Jacking Plan Support Calculations
STP 5600 (12)

Colchester, Vermont

CEE 38-mi-15

Prepared for:
A.L. St Onge Contractor, Inc

By:
Calderwood Engineering
August, 2015

Rev 1:
-Removed HP section. W 36x135 Diaphragms used for jacking.
-Added bolt and welded stiffener calculations.

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

Colchester, Vermont

Jacking Plan, *Rev 1*

TH 27 (Mill Pond Road) Bridge 12
Colchester Bridge 12 - STP 5600(12)

Location:
Town of Colchester in Chittenden County on TH 27 over the Indian Brook adjacent to the Mill Pond Dam. Approximately 0.24 miles south of the intersection of VT 2A and TH 27

References:
-AISC 9th, ASD
-NDS

Section Properties of W 36x135 Diaphragm:

$A_{w36} := 39.9\ in^2$ $d := 35.55\ in$ $t_w := 0.6\ in$ $b_f := 12\ in$ $t_f := 0.79\ in$

$I_x := 7800\ in^4$ $S_x := 439\ in^3$ $r_x := 14\ in$ $Z_x := 509\ in^3$ $F_y := 50\ ksi$

$F_u := 65\ ksi$ $E := 29000\ ksi$

Calculate Loading:

-Conservatively, say jack is placed midspan of diaphragm in order to maximize stresses.
-Say (1) jack carries 100% of (2) beams.

$P_{1G1A} := 13142\ lbf$ $P_{2G2A} := 13646\ lbf$ $P_{3G3A} := 15696\ lbf$ $P_{4G4A} := 15989\ lbf$

$P_{diaph} := 1250\ lbf$ per diaphragm

Heaviest Lift:
$P_{total} := (P_{4G4A} + P_{3G3A} + P_{diaph} \cdot 6) \cdot 1.15 = 45.063\ kip$

Added 15% for misc components, rigging, etc.

$P_{jack} := \frac{P_{total}}{2} = 22.531\ kip$ Reaciton at each abutment

$A_{jack} := 6\ in \cdot 6\ in = 36\ in^2$

First: Check timber crib Mixed Oak No.2 $F_c := 800\ psi$ Compression perpendicular to grain. Ref: NDS

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

$w_{jack} := \frac{P_{jack}}{A_{jack}} = 625.872\ psi$ (Fc > load) without adjustment factors, Wood crib okay.

Check Bending in W 36x135

-Compact section for Fy = 50ksi

$L_{w36} := 9.04167\ ft$ Longest diaphragm (worst case)

$L_b := L_{w36} = 9.042\ ft$ $A_f := b_f \cdot t_f = 9.48\ in^2$

Check Slenderness:

$b := \frac{b_f}{2} = 6\ in$ $t := t_f = 0.79\ in$

$$check := \begin{cases} \text{if } \frac{b}{t} < \frac{65}{\sqrt{\frac{F_y}{ksi}}} \\ \quad \text{"Compact"} \\ \text{else} \\ \quad \text{"Noncompact"} \end{cases} = \text{"Compact"}$$

Table B5.1, ASD

$$L_c := min\left(\frac{76 \cdot b_f}{\sqrt{\frac{F_y}{ksi}}}, \frac{20000}{\left(\frac{d}{A_f}\right) \cdot \frac{F_y}{ksi}}\right) = 8.889\ ft$$

Eq. F1-2, ASD

Lb>Lc, calculate Fb:

$C_b := 1.0$ $F_b := min\left(0.6 \cdot F_y, \frac{12 \cdot 10^3 \cdot C_b}{L_{w36} \cdot \frac{d}{A_f}} \cdot ksi\right) = 29.493\ ksi$

$M_{max} := \frac{P_{jack} \cdot L_{w36}}{4} = 611.164\ kip \cdot in$

Simply supported, concentracted load at center to maximize moment

$F_{b\_max} := \frac{M_{max}}{S_x} = 1.392\ ksi$

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

$$FS := \frac{F_b}{F_{b\_max}} = 21.185$$

Check Local Web Yielding:

-Eq K1-2, ASD

$N := 6\ in$ $\quad k := 1.6875\ in$ $\quad \frac{P_{jack}}{t_w \cdot (N + 5 \cdot k)} = 2.601\ ksi$

$$check1 := \text{if } \frac{P_{jack}}{t_w \cdot (N + 5 \cdot k)} < 0.66\ F_y \ \text{"Good"} \ \text{else} \ \text{"Check web"} = \text{"Good"}$$

Check web crippling:

-Eq K1-4, ASD

$F_{yw} := F_y = 50\ ksi$ $\quad N = 6\ in$ $\quad t_w = 0.6\ in$

$d = 35.55\ in$ $\quad t_f = 0.79\ in$

$$R := \left(67.5 \cdot \left(\frac{t_w}{in}\right)^2 \cdot \left(1 + 3 \cdot \left(\frac{N}{d}\right) \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right) \cdot \sqrt{\frac{F_{yw}}{ksi} \cdot \left(\frac{t_f}{t_w}\right)}\right) \cdot kip = 263.241\ kip$$

$$check2 := \text{if } R > P_{jack} \ \text{"Good"} \ \text{else} \ \text{"Check web"} = \text{"Good"}$$

Sidesway Web Buckling:

-K5, ASD

$l := L_{w36} = 108.5\ in$ $\quad d_c := d - 2\ k = 32.175\ in$ $\quad h := d_c = 32.175\ in$

$$\frac{\frac{d_c}{t_w}}{\frac{l}{b_f}} = 5.931$$

>1.7, Loaded flange is unrestrained. Sidesway web buckling need not be checked. Ref: ASD K5

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

Check shear stress:
F4, ASD

$$\frac{h}{t_w} = 53.625 \qquad \frac{380}{\sqrt{\frac{F_y}{ksi}}} = 53.74$$

$$F_v := \text{if } \frac{h}{t_w} \le \frac{380}{\sqrt{\frac{F_y}{ksi}}} \;\; \| \; 0.4\, F_y \;\; \text{else} \;\; \| \; \text{“Calculate Fv”} = 20\ ksi$$

$$V_{max} := \frac{P_{jack}}{2} = 11.266\ kip$$

$$V_{allow} := F_v \cdot (h \cdot t_w) = 386.1\ kip$$

$$FS := \frac{V_{allow}}{V_{max}} = 34.272$$

Check steel plate in bending:
-Model as a cantilever at edge of jack head
-Jack head is 3 inches in diameter

$$L_{plate} := 3\ in \qquad S_{plate} := \frac{1\ in \cdot (0.5\ in)^2}{6} = 0.042\ in^3$$ per inch

$$w_{plate} := \frac{P_{jack}}{6\ in \cdot 6\ in} = 0.626\ ksi \qquad F_{y\_plate} := 36\ ksi$$

$$w_{plate2} := w_{plate} \cdot 1\ in = 0.626\ \frac{kip}{in}$$ load per inch of plate

$$M_{max\_plate} := \frac{w_{plate2} \cdot (L_{plate} - 1.5\ in)^2}{2} = 0.704\ kip \cdot in$$

$$M_{allow} := F_{y\_plate} \cdot S_{plate} = 1.5\ kip \cdot in$$

$$FS := \frac{M_{allow}}{M_{max\_plate}} = 2.13$$

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

All checks okay with stresses maximized. Okay to place jack anywhere along diaphragm in order to ensure even lift.

Check shear in bolts:

-Each side has (10) ASTM A325 7/8" Dia. high strength bolts.

$V_{allow} := 12.6\ kip$ Per bolt, AISC 9th, Table 1-D, standard hole, threads in shear plane.

$$V_{bolt} := \frac{\left(\frac{P_{jack}}{2}\right)}{10} = 1.127\ kip$$

$$check := \begin{array}{l} \text{if } V_{allow} > V_{bolt} \\ \quad \text{"Good"} \\ \text{else} \\ \quad \text{"Check Bolts"} \end{array} = \text{"Good"}$$

Check weld of stiffener:

-5/16" fillet weld both sides.

$$throat := 0.707 \cdot \left(\frac{5}{16}\ in\right) = 0.221\ in$$

$F_{weld} := 70\ ksi$

$V_{all} := 0.3 \cdot F_{weld} = 21\ ksi$ Table J2.5, ASD

Conservatively say 12" of weld total

$l_{weld} := 12\ in$

$P_{weld\_all} := V_{all} \cdot throat \cdot l_{weld} = 55.676\ kip$

$$V_{weld} := \frac{P_{jack}}{2} = 11.266\ kip$$

$$check := \begin{array}{l} \text{if } P_{weld\_all} > V_{weld} \\ \quad \text{"Good"} \\ \text{else} \\ \quad \text{"Check weld"} \end{array} = \text{"Good"}$$

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

Check base metal:

$$A_{base} := l_{weld} \cdot \left(\frac{5}{16}\ in\right) = 3.75\ in^2 \qquad F_v := 0.3 \cdot F_u$$

$$P_{base\_all} := A_{base} \cdot F_v = 73.125\ kip$$

$$check := \begin{array}{l} \text{if } P_{base\_all} > V_{weld} \\ \quad \| \text{“Good”} \\ \text{else} \\ \quad \| \text{“Check base metal”} \end{array} = \text{“Good”}$$

Calculate required location of jacks:

-Jacks in bays (1) & (3) carry 100% of fascia beams and 50% of interior beams. Jack in bay (2) carries 50% of interior beams.

-Calculate centroid of each bay

	d (ft)	weight (lb)	Total wt on jack (lb)	Centroid of bay from WP
1G1A	1.97396	13142		
Bay 1			19965	5.2704
2G2A	11.61979	13646		
Bay 2			14671	16.7797
3G3A	21.26563	15696		
Bay 3			23746	27.7235
4G4A	30.91146	15898		

Notes:
d = distance to centroid of each beam from WP
wt on jack 1 = 100% 1G41 + 50% 2G32
wt on jack 2 = 50% 2G2A + 50% 3G3A
wt on jack 3 = 100% 4G4A + 50% 3G3A

Centroid Equation:

$$Centroid := \boxed{d_{1G1A}} \cdot \left(\frac{wt_{1G1A}}{jack_1}\right) + d_{2G2A} \cdot \left(\frac{0.5 \cdot wt_{2G2A}}{jack_1}\right)$$

See sheet 7 for sketch of centroid for clarity.

1'-10 1/2"
7'-9 1/2"
3'-2 9/16"
6'-5 7/16"
5'-1 7/16"
4'-6 9/16"
Beam Centroid
Bay Centroid
WP
27'-8 11/16"
16'-9 3/8"
5'-3 1/4"
1'-11 11/16"
11'-7 7/16"
21'-3 3/16"
30'-10 5/16"