Erection Plan Support Calculations
BRO 1448(25)

Fairfield, Vermont

CEE 38-mi-15

Prepared for:
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Fairfield, Vermont

Erection Plan

TH 47 (Elm Brook Road) Bridge 46
Fairfield BRO 1448(41)

Location:
Town of Fairfield in Franklin County on TH 47 (Elm Brook Road) over the Black Creek. Approximately 0.05 miles west of intersection with VT 36.

References:
-AASHTO LRFD BDS Seventh ed.
-Steel Construction, ASD
-Use Strength 1 Factors for construction

Waste block bearing capacity:
-Utilize crane mats to distribute loading
-Blocks: (2'x2'x6')
-Set-up: 3 blocks tall, 5 blocks long, sufficient crane mats on top of blocks.

$AB_1 := 38240\ lbf$ -assume abutment load fully on front axles
$Cr := 33996\ lbf$ -taken from Manual, upper facing front, front axles

Loading:

$P := \frac{AB_1}{2} + \frac{Cr}{2} = 36.118\ kip$, per outrigger.

$LL := 1.75$ $DL := 1.25$ LRFD strength 1
$P_{LL} := P \cdot LL = 63.207\ kip$
$f'_c := 2000\ psi$
$A_1 := 1\ ft^2$ assume 1ft x 1ft outrigger
$m := 1$ assume, conservative
$\phi := 0.7$ bearing resistance, AASHTO LRFD
$P_n := 0.85 \cdot f'_c \cdot A_1 \cdot m$ (5.7.5-2, AASHTO)
$P_r := \phi \cdot P_n$
$P_r = 171.36\ kip$

$$check := \begin{cases} \text{if } P_r > P_{LL} \\ \quad \text{"Bearing Resistance Okay"} \\ \text{else} \\ \quad \text{"Inadequate Bearing Strength"} \end{cases} = \text{"Bearing Resistance Okay"}$$

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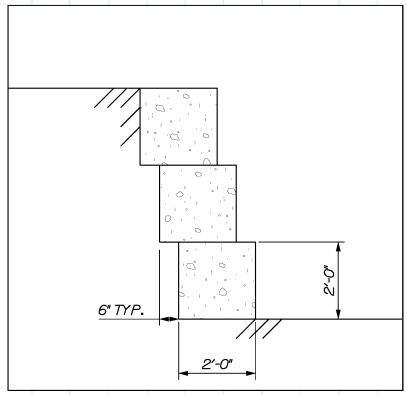
Check soil bearing resistance under waste blocks:

-Model as a spread footing
-Load footing in center
-Bearing on granular fill
-Step waste blocks back 6" per tier



$cN_{cm} := 0$

$\gamma D_f N_{qm} := 0$

$B := 2\ ft$

$L := 30\ ft$

$H := 6\ ft$

$\phi := 30\ deg$

$\gamma := 120\ pcf$

$N_\gamma := 22.4$ Table 10.6.3.1.2a-1, AASHTO LRFD

$i_\gamma := 1$

$C_{w\gamma} := 1.0$

$$s_\gamma := 1 - 0.4 \cdot \left(\frac{B}{L}\right)$$

$$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$$

$q_n := cN_{cm} + \gamma D_f N_{qm} + 0.5 \cdot \gamma \cdot B \cdot N_{\gamma m} \cdot C_{w\gamma}$ Eq. 10.6.3.1.2a-1, AASTHO LRFD

$q_n := 0.5 \cdot \gamma \cdot B \cdot N_{\gamma m} \cdot C_{w\gamma}$, simplified

$q_n = 2.616\ ksf$, soil capacity

$w_{conc} := 6\ ft \cdot 2\ ft \cdot 2\ ft \cdot 150\ pcf = 3.6\ kip$, per waste block

$n_{blocks} := 15$

$$q := \frac{DL \cdot (w_{conc} \cdot n_{blocks}) + (P_{LL} \cdot 2)}{(6\ ft \cdot 5) \cdot 3\ ft} = 2.155\ ksf$$

, conservatively assume 50% LL on waste blocks even with crane mats present

$check :=$ if $q_n > q$ = "Soil resistance Okay"
  "Soil resistance Okay"
else
  "Bearing Resistance Inadequate"

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Check live load surcharge overturning:

-Crane drives up to waste blocks

-Use 3.11.6.4 AASHTO LRFD

$M_{conc\_1} := (30\ ft \cdot 2\ ft \cdot 2\ ft \cdot 150\ pcf) \cdot 1\ ft$

$M_{conc\_2} := (30\ ft \cdot 2\ ft \cdot 2\ ft \cdot 150\ pcf) \cdot 1.5\ ft$

$M_{conc\_3} := (30\ ft \cdot 2\ ft \cdot 2\ ft \cdot 150\ pcf) \cdot 2\ ft$

$M_{res\_conc} := M_{conc\_1} + M_{conc\_2} + M_{conc\_3} = 81\ kip \cdot ft$

According to AASHTO LRFD, Live load surcharge occurs at 1/2 wall height distance from wall. Therefore, crane will be 3 feet from wall when liveload occurs and loading will be distributed on the crane mats. Assume 6'-0" x 10'-0" crane mats.

$A_{mat} := 6\ ft \cdot 10\ ft = 60\ ft^2$

$P = 36.118\ kip$

$w_{crane} := \frac{P}{A_{mat}} = 0.602\ ksf$

$A_{mat\_resist} := 2\ ft \cdot 6\ ft$

$P_{mat} := A_{mat\_resist} \cdot w_{crane} = 7.224\ kip$

$M_{res\_mat} := 2 \cdot (P_{mat} \cdot 1\ ft) = 14.447\ ft \cdot kip$ (2 outriggers)

$M_{res} := M_{res\_conc} + M_{res\_mat} = 95.447\ ft \cdot kip$

Check overturning:

$h_{eq} := 4\ ft$ Table 3.11.6.4-1

$\theta := 90\ deg$

$\beta := 0\ deg$

$\delta := 24\ deg$ Table 3.11.5.3-1, AASHTO LRFD

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$$\Gamma := \left(1+\sqrt{\frac{(\sin(\phi+\delta)\cdot\sin(\phi-\beta))}{\sin(\theta-\delta)\cdot\sin(\theta+\beta)}}\right)^2$$ Eq. 3.11.5.3-2

$$k_a := \frac{\sin(\theta+\phi)^2}{\Gamma\cdot\left(\sin(\theta)^2\cdot\sin(\theta-\delta)\right)} = 0.296$$ Eq. 3.11.5.3-1

$$LS := \gamma\cdot k_a\cdot h_{eq} = 0.142\ ksf$$

$$M_o := LS\cdot(30\ ft\cdot H)\cdot\left(\frac{H}{2}\right) = 76.721\ kip\cdot ft$$

$$check := \begin{cases} \text{"Good"} & \text{if } M_{res} > M_o \\ \text{"Check overturning"} & \text{else} \end{cases} = \text{"Good"}$$

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Deadman Push-pull System Calulations:

By inspection, HP 14x73 okay in tension/compression

$M_{res} := 57.88\ kip \cdot 1.5\ ft$ Dead load resisting moment of abutment

$P := \frac{M_{res}}{5\ ft} = 17.364\ kip$ Force Req'd to adjust abutment

$P_f := P \cdot DL = 21.705\ kip$

Check deadman stability:

$H := 27.2\ in$, depth of two HP 14x73 beams

$k_p := 6.5$

$R := 0.467$, AASTHO LRFD, Fig 3.11.5.4-2

$k_p := k_p \cdot R = 3.036$

$\gamma = 120\ pcf$

$$P_p := \frac{\left(k_p \cdot \gamma \cdot H^2\right)}{2} = 935.743\ plf$$

$L_{DM} := 26\ ft$ same as the abutment length for ease of construction.

$P_{allow} := P_p \cdot L_{DM} = 24.329\ kip$

$$check := \begin{cases} \text{"Deadman stable"} & \text{if } P_{allow} > P_f \\ \text{"Deadman unstable"} & \text{else} \end{cases} = \text{"Deadman stable"}$$

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Design Bolted Connection for Deadman:

$P_{dead} := P_f \cdot DL = 27.131\ kip$ Strength 1

$P_p := P_{dead}$ passive pressure only resists as much as needed.

$V_{bolt} := 17.364\ kip$ model system as a centeliever beam @ bolted connection

$M_{bolt} := P_p \cdot \left(\frac{2}{3}\right) \cdot H = 491.98\ kip \cdot in$ $D_{bolt} := \frac{7}{8}\ in$

Two HP beams attached to deadman: $t_f := 0.505\ in$

$V_{bolt} := \frac{V_{bolt}}{2} = 8.682\ kip$

$M_{bolt} := \frac{M_{bolt}}{2} = 245.99\ kip \cdot in$

Use (4) bolts.

Check shear resistance:

$N_s := 1$ $A_b := 4 \cdot \left(\frac{\left(\frac{7}{8}\ in\right)^2 \cdot 3.1415}{4}\right) = 2.405\ in^2$ $F_{ub} := 60\ ksi$

$R_n := 0.38 \cdot A_b \cdot F_{ub} \cdot N_s$ $\phi_t := 0.8$ (Eq. 6.13.2.7-1, AASHTO LRFD)

$R_n = 54.839\ kip$ $\phi_s := \phi_t$

$$check := \begin{cases} \text{"Good"} & \text{if } R_n > V_{bolt} \\ \text{"Check Bolts"} & \text{else} \end{cases} = \text{"Good"}$$

Check combined tension and shear (moment):

$\frac{V_{bolt}}{R_n} = 0.158$

$$T_n := \begin{cases} 0.76 \cdot A_b \cdot F_{ub} & \text{if } \frac{V_{bolt}}{R_n} \le 0.33 \\ 0.76 \cdot (2 \cdot A_b) \cdot F_{ub} \cdot \sqrt{1 - \left(\frac{V_{bolt}}{\phi_s \cdot R_n}\right)^2} & \text{else} \end{cases} = 109.678\ kip$$

Eq. 6.13.2.11-1/-2
AASHTO LRFD

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<u>Find tension in bolts:</u>
-say bolts spaced 6" apart
-moment = force couple

$$F_{bolt} := \frac{M_{bolt}}{6\ in} = 40.998\ kip$$

$$check := \begin{cases} \text{if } T_n > F_{bolt} \\ \quad \text{"Good"} \\ \text{else} \\ \quad \text{"Check bolts"} \end{cases} = \text{"Good"}$$

Use (4) 7/8" A325 bolts in a 6"x6" layout.

Check Spacing:

$min := 3 \cdot D_{bolt} = 2.625\ in$

$max := 4\ in + 4\ t_f = 6.02\ in$

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Check HP 14x73 pile capacity for HLT150 loaded with FA-AB4 at max radius

Load per pile:

$P := 93.9\ kip$ from BeamBoy, conservative because analyzed as if only rear and front most outriggers in use

Piles driven to rock:
-Analyze as a totally unbraced section

$P_{LL} := P \cdot LL = 164.325\ kip$
$L_1 := 18\ ft$ depth to bedrock, from Contract Details Boring Log
$E := 29000000\ psi$
$A_{pile} := 21.4\ in^2$
$r_{yy} := 3.49\ in$
$k_1 := 1.20$
$F_y := 50000\ psi$
$\varphi_{cm} := 0.7$

Weak Axis Axial Compression

$$P_{ey1} := \frac{\pi^2 \cdot E}{\left(k_1 \cdot \frac{L_1}{r_{yy}}\right)^2} \cdot A_{pile} = 1110.43\ kip$$

Elastic Flexural Buckling Resistance AASHTO 6.9.4.1.2

$Q := 1.0$

$P_o := Q \cdot A_{pile} \cdot F_y = \left(1.07 \cdot 10^3\right)\ kip$

$$\frac{P_{ey1}}{P_o} = 1.038$$

Pe/Po > 0.44

$$P_{ny1} := \left(0.658^{\left(\frac{P_o}{P_{ey1}}\right)}\right) \cdot P_o = 714.87\ kip$$

$P_{r1} := \varphi_{cm} \cdot P_{ny1} = 500.41\ kip$

```
check := if P_r1 > P_LL
             "Pile Capacity Okay"
         else
             "Check Pile Capacity"
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= "Pile Capacity Okay"

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Check steel plate on driven HP 14x73 in bending:

4'x4'x1" plate
Use an outrigger area of 2'x2'
Analyze on a per inch basis

Calculate bending stress:
-Analyze as a canteliever with outrigger distributed load
-Edge of HP-beam acts as support

$$w := \frac{P_{LL}}{(2\ ft \cdot 2\ ft)} = 0.285\ ksi$$

$$M_B := w \cdot 5.2\ in \cdot \frac{5.2\ in}{2} \cdot 1\ in = 3.857\ in \cdot kip$$

Calculate capacity:

$f_y := 36\ ksi$ $\quad b := 1\ in$

$h := 1\ in$

$$S_x := \frac{b \cdot h^2}{6}$$

$$M_y := S_x \cdot f_y$$

$$M_y = 6\ in \cdot kip$$

$$check := \begin{cases} \text{if } M_y > M_B \\ \quad \text{"Good"} \\ \text{else} \\ \quad \text{"Check Plate"} \end{cases} = \text{"Good"}$$

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Check if shackle okay for shear block failure:

$t_{flange} := 0.505\ in$

$d_{hole} := 1\ in$

$P_f = 21.705\ kip$ assume 90 degree pull, conservative.

Try: Bolt 2.5" from edge of

Use ASD Table I-G

$A_v := 2.5\ in \cdot t_{flange} = 1.263\ in^2$

$F_u := 65\ ksi$

$A_t := 0\ in^2$

$R_{BS} := 0.3 \cdot A_v \cdot F_u + 0.5\ A_t \cdot F_u$ ("From AISC ASD Sect. J4")

$R_{BS} = 24.619\ kip$

$$check := \begin{array}{l} \text{if } R_{BS} > P_f \\ \quad \| \text{ "Good"} \\ \text{else} \\ \quad \| \text{ "Check Shackle"} \end{array} \quad = \text{"Good"}$$

BEAMBOY V2.2 REPORT

HLT 150 Reactions

LOAD CONFIGURATION

Point Loads

A) 28900 lb., x=0 ft.
B) 8750 lb., x=64.9 ft.
C) 20800 lb., x=67 ft.
D) 6000 lb., x=76.4 ft.

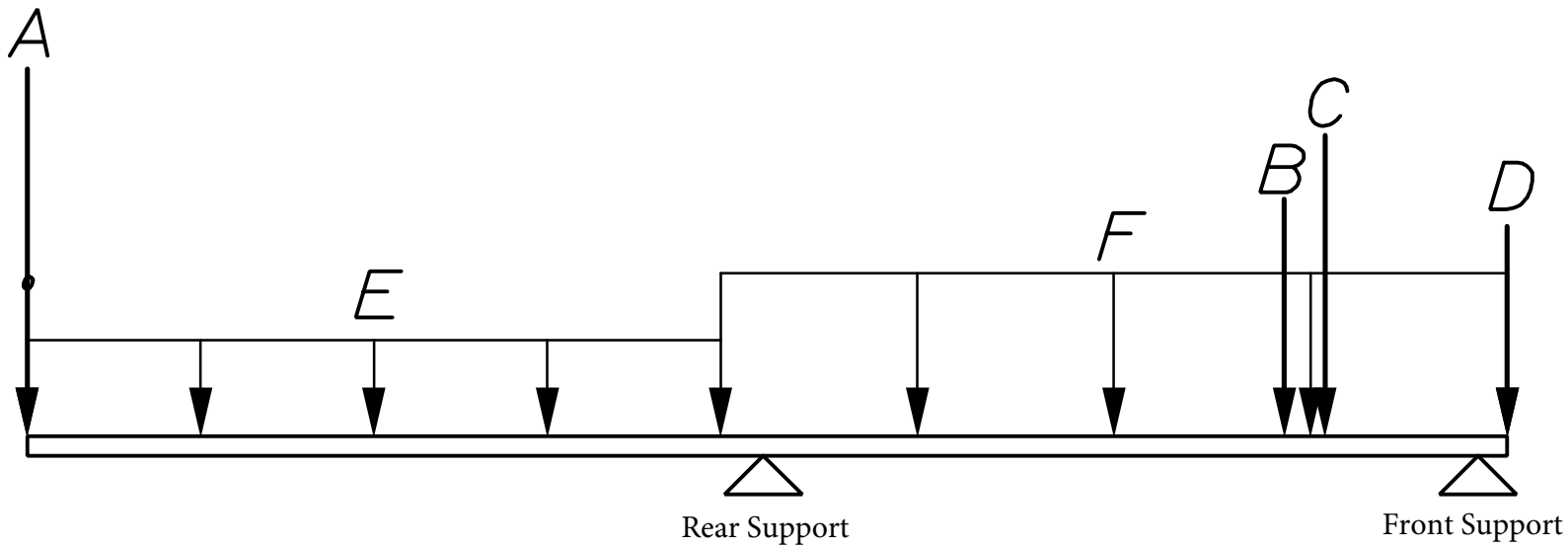
Distributed Loads

E) Start=131 lb./ft., x=0 ft.; End=131 lb./ft., x=35.8 ft.
F) Start=1020 lb./ft., x=35.8 ft.; End=1020 lb./ft., x=76.4 ft.

Supports

Rear Support: Simple support; 38 ft., Reaction=93900 lb.
Front Support: Simple support; 74.9 ft., Reaction=16800 lb.

4/21/2015



HLT 150 LOADING