 | -8.77 | -32.13 | | | | |
| 2.00 | -10.93 | 94.15 | -41.99 | 105.08 | 57.27 | 86.19 | 9.57 |
| 5.50 | -76.23 | -76.23 | 106.85 | | | | |
| 9.00 | -83.79 | 55.55 | -173.17 | 139.33 | 56.74 | 85.92 | 9.50 |
| 12.50 | 47.08 | 47.08 | 64.11 | | | | |
| 16.00 | -141.36 | 1.22 | -93.43 | 142.58 | 57.52 | 86.31 | 9.60 |
| 19.50 | -7.33 | -7.33 | -46.07 | | | | |
| 23.00 | -16.81 | 132.87 | -88.33 | 149.68 | 58.00 | 86.55 | 9.65 |
| 26.50 | -54.92 | -54.92 | 52.85 | | | | |
| 30.00 | -64.54 | 63.49 | -155.99 | 128.03 | 56.96 | 86.03 | 9.53 |
| 33.50 | 53.07 | 53.07 | 105.31 | | | | |
| 37.00 | -107.39 | 11.97 | -99.17 | 119.36 | 57.11 | 86.10 | 9.55 |
| 37.90 | 9.29 | 9.29 | -31.59 | | | | |
| 38.80 | 6.61 | 6.61 | -24.43 | | | | |

## INTEGRAL ABUTMENT DESIGN:

### SUMMARY OF VERTICAL LOADING ANALYSIS RESULTS:

| | | |
|---|---|---|
| Maximum Factored Cap Beam Moment, | Mu,max= | 354.43 k*ft |
| Minumum Factored Cap Beam Moment, | Mu,min= | -338.16 k*ft |
| Maximum Factored Cap Beam Shear, | Vu,max= | 307.75 k |
| | | |
| Maximum Factored Pile Reaction, | Pu,max= | 312.42 k |
| Minimum Factored Pile Reaction, | Pu,max= | 83.37 k |
| Maximum Factored Pile Moment, | Mpile = | 165.45 k*ft |
| Maximum Factored Pile Shear, | Vpile = | 18.45 k |

PASSIVE EARTH PRESSURE ON CAP BEAM AND BACKWALL:




Compute earth pressure forces on wingwall by dividing the wingwall into 10 segments:

