UNIVERSITY OF WYOMING
CIVIL AND ARCHITECTURAL ENGINEERING

Name: _____ 0/

Date: Class: Assignment:

COMPOSITE

LENGTH = 55 ft

FOUR STRIPED LANES

NO DIAPHRAGM @ ℄

AASHTO 9th UPDATED WITH AASHTO 10th

UNIVERSITY OF WYOMING
CIVIL AND ARCHITECTURAL ENGINEERING

Name: _____ 1/

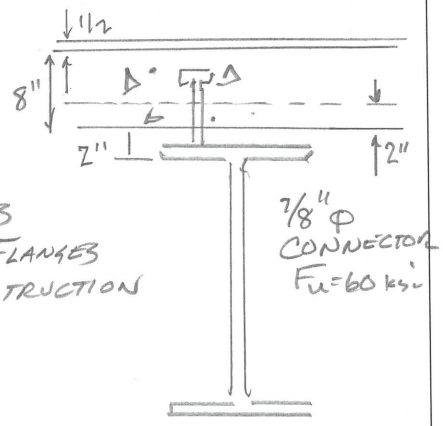
Date: Class: Assignment:

DESIGN EXAMPLE

COMPOSITE

$F_y = 50$ ksi

8" STRUCTURAL DECK
½" SACRIFICIAL
SIP - 2" 15 lb/ft²
HAUNCH = 2" FROM TOP OF WEB



OWNER WANTS 4 STRIPED LANES AND 56ft ROADWAY WIDTH

RAILINGS/BARRIERS ARE 1.5 ft AND WEIGH 250 lb/ft
50% ON 2 OUTER GIRDERS

HL93 DESIGN

ADD'L DC2 LOADING OF 50 lb/ft
100% ON CRITICAL GIRDER

25psf WEARING SURFACE

NO USER DEFINED TRUCK

DECKING DOES NOT BRACE FLANGES DURING CONSTRUCTION

CONSTRUCTION w_s = 275 lb/ft
P = 3000 lb

5% MISC. STL FOR DIAPHRAGMS

FATIGUE ADTT$_{SL}$ = 1200

Bridge Layout

Bridge Length (ft)	55			Type of Bridge	Composite
Roadway Width (ft)	56				
Number Striped Lanes	4	Bridge Width = Roadway Width + 2 * Barrier Width			
Barrier Width (ft)	1.5				
Est. Overhang = XX% GS	20%				

Number of Girders	Girder Spacing (ft)	Overhang	Roadway Width	Bridge Width
4	17.35	3.47	56.00	59.00
5	13.41	2.68	56.00	59.00
6	10.93	2.19	56.00	59.00
7	9.22	1.84	56.00	59.00
8	7.97	1.59	56.00	59.00
9	7.02	1.40	56.00	59.00
10	6.28	1.26	56.00	59.00
11	5.67	1.13	56.00	59.00
12	5.18	1.04	56.00	59.00
13	4.76	0.95	56.00	59.00

Cross Section Trial Number of Girders	Girder Spacing	Calculated Overhang	Overhang	Roadway	Bridge
7	9.25	1.75	1.75	56.00	59.00
	Overhang = 18.9% of Girder Spacing				8.00 ft of Shoulder

NonComposite Bridge Information

Type of Decking	Corrugated Metal Deck (gravel or other)
DC1 Deck Only Loading (psf)	80

Composite Bridge Information

		Check For LLDF (Warning if Violation)
Deck f'c (psi)	4000	
Structural Deck Thickness (in)	8	
Sacrificial Concrete Deck (in)	0.5	
Haunch from Top of Web (in)	2	
Stay-in-Place (SIP) Forms?	Yes	
Weight of SIP (psf)	15	
Depth of SIP (in)	2	
Shear Connector Diameter (in)	0.875	
Shear Connector Fu (ksi)	60	
DC1 Deck Only Loading (psf)	108.75	

Fatigue (AASHTO 10th Edition Applied)

Design Life (yrs)	75	
Average Daily Truck Traffic Single Lane $(ADTT)_{SL}$	1200	Fatigue I Controls
If ADTT > 974 Fatigue I Controls		

User Defined Truck? (up to 9 Axles) No

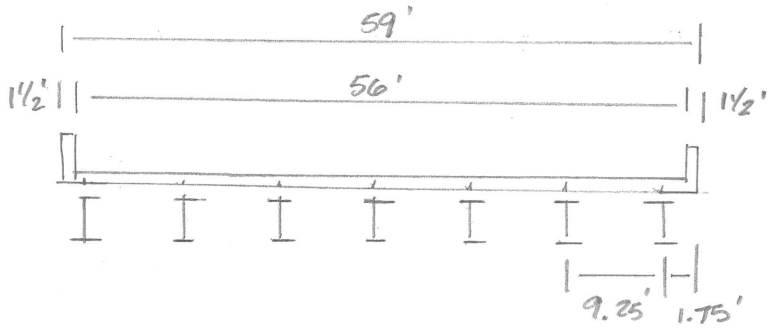
1st Axle (kips) and Spacing to Next Axle (ft)	
2nd Axle (kips) and Spacing to Next Axle (ft)	
3rd Axle (kips) and Spacing to Next Axle (ft)	
4th Axle (kips) and Spacing to Next Axle (ft)	
5th Axle (kips) and Spacing to Next Axle (ft)	
6thAxle (kips) and Spacing to Next Axle (ft)	
7th Axle (kips) and Spacing to Next Axle (ft)	
8th Axle (kips) and Spacing to Next Axle (ft)	
9th Axle (kips)	
User Vehicle Live Load Factor	
Apply Lane Load to User Truck?	No
Single Lane or 2 or More Lane Distribution Factor?	
User Vehicle Impact Factor for Str I / Serv II Design	

Line Girder Dead Loading

DC1 Girder Deck (lb/ft)	916.6
DC2 Barrier (lb/ft)	125
DC1 (no stl) + Additional DC1 (lb/ft)	**916.6**
DC2 + Additional DC2 (lb/ft)	**175**
DW (lb/ft)	**200.0**
Add'l DC1 on Bridge (Overhang ,Haunch, Utilities, etc) (lb/ft)	0
Max % on Additional DC1 on Girder	100%
DC2 Barrier Load (lb/ft)	250
Max % on Girder	50%
Add'l DC2 on Bridge Utilities, etc) (lb/ft)	50
Max % Additional DC2 on Girder	100%
Wearing Surface (psf)	25
% Misc Stl for Diaphrams, etc	5%

Construction Loading

AT END OF OVERHANG FOR LATERAL BENDING	May be 0 for many types of decking
Construