Demolition Calculations

For

Bridge 46S and 46N

Waterbury, VT

CEE 074-mi-14

Prepared for:

Back & Bellucci, Inc

By:

Calderwood Engineering etc

February 4th, 2014

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Project: Waterbury Demo Calculations
Contractor: Beck & Bellucci

Design Computations by: : Gregory MacAlister, EIT

Project Notes:

Use ASD design methodology to check the stresses in the existing girders during deck demolition. Use 56k Excavator (CAT 324 DL) and 121k Truck & Tailer (See Dimensions sheet 2). Apply a 30% impact factor to the Excavator only during deck removal. Truck/Trailer or excavator shall not move at speed exceeding 5mph, no impact factor will be included for moving of equipment.

Removal of the deck will start @ Pier #3 and work outwards to each abutment.

Existing typical section consists of (5) girders spaced @ 7'-6" with (2) 2'-5" Overhangs. 8" Concrete Deck. 12" Reveal on Concrete Parapet.

(5) Different Girder Existing Sizes. Girders are simply supported single spans.

- **W36x160 w/ 13"x7/8"x 39'-6" Bottom Cover Plate**
  66.818' Max Span (Beam N1-A) Used 67' For Span

- **W36x170 w/ 14"x 1"x 51'-9" Bottom Cover Plate**
  71.814' Max Span (Beam N2-A) Used 72' For Span

- **W36x194 w/ 14"x 1 1/8"x 54'-0" Bottom Cover Plate**
  76.988' Max Span (Beam N3-C) Used 77' For Span

- **W36x245 w/ 14"x 1"x 51'-10" Bottom Cover Plate (This Beam Size is only used as an Interior beam)**
  81.729' Max Span (Beam N3-D) Used 82' For Span

- **W36x300 w/ 14"x 1"x 52'-8" Bottom Cover Plate (This Beam Size is only used as an exterior beam)**
  86.711' Max Span (Beam N3-E) Used 87' For Span

AISC_Manual_Label	W	A	d	b_f	t_w	t_f
W36X300	300	88.3	36.7	16.66	0.945	1.68
W36X245	245	72.1	36.1	16.51	0.800	1.35
W36X194	194	57.0	36.5	12.11	0.765	1.26
W36X170	170	50.0	36.2	12.03	0.680	1.10
W36X160	160	47.0	36.0	12.00	0.650	1.02

$S := 7.5\ ft$ $\quad OH := 2\ ft + \frac{5}{12}\ ft = 2.417\ ft$ $\quad \gamma_{conc.} := 150\ pcf$

$d_{deck} := 8\ in$

$H_w := 12\ in$ Barrier/Curb Height

$B_w := 2\ ft + \frac{5}{12}\ ft = 2.417\ ft$ Barrier/Curb Width

$w_{int} := S \cdot d_{deck} \cdot \gamma_{conc.} = 750\ \frac{lbf}{ft}$ $\quad w_{ext} := \left(\frac{S}{2} + OH\right) \cdot d_{deck} \cdot \gamma_{conc.} + H_w \cdot B_w \cdot \gamma_{conc.} = 979.167\ \frac{lbf}{ft}$

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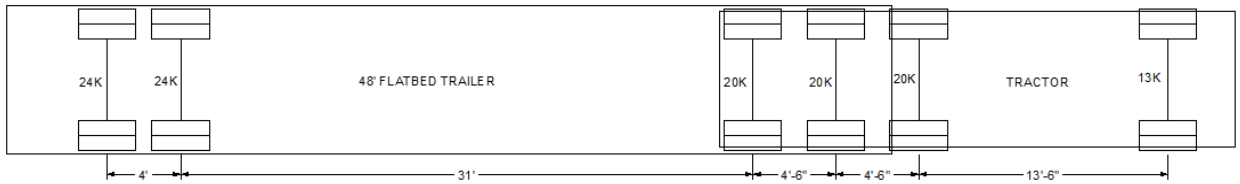
For the Truck and Trailer Use Below Axle Dimensions



P6 P5 P4 P3 P2 P1

Calculate Centroid of Truck/Trailer, Start 1ft from P1

$P_1 := 13\ kip$ $\quad x_1 := 1\ ft$

$P_2 := 20\ kip$ $\quad x_2 := x_1 + 13.5\ ft = 14.5\ ft$

$P_3 := 20\ kip$ $\quad x_3 := x_2 + 4.5\ ft = 19\ ft$

$P_4 := 20\ kip$ $\quad x_4 := x_3 + 4.5\ ft = 23.5\ ft$

$P_5 := 24\ kip$ $\quad x_5 := x_4 + 31\ ft = 54.5\ ft$

$P_6 := 24\ kip$ $\quad x_6 := x_5 + 4\ ft = 58.5\ ft$

$$C.G._{Trailer} := \frac{(P_1 \cdot x_1 + P_2 \cdot x_2 + P_3 \cdot x_3 + P_4 \cdot x_4 + P_5 \cdot x_5 + P_6 \cdot x_6)}{(P_1 + P_2 + P_3 + P_4 + P_5 + P_6)} - 1\ ft = 30.942\ ft$$

Distance from Axle to C.G.

$X_1 := C.G._{Trailer} = 30.94\ ft$

$X_2 := C.G._{Trailer} - (x_2 - 1\ ft) = 17.44\ ft$

$X_3 := C.G._{Trailer} - (x_3 - 1\ ft) = 12.94\ ft$

$X_4 := C.G._{Trailer} - (x_4 - 1\ ft) = 8.44\ ft$

$X_5 := C.G._{Trailer} - (x_5 - 1\ ft) = -22.56\ ft$

$X_6 := C.G._{Trailer} - (x_6 - 1\ ft) = -26.56\ ft$

Note that the above axle loads are Axle capacities. Actual Axle loading will be lower than loads used. Even with the trailer fully loaded we do not expect to reach the axle capacity. Therefore, Conservative

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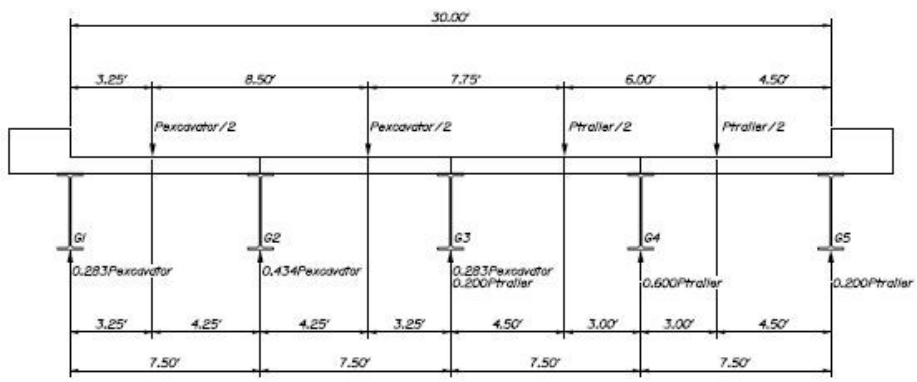
Calculate Live Load Distribution Factors

Look @ Typical section with Excavator and Truck Side by side centered on Girders 2 and 4.



Assuming the deck is cut longitudinally along the girder lines, calculate LL D.F. looking at deck simply supported by adjacent girders. For simplicity assume P=1000lbs

Excavator D.F.

Take the moment about adjacent girder

$$P_{excavator} := 1000\ lbf$$

$$G1 := \frac{\left(\frac{P_{excavator}}{2} \cdot 4.25\ ft\right)}{7.5\ ft} = 283.333\ lbf \qquad D.F._{G1ex} := \frac{G1}{P_{excavator}} = 0.283$$

$$G2 := \frac{\left(\frac{P_{excavator}}{2} \cdot 3.25\ ft\right)}{7.5\ ft} = 216.667\ lbf \qquad D.F._{G2ex} := 2 \cdot \frac{G2}{P_{excavator}} = 0.433$$

$$G3 := \frac{\left(\frac{P_{excavator}}{2} \cdot 4.25\ ft\right)}{7.5\ ft} = 283.333\ lbf \qquad D.F._{G3ex} := \frac{G3}{P_{excavator}} = 0.283$$

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Truck D.F.

Take the moment about adjacent girder

$P_{truck} := 1000\ lbf$

$$G3 := \frac{\left(\frac{P_{truck}}{2} \cdot 3.0\ ft\right)}{7.5\ ft} = 200\ lbf \qquad D.F._{G3truck} := \frac{G3}{P_{truck}} = 0.2$$

$$G4 := \frac{\left(\frac{P_{truck}}{2} \cdot 4.5\ ft\right)}{7.5\ ft} = 300\ lbf \qquad D.F._{G4truck} := 2 \cdot \frac{G4}{P_{truck}} = 0.6$$

$$G5 := \frac{\left(\frac{P_{truck}}{2} \cdot 3.0\ ft\right)}{7.5\ ft} = 200\ lbf \qquad D.F._{G5truck} := \frac{G5}{P_{truck}} = 0.2$$

Calculate Worst Case Exterior D.F. (Place Excavato or Trailer 2ft From Curb)

$$G5 := \frac{\left(\frac{P_{truck}}{2} \cdot 5.5\ ft\right)}{7.5\ ft} = 366.667\ lbf \qquad D.F._{Ext} := \frac{G5}{P_{truck}} = 0.367$$

$$G4_{Ext1} := \frac{\left(\frac{P_{truck}}{2} \cdot 2.0\ ft\right)}{7.5\ ft} = 133.333\ lbf \qquad D.F._{G4Ext1} := \frac{G4_{Ext1}}{P_{truck}} = 0.133$$

$$G4_{Ext2} := \frac{\left(\frac{P_{truck}}{2} \cdot 5.0\ ft\right)}{7.5\ ft} = 333.333\ lbf \qquad D.F._{G4Ext2} := \frac{G4_{Ext2}}{P_{truck}} = 0.333$$

$D.F._{G4Ext} := D.F._{G4Ext1} + D.F._{G4Ext2} = 0.467$ G4 D.F. When G5 is fully Loaded

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Check W36x160 Beams During Demo

W36x160 Section Properties

Component	H (in)	W (in)	A (in^2)	y (in)	Ay (in^3)	I (in^4)	d (in)	Ad^2+I (in^4)
W36x160	36	12	47	18	846	9750	3.59	10356.67
Cover Plate	0.875	13	11.375	36.4375	414.48	0.7257	14.84	2507.40
Sum	36.88	25.00	58.38	54.44	1260.48	9750.73	18.44	12864.06
Ybar (in)	21.6							
Yt (in)	Yb (in)		A (in^2)	Sbot (in^3)	Stop (in^3)	I (in^4)		Wt (lbs/ft)
21.59	15.28		58.375	841.76	595.76	12864.06		198.64

Calculate allowable bending stress per AISC 9th Edition

$S_b = 841.765\ in^3$ $\quad S_t = 595.759\ in^3$ $\quad w_{self} = 198.637\ \frac{lbf}{ft}$ $\quad d = 36.875\ in$

$t_{cvrplt} = 0.875\ in$ $\quad b_{cvrplt} = 13\ in$ $\quad t_{cvrplt} = 0.875\ in$

$b_{cf} := b_{fW36x160} = 12\ in$ $\quad t_{cf} := t_{fW36x160} = 1.02\ in$ $\quad A_{cf} := b_{cf} \cdot t_{cf} = 12.24\ in^2$

$b_{tf} := b_{fW36x160} = 12\ in$ $\quad t_{tfbeam} := t_{fW36x160} = 1.02\ in$ $\quad t_{tf} := t_{tfbeam} + t_{cvrplt} = 1.895\ in$

$A_{tf} := b_{tf} \cdot t_{cf} + t_{cvrplt} \cdot b_{cvrplt} = 23.615\ in^2$ $\quad L := 67\ ft$

$d_{web} := d - t_{cf} - t_{tf} = 33.96\ in$ $\quad t_w := t_{wW36x160} = 0.65\ in$ $\quad F_y := 33\ ksi$

$$L_{c1} := \left| \frac{\left(\frac{76 \cdot b_{cf}}{in}\right)}{\sqrt{\frac{F_y}{ksi}}} \right| \cdot in = 158.759\ in$$

$$L_{c2} := \frac{(20000)}{\left(\left(\frac{d}{in}\right) \cdot \frac{F_y}{ksi}\right)} \cdot in = 201.171\ in$$

$L_c := min\left(L_{c1}, L_{c2}\right) = 158.759\ in$

$L_c = 13.23\ ft$

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Calculate Moments Due to Live Loads

Excavator Moment

$P_{exc} := 56\ kip$ Look at Excavator as Single 56k Point Load

Maximum Moment Occurs When Excavator is at Midspan

$M_{uexc} := \frac{\langle P_{exc} \cdot L \rangle}{4} = 938\ kip \cdot ft$ Undistributed, Unfactored

Trailer Moment

Check Moment When Centroid of Trailer is at Midspan

$P_1 := 13\ kip$ $Z_1 := \frac{L}{2} + X_1 = 64.4\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $Z_2 := \frac{L}{2} + X_2 = 50.9\ ft$

$P_3 := 20\ kip$ $Z_3 := \frac{L}{2} + X_3 = 46.4\ ft$

$P_4 := 20\ kip$ $Z_4 := \frac{L}{2} + X_4 = 41.9\ ft$

$P_5 := 24\ kip$ $Z_5 := \frac{L}{2} + X_5 = 10.9\ ft$

$P_6 := 24\ kip$ $Z_6 := \frac{L}{2} + X_6 = 6.9\ ft$

$M_{utruck1} := 954\ kip \cdot ft$ (P. A1)

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Check Moment When P3 of Trailer is at Midspan

$P_1 := 13\ kip$ $\quad Z_1 := \frac{L}{2} + (x_3 - x_1) = 51.5\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $\quad Z_2 := \frac{L}{2} + (x_3 - x_2) = 38\ ft$ $\quad Z_2 := \frac{L}{2} + (X_2 - X_3) = 38\ ft$

$P_3 := 20\ kip$ $\quad Z_3 := \frac{L}{2} = 33.5\ ft$

$P_4 := 20\ kip$ $\quad Z_4 := \frac{L}{2} + (x_3 - x_4) = 29\ ft$

$P_5 := 24\ kip$ $\quad Z_5 := \frac{L}{2} + (x_3 - x_5) = -2\ ft$ Not on This Span

$P_6 := 24\ kip$ $\quad Z_6 := \frac{L}{2} + (x_3 - x_6) = -6\ ft$ Not on This Span

$M_{utruck2} := 1020\ kip \cdot ft$ (P. A2)

$M_{utruck} := \max(M_{utruck1}, M_{utruck2}) = 1020\ kip \cdot ft$

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Calculate Stress in Beam with Truck & Excavator @ Midspan w/ Full Dead Load form the Deck

$w_{deadext} := 1.15 \cdot w_{self} + w_{ext} = 1207.599 \ \frac{lbf}{ft}$ $\qquad M_{deadext} := \frac{\left(w_{deadext} \cdot L^2\right)}{8} = 677.614 \ kip \cdot ft$

$w_{deadint} := 1.15 \cdot w_{self} + w_{int} = 978.433 \ \frac{lbf}{ft}$ $\qquad M_{deadint} := \frac{\left(w_{deadint} \cdot L^2\right)}{8} = 549.023 \ kip \cdot ft$

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1021.548 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 20.576 \ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 955.49 \ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 19.246 \ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1018.79 \ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 20.521 \ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1161.023 \ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 23.386 \ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1051.614 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 21.182 \ ksi$

$f_b := \max\left(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}\right) = 23.386 \ ksi$

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At this stage the deck will still be on the girders, Assume that the deck can laterally brace the beams @ Midspan so Lb<Lc . Therefore, Fb=0.66Fy

$F_b := 0.66 \cdot F_y = 21.78\ ksi$ < fb, Check Amount Overstressed

$F_{overstressed} := \frac{\langle f_b - F_b \rangle}{F_b} = 7.373\%$ Only Overstressed on G4, Say OK with conservative axle loading.

Check Assumption that Deck can Support Deck Laterally. To consider Laterally braced 2% of compressive stress in top flange shall be resisted.

$f_b = 23.386\ ksi$ $A_{cf} = 12.24\ in^2$ $F_{resist} := 0.02 \cdot f_b \cdot A_{cf} = 5.725\ kip$

$\mu := 0.3$ Coefficient of Friction Between Deck and Girder

Weight of (2) Deck Slab, Assume 4ft Length

$w_{slab} := 2 \cdot S \cdot d_{deck} \cdot \gamma_{conc.} \cdot 4\ ft = 6\ kip$

Assume (2) Truck Axle will be on Deck Panels

$P_{truck} := 2 \cdot D.F._{G4truck} \cdot P_3 = 24\ kip$

$P_{total} := w_{slab} + P_{truck} = 30\ kip$

$P_{resist} := \mu \cdot P_{total} = 9\ kip$ > Fresist, Ok to look at as Laterally Braced

Note: Shear connectors between existing beams and deck will increase the lateral support from the deck.

Calculate Bending Stress With Deck removed to the first diaphragm. Place Centroid of Excavator 7.5 feet from the end of the deck. Place Centroid of P6 3 ft from the end of the deck (Assuming the truck is backed onto the span)

$M_{deadint} := 354\ kip \cdot ft$ @ 42.7ft (P. A3) $M_{deadext} := 430\ kip \cdot ft$ @ 42.7ft (P. A4)

$M_{uexc} := 806\ kip \cdot ft \cdot 1.3$ (Including Impact) @ 42.7ft (P. A5) $M_{utruck} := 799\ kip \cdot ft$ @ 42.7ft (P. A6)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 814.193\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 16.4\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 808.047\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 16.276\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 810.677\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 16.329\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 833.4\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 16.787\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 722.967\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 14.562\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 16.787\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 19.8ft

$L_b := 19.8\ ft = 237.6\ in$ (Diaphragm Spacing scaled off of existing plans for beam N1-D @ Pier Side of Span)

$Check_{Fb} :=$ if $L_b < L_c$
"Fb=0.66Fy"
else
"Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Check Equation F1-6, F1-7, & F1-8"

$d_{compweb} := \frac{d_{web}}{2} \cdot \frac{1}{3} = 5.66\ in$ $A_{compweb} := d_{compweb} \cdot t_w = 3.679\ in^2$

$A_t := A_{compweb} + A_{cf} = 15.919\ in^2$

$$I_t := \frac{\left(t_{cf} \cdot b_{cf}^3\right)}{12} + \frac{\left(d_{compweb} \cdot t_w^3\right)}{12} = 147.01\ in^4$$

$$r_T := \sqrt{\frac{I_t}{A_t}} = 3.039\ in$$

$l := L_b = 237.6\ in$ $\frac{l}{r_T} = 78.186$ Assume $C_b := 1.0$

$$Limit_1 := \sqrt{\frac{\left(102 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 55.596 \qquad Limit_2 := \sqrt{\frac{\left(510 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 124.316$$

$$F_{b1} := \left(\frac{2}{3} - \frac{\left(\frac{F_y}{ksi} \cdot \left(\frac{l}{r_T}\right)^2\right)}{1530 \cdot 10^3 \cdot C_b}\right) \cdot F_y = 17.649\ ksi$$ (F1-6)

$$F_{b2} := \frac{\left(170 \cdot 10^3 \cdot C_b\right)}{\left(\frac{l}{r_T}\right)^2} \cdot ksi = 27.809\ ksi$$ (F1-7)

$$F_{b3} := \frac{\left(12 \cdot 10^3 \cdot C_b\right)}{\left(l \cdot \frac{d}{A_{cf}}\right)} \cdot ksi = 16.764\ ksi$$ (F1-8)

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$$F_b := \text{if } \frac{l}{r_T} < \text{Limit}_2 \;\; \max\langle F_{b1}, F_{b3}\rangle \;\; \text{else} \;\; \max\langle F_{b2}, F_{b3}\rangle$$

$F_b = 17.649$ ksi

Considering beams braced @ diaphragms only

$F_{bfull} := 0.60 \cdot F_y = 19.8$ ksi

$F_b := min\langle F_b, F_{bfull}\rangle = 17.649$ ksi

Fb ≤ 0.60Fy

$$\text{Check} := \text{if } F_b > f_b \;\; \text{"OK"} \;\; \text{else} \;\; \text{"No Good"}$$

Check = "OK"

Calculate Bending Stress With Deck removed to the Midspan. Place Centroid of Excavator 7.5 feet from the end of the deck and P6 3 ft from the end of the deck.

$M_{deadint} := 360\ kip \cdot ft$ (P. A7)

$M_{deadext} := 432\ kip \cdot ft$ (P. A8)

$M_{uexc} := 728\ kip \cdot ft \cdot 1.3$ @ 33.5ft (P. A9)
(Including Impact)

$M_{utruck} := 684\ kip \cdot ft$ @ 33.5ft (P. A10)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 779.013\ kip \cdot ft$

$f_{bG1} := \frac{M_{uG1}}{S_t} = 15.691\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 770.107\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 15.512\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 764.947\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 15.408\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 770.4\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 15.518\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 682.8\ kip \cdot ft$

$f_{bG5} := \frac{M_{uG5}}{S_t} = 13.753\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 15.691\ ksi$

Calculate Allowable Stress in Girders with Unbraced Length of 22ft

$L_b := 22.0\ ft = 264\ in$ (Diaphragm Spacing scaled off of existing plans for beam N1-E @ Midspan)

$Check_{Fb} :=$ if $L_b < L_c$
"Fb=0.66Fy"
else
"Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Check Equation F1-6, F1-7, & F1-8"

$d_{compweb} := \frac{d_{web}}{2} \cdot \frac{1}{3} = 5.66\ in$ $A_{compweb} := d_{compweb} \cdot t_w = 3.679\ in^2$

$A_t := A_{compweb} + A_{cf} = 15.919\ in^2$

$$I_t := \frac{\left(t_{cf} \cdot b_{cf}^3\right)}{12} + \frac{\left(d_{compweb} \cdot t_w^3\right)}{12} = 147.01\ in^4$$

$$r_T := \sqrt{\frac{I_t}{A_t}} = 3.039\ in$$

$l := L_b = 264\ in$ $\frac{l}{r_T} = 86.874$ Assume $C_b := 1.0$

$$Limit_1 := \sqrt{\frac{\left(102 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 55.596 \qquad Limit_2 := \sqrt{\frac{\left(510 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 124.316$$

$$F_{b1} := \left(\frac{2}{3} - \frac{\left(\frac{F_y}{ksi} \cdot \left(\frac{l}{r_T}\right)^2\right)}{1530 \cdot 10^3 \cdot C_b}\right) \cdot F_y = 16.628\ ksi$$ (F1-6)

$$F_{b2} := \frac{\left(170 \cdot 10^3 \cdot C_b\right)}{\left(\frac{l}{r_T}\right)^2} \cdot ksi = 22.525\ ksi$$ (F1-7)

$$F_{b3} := \frac{\left(12 \cdot 10^3 \cdot C_b\right)}{\left(l \cdot \frac{d}{A_{cf}}\right)} \cdot ksi = 15.088\ ksi$$ (F1-8)

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$$F_b := \text{if } \frac{l}{r_T} < \text{Limit}_2 \;\; \max\langle F_{b1}, F_{b3}\rangle \;\; \text{else} \;\; \max\langle F_{b2}, F_{b3}\rangle$$

$F_b = 16.628$ ksi — Considering beams braced @ diaphragms only

$F_{bfull} = 19.8$ ksi

$F_b := min\langle F_b, F_{bfull}\rangle = 16.628$ ksi — Fb ≤ 0.60Fy

$$\text{Check} := \text{if } F_b > f_b \;\; \text{"OK"} \;\; \text{else} \;\; \text{"No Good"}$$

Check = "OK"

Note: Dead loads are taken @ Max Moment not located @ midspan, Therefore the dead load moments are conservative.

Therefore W36x160 Girders are ok for removal of Deck

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Check W36x170 Beams During Demo

W36x170 Section Properties

Component	H (in)	W (in)	A (in^2)	y (in)	Ay (in^3)	I (in^4)	d (in)	Ad^2+I (in^4)
W36x170	36.2	12	50	18.1	905	10500	4.07	11327.74
Cover Plate	1	14	14	36.7	513.80	1.1667	14.53	2957.37
Sum	37.20	26.00	64.00	54.80	1418.80	10501.17	18.60	14285.10
Ybar (in)	22.2							
Yt (in)	Yb (in)		A (in^2)	Sbot (in^3)	Stop (in^3)	I (in^4)		Wt (lbs/ft)
22.17	15.03		64	950.36	644.38	14285.10		217.78

Calculate allowable bending stress per AISC 9th Edition

$S_b = 950.36\ in^3$ $\quad S_t = 644.38\ in^3$ $\quad w_{self} = 217.778\ \frac{lbf}{ft}$ $\quad d = 37.2\ in$

$t_{cvrplt} = 1\ in$ $\quad b_{cvrplt} = 14\ in$ $\quad t_{cvrplt} = 1\ in$

$b_{cf} := b_{fW36x170} = 12.03\ in$ $\quad t_{cf} := t_{fW36x170} = 1.1\ in$ $\quad A_{cf} := b_{cf} \cdot t_{cf} = 13.233\ in^2$

$b_{tf} := b_{fW36x170} = 12.03\ in$ $\quad t_{tfbeam} := t_{fW36x170} = 1.1\ in$ $\quad t_{tf} := t_{tfbeam} + t_{cvrplt} = 2.1\ in$

$A_{tf} := b_{tf} \cdot t_{cf} + t_{cvrplt} \cdot b_{cvrplt} = 27.233\ in^2$ $\quad L := 72\ ft$

$d_{web} := d - t_{cf} - t_{tf} = 34\ in$ $\quad t_w := t_{wW36x170} = 0.68\ in$ $\quad F_y := 33\ ksi$

$$L_{c1} := \left(\frac{\left(76 \cdot b_{cf}\right)}{\frac{in}{\sqrt{\frac{F_y}{ksi}}}} \right) \cdot in = 159.156\ in$$

$$L_{c2} := \frac{(20000)}{\left(\left(\frac{\frac{d}{in}}{\frac{A_{cf}}{in^2}} \right) \cdot \frac{F_y}{ksi} \right)} \cdot in = 215.591\ in$$

$L_c := min\left(L_{c1}, L_{c2}\right) = 159.156\ in$

$L_c = 13.263\ ft$

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Calculate Moments Due to Live Loads

Excavator Moment

$P_{exc} := 56\ kip$ Look at Excavator as Single 56k Point Load

Maximum Moment Occurs When Excavator is at Midspan

$M_{uexc} := \frac{(P_{exc} \cdot L)}{4} = 1008\ kip \cdot ft$ Undistributed, Unfactored

Truck Moment

Check Moment When Centroid of Trailer is at Midspan

$P_1 := 13\ kip$ $Z_1 := \frac{L}{2} + X_1 = 66.9\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $Z_2 := \frac{L}{2} + X_2 = 53.4\ ft$

$P_3 := 20\ kip$ $Z_3 := \frac{L}{2} + X_3 = 48.9\ ft$

$P_4 := 20\ kip$ $Z_4 := \frac{L}{2} + X_4 = 44.4\ ft$

$P_5 := 24\ kip$ $Z_5 := \frac{L}{2} + X_5 = 13.4\ ft$

$P_6 := 24\ kip$ $Z_6 := \frac{L}{2} + X_6 = 9.4\ ft$

$M_{utruck1} := 1110\ kip \cdot ft$ (P. B1)

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Check Moment When P3 of Trailer is at Midspan

$P_1 := 13\ kip$ $\quad Z_1 := \frac{L}{2} + (x_3 - x_1) = 54\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $\quad Z_2 := \frac{L}{2} + (x_3 - x_2) = 40.5\ ft$

$P_3 := 20\ kip$ $\quad Z_3 := \frac{L}{2} = 36\ ft$

$P_4 := 20\ kip$ $\quad Z_4 := \frac{L}{2} + (x_3 - x_4) = 31.5\ ft$

$P_5 := 24\ kip$ $\quad Z_5 := \frac{L}{2} + (x_3 - x_5) = 0.5\ ft$

$P_6 := 24\ kip$ $\quad Z_6 := \frac{L}{2} + (x_3 - x_6) = -3.5\ ft$ Not on This Span

$M_{utruck2} := 1110\ kip \cdot ft$ (P. B2)

$M_{utruck} := \max(M_{utruck1}, M_{utruck2}) = 1110\ kip \cdot ft$

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Calculate Stress in Beam with Truck & Excavator @ Midspan w/ Full Dead Load form the Deck

$w_{deadext} := 1.15 \cdot w_{self} + w_{ext} = 1229.611 \ \frac{lbf}{ft}$ $\qquad M_{deadext} := \frac{\left(w_{deadext} \cdot L^2\right)}{8} = 796.788 \ kip \cdot ft$

$w_{deadint} := 1.15 \cdot w_{self} + w_{int} = 1000.444 \ \frac{lbf}{ft}$ $\qquad M_{deadint} := \frac{\left(w_{deadint} \cdot L^2\right)}{8} = 648.288 \ kip \cdot ft$

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1166.388 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 21.721 \ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 1085.088 \ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 20.207 \ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1155.888 \ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 21.526 \ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1314.288 \ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 24.475 \ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1203.788 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 22.418 \ ksi$

$f_b := \max\left(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}\right) = 24.475 \ ksi$

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At this stage the deck will still be on the girders, Assume that the deck can laterally brace the beams @ Midspan so Lb<Lc . Therefore, Fb=0.66Fy

$F_b := 0.66 \cdot F_y = 21.78\ ksi$ < fb, Check Amount Overstressed

$F_{overstressed} := \frac{\langle f_b - F_b \rangle}{F_b} = 12.376\%$ Only Overstressed on G4& G5, Say OK with conservative axle loading.

Check Assumption that Deck can Support Deck Laterally. To consider Laterally braced 2% of compressive stress in top flange shall be resisted.

$f_b = 24.475\ ksi$ $A_{cf} = 13.233\ in^2$ $F_{resist} := 0.02 \cdot f_b \cdot A_{cf} = 6.478\ kip$

$\mu := 0.3$ Coefficient of Friction Between Deck and Girder

Weight of (2) Deck Slab, Assume 4ft Length

$w_{slab} := 2 \cdot S \cdot d_{deck} \cdot \gamma_{conc.} \cdot 4\ ft = 6\ kip$

Assume (2) Truck Axle will be on Deck Panels

$P_{truck} := 2 \cdot D.F._{G4truck} \cdot P_3 = 24\ kip$

$P_{total} := w_{slab} + P_{truck} = 30\ kip$

$P_{resist} := \mu \cdot P_{total} = 9\ kip$ > Fresist, Ok to look at as Laterally Braced

Note: Shear connectors between existing beams and deck will increase the lateral support from the deck.

Girder #5 When G4 is Fully Loaded

$M_{uG5a} := D.F._{G5truck} \cdot M_{utruck} + M_{deadext} = 1018.788\ kip \cdot ft$ (Using D.F.=0.2)

$f_{bG5a} := \frac{M_{uG5a}}{S_t} = 18.972\ ksi$ <Fb

Girder #4 When G5 is Fully Loaded

$M_{uG4a} := D.F._{G4Ext} \cdot M_{utruck} + M_{deadint} = 1166.288\ kip \cdot ft$ (Using D.F.=0.467)

$f_{bG4a} := \frac{M_{uG4a}}{S_t} = 21.72\ ksi$ <Fb, Both Girder G4 & G5 will never be overstressed at the same time.

Say OK

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Calculate Bending Stress With Deck removed to the first diaphragm (14.7 ft from Beam Support N2-D). Place Centroid of Excavator 7.5 feet from the end of the deck. Place Centroid of P6 3 ft from the end of the deck (Assuming the truck is backed onto the span)

$M_{deadint} := 357\ kip \cdot ft$ @ 57.3ft (P. B3)

$M_{deadext} := 434\ kip \cdot ft$ @ 57.3ft (P. B4)

$M_{uexc} := 569\ kip \cdot ft \cdot 1.3 = 739.7\ kip \cdot ft$ (Including Impact) @ 57.3ft (P. B5)

$M_{utruck} := 694\ kip \cdot ft$ @ 57.3ft (P. B6)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 705.223\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 13.133\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 677.537\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 12.617\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 705.382\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 13.136\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 773.4\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 14.403\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 688.467\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 12.821\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 14.403\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 14.7ft

$L_b := 14.7\ ft = 176.4\ in$ (Diaphragm Spacing scaled off of existing plans for beam N2-D @ Pier #2 Side of Span)

$Check_{Fb} :=$ if $L_b < L_c$
"Fb=0.66Fy"
else
"Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Check Equation F1-6, F1-7, & F1-8"

$d_{compweb} := \frac{d_{web}}{2} \cdot \frac{1}{3} = 5.667\ in$ $A_{compweb} := d_{compweb} \cdot t_w = 3.853\ in^2$

$A_t := A_{compweb} + A_{cf} = 17.086\ in^2$

$$I_t := \frac{\left(t_{cf} \cdot b_{cf}^3\right)}{12} + \frac{\left(d_{compweb} \cdot t_w^3\right)}{12} = 159.739\ in^4$$

$$r_T := \sqrt{\frac{I_t}{A_t}} = 3.058\ in$$

$l := L_b = 176.4\ in$ $\frac{l}{r_T} = 57.692$ Assume $C_b := 1.0$

$$Limit_1 := \sqrt{\frac{\left(102 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 55.596 \qquad Limit_2 := \sqrt{\frac{\left(510 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 124.316$$

$$F_{b1} := \left(\frac{2}{3} - \frac{\left(\frac{F_y}{ksi} \cdot \left(\frac{l}{r_T}\right)^2\right)}{1530 \cdot 10^3 \cdot C_b}\right) \cdot F_y = 19.631\ ksi$$ (F1-6)

$$F_{b2} := \frac{\left(170 \cdot 10^3 \cdot C_b\right)}{\left(\frac{l}{r_T}\right)^2} \cdot ksi = 51.076\ ksi$$ (F1-7)

$$F_{b3} := \frac{\left(12 \cdot 10^3 \cdot C_b\right)}{\left(l \cdot \frac{d}{A_{cf}}\right)} \cdot ksi = 24.199\ ksi$$ (F1-8)

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$$F_b := \text{if } \frac{l}{r_T} < \text{Limit}_2 \;\; \max\langle F_{b1}, F_{b3}\rangle \;\; \text{else} \;\; \max\langle F_{b2}, F_{b3}\rangle$$

$F_b = 24.199$ ksi

Considering beams braced @ diaphragms only

$F_{bfull} = 19.8$ ksi

$F_b := min\langle F_b, F_{bfull}\rangle = 19.8$ ksi

Fb ≤ 0.60Fy

$$\text{Check} := \text{if } F_b > f_b \;\; \text{"OK"} \;\; \text{else} \;\; \text{"No Good"}$$

Check = "OK"

Calculate Bending Stress With Deck removed to the Midspan. Place Centroid of Excavator 7.5 feet from the end of the deck and P6 3 ft from the end of the deck.

$M_{deadint} := 428\ kip \cdot ft$ (P. B7)

$M_{deadext} := 511\ kip \cdot ft$ (P. B8)

$M_{uexc} := 798\ kip \cdot ft \cdot 1.3 = 1037.4\ kip \cdot ft$ (Including Impact) @ 36ft (P. B9)

$M_{utruck} := 744\ kip \cdot ft$ @ 36ft (P. B10)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 891.38\ kip \cdot ft$

$f_{bG1} := \frac{M_{uG1}}{S_t} = 16.6\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 877.54\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 16.342\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 870.73\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 16.215\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 874.4\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 16.284\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 783.8\ kip \cdot ft$

$f_{bG5} := \frac{M_{uG5}}{S_t} = 14.596\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 16.6\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 17.9ft

$L_b := 17.9\ ft = 214.8\ in$ (Diaphragm Spacing scaled off of existing plans for beam N2-E @ Midspan)

$Check_{Fb} :=$ if $L_b < L_c$
"Fb=0.66Fy"
else
"Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Check Equation F1-6, F1-7, & F1-8"

$d_{compweb} := \frac{d_{web}}{2} \cdot \frac{1}{3} = 5.667\ in$ $A_{compweb} := d_{compweb} \cdot t_w = 3.853\ in^2$

$A_t := A_{compweb} + A_{cf} = 17.086\ in^2$

$$I_t := \frac{\left(t_{cf} \cdot b_{cf}^3\right)}{12} + \frac{\left(d_{compweb} \cdot t_w^3\right)}{12} = 159.739\ in^4$$

$$r_T := \sqrt{\frac{I_t}{A_t}} = 3.058\ in$$

$l := L_b = 214.8\ in$ $\frac{l}{r_T} = 70.251$ Assume $C_b := 1.0$

$$Limit_1 := \sqrt{\frac{\left(102 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 55.596 \qquad Limit_2 := \sqrt{\frac{\left(510 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 124.316$$

$$F_{b1} := \left(\frac{2}{3} - \frac{\left(\frac{F_y}{ksi} \cdot \left(\frac{l}{r_T}\right)^2\right)}{1530 \cdot 10^3 \cdot C_b}\right) \cdot F_y = 18.487\ ksi$$ (F1-6)

$$F_{b2} := \frac{\left(170 \cdot 10^3 \cdot C_b\right)}{\left(\frac{l}{r_T}\right)^2} \cdot ksi = 34.446\ ksi$$ (F1-7)

$$F_{b3} := \frac{\left(12 \cdot 10^3 \cdot C_b\right)}{\left(l \cdot \frac{d}{A_{cf}}\right)} \cdot ksi = 19.873\ ksi$$ (F1-8)

$$F_b := \text{if } \frac{l}{r_T} < \text{Limit}_2 \;\; \max\langle F_{b1}, F_{b3}\rangle \;\; \text{else} \;\; \max\langle F_{b2}, F_{b3}\rangle$$

$F_b = 19.873$ ksi

Considering beams braced @ diaphragms only

$F_{bfull} = 19.8$ ksi

$F_b := min\langle F_b, F_{bfull}\rangle = 19.8$ ksi

Fb ≤ 0.60Fy

$$\text{Check} := \text{if } F_b > f_b \;\; \text{"OK"} \;\; \text{else} \;\; \text{"No Good"}$$

Check = "OK"

Note: Dead loads are taken @ Max Moment not located @ midspan, Therefore the dead load moments are conservative.

Therefore W36x170 Girders are ok for removal of Deck

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Check W36x194 Beams During Demo

W36x194 Section Properties

Component	H (in)	W (in)	A (in^2)	y (in)	Ay (in^3)	I (in^4)	d (in)	Ad^2+I (in^4)
W36x194	36.5	12	57.0	18.25	1040.25	12100	4.07	13045.50
Cover Plate	1.125	14	15.75	37.0625	583.73	1.6611	14.74	3423.48
Sum	37.63	26.00	72.75	55.31	1623.98	12101.66	18.81	16468.99
Ybar (in)	22.3							
Yt (in)	Yb (in)		A (in^2)	Sbot (in^3)	Stop (in^3)	I (in^4)		Wt (lbs/ft)
22.32	15.30		72.75	1076.25	737.76	16468.99		247.55

Calculate allowable bending stress per AISC 9th Edition

$S_b = 1076.25\ in^3$ $\quad S_t = 737.765\ in^3$ $\quad w_{self} = 247.552\ \frac{lbf}{ft}$ $\quad d = 37.625\ in$

$t_{cvrplt} = 1.125\ in$ $\quad b_{cvrplt} = 14\ in$ $\quad t_{cvrplt} = 1.125\ in$

$b_{cf} := b_{fW36x194} = 12.11\ in$ $\quad t_{cf} := t_{fW36x194} = 1.26\ in$ $\quad A_{cf} := b_{cf} \cdot t_{cf} = 15.259\ in^2$

$b_{tf} := b_{fW36x194} = 12.11\ in$ $\quad t_{tfbeam} := t_{fW36x194} = 1.26\ in$ $\quad t_{tf} := t_{tfbeam} + t_{cvrplt} = 2.385\ in$

$A_{tf} := b_{tf} \cdot t_{cf} + t_{cvrplt} \cdot b_{cvrplt} = 31.009\ in^2$ $\quad L := 77\ ft$

$d_{web} := d - t_{cf} - t_{tf} = 33.98\ in$ $\quad t_w := t_{wW36x194} = 0.765\ in$ $\quad F_y := 33\ ksi$

$$L_{c1} := \left(\frac{\left(76 \cdot b_{cf}\right)}{\frac{in}{\sqrt{\frac{F_y}{ksi}}}} \right) \cdot in = 160.214\ in \qquad L_{c2} := \frac{(20000)}{\left(\left(\frac{\frac{d}{in}}{\frac{A_{cf}}{in^2}} \right) \cdot \frac{F_y}{ksi} \right)} \cdot in = 245.784\ in$$

$L_c := min\left(L_{c1}, L_{c2}\right) = 160.214\ in$

$L_c = 13.351\ ft$

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Calculate Moments Due to Live Loads

Excavator Moment

$P_{exc} := 56\ kip$ Look at Excavator as Single 56k Point Load

Maximum Moment Occurs When Excavator is at Midspan

$M_{uexc} := \frac{\langle P_{exc} \cdot L \rangle}{4} = 1078\ kip \cdot ft$ Undistributed, Unfactored

Truck Moment

Check Moment When Centroid of Trailer is at Midspan

$P_1 := 13\ kip$ $Z_1 := \frac{L}{2} + X_1 = 69.4\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $Z_2 := \frac{L}{2} + X_2 = 55.9\ ft$

$P_3 := 20\ kip$ $Z_3 := \frac{L}{2} + X_3 = 51.4\ ft$

$P_4 := 20\ kip$ $Z_4 := \frac{L}{2} + X_4 = 46.9\ ft$

$P_5 := 24\ kip$ $Z_5 := \frac{L}{2} + X_5 = 15.9\ ft$

$P_6 := 24\ kip$ $Z_6 := \frac{L}{2} + X_6 = 11.9\ ft$

$M_{utruck1} := 1260\ kip \cdot ft$ (P. C1)

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Check Moment When P3 of Trailer is at Midspan

$P_1 := 13\ kip$ $\quad Z_1 := \frac{L}{2} + (x_3 - x_1) = 56.5\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $\quad Z_2 := \frac{L}{2} + (x_3 - x_2) = 43\ ft$

$P_3 := 20\ kip$ $\quad Z_3 := \frac{L}{2} = 38.5\ ft$

$P_4 := 20\ kip$ $\quad Z_4 := \frac{L}{2} + (x_3 - x_4) = 34\ ft$

$P_5 := 24\ kip$ $\quad Z_5 := \frac{L}{2} + (x_3 - x_5) = 3\ ft$

$P_6 := 24\ kip$ $\quad Z_6 := \frac{L}{2} + (x_3 - x_6) = -1\ ft$ Not on This Span

$M_{utruck2} := 1230\ kip \cdot ft$ (P. C2)

$M_{utruck} := \max(M_{utruck1}, M_{utruck2}) = 1260\ kip \cdot ft$

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Calculate Stress in Beam with Truck & Excavator @ Midspan w/ Full Dead Load form the Deck

$w_{deadext} := 1.15 \cdot w_{self} + w_{ext} = 1263.852 \ \frac{lbf}{ft}$ $\qquad M_{deadext} := \frac{\left(w_{deadext} \cdot L^2\right)}{8} = 936.672 \ kip \cdot ft$

$w_{deadint} := 1.15 \cdot w_{self} + w_{int} = 1034.685 \ \frac{lbf}{ft}$ $\qquad M_{deadint} := \frac{\left(w_{deadint} \cdot L^2\right)}{8} = 766.831 \ kip \cdot ft$

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1331.939 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 21.664 \ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 1233.964 \ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 20.071 \ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1324.264 \ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 21.54 \ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1522.831 \ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 24.769 \ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1398.672 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 22.75 \ ksi$

$f_b := \max\left(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}\right) = 24.769 \ ksi$

At this stage the deck will still be on the girders, Assume that the deck can laterally brace the beams @ Midspan so Lb<Lc . Therefore, Fb=0.66Fy

$F_b := 0.66 \cdot F_y = 21.78\ ksi$ < fb, Check Amount Overstressed

$F_{overstressed} := \frac{(f_b - F_b)}{F_b} = 13.725\%$ Only Overstressed on G4 & G5, Say OK due to conservative Axle Loading

Check Assumption that Deck can Support Deck Laterally. To consider Laterally braced 2% of compressive stress in top flange shall be resisted.

$f_b = 24.769\ ksi$ $A_{cf} = 15.259\ in^2$ $F_{resist} := 0.02 \cdot f_b \cdot A_{cf} = 7.559\ kip$

$\mu := 0.3$ Coefficient of Friction Between Deck and Girder

Weight of (2) Deck Slab, Assume 4ft Length

$w_{slab} := 2 \cdot S \cdot d_{deck} \cdot \gamma_{conc.} \cdot 4\ ft = 6\ kip$

Assume (2) Truck Axle will be on Deck Panels

$P_{truck} := 2 \cdot D.F._{G4truck} \cdot P_3 = 24\ kip$

$P_{total} := w_{slab} + P_{truck} = 30\ kip$

$P_{resist} := \mu \cdot P_{total} = 9\ kip$ > Fresist, Ok to look at as Laterally Braced

Note: Shear connectors between existing beams and deck will increase the lateral support from the deck.

Girder #5 When G4 is Fully Loaded

$M_{uG5a} := D.F._{G5truck} \cdot M_{utruck} + M_{deadext} = 1188.672\ kip \cdot ft$ (Using D.F.=0.2)

$f_{bG5a} := \frac{M_{uG5a}}{S_t} = 19.334\ ksi$ <Fb, Both Girder G4 & G5 will not be overstressed at the same time.

Girder #4 When G5 is Fully Loaded

(Using D.F.=0.467)

$M_{uG4a} := D.F._{G4Ext} \cdot M_{utruck} + M_{deadint} = 1354.831\ kip \cdot ft$

$f_{bG4a} := \frac{M_{uG4a}}{S_t} = 22.04\ ksi$ <Fb, Both Girder G4 & G5 will be slightly overstressed at the same time. (4.5% Max)

Say OK

Calculate Bending Stress With Deck removed to the first diaphragm (23 ft from Beam Support S5-4). Place Centroid of Excavator 7.5 feet from the end of the deck. Place Centroid of P6 3 ft from the end of the deck (Assuming the truck is backed onto the span)

$M_{deadint} := 504\ kip \cdot ft$ @ 54ft (P. C3)

$M_{deadext} := 604\ kip \cdot ft$ @ 54ft (P. C4)

$M_{uexc} := 853\ kip \cdot ft \cdot 1.3 = 1108.9\ kip \cdot ft$ (Including Impact) @ 54ft (P. C5)

$M_{utruck} := 909\ kip \cdot ft$ @ 54ft (P. C6)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1010.597\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 16.438\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 984.523\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 16.014\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 999.988\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 16.265\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1049.4\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 17.069\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 937.3\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 15.246\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 17.069\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 23ft

$L_b := 23\ ft = 276\ in$ (Diaphragm Spacing scaled off of existing plans for beam S5-E @ Pier #2 Side of Span)

$Check_{Fb} :=$ if $L_b < L_c$
"Fb=0.66Fy"
else
"Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Check Equation F1-6, F1-7, & F1-8"

$d_{compweb} := \frac{d_{web}}{2} \cdot \frac{1}{3} = 5.663\ in$ $A_{compweb} := d_{compweb} \cdot t_w = 4.332\ in^2$

$A_t := A_{compweb} + A_{cf} = 19.591\ in^2$

$$I_t := \frac{\left(t_{cf} \cdot b_{cf}^3\right)}{12} + \frac{\left(d_{compweb} \cdot t_w^3\right)}{12} = 186.687\ in^4$$

$$r_T := \sqrt{\frac{I_t}{A_t}} = 3.087\ in$$

$l := L_b = 276\ in$ $\frac{l}{r_T} = 89.409$ Assume $C_b := 1.0$

$$Limit_1 := \sqrt{\frac{\left(102 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 55.596 \qquad Limit_2 := \sqrt{\frac{\left(510 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 124.316$$

$$F_{b1} := \left(\frac{2}{3} - \frac{\left(\frac{F_y}{ksi} \cdot \left(\frac{l}{r_T}\right)^2\right)}{1530 \cdot 10^3 \cdot C_b}\right) \cdot F_y = 16.31\ ksi$$ (F1-6)

$$F_{b2} := \frac{\left(170 \cdot 10^3 \cdot C_b\right)}{\left(\frac{l}{r_T}\right)^2} \cdot ksi = 21.266\ ksi$$ (F1-7)

$$F_{b3} := \frac{\left(12 \cdot 10^3 \cdot C_b\right)}{\left(l \cdot \frac{d}{A_{cf}}\right)} \cdot ksi = 17.632\ ksi$$ (F1-8)

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$$F_b := \text{if } \frac{l}{r_T} < \text{Limit}_2 \;\; \max\langle F_{b1}, F_{b3}\rangle \;\; \text{else} \;\; \max\langle F_{b2}, F_{b3}\rangle$$

$F_b = 17.632$ ksi

Considering beams braced @ diaphragms only

$F_{bfull} = 19.8$ ksi

$F_b := min\langle F_b, F_{bfull}\rangle = 17.632$ ksi

Fb ≤ 0.60Fy

$$\text{Check} := \text{if } F_b > f_b \;\; \text{"OK"} \;\; \text{else} \;\; \text{"No Good"}$$

Check = "OK"

Calculate Bending Stress With Deck removed to the Midspan. Place Centroid of Excavator 7.5 feet from the end of the deck and P6 3 ft from the end of the deck.

$M_{deadint} := 489\ kip \cdot ft$ (P. C7)

$M_{deadext} := 574\ kip \cdot ft$ (P. C8)

$M_{uexc} := 868\ kip \cdot ft \cdot 1.3 = 1128.4\ kip \cdot ft$ (Including Impact) @ 38.5ft (P. C9)

$M_{utruck} := 809\ kip \cdot ft$ @ 38.5ft (P. C10)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 987.747\ kip \cdot ft$

$f_{bG1} := \frac{M_{uG1}}{S_t} = 16.066\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 977.973\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 15.907\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 970.513\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 15.786\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 974.4\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 15.849\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 870.633\ kip \cdot ft$

$f_{bG5} := \frac{M_{uG5}}{S_t} = 14.161\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 16.066\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 18.9ft

$L_b := 18.9\ ft = 226.8\ in$ (Diaphragm Spacing scaled off of existing plans for beam S4-E @ Midspan)

$Check_{Fb} :=$ if $L_b < L_c$
"Fb=0.66Fy"
else
"Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Check Equation F1-6, F1-7, & F1-8"

$d_{compweb} := \frac{d_{web}}{2} \cdot \frac{1}{3} = 5.663\ in$ $A_{compweb} := d_{compweb} \cdot t_w = 4.332\ in^2$

$A_t := A_{compweb} + A_{cf} = 19.591\ in^2$

$$I_t := \frac{\left(t_{cf} \cdot b_{cf}^3\right)}{12} + \frac{\left(d_{compweb} \cdot t_w^3\right)}{12} = 186.687\ in^4$$

$$r_T := \sqrt{\frac{I_t}{A_t}} = 3.087\ in$$

$l := L_b = 226.8\ in$ $\frac{l}{r_T} = 73.471$ Assume $C_b := 1.0$

$$Limit_1 := \sqrt{\frac{\left(102 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 55.596 \qquad Limit_2 := \sqrt{\frac{\left(510 \cdot 10^3 \cdot C_b\right)}{\frac{F_y}{ksi}}} = 124.316$$

$$F_{b1} := \left(\frac{2}{3} - \frac{\left(\frac{F_y}{ksi} \cdot \left(\frac{l}{r_T}\right)^2\right)}{1530 \cdot 10^3 \cdot C_b}\right) \cdot F_y = 18.158\ ksi$$ (F1-6)

$$F_{b2} := \frac{\left(170 \cdot 10^3 \cdot C_b\right)}{\left(\frac{l}{r_T}\right)^2} \cdot ksi = 31.493\ ksi$$ (F1-7)

$$F_{b3} := \frac{\left(12 \cdot 10^3 \cdot C_b\right)}{\left(l \cdot \frac{d}{A_{cf}}\right)} \cdot ksi = 21.457\ ksi$$ (F1-8)

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$$F_b := \text{if } \frac{l}{r_T} < Limit_2 \;\; \max\langle F_{b1}, F_{b3}\rangle \;\; \text{else} \;\; \max\langle F_{b2}, F_{b3}\rangle$$

$F_b = 21.457$ ksi

Considering beams braced @ diaphragms only

$F_{bfull} = 19.8$ ksi

$F_b := min\langle F_b, F_{bfull}\rangle = 19.8$ ksi

$$Check := \text{if } F_b > f_b \;\; \text{"OK"} \;\; \text{else} \;\; \text{"No Good"}$$

$Check =$ "OK"

Note: Dead loads are taken @ Max Moment not located @ midspan, Therefore the dead load moments are conservative.

Therefore W36x194 Girders are ok for removal of Deck

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Check W36x245 Beams During Demo

W36x245 Section Properties

Component	H (in)	W (in)	A (in^2)	y (in)	Ay (in^3)	I (in^4)	d (in)	Ad^2+I (in^4)
W36x245	36.08	16.5	72.1	18.04	1300.684	16100	3.01	16755.25
Cover Plate	1	14	14	36.58	512.12	1.1667	15.53	3375.68
Sum	37.08	30.50	86.10	54.62	1812.80	16101.17	18.54	20130.93
Ybar (in)	21.1							
Yt (in)	Yb (in)		A (in^2)	Sbot (in^3)	Stop (in^3)	I (in^4)		Wt (lbs/ft)
21.05	16.03		86.1	1256.19	956.13	20130.93		292.98

Calculate allowable bending stress per AISC 9th Edition

$S_b = 1256.192\ in^3$ $\quad S_t = 956.128\ in^3$ $\quad w_{self} = 292.979\ \frac{lbf}{ft}$ $\quad d = 37.08\ in$

$t_{cvrplt} = 1\ in$ $\quad b_{cvrplt} = 14\ in$ $\quad t_{cvrplt} = 1\ in$

$b_{cf} := b_{fW36x245} = 16.51\ in$ $\quad t_{cf} := t_{fW36x245} = 1.35\ in$ $\quad A_{cf} := b_{cf} \cdot t_{cf} = 22.289\ in^2$

$b_{tf} := b_{fW36x245} = 16.51\ in$ $\quad t_{tfbeam} := t_{fW36x245} = 1.35\ in$ $\quad t_{tf} := t_{tfbeam} + t_{cvrplt} = 2.35\ in$

$A_{tf} := b_{tf} \cdot t_{cf} + t_{cvrplt} \cdot b_{cvrplt} = 36.289\ in^2$ $\quad L := 82\ ft$

$d_{web} := d - t_{cf} - t_{tf} = 33.38\ in$ $\quad t_w := t_{wW36x245} = 0.8\ in$ $\quad F_y := 33\ ksi$

$$L_{c1} := \left(\frac{\left(76 \cdot b_{cf}\right)}{\frac{in}{\sqrt{\frac{F_y}{ksi}}}} \right) \cdot in = 218.426\ in$$

$$L_{c2} := \frac{(20000)}{\left(\left(\frac{\frac{d}{in}}{\frac{A_{cf}}{in^2}} \right) \cdot \frac{F_y}{ksi} \right)} \cdot in = 364.298\ in$$

$L_c := min\left(L_{c1}, L_{c2}\right) = 218.426\ in$

$L_c = 18.202\ ft$ $\quad L_{bmax} := 17.9\ ft$

For Girder N3-D The maximum girder spacing is 17.9ft which is at the bearing, the maximum moment will occur at midspan. Conservatively use diaphragm spacing of 17.9ft < Lc = 18.20, Therefore Fb=0.66Fy

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Calculate Moments Due to Live Loads

Excavator Moment

$P_{exc} := 56\ kip$ Look at Excavator as Single 56k Point Load

Maximum Moment Occurs When Excavator is at Midspan

$M_{uexc} := \frac{(P_{exc} \cdot L)}{4} = 1148\ kip \cdot ft$ Undistributed, Unfactored

Truck Moment

Check Moment When Centroid of Trailer is at Midspan

$P_1 := 13\ kip$ $Z_1 := \frac{L}{2} + X_1 = 71.9\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $Z_2 := \frac{L}{2} + X_2 = 58.4\ ft$

$P_3 := 20\ kip$ $Z_3 := \frac{L}{2} + X_3 = 53.9\ ft$

$P_4 := 20\ kip$ $Z_4 := \frac{L}{2} + X_4 = 49.4\ ft$

$P_5 := 24\ kip$ $Z_5 := \frac{L}{2} + X_5 = 18.4\ ft$

$P_6 := 24\ kip$ $Z_6 := \frac{L}{2} + X_6 = 14.4\ ft$

$M_{utruck1} := 1410\ kip \cdot ft$ (P. D1)

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Check Moment When P3 of Trailer is at Midspan

$P_1 := 13\ kip$ $\quad Z_1 := \frac{L}{2} + (x_3 - x_1) = 59\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $\quad Z_2 := \frac{L}{2} + (x_3 - x_2) = 45.5\ ft$

$P_3 := 20\ kip$ $\quad Z_3 := \frac{L}{2} = 41\ ft$

$P_4 := 20\ kip$ $\quad Z_4 := \frac{L}{2} + (x_3 - x_4) = 36.5\ ft$

$P_5 := 24\ kip$ $\quad Z_5 := \frac{L}{2} + (x_3 - x_5) = 5.5\ ft$

$P_6 := 24\ kip$ $\quad Z_6 := \frac{L}{2} + (x_3 - x_6) = 1.5\ ft$

$M_{utruck2} := 1370\ kip \cdot ft$ (P. D2)

$M_{utruck} := \max(M_{utruck1}, M_{utruck2}) = 1410\ kip \cdot ft$

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Calculate Stress in Beam with Truck & Excavator @ Midspan w/ Full Dead Load form the Deck

$w_{deadext} := 1.15 \cdot w_{self} + w_{ext} = 1316.093 \ \frac{lbf}{ft}$ $\qquad M_{deadext} := \frac{(w_{deadext} \cdot L^2)}{8} = 1106.176 \ kip \cdot ft$

$w_{deadint} := 1.15 \cdot w_{self} + w_{int} = 1086.926 \ \frac{lbf}{ft}$ $\qquad M_{deadint} := \frac{(w_{deadint} \cdot L^2)}{8} = 913.561 \ kip \cdot ft$

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1527.109 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 19.166 \ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 1411.028 \ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 17.709 \ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1520.828 \ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 19.087 \ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1759.561 \ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 22.084 \ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1623.176 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 20.372 \ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 22.084 \ ksi$

$F_b := 0.66 \cdot F_y = 21.78 \ ksi$ < fb, Check Amount Overstressed

$F_{overstressed} := \frac{(f_b - F_b)}{F_b} = 1.394\%$ Say OK, Only Overstressed on G4

Calculate Bending Stress With Deck removed to the first diaphragm (17.9 ft from Beam Support N3-D). Place Centroid of Excavator 7.5 feet from the end of the deck. Place Centroid of P6 3 ft from the end of the deck (Assuming the truck is backed onto the span)

$M_{deadint} := 531\ kip \cdot ft$ @ 64.1ft (P. D3) $M_{deadext} := 635\ kip \cdot ft$ @ 64.1ft (P. D4)

$M_{uexc} := 692\ kip \cdot ft \cdot 1.3 = 899.6\ kip \cdot ft$ (Including Impact) @ 64.1ft (P. D5) $M_{utruck} := 912\ kip \cdot ft$ @ 64.1ft (P. D6)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 964.853\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 12.11\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 920.827\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 11.557\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 968.287\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 12.153\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1078.2\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 13.532\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 969.4\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 12.167\ ksi$

$f_b := \max\left(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}\right) = 13.532\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 17.9ft

$L_b := 17.9\ ft = 214.8\ in$ (Diaphragm Spacing scaled off of existing plans for beam S5-E @ Pier #2 Side of Span)

$Check_{Fb} :=$ if $L_b < L_c$
  "Fb=0.66Fy"
else
  "Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Fb=0.66Fy"

$F_b := 0.66 \cdot F_y = 21.78\ ksi$

$Check :=$ if $F_b > f_b$
  "OK"
else
  "No Good"

$Check =$ "OK"

Calculate Bending Stress With Deck removed to the Midspan. Place Centroid of Excavator 7.5 feet from the end of the deck and P6 3 ft from the end of the deck.

$M_{deadint} := 628\ kip \cdot ft$ (P. D7)

$M_{deadext} := 736\ kip \cdot ft$ (P. D8)

$M_{uexc} := 938\ kip \cdot ft \cdot 1.3 = 1219.4\ kip \cdot ft$ (Including Impact) @ 38.5ft (P. D9)

$M_{utruck} := 894\ kip \cdot ft$ @ 38.5ft (P. D10)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1183.113\ kip \cdot ft$

$f_{bG1} := \frac{M_{uG1}}{S_t} = 14.849\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 1156.407\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 14.514\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1152.297\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 14.462\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1164.4\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 14.614\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1063.8\ kip \cdot ft$

$f_{bG5} := \frac{M_{uG5}}{S_t} = 13.351\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 14.849\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 17.9ft

$L_b := 17.9\ ft = 214.8\ in$ (Diaphragm Spacing scaled off of existing plans for beam N3-D @ Midspan)

$Check_{Fb} :=$ if $L_b < L_c$
"Fb=0.66Fy"
else
"Check Equation F1-6, F1-7, & F1-8"

$Check_{Fb} =$ "Fb=0.66Fy"

$F_b := 0.66 \cdot F_y = 21.78\ ksi$

$Check :=$ if $F_b > f_b$
"OK"
else
"No Good"

$Check =$ "OK"

Note: Dead loads are taken @ Max Moment not located @ midspan, Therefore the dead load moments are conservative.

Therefore W36x245 Girders are ok for removal of Deck

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Check W36x300 Beams During Demo

W36x300 Section Properties

Component	H (in)	W (in)	A (in^2)	y (in)	Ay (in^3)	I (in^4)	d (in)	Ad^2+I (in^4)
W36x300	36.74	16.65	88.3	18.37	1622.071	20300	2.58	20888.86
Cover Plate	1	14	14	37.24	521.36	1.1667	16.29	3715.17
Sum	37.74	30.65	102.30	55.61	2143.43	20301.17	18.87	24604.02
Ybar (in)	21.0							
Yt (in)	Yb (in)		A (in^2)	Sbot (in^3)	Stop (in^3)	I (in^4)		Wt (lbs/ft)
20.95	16.79		102.3	1465.61	1174.28	24604.02		348.10

Calculate allowable bending stress per AISC 9th Edition

$S_b = 1465.607\ in^3$ $\quad S_t = 1174.282\ in^3$ $\quad w_{self} = 348.104\ \frac{lbf}{ft}$ $\quad d = 37.74\ in$

$t_{cvrplt} = 1\ in$ $\quad b_{cvrplt} = 14\ in$ $\quad t_{cvrplt} = 1\ in$

$b_{cf} := b_{fW36x300} = 16.66\ in$ $\quad t_{cf} := t_{fW36x300} = 1.68\ in$ $\quad A_{cf} := b_{cf} \cdot t_{cf} = 27.989\ in^2$

$b_{tf} := b_{fW36x300} = 16.66\ in$ $\quad t_{tfbeam} := t_{fW36x300} = 1.68\ in$ $\quad t_{tf} := t_{tfbeam} + t_{cvrplt} = 2.68\ in$

$A_{tf} := b_{tf} \cdot t_{cf} + t_{cvrplt} \cdot b_{cvrplt} = 41.989\ in^2$ $\quad L := 87\ ft$

$d_{web} := d - t_{cf} - t_{tf} = 33.38\ in$ $\quad t_w := t_{wW36x300} = 0.945\ in$ $\quad F_y := 33\ ksi$

$$L_{c1} := \left(\frac{\left(76 \cdot b_{cf}\right)}{\frac{in}{\sqrt{\frac{F_y}{ksi}}}} \right) \cdot in = 220.41\ in$$

$$L_{c2} := \frac{(20000)}{\left(\left(\frac{\frac{d}{in}}{\frac{A_{cf}}{in^2}} \right) \cdot \frac{F_y}{ksi} \right)} \cdot in = 449.468\ in$$

$L_c := min\left(L_{c1}, L_{c2}\right) = 220.41\ in$

$L_c = 18.368\ ft$

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Calculate Moments Due to Live Loads

Excavator Moment

$P_{exc} := 56\ kip$ Look at Excavator as Single 56k Point Load

Maximum Moment Occurs When Excavator is at Midspan

$M_{uexc} := \frac{(P_{exc} \cdot L)}{4} = 1218\ kip \cdot ft$ Undistributed, Unfactored

Truck Moment

Check Moment When Centroid of Trailer is at Midspan

$P_1 := 13\ kip$ $Z_1 := \frac{L}{2} + X_1 = 74.4\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $Z_2 := \frac{L}{2} + X_2 = 60.9\ ft$

$P_3 := 20\ kip$ $Z_3 := \frac{L}{2} + X_3 = 56.4\ ft$

$P_4 := 20\ kip$ $Z_4 := \frac{L}{2} + X_4 = 51.9\ ft$

$P_5 := 24\ kip$ $Z_5 := \frac{L}{2} + X_5 = 20.9\ ft$

$P_6 := 24\ kip$ $Z_6 := \frac{L}{2} + X_6 = 16.9\ ft$

$M_{utruck1} := 1560\ kip \cdot ft$ (P. E1)

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Check Moment When P3 of Trailer is at Midspan

$P_1 := 13\ kip$ $\quad Z_1 := \frac{L}{2} + (x_3 - x_1) = 61.5\ ft$ (Distance from Beam Support)

$P_2 := 20\ kip$ $\quad Z_2 := \frac{L}{2} + (x_3 - x_2) = 48\ ft$

$P_3 := 20\ kip$ $\quad Z_3 := \frac{L}{2} = 43.5\ ft$

$P_4 := 20\ kip$ $\quad Z_4 := \frac{L}{2} + (x_3 - x_4) = 39\ ft$

$P_5 := 24\ kip$ $\quad Z_5 := \frac{L}{2} + (x_3 - x_5) = 8\ ft$

$P_6 := 24\ kip$ $\quad Z_6 := \frac{L}{2} + (x_3 - x_6) = 4\ ft$

$M_{utruck2} := 1520\ kip \cdot ft$ (P. E2)

$M_{utruck} := \max(M_{utruck1}, M_{utruck2}) = 1560\ kip \cdot ft$

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Calculate Stress in Beam with Truck & Excavator @ Midspan w/ Full Dead Load form the Deck

$w_{deadext} := 1.15 \cdot w_{self} + w_{ext} = 1379.486 \ \frac{lbf}{ft}$ $\qquad M_{deadext} := \frac{\left(w_{deadext} \cdot L^2\right)}{8} = 1305.167 \ kip \cdot ft$

$w_{deadint} := 1.15 \cdot w_{self} + w_{int} = 1150.32 \ \frac{lbf}{ft}$ $\qquad M_{deadint} := \frac{\left(w_{deadint} \cdot L^2\right)}{8} = 1088.346 \ kip \cdot ft$

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1751.767 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 17.901 \ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 1616.146 \ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 16.515 \ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1745.446 \ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 17.837 \ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 2024.346 \ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 20.687 \ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1877.167 \ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 19.183 \ ksi$

$f_b := \max\left(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}\right) = 20.687 \ ksi$

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For Girder N3-E The maximum girder spacing is 20.2ft which is at the bearing, the maximum moment will occur at midspan. The diaphragm spacing is 16.9ft < Lc = 18.37, Therefore Fb=0.66Fy

$F_b := 0.66 \cdot F_y = 21.78\ ksi$ > fb, OK

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Calculate Bending Stress With Deck removed to the first diaphragm (17 ft from Beam Support N3-E). Place Centroid of Excavator 7.5 feet from the end of the deck. Place Centroid of P6 3 ft from the end of the deck (Assuming the truck is backed onto the span)

$M_{deadint} := 600\ kip \cdot ft$ @ 70ft (P. E3)

$M_{deadext} := 710\ kip \cdot ft$ @ 70ft (P. E4)

$M_{uexc} := 684\ kip \cdot ft \cdot 1.3 = 889.2\ kip \cdot ft$ (Including Impact) @ 70ft (P. E5)

$M_{utruck} := 956\ kip \cdot ft$ @ 70ft (P. E6)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1036.04\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG1} := \frac{M_{uG1}}{S_t} = 10.587\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 985.32\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 10.069\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1043.14\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 10.66\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1173.6\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 11.993\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1060.533\ kip \cdot ft$ (Using Exterior D.F.)

$f_{bG5} := \frac{M_{uG5}}{S_t} = 10.838\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 11.993\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 17.9ft

$L_b := 17.9\ ft = 214.8\ in$ (Diaphragm Spacing scaled off of existing plans for beam S5-E @ Pier #2 Side of Span)

$$Check_{Fb} := \begin{cases} \text{“Fb=0.66Fy”} & \text{if } L_b < L_c \\ \text{“Check Equation F1-6, F1-7, \& F1-8”} & \text{else} \end{cases}$$

$Check_{Fb} = \text{“Fb=0.66Fy”}$

$F_b := 0.66 \cdot F_y = 21.78\ ksi$

$$Check := \begin{cases} \text{“OK”} & \text{if } F_b > f_b \\ \text{“No Good”} & \text{else} \end{cases}$$

$Check = \text{“OK”}$

Calculate Bending Stress With Deck removed to the Midspan. Place Centroid of Excavator 7.5 feet from the end of the deck and P6 3 ft from the end of the deck.

$M_{deadint} := 738\ kip \cdot ft$ (P. E7)

$M_{deadext} := 847\ kip \cdot ft$ (P. E8)

$M_{uexc} := 1010\ kip \cdot ft \cdot 1.3 = 1313\ kip \cdot ft$ (Including Impact) @ 43.5ft (P. E9)

$M_{utruck} := 987\ kip \cdot ft$ @ 43.5ft (P. E10)

Girder #1

$M_{uG1} := D.F._{Ext} \cdot M_{uexc} + M_{deadext} = 1328.433\ kip \cdot ft$

$f_{bG1} := \frac{M_{uG1}}{S_t} = 13.575\ ksi$

Girder #2

$M_{uG2} := D.F._{G2ex} \cdot M_{uexc} + M_{deadint} = 1306.967\ kip \cdot ft$

$f_{bG2} := \frac{M_{uG2}}{S_t} = 13.356\ ksi$

Girder #3

$M_{uG3} := D.F._{G3ex} \cdot M_{uexc} + D.F._{G3truck} \cdot M_{utruck} + M_{deadint} = 1307.417\ kip \cdot ft$

$f_{bG3} := \frac{M_{uG3}}{S_t} = 13.361\ ksi$

Girder #4

$M_{uG4} := D.F._{G4truck} \cdot M_{utruck} + M_{deadint} = 1330.2\ kip \cdot ft$

$f_{bG4} := \frac{M_{uG4}}{S_t} = 13.593\ ksi$

Girder #5

$M_{uG5} := D.F._{Ext} \cdot M_{utruck} + M_{deadext} = 1208.9\ kip \cdot ft$

$f_{bG5} := \frac{M_{uG5}}{S_t} = 12.354\ ksi$

$f_b := \max(f_{bG1}, f_{bG2}, f_{bG3}, f_{bG4}, f_{bG5}) = 13.593\ ksi$

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Calculate Allowable Stress in Girders with Unbraced Length of 16.9ft

$L_b := 16.9\ ft = 202.8\ in$ (Diaphragm Spacing scaled off of existing plans for beam N3-E @ Midspan)

$$Check_{Fb} := \begin{cases} \text{"Fb=0.66Fy"} & \text{if } L_b < L_c \\ \text{"Check Equation F1-6, F1-7, \& F1-8"} & \text{else} \end{cases}$$

$Check_{Fb} = \text{"Fb=0.66Fy"}$

$F_b := 0.66 \cdot F_y = 21.78\ ksi$

$$Check := \begin{cases} \text{"OK"} & \text{if } F_b > f_b \\ \text{"No Good"} & \text{else} \end{cases}$$

$Check = \text{"OK"}$

Note: Dead loads are taken @ Max Moment not located @ midspan, Therefore the dead load moments are conservative.

Therefore W36x300 Girders are ok for removal of Deck

Appendix A

W36x160 Load Case Moments

BEAMBOY V2.2 REPORT

W36x160 Truck Centroid @ Midspan

LOAD CONFIGURATION

Point Loads

13000 lb., x=64.4 ft.
20000 lb., x=50.9 ft.
20000 lb., x=46.4 ft.
20000 lb., x=41.9 ft.
24000 lb., x=10.9 ft.
24000 lb., x=6.9 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 954000 lb.-ft. at x=41.9 ft.
Maximum Bending Stress = 19.2 ksi at x=41.9 ft.
Maximum Deflection = -1.97 in. at x=34.7 ft.
Maximum Slope = 0.471 degrees at x=67 ft.

Mu=954kip-ft

2/2/2015

BEAMBOY V2.2 REPORT

W36x160 Truck P3 @ Midspan

BEAM PROPERTIES

Beam Length = 67 ft.
Moment of Inertia = 12900 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 21.6 in.

LOAD CONFIGURATION

Point Loads

13000 lb., x=51.5 ft.
20000 lb., x=38 ft.
20000 lb., x=33.5 ft.
20000 lb., x=29 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1020000 lb.-ft. at x=33.5 ft.
Maximum Bending Stress = 20.5 ksi at x=33.5 ft.
Maximum Deflection = -1.96 in. at x=33.9 ft.
Maximum Slope = 0.436 degrees at x=67 ft.

Mu=1020 kip-ft

2/2/2015

BEAMBOY V2.2 REPORT

Dead Load Moment_Interior_1st Diaphragm

BEAM PROPERTIES

Beam Length = 67 ft.
Moment of Inertia = 12900 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 21.6 in.

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=230 lb./ft., x=0 ft.; End=230 lb./ft., x=67 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=47.2 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 479000 lb.-ft. at x=31.3 ft.
Maximum Bending Stress = 9650 psi at x=31.3 ft.
Maximum Deflection = -1.01 in. at x=32.8 ft.
Maximum Slope = -0.237 degrees at x=0.0067 ft.

VALUES AT A POINT (X=47.2 ft.)

Bending Moment=354000 lb.-ft.
Bending Stress=7140 psi
Deflection=-0.794 in.
Slope=0.138 degrees

Mu=354 kip-ft

1/28/2015

BEAMBOY V2.2 REPORT

W36x160 Dead load Moment_Exterior_1st Diaphragm

BEAM PROPERTIES

Beam Length = 67 ft.
Moment of Inertia = 12900 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 21.6 in.

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=230 lb./ft., x=0 ft.; End=230 lb./ft., x=67 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=47.2 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 586000 lb.-ft. at x=31.1 ft.
Maximum Bending Stress = 11.8 ksi at x=31.1 ft.
Maximum Deflection = -1.24 in. at x=32.7 ft.
Maximum Slope = -0.29 degrees at x=0.0067 ft.

VALUES AT A POINT (X=47.2 ft.)

Bending Moment=430000 lb.-ft.
Bending Stress=8670 psi
Deflection=-0.968 in.
Slope=0.169 degrees

Mu=430 kip-ft

1/28/2015

BEAMBOY V2.2 REPORT

Excavator Moment 7.5ft from End of Deck_1st Diaphragm

BEAM PROPERTIES

Beam Length = 67 ft.
Moment of Inertia = 12900 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 21.6 in.

LOAD CONFIGURATION

Point Loads

56000 lb., x=39.7 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 906000 lb.-ft. at x=39.7 ft.
Maximum Bending Stress = 18.3 ksi at x=39.7 ft.
Maximum Deflection = -1.55 in. at x=35.3 ft.
Maximum Slope = 0.356 degrees at x=67 ft.

VALUES AT A POINT (X=42.7 ft.)

Bending Moment=806000 lb.-ft.
Bending Stress=16.3 ksi
Deflection=-1.45 in.
Slope=0.14 degrees

Mu=806 kip-ft

1/28/2015

BEAMBOY V2.2 REPORT

Back of Truck 3ft from Edge of Deck_1st Diaphragm

BEAM PROPERTIES

Beam Length = 67 ft.
Moment of Inertia = 12900 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 21.6 in.

LOAD CONFIGURATION

Point Loads

24000 lb., x=44.2 ft.
24000 lb., x=40.2 ft.
20000 lb., x=9.2 ft.
20000 lb., x=4.7 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 825000 lb.-ft. at x=40.2 ft.
Maximum Bending Stress = 16.6 ksi at x=40.2 ft.
Maximum Deflection = -1.62 in. at x=34.5 ft.
Maximum Slope = 0.368 degrees at x=67 ft.

VALUES AT A POINT (X=42.7 ft.)

Bending Moment=799000 lb.-ft.
Bending Stress=16.1 ksi
Deflection=-1.49 in.
Slope=0.144 degrees

Mu=799 kip-ft

1/28/2015

BEAMBOY V2.2 REPORT

W36x160 Dead load Moment_Interior_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=230 lb./ft., x=0 ft.; End=230 lb./ft., x=67 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=33.5 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 360000 lb.-ft. at x=27.1 ft.
Maximum Bending Stress = 7250 psi at x=27.1 ft.
Maximum Deflection = -0.738 in. at x=31.8 ft.
Maximum Slope = -0.181 degrees at x=0.0067 ft.

Mu=360 kip-ft

1/21/2015

BEAMBOY V2.2 REPORT

W36x160 Dead load Moment_Exterior_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=230 lb./ft., x=0 ft.; End=230 lb./ft., x=67 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=33.5 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 432000 lb.-ft. at x=26.7 ft.
Maximum Bending Stress = 8700 psi at x=26.7 ft.
Maximum Deflection = -0.878 in. at x=31.6 ft.
Maximum Slope = -0.217 degrees at x=0.0067 ft.

Mu=432 kip-ft

1/21/2015

BEAMBOY V2.2 REPORT

Excavator Moment 7.5ft From End of Deck_Midspan

BEAM PROPERTIES

Beam Length = 67 ft.
Moment of Inertia = 12900 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 21.6 in.

LOAD CONFIGURATION

Point Loads

56000 lb., x=26 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 891000 lb.-ft. at x=26 ft.
Maximum Bending Stress = 18 ksi at x=26 ft.
Maximum Deflection = -1.52 in. at x=31.3 ft.
Maximum Slope = -0.355 degrees at x=0.0067 ft.

VALUES AT A POINT (X=33.5 ft.)

Bending Moment=728000 lb.-ft.
Bending Stress=14.7 ksi
Deflection=-1.51 in.
Slope=0.0358 degrees

Mu=728 kip-ft

1/28/2015

BEAMBOY V2.2 REPORT

Truck Moment With P6 3ft From End of Deck_Midspan

BEAM PROPERTIES

Beam Length = 67 ft.
Moment of Inertia = 12900 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 21.6 in.

LOAD CONFIGURATION

Point Loads

24000 lb., x=30.5 ft.
24000 lb., x=26.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 67 ft.

MAXIMUM VALUES

Maximum Bending Moment = 745000 lb.-ft. at x=30.5 ft.
Maximum Bending Stress = 15 ksi at x=30.5 ft.
Maximum Deflection = -1.35 in. at x=32 ft.
Maximum Slope = -0.305 degrees at x=0.0067 ft.

VALUES AT A POINT (X=33.5 ft.)

Bending Moment=684000 lb.-ft.
Bending Stress=13.8 ksi
Deflection=-1.34 in.
Slope=0.0224 degrees

Mu=684 kip-ft

1/28/2015

Appendix B

W36x170 Load Case Moments

BEAMBOY V2.2 REPORT

W36x170 Truck C.G. @ Midspan

BEAM PROPERTIES

Beam Length = 72 ft.
Moment of Inertia = 14300 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 22.2 in.

LOAD CONFIGURATION

Point Loads

13000 lb., x=66.9 ft.
20000 lb., x=53.4 ft.
20000 lb., x=48.9 ft.
20000 lb., x=44.4 ft.
24000 lb., x=13.4 ft.
24000 lb., x=9.4 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1110000 lb.-ft. at x=44.4 ft.
Maximum Bending Stress = 20.6 ksi at x=44.4 ft.
Maximum Deflection = -2.4 in. at x=37 ft.
Maximum Slope = 0.528 degrees at x=72 ft.

Mu=1110 kip-ft

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Truck P3 @ Midspan

BEAM PROPERTIES

Beam Length = 72 ft.
Moment of Inertia = 14300 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 22.2 in.

LOAD CONFIGURATION

Point Loads

13000 lb., x=54 ft.
20000 lb., x=40.5 ft.
20000 lb., x=36 ft.
20000 lb., x=31.5 ft.
24000 lb., x=0.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1110000 lb.-ft. at x=36 ft. Mu=1110 kip-ft
Maximum Bending Stress = 20.8 ksi at x=36 ft.
Maximum Deflection = -2.22 in. at x=36.4 ft.
Maximum Slope = 0.459 degrees at x=72 ft.

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Dead Load Int_1st Diaphragm

BEAM PROPERTIES

Beam Length = 72 ft.
Moment of Inertia = 14300 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 22.2 in.

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=250 lb./ft., x=0 ft.; End=250 lb./ft., x=72 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=57.3 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 608000 lb.-ft. at x=34.9 ft.
Maximum Bending Stress = 11.3 ksi at x=34.9 ft.
Maximum Deflection = -1.35 in. at x=35.6 ft.
Maximum Slope = -0.291 degrees at x=0.0072 ft.

VALUES AT A POINT (X=57.3 ft.)

Bending Moment=357000 lb.-ft. Mu=357 kip-ft
Bending Stress=6650 psi
Deflection=-0.802 in.
Slope=0.225 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Dead Load Ext_1st Diaphragm

BEAM PROPERTIES

Beam Length = 72 ft.
Moment of Inertia = 14300 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 22.2 in.

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=250 lb./ft., x=0 ft.; End=250 lb./ft., x=72 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=57.3 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 745000 lb.-ft. at x=34.8 ft.
Maximum Bending Stress = 13.9 ksi at x=34.8 ft.
Maximum Deflection = -1.66 in. at x=35.6 ft.
Maximum Slope = -0.356 degrees at x=0.0072 ft.

VALUES AT A POINT (X=57.3 ft.)

Bending Moment=434000 lb.-ft. Mu=434 kip-ft
Bending Stress=8090 psi
Deflection=-0.98 in.
Slope=0.275 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Excavator_1st Diaphragm

BEAM PROPERTIES

Beam Length = 72 ft.
Moment of Inertia = 14300 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 22.2 in.

LOAD CONFIGURATION

Point Loads

56000 lb., x=49.8 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 860000 lb.-ft. at x=49.8 ft.
Maximum Bending Stress = 16 ksi at x=49.8 ft.
Maximum Deflection = -1.48 in. at x=39.5 ft.
Maximum Slope = 0.348 degrees at x=72 ft.

VALUES AT A POINT (X=57.3 ft.)

Bending Moment=569000 lb.-ft. Mu=569 kip-ft
Bending Stress=10.6 ksi
Deflection=-0.985 in.
Slope=0.264 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Truck P6 3ft from End_1st Diaphragm

BEAM PROPERTIES

Beam Length = 72 ft.
Moment of Inertia = 14300 in^4
Modulus of Elasticity = 29000000 psi
Distance From Neutral Axis to Furthest Fiber = 22.2 in.

LOAD CONFIGURATION

Point Loads

24000 lb., x=54.3 ft.
24000 lb., x=50.3 ft.
20000 lb., x=19.3 ft.
20000 lb., x=14.8 ft.
20000 lb., x=10.3 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 928000 lb.-ft. at x=50.3 ft.
Maximum Bending Stress = 17.3 ksi at x=50.3 ft.
Maximum Deflection = -2.27 in. at x=35.8 ft.
Maximum Slope = -0.505 degrees at x=0.0072 ft.

VALUES AT A POINT (X=57.3 ft.)

Bending Moment=694000 lb.-ft. Mu=694 kip-ft
Bending Stress=12.9 ksi
Deflection=-1.38 in.
Slope=0.382 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Dead Load Int_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=250 lb./ft., x=0 ft.; End=250 lb./ft., x=72 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=36 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 428000 lb.-ft. at x=29.3 ft.
Maximum Bending Stress = 7980 psi at x=29.3 ft.
Maximum Deflection = -0.915 in. at x=34.2 ft.
Maximum Slope = -0.208 degrees at x=0.0072 ft.

Mu=428 kip-ft

VALUES AT A POINT (X=36 ft.)

Bending Moment=405000 lb.-ft.
Bending Stress=7550 psi
Deflection=-0.912 in.
Slope=0.0145 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Dead Load Ext_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=250 lb./ft., x=0 ft.; End=250 lb./ft., x=72 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=36 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 511000 lb.-ft. at x=28.8 ft. Mu=511 kip-ft
Maximum Bending Stress = 9530 psi at x=28.8 ft.
Maximum Deflection = -1.08 in. at x=34 ft.
Maximum Slope = -0.248 degrees at x=0.0072 ft.

VALUES AT A POINT (X=36. ft.)

Bending Moment=480000 lb.-ft.
Bending Stress=8940 psi
Deflection=-1.08 in.
Slope=0.019 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Excavator_Midspan

LOAD CONFIGURATION

Point Loads

56000 lb., x=28.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 964000 lb.-ft. at x=28.5 ft.
Maximum Bending Stress = 18 ksi at x=28.5 ft.
Maximum Deflection = -1.71 in. at x=33.8 ft.
Maximum Slope = -0.37 degrees at x=0.0072 ft.

VALUES AT A POINT (X=36 ft.)

Bending Moment=798000 lb.-ft. Mu=798 kip-ft
Bending Stress=14.9 ksi
Deflection=-1.71 in.
Slope=0.0356 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x170 Truck_Midspan

LOAD CONFIGURATION

Point Loads

24000 lb., x=33 ft.
24000 lb., x=29 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 72 ft.

MAXIMUM VALUES

Maximum Bending Moment = 806000 lb.-ft. at x=33 ft.
Maximum Bending Stress = 15 ksi at x=33 ft.
Maximum Deflection = -1.51 in. at x=34.5 ft.
Maximum Slope = -0.317 degrees at x=0.0072 ft.

VALUES AT A POINT (X=36. ft.)

Bending Moment=744000 lb.-ft. Mu=744 kip-ft
Bending Stress=13.9 ksi
Deflection=-1.51 in.
Slope=0.0222 degrees

2/2/2015

Appendix C

W36x194 Load Case Moments

BEAMBOY V2.2 REPORT

W36x194 Truck Centroid @ Midspan

LOAD CONFIGURATION

Point Loads

13000 lb., x=69.4 ft.
20000 lb., x=55.9 ft.
20000 lb., x=51.4 ft.
20000 lb., x=46.9 ft.
24000 lb., x=15.9 ft.
24000 lb., x=11.9 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1260000 lb.-ft. at x=46.9 ft.
Maximum Bending Stress = 20.4 ksi at x=46.9 ft.
Maximum Deflection = -2.72 in. at x=39.4 ft.
Maximum Slope = 0.555 degrees at x=77 ft.

Mu=1260 kip-ft

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Truck P3 @ Midspan

LOAD CONFIGURATION

Point Loads

13000 lb., x=56.5 ft.
20000 lb., x=43 ft.
20000 lb., x=38.5 ft.
20000 lb., x=34 ft.
24000 lb., x=3 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1230000 lb.-ft. at x=38.5 ft. Mu=1230 kip-ft
Maximum Bending Stress = 20.1 ksi at x=38.5 ft.
Maximum Deflection = -2.46 in. at x=38.8 ft.
Maximum Slope = 0.472 degrees at x=77 ft.

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Dead Loads Int_1st Diaphragm

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=285 lb./ft., x=0 ft.; End=285 lb./ft., x=77 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=54 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 671000 lb.-ft. at x=36 ft.
Maximum Bending Stress = 10.9 ksi at x=36 ft.
Maximum Deflection = -1.46 in. at x=37.7 ft.
Maximum Slope = -0.298 degrees at x=0.0077 ft.

VALUES AT A POINT (X=54 ft.)

Bending Moment=504000 lb.-ft. Mu=504 kip-ft
Bending Stress=8180 psi
Deflection=-1.16 in.
Slope=0.171 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Dead Loads Ext_1st Diaphragm

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=285 lb./ft., x=0 ft.; End=285 lb./ft., x=77 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=54 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 812000 lb.-ft. at x=35.8 ft.
Maximum Bending Stress = 13.2 ksi at x=35.8 ft.
Maximum Deflection = -1.77 in. at x=37.7 ft.
Maximum Slope = -0.361 degrees at x=0.0077 ft.

VALUES AT A POINT (X=54 ft.)

Bending Moment=604000 lb.-ft. Mu=604 kip-ft
Bending Stress=9810 psi
Deflection=-1.4 in.
Slope=0.208 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Excavator_1st Diaphragm

LOAD CONFIGURATION

Point Loads

56000 lb., x=51 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 964000 lb.-ft. at x=51 ft.
Maximum Bending Stress = 15.7 ksi at x=51 ft.
Maximum Deflection = -1.67 in. at x=41.8 ft.
Maximum Slope = 0.355 degrees at x=77 ft.

VALUES AT A POINT (X=54. ft.)

Bending Moment=853000 lb.-ft. Mu=853 kip-ft
Bending Stress=13.9 ksi
Deflection=-1.44 in.
Slope=0.186 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Truck_1st Diaphragm

LOAD CONFIGURATION

Point Loads

24000 lb., x=51 ft.
24000 lb., x=47 ft.
20000 lb., x=16 ft.
20000 lb., x=11.5 ft.
20000 lb., x=7 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1090000 lb.-ft. at x=47 ft.
Maximum Bending Stress = 17.7 ksi at x=47 ft.
Maximum Deflection = -2.37 in. at x=38.5 ft.
Maximum Slope = -0.493 degrees at x=0.0077 ft.

VALUES AT A POINT (X=54 ft.)

Bending Moment=909000 lb.-ft. Mu=909 kip-ft
Bending Stress=14.8 ksi
Deflection=-1.91 in.
Slope=0.277 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Dead Loads Int_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=285 lb./ft., x=0 ft.; End=285 lb./ft., x=77 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=38.5 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 514000 lb.-ft. at x=31.5 ft.
Maximum Bending Stress = 8360 psi at x=31.5 ft.
Maximum Deflection = -1.1 in. at x=36.7 ft.
Maximum Slope = -0.232 degrees at x=0.0077 ft.

VALUES AT A POINT (X=38.5 ft.)

Bending Moment=489000 lb.-ft. Mu=489 kip-ft
Bending Stress=7950 psi
Deflection=-1.09 in.
Slope=0.0154 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Dead Loads Ext_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=285 lb./ft., x=0 ft.; End=285 lb./ft., x=77 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=38.5 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 610000 lb.-ft. at x=31 ft.
Maximum Bending Stress = 9900 psi at x=31 ft.
Maximum Deflection = -1.29 in. at x=36.5 ft.
Maximum Slope = -0.275 degrees at x=0.0077 ft.

VALUES AT A POINT (X=38.5 ft.)

Bending Moment=574000 lb.-ft. Mu=574 kip-ft
Bending Stress=9330 psi
Deflection=-1.28 in.
Slope=0.0201 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Excavator_Midspan

LOAD CONFIGURATION

Point Loads

56000 lb., x=31 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1040000 lb.-ft. at x=31 ft.
Maximum Bending Stress = 16.9 ksi at x=31 ft.
Maximum Deflection = -1.83 in. at x=36.3 ft.
Maximum Slope = -0.367 degrees at x=0.0077 ft.

VALUES AT A POINT (X=38.5 ft.)

Bending Moment=868000 lb.-ft. Mu=868 kip-ft
Bending Stress=14.1 ksi
Deflection=-1.82 in.
Slope=0.0338 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x194 Truck_Midspan

LOAD CONFIGURATION

Point Loads

24000 lb., x=35.5 ft.
24000 lb., x=31.5 ft.
20000 lb., x=0.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 77 ft.

MAXIMUM VALUES

Maximum Bending Moment = 872000 lb.-ft. at x=35.5 ft.
Maximum Bending Stress = 14.2 ksi at x=35.5 ft.
Maximum Deflection = -1.62 in. at x=37 ft.
Maximum Slope = -0.319 degrees at x=0.0077 ft.

VALUES AT A POINT (X=38.5 ft.)

Bending Moment=809000 lb.-ft. Mu=809 kip-ft
Bending Stress=13.1 ksi
Deflection=-1.62 in.
Slope=0.0215 degrees

2/2/2015

Appendix D

W36x245 Load Case Moments

BEAMBOY V2.2 REPORT

W36x245 Truck C.G. @ Midspan

LOAD CONFIGURATION

Point Loads

13000 lb., x=71.9 ft.
20000 lb., x=58.4 ft.
20000 lb., x=53.9 ft.
20000 lb., x=49.4 ft.
24000 lb., x=18.4 ft.
24000 lb., x=14.4 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1410000 lb.-ft. at x=49.4 ft. Mu=1410 kip-ft
Maximum Bending Stress = 17.6 ksi at x=49.4 ft.
Maximum Deflection = -2.84 in. at x=41.8 ft.
Maximum Slope = 0.538 degrees at x=82 ft.

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Truck P3 @ Midspan

LOAD CONFIGURATION

Point Loads

13000 lb., x=59 ft.
20000 lb., x=45.5 ft.
20000 lb., x=41 ft.
20000 lb., x=36.5 ft.
24000 lb., x=5.5 ft.
24000 lb., x=1.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1370000 lb.-ft. at x=41 ft. Mu=1370 kip-ft
Maximum Bending Stress = 17.2 ksi at x=41 ft.
Maximum Deflection = -2.56 in. at x=41.1 ft.
Maximum Slope = -0.466 degrees at x=0.0082 ft.

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Dead Loads In_1st Diaphragm

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=340 lb./ft., x=0 ft.; End=340 lb./ft., x=82 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=64.1 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 857000 lb.-ft. at x=39.7 ft.
Maximum Bending Stress = 10.2 ksi at x=39.7 ft.
Maximum Deflection = -1.67 in. at x=40.6 ft.
Maximum Slope = -0.316 degrees at x=0.0082 ft.

VALUES AT A POINT (X=64.1 ft.)

Bending Moment=531000 lb.-ft. Mu=531 kip-ft
Bending Stress=6340 psi
Deflection=-1.05 in.
Slope=0.236 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Dead Loads Ext_1st Diaphragm

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=340 lb./ft., x=0 ft.; End=340 lb./ft., x=82 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=64.1 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1030000 lb.-ft. at x=39.5 ft.
Maximum Bending Stress = 12.3 ksi at x=39.5 ft.
Maximum Deflection = -2.01 in. at x=40.5 ft.
Maximum Slope = -0.38 degrees at x=0.0082 ft.

VALUES AT A POINT (X=64.1 ft.)

Bending Moment=635000 lb.-ft. Mu=635 kip-ft
Bending Stress=7570 psi
Deflection=-1.26 in.
Slope=0.284 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Excavator_1st Diaphragm

LOAD CONFIGURATION

Point Loads

56000 lb., x=56.6 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 982000 lb.-ft. at x=56.6 ft.
Maximum Bending Stress = 12.3 ksi at x=56.6 ft.
Maximum Deflection = -1.56 in. at x=45 ft.
Maximum Slope = 0.321 degrees at x=82 ft.

VALUES AT A POINT (X=64.1 ft.)

Bending Moment=692000 lb.-ft. Mu=692 kip-ft
Bending Stress=8660 psi
Deflection=-1.09 in.
Slope=0.233 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Truck_1st Diaphragm

LOAD CONFIGURATION

Point Loads

24000 lb., x=61.1 ft.
24000 lb., x=57.1 ft.
20000 lb., x=26.1 ft.
20000 lb., x=21.6 ft.
20000 lb., x=17.1 ft.
13000 lb., x=3.6 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1270000 lb.-ft. at x=26.1 ft.
Maximum Bending Stress = 15.8 ksi at x=26.1 ft.
Maximum Deflection = -2.73 in. at x=40.4 ft.
Maximum Slope = -0.528 degrees at x=0.0082 ft.

VALUES AT A POINT (X=64.1 ft.)

Bending Moment=912000 lb.-ft. Mu=912 kip-ft
Bending Stress=11.4 ksi
Deflection=-1.74 in.
Slope=0.387 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Dead Loads Int_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=340 lb./ft., x=0 ft.; End=340 lb./ft., x=82 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=41 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 628000 lb.-ft. at x=33.9 ft. Mu=628 kip-ft
Maximum Bending Stress = 7490 psi at x=33.9 ft.
Maximum Deflection = -1.19 in. at x=39.2 ft.
Maximum Slope = -0.236 degrees at x=0.0082 ft.

VALUES AT A POINT (X=41 ft.)

Bending Moment=601000 lb.-ft.
Bending Stress=7170 psi
Deflection=-1.19 in.
Slope=0.0145 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Dead Loads Int_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=340 lb./ft., x=0 ft.; End=340 lb./ft., x=82 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=41 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 736000 lb.-ft. at x=33.4 ft. Mu=736 kip-ft
Maximum Bending Stress = 8780 psi at x=33.4 ft.
Maximum Deflection = -1.38 in. at x=39 ft.
Maximum Slope = -0.276 degrees at x=0.0082 ft.

VALUES AT A POINT (X=41 ft.)

Bending Moment=698000 lb.-ft.
Bending Stress=8320 psi
Deflection=-1.38 in.
Slope=0.0189 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Excavator_Midspan

LOAD CONFIGURATION

Point Loads

56000 lb., x=33.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1110000 lb.-ft. at x=33.5 ft.
Maximum Bending Stress = 13.9 ksi at x=33.5 ft.
Maximum Deflection = -1.82 in. at x=38.8 ft.
Maximum Slope = -0.341 degrees at x=0.0082 ft.

VALUES AT A POINT (X=41.0 ft.)

Bending Moment=938000 lb.-ft.
Bending Stress=11.7 ksi
Deflection=-1.81 in.
Slope=0.0301 degrees

Mu=938 kip-ft

2/2/2015

BEAMBOY V2.2 REPORT

W36x245 Truck_Midspan

LOAD CONFIGURATION

Point Loads

24000 lb., x=38 ft.
24000 lb., x=34 ft.
20000 lb., x=3 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 82 ft.

MAXIMUM VALUES

Maximum Bending Moment = 959000 lb.-ft. at x=38 ft.
Maximum Bending Stress = 12 ksi at x=38 ft.
Maximum Deflection = -1.67 in. at x=39.3 ft.
Maximum Slope = -0.313 degrees at x=0.0082 ft.

VALUES AT A POINT (X=41.0 ft.)

Bending Moment=894000 lb.-ft. Mu=894 kip-ft
Bending Stress=11.2 ksi
Deflection=-1.67 in.
Slope=0.0214 degrees

2/2/2015

Appendix E

W36x300 Load Case Moments

BEAMBOY V2.2 REPORT

W36x300 Truck C.G. @ Midpsan

LOAD CONFIGURATION

Point Loads

13000 lb., x=74.4 ft.
20000 lb., x=60.9 ft.
20000 lb., x=56.4 ft.
20000 lb., x=51.9 ft.
24000 lb., x=20.9 ft.
24000 lb., x=16.9 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1560000 lb.-ft. at x=51.9 ft. Mu=1560 kip-ft
Maximum Bending Stress = 16 ksi at x=51.9 ft.
Maximum Deflection = -2.9 in. at x=44.3 ft.
Maximum Slope = 0.514 degrees at x=87 ft.

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Truck P3 @ Midspan

LOAD CONFIGURATION

Point Loads

13000 lb., x=61.5 ft.
20000 lb., x=48 ft.
20000 lb., x=43.5 ft.
20000 lb., x=39 ft.
24000 lb., x=8 ft.
24000 lb., x=4 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1520000 lb.-ft. at x=43.5 ft. Mu=1520 kip-ft
Maximum Bending Stress = 15.6 ksi at x=43.5 ft.
Maximum Deflection = -2.64 in. at x=43.4 ft.
Maximum Slope = -0.463 degrees at x=0.0087 ft.

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Dead Loads Int_1st Diaphragm

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=405 lb./ft., x=0 ft.; End=405 lb./ft., x=87 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=70 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1040000 lb.-ft. at x=42.4 ft.
Maximum Bending Stress = 10.6 ksi at x=42.4 ft.
Maximum Deflection = -1.97 in. at x=43.2 ft.
Maximum Slope = -0.349 degrees at x=0.0087 ft.

VALUES AT A POINT (X=70 ft.)

Bending Moment=600000 lb.-ft. Mu=600 kip-ft
Bending Stress=6150 psi
Deflection=-1.13 in.
Slope=0.276 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Dead Loads Ext_1st Diaphragm

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=405 lb./ft., x=0 ft.; End=405 lb./ft., x=87 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=70 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1240000 lb.-ft. at x=42.3 ft.
Maximum Bending Stress = 12.7 ksi at x=42.3 ft.
Maximum Deflection = -2.34 in. at x=43.1 ft.
Maximum Slope = -0.416 degrees at x=0.0087 ft.

VALUES AT A POINT (X=70 ft.)

Bending Moment=710000 lb.-ft. Mu=710 kip-ft
Bending Stress=7270 psi
Deflection=-1.34 in.
Slope=0.329 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Excavator_1st Diaphragm

LOAD CONFIGURATION

Point Loads

56000 lb., x=62.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 986000 lb.-ft. at x=62.5 ft.
Maximum Bending Stress = 12.3 ksi at x=62.5 ft.
Maximum Deflection = -1.74 in. at x=48.2 ft.
Maximum Slope = 0.347 degrees at x=87 ft.

VALUES AT A POINT (X=70 ft.)

Bending Moment=684000 lb.-ft. Mu=684 kip-ft
Bending Stress=8560 psi
Deflection=-1.14 in.
Slope=0.265 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Truck_1st Diaphragm

LOAD CONFIGURATION

Point Loads

24000 lb., x=67 ft.
24000 lb., x=63 ft.
20000 lb., x=32 ft.
20000 lb., x=27.5 ft.
20000 lb., x=23 ft.
13000 lb., x=9.5 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1510000 lb.-ft. at x=32 ft.
Maximum Bending Stress = 15.5 ksi at x=32 ft.
Maximum Deflection = -2.87 in. at x=42.8 ft.
Maximum Slope = -0.516 degrees at x=0.0087 ft.

VALUES AT A POINT (X=70 ft.)

Bending Moment=956000 lb.-ft. Mu=956 kip-ft
Bending Stress=9800 psi
Deflection=-1.66 in.
Slope=0.404 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Dead Loads Int_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=405 lb./ft., x=0 ft.; End=405 lb./ft., x=87 ft.
Start=750 lb./ft., x=0 ft.; End=750 lb./ft., x=43.5 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 767000 lb.-ft. at x=36.4 ft.
Maximum Bending Stress = 7850 psi at x=36.4 ft.
Maximum Deflection = -1.41 in. at x=41.8 ft.
Maximum Slope = -0.262 degrees at x=0.0087 ft.

VALUES AT A POINT (X=43.5 ft.)

Bending Moment=738000 lb.-ft. Mu=738 kip-ft
Bending Stress=7560 psi
Deflection=-1.41 in.
Slope=0.0149 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Dead Loads Ext_Midspan

LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=405 lb./ft., x=0 ft.; End=405 lb./ft., x=87 ft.
Start=980 lb./ft., x=0 ft.; End=980 lb./ft., x=43.5 ft.

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 888000 lb.-ft. at x=35.8 ft.
Maximum Bending Stress = 9090 psi at x=35.8 ft.
Maximum Deflection = -1.62 in. at x=41.5 ft.
Maximum Slope = -0.303 degrees at x=0.0087 ft.

VALUES AT A POINT (X=43.5 ft.)

Bending Moment=847000 lb.-ft.
Bending Stress=8670 psi
Deflection=-1.62 in.
Slope=0.0194 degrees

Mu=847 kip-ft

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Excavator_Midspan

LOAD CONFIGURATION

Point Loads

56000 lb., x=36 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1180000 lb.-ft. at x=36 ft.
Maximum Bending Stress = 14.8 ksi at x=36 ft.
Maximum Deflection = -2.19 in. at x=41.3 ft.
Maximum Slope = -0.384 degrees at x=0.0087 ft.

VALUES AT A POINT (X=43.5 ft.)

Bending Moment=1010000 lb.-ft. Mu=1010 kip-ft
Bending Stress=12.6 ksi
Deflection=-2.18 in.
Slope=0.0325 degrees

2/2/2015

BEAMBOY V2.2 REPORT

W36x300 Truck_Midspan

LOAD CONFIGURATION

Point Loads

24000 lb., x=40.3 ft.
24000 lb., x=36.5 ft.
20000 lb., x=5.5 ft.
20000 lb., x=1 ft.

Distributed Loads

Moments

Supports

Simple support; 0 ft.
Simple support; 87 ft.

MAXIMUM VALUES

Maximum Bending Moment = 1060000 lb.-ft. at x=40.3 ft.
Maximum Bending Stress = 10.9 ksi at x=40.3 ft.
Maximum Deflection = -1.71 in. at x=41.6 ft.
Maximum Slope = -0.309 degrees at x=0.0087 ft.

VALUES AT A POINT (X=43.5 ft.)

Bending Moment=987000 lb.-ft. Mu=987 kip-ft
Bending Stress=10.1 ksi
Deflection=-1.71 in.
Slope=0.022 degrees

2/2/2015