Jacking Plan Support Calculations
STP 5600 (12)

Colchester, Vermont

CEE 38-mi-15

Prepared for:
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Colchester, Vermont

Jacking Plan

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 HP 12x63

$A_{HP} := 18.4\ in^2$ $d := 11.9\ in$ $t_w := 0.515\ in$ $b_f := 12.1\ in$ $t_f := 0.515\ in$

$I_x := 472\ in^4$ $S_x := 79.1\ in^3$ $r_x := 5.06\ in$ $Z_x := 88.3\ in^3$ $F_y := 50\ ksi$

$E := 29000\ ksi$

Calculate Loading:

-Conservatively, say jack is placed midspan of HP beam 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:
$P_{total} := (P_{4G4A} + P_{3G3A} + P_{diaph} \cdot 6) \cdot 1.15 = 45.063\ kip$

Add 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

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

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Check Bending in HP 12x63:

-Compact section for Fy = 50ksi

C-C girder = 9'-8", Use: $L_{HP} := 9.5\ ft$

$L_b := L_{HP} = 9.5\ ft$ $\quad A_f := b_f \cdot t_f = 6.232\ in^2$

Check Slenderness:

$b := \frac{b_f}{2} = 6.05\ in$ $\quad t := t_f = 0.515\ in$

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

Table B5.1, ASD

$$L_c := min\left(\frac{76 \cdot b_f}{\sqrt{\frac{F_y}{ksi}}}, \frac{20000}{\left(\frac{d}{A_f}\right) \cdot \frac{F_y}{ksi}}\right) = 10.838\ ft$$

Eq. F1-2, ASD

$F_b := 0.6 \cdot F_y = 30\ ksi$ Eq. F1-5, Lb < Lc, noncompact

$$M_{max} := \frac{P_{jack} \cdot L_{HP}}{4} = 642.144\ kip \cdot in$$

Simply supported, concentracted load at center

$$F_{b_max} := \frac{M_{max}}{S_x} = 8.118\ ksi$$

$$FS := \frac{F_b}{F_{b_max}} = 3.695$$

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Check Local Web Yielding:

- Eq K1-2, ASD

$N := 6\ in$ $\quad k := 1.25\ in$ $\quad \dfrac{P_{jack}}{t_w \cdot (N + 5 \cdot k)} = 3.571\ ksi$

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

Check web crippling:

-Eq K1-4, ASD

$F_{yw} := F_y = 50\ ksi$ $\quad N := 6\ in$ $\quad t_w = 0.515\ in$

$d = 11.9\ in$ $\quad t_f = 0.515\ in$

$$R := \left(67.5 \cdot \left(\frac{t_w}{in}\right)^2 \cdot \left(1 + 3 \cdot \left(\frac{N}{d}\right) \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right) \cdot \sqrt{\frac{F_{yw}}{ksi} \cdot \left(\frac{t_f}{t_w}\right)}\right) \cdot kip = 318.073\ kip$$

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

Sidesway Web Buckling:

-K5, ASD

$l := L_{HP} = 114\ in$ $\quad d_c := d - 2\ k = 9.4\ in$ $\quad h := 11.4\ in$

$$\frac{\dfrac{d_c}{t_w}}{\dfrac{l}{b_f}} = 1.937$$

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

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Check shear stress:

-F4, ASD

$\frac{h}{t_w} = 22.136$ $\qquad \frac{380}{\sqrt{\frac{F_y}{ksi}}} = 53.74$

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

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

$$V_{allow} := F_v \cdot (h \cdot t_w) = 117.42\ kip$$

$$FS := \frac{V_{allow}}{V_{max}} = 10.423$$

Check existing flange in bending:

-Model flange as cantilever

$t_{f1} := 0.875\ in \qquad b_{f1} := 18\ in \qquad t_{w1} := 0.5\ in$

$L_{f1} := \frac{b_{f1} - t_{w1}}{2} = 8.75\ in$ Length of flange in bending

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

Say load is distributed evenly along length of flange:

$$w_{flange} := \frac{P_{reaction}}{L_{f1}} = 1.288\ \frac{kip}{in}$$

$$M_{flange} := \frac{w_{flange} \cdot L_{f1}^{\ 2}}{2} = 49.287\ kip \cdot in$$

$b_{f1} := b_f = 12.1\ in$ say width of flange equal to width of HP beam resists bending, conservative.

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$$S_{x_flange} := \frac{b_{f1} \cdot t_{f1}^{2}}{3} = 3.088\ in^{3}$$

$$M_y := F_y \cdot S_{x_flange} = 154.401\ kip \cdot in$$

$$FS := \frac{M_y}{M_{flange}} = 3.133$$

$$check2 := \begin{cases} \text{"Good"} & \text{if } M_y > M_{flange} \\ \text{"Check bending"} & \text{else} \end{cases} = \text{"Good"}$$

Check steel plate in bending:

-Model as a cantilever at center of plate

$L_{plate} := 3\ in$ $\qquad S_{plate} := \frac{0.5\ in \cdot 1\ in^{2}}{3} = 0.167\ in^{3}$ 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

$$M_{max_plate} := \frac{w_{plate2} \cdot L_{plate}^{2}}{2} = 2.816\ kip \cdot in$$

$$M_{allow} := F_{y_plate} \cdot S_{plate} = 6\ kip \cdot in$$

$$FS := \frac{M_{allow}}{M_{max_plate}} = 2.13$$

All check okay with stresses maximized. Okay to place jack anywhere along HP beam in order to ensure even lift.

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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:

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

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"