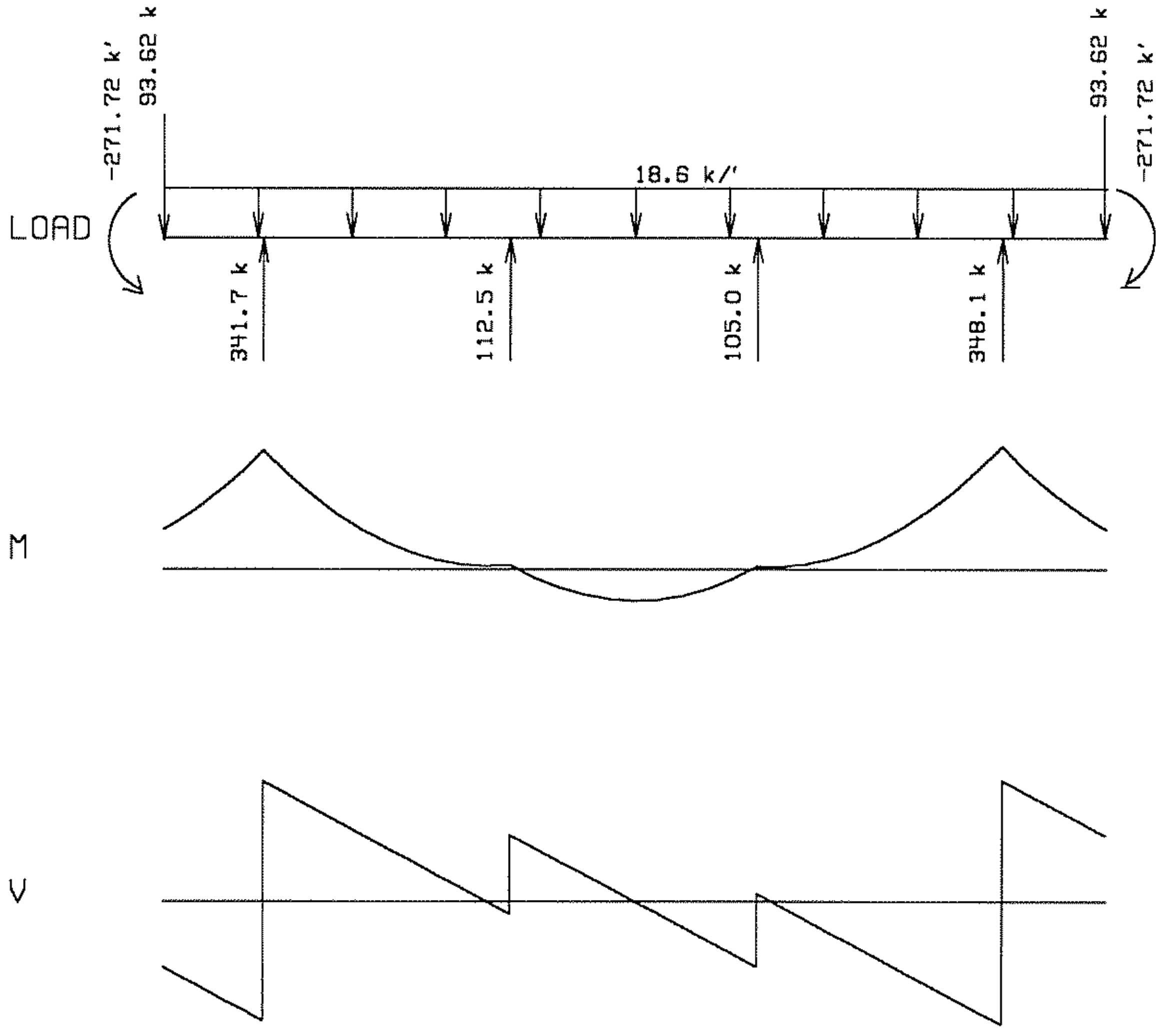
| No. | X (ft) | DX (ft) | DY (ft) | P at bot (ksf) | Force (k) | Moment (k*ft) |
|---|---|---|---|---|---|---|
| 1 | 7.600 | .800 | 3.333 | 1.933 | 2.58 | 19.59 |
| 2 | 6.800 | .800 | 4.000 | 2.320 | 3.71 | 25.24 |
| 3 | 6.000 | .800 | 4.667 | 2.707 | 5.05 | 30.31 |
| 4 | 5.200 | .800 | 5.333 | 3.093 | 6.60 | 34.32 |
| 5 | 4.400 | .800 | 6.000 | 3.480 | 8.35 | 36.75 |
| 6 | 3.600 | .800 | 6.667 | 3.867 | 10.31 | 37.12 |
| 7 | 2.800 | .800 | 7.333 | 4.253 | 12.48 | 34.93 |
| 8 | 2.000 | .800 | 8.000 | 4.640 | 14.85 | 29.70 |
| 9 | 1.200 | .800 | 8.000 | 4.640 | 14.85 | 17.82 |
| 10 | .400 | .800 | 8.000 | 4.640 | 14.85 | 5.94 |
| | | | | Totals = | 93.62 k | 271.72 k*ft |

Horizontal Pressures on Cap Beam and Backwall:
Earth Pressure at construction jt=( 2.00 ft)*( .145 kcf)*(4.00)
= 1.160 ksf
Earth Pressure at top of cap beam=( 6.00 ft)*( .145 kcf)*(4.00)
= 3.480 ksf
Earth Pressure at bot of cap beam=(10.00 ft)*( .145 kcf)*(4.00)
= 5.800 ksf

Horizontal Forces on Cap Beam and Backwall:
Earth Force on Backwall = .5*(1.160 + 3.480)*(4.00)= 9.28 k/ft
Earth Force on cap beam =.5*(3.480 + 5.800)*(4.00)=18.56 k/ft

INTEGRAL ABUTMENT DESIGN:

CAP BEAM HORIZONTAL ANALYSIS: PASSIVE PRESSURE EARTH PRESSURE



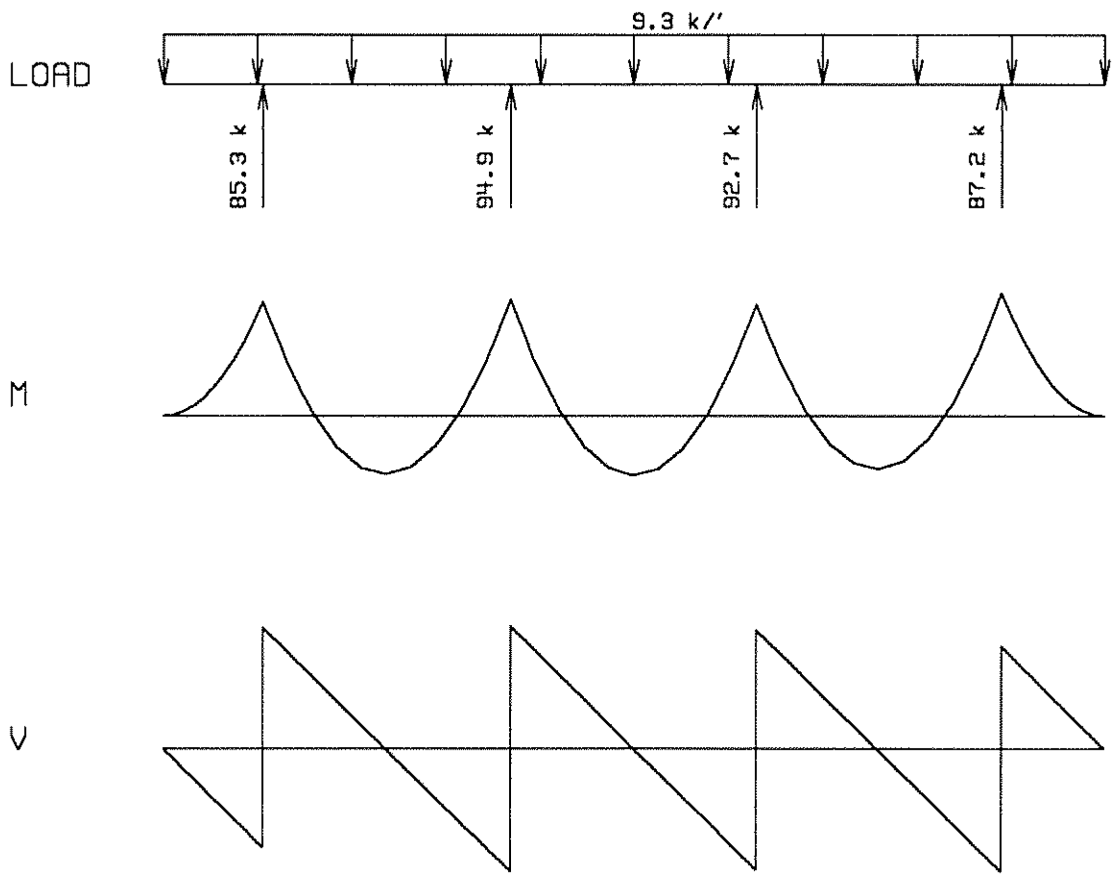

CAP BEAM HORIZONTAL LOADING (UNFACTORED)

| X (ft) | Vleft (k) | Vright (k) | M (k*ft) | Reaction (k) |
|---|---|---|---|---|
| 0.00 | -93.62 | -93.62 | -271.72 | |
| 2.06 | -131.90 | -131.90 | -504.25 | |
| 4.12 | -170.17 | 171.55 | -815.72 | 341.72 |
| 9.21 | 77.20 | 77.20 | -183.46 | |
| 14.29 | -17.15 | 95.40 | -30.83 | 112.55 |
| 19.37 | 1.05 | 1.05 | 214.30 | |
| 24.46 | -93.29 | 11.68 | -20.12 | 104.97 |
| 29.49 | -81.70 | -81.70 | -196.28 | |
| 34.52 | -175.09 | 173.05 | -842.32 | 348.14 |
| 36.66 | 133.34 | 133.34 | -514.53 | |
| 38.80 | 93.62 | 93.62 | -271.72 | |

FIRM:DesignCalcs, Inc.                    JOB NO.1234567890   SHEET NO:  28
MADE BY:KJH  DATE:03-28-2014              CHECKED BY:          DATE:
TITLE:Example INTEGRAL abument calculation

INTEGRAL ABUTMENT DESIGN:

BACKWALL HORIZONTAL ANALYSIS: PASSIVE PRESSURE EARTH PRESSURE




BACKWALL HORIZONTAL LOADING (UNFACTORED)

| X (ft) | Vleft (k) | Vright (k) | M (k*ft) | Reaction (k) |
|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | |
| 2.06 | -19.14 | -19.14 | -19.73 | |
| 4.12 | -38.27 | 46.99 | -78.93 | 85.26 |
| 9.21 | -.19 | -.19 | 40.01 | |
| 14.29 | -47.36 | 47.53 | -80.86 | 94.89 |
| 19.37 | .36 | .36 | 40.84 | |
| 24.46 | -46.81 | 45.92 | -77.23 | 92.74 |
| 29.49 | -.77 | -.77 | 36.37 | |
| 34.52 | -47.46 | 39.71 | -84.97 | 87.17 |
| 36.66 | 19.86 | 19.86 | -21.24 | |
| 38.80 | 0.00 | 0.00 | 0.00 | |

INTEGRAL ABUTMENT DESIGN:

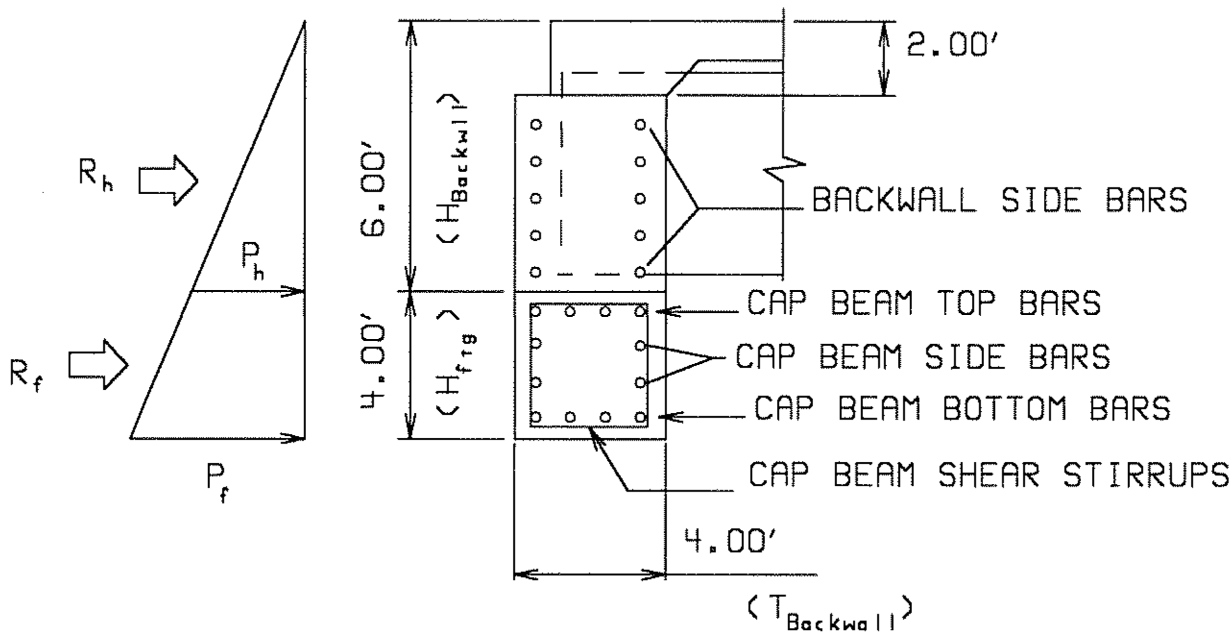
```
---------------------------------------------------------------------
|  SUMMARY OF HORIZONTAL LOADING ANALYSIS RESULTS:                   |
|  -----------------------------------------------                   |
|  Maximum Cap Beam Horiz Moment, Mmax=   214.30 k*ft (unfactored)|
|  Minumum Cap Beam Horiz Moment, Mmin=  -842.32 k*ft (unfactored)|
|  Maximum Cap Beam Horiz Shear,  Vmax=   175.09 k    (unfactored)|
|                                                                  |
|  Maximum Backwall Horiz Moment, Mmax=    40.84 k*ft (unfactored)|
|  Minumum Backwall Horiz Moment, Mmin=   -84.97 k*ft (unfactored)|
|  Maximum Backwall Horiz Shear,  Vmax=    47.53 k    (unfactored)|
---------------------------------------------------------------------
```

Load Factor for Passive Pressure, $_{PASSIVE}$ = 1.20

```
---------------------------------------------------------------------
|  FACTORED HORIZONTAL LOADING ANALYSIS RESULTS:                    |
|  -----------------------------------------------                  |
|  Max. Factored Cap Beam Horiz Moment, Mu,max=   257.16 k*ft      |
|  Min. Factored Cap Beam Horiz Moment, Mu,min= -1010.78 k*ft      |
|  Max. Factored Cap Beam Horiz Shear,  Vu,max=   210.11 k         |
|                                                                  |
|  Max. Factored Backwall Horiz Moment, Mu,max=    49.01 k*ft      |
|  Min. Factored Backwall Horiz Moment, Mu,min=  -101.97 k*ft      |
|  Max. Factored Backwall Horiz Shear,  Vu,max=    57.03 k         |
---------------------------------------------------------------------
```

## INTEGRAL ABUTMENT DESIGN:

### CAP BEAM DESIGN FOR VERTICAL LOADS:




REINFORCING BARS

### Cap Beam Bottom Bar Design:

Mu =    354.4 k*ft
Min. depth of cap beam, $H_{ftg}$ =  48.00 in
$d_{bot}$ =  44.50 in

Determine minimum reinforcement design moment (LRFD 5.7.3.3.2):
Mmin = 1.2*Mcr, based on a modulus of rupture,
= 1.2 * 1/6 * b * $h^2$ * fr
= 1.2 * 1/6 * ( 48.00 in) * ( $48.00)^2$*( .740 ksi)/12
=  1364.0 k*ft >   354.43 k*ft
Or,
Mmin = 1.33 *   354.43
=   471.39 k*ft (governs)<  1364.0 k*ft

By trial and error, compression block depth is
a =    .87 in

As,req'd = Mu/[($\phi$ * Fy * (d - a/2)]
= 12*(  471.39)/[(0.9 * 60 ksi * ( 44.50 in -   .87 in/2)]
=   2.38 sq. in. (Cap Beam Bottom Bar

Check a:
a = As * fy/(0.85*b*fc')
= (  2.38 sq. in)*(60 ksi)/(0.85 *  48.00 in * 4.00 ksi)
=    .87 in (Checks)

INTEGRAL ABUTMENT DESIGN:

CAP BEAM DESIGN FOR VERTICAL LOADS:

Cap Beam Top Bar Design:

Mu = -338.2 k*ft
$d_{top}$ = 45.50 in

Determine minimum reinforcement design moment (LRFD 5.7.3.3.2):
Mmin = 1.2*Mcr, based on a modulus of rupture,
= 1.2 * 1/6 * b * $h^2$ * fr
= 1.2 * 1/6 * ( 48.00 in) * ( $48.00)^2$*( .740 ksi)/12
= 1364.0 k*ft > 338.16 k*ft
Or,
Mmin = 1.33 * 338.16
= 449.76 k*ft (governs)< 1364.0 k*ft

By trial and error, compression block depth is
a = .81 in

As,req'd = Mu/[(φ * Fy * (d - a/2)]
= 12*( 449.76)/[(0.9 * 60 ksi * ( 45.50 in - .81 in/2)]
= 2.22 sq. in. (Cap Beam Top Bars)

Check a:
a = As * fy/(0.85*b*fc')
= ( 2.22 sq. in)*(60 ksi)/(0.85 * 48.00 in * 4.00 ksi)
= .81 in (Checks)

INTEGRAL ABUTMENT DESIGN:

CAP BEAM DESIGN FOR VERTICAL LOADS:

Cap Beam Shear Stirrup Design:

Vu = 307.8 k
d = 44.50 in.

Concrete shear strength,
fcv = 2 * $(fc)^{.5}$
= 2*$(4000)^{.5}$
= 126 psi = .126 ksi

Maximum portion of shear force that can be carried by concrete,
Vcu = $\varphi$ * fcv * bw *d
= 0.85 * ( .126 ksi) * ( 48.00 in) * ( 44.50 in)
= 229.7 k < 307.8 k (Shear reinforcment is required)

Portion of shear force to be carried by stirrups,
Vs = Vu - Vcu
= 307.75 k - 229.7 k
= 78.09 k

The maximum allowable shear that can be carried by stirrups is,
Vsmax = $\varphi$ * 4 * fcv * bw * d
= 0.85*4*( .126 ksi)*( 48.0 in)*( 44.5 in)
= 918.6 k> 78.09 k (OK)

Required area of shear stirrups,
Av,req'd = Vsu * s/($\varphi$ * Fy * d)
= ( 78.1 k)*(12 in)/(0.85 * 60 ksi * 44.50 in)
= .41 sq. in. per foot

INTEGRAL ABUTMENT DESIGN:

CAP BEAM DESIGN FOR HORIZONTAL LOADS:

Cap Beam Side Bar Design:

Mu = 1010.8 k*ft
Width of cap beam, $T_{backwall}$ = 48.00 in
$d_{bot}$ = 45.50 in

Determine minimum reinforcement design moment (LRFD 5.7.3.3.2):
Mmin = 1.2*Mcr, based on a modulus of rupture,
= $1.2 * 1/6 * b * h^2 * fr$
= $1.2 * 1/6 * (48.00 \text{ in}) * (48.00)^2 * (.740 \text{ ksi})/12$
= 1364.0 k*ft > 1010.78 k*ft
Or,
Mmin = 1.33 * 1010.78
= 1344.34 k*ft (governs) < 1364.0 k*ft

By trial and error, compression block depth is
a = 2.48 in

As,req'd = $Mu/[(\varphi * Fy * (d - a/2)]$
= 12*( 1344.34)/[(0.9 * 60 ksi * ( 45.50 in - 2.48 in/2)]
= 6.75 sq. in. (Cap Beam Side Bars)

Check a:
a = As * fy/(0.85*b*fc')
= ( 6.75 sq. in)*(60 ksi)/(0.85 * 48.00 in * 4.00 ksi)
= 2.48 in (Checks)

## INTEGRAL ABUTMENT DESIGN:

## CAP BEAM DESIGN FOR HORIZONTAL LOADS:

### Cap Beam Shear Stirrup Design:

Vu = 210.1 k
d = 45.50 in.

Concrete shear strength,
$fcv = 2 * (fc)^{.5}$
$= 2*(4000)^{.5}$
= 126 psi = .126 ksi

Maximum portion of shear force that can be carried by concrete,
$Vcu = \varphi * fcv * bw * d$
= 0.85 * ( .126 ksi) * ( 48.00 in) * ( 45.50 in)
= 234.8 k > 210.1 k

Check if minimum shear reinforcement is required:
1/2*Vcu =1/2*( 234.8 k)= 117.4 k< 210.1 k

Provide minimum shear reinforcement.

Av, min = 50*bw*s/Fy
= 50*( 48.00 in)*(12 in)/(60000 psi)
= .480 sq. in. per foot

## INTEGRAL ABUTMENT DESIGN:

### BACKWALL DESIGN FOR HORIZONTAL LOADS:

#### Backwall Side Bar Design:

Mu = 102.0 k*ft
Width of backwall, $T_{backwall}$ = 48.00 in
$d_{bot}$ = 45.50 in

Determine minimum reinforcement design moment (LRFD 5.7.3.3.2):
Mmin = 1.2*Mcr, based on a modulus of rupture,
= 1.2 * 1/6 * b * $h^2$ * fr
= 1.2 * 1/6 * ( 48.00 in) * $(48.00)^2$ *( .740 ksi)/12
= 1364.0 k*ft > 101.97 k*ft
Or,
Mmin = 1.33 * 101.97
= 135.62 k*ft (governs)< 1364.0 k*ft

By trial and error, compression block depth is
a = .24 in

As,req'd = Mu/[($\phi$ * Fy * (d - a/2)]
= 12*( 135.62)/[(0.9 * 60 ksi * ( 45.50 in - .24 in/2)]
= .66 sq. in. (Backwall Side Bars)

Check a:
a = As * fy/(0.85*b*fc')
= ( .66 sq. in)*(60 ksi)/(0.85 * 48.00 in * 4.00 ksi)
= .24 in (Checks)

INTEGRAL ABUTMENT DESIGN:

Notes:

1. This program does not check pile capacity. The designer will need to determine if the piles have sufficient resistance for the computed factored axial and moments loads.

2. This program does not perform a push-over analysis, if applicable for for seismic loading.

3. This program does not check anchor bolt connections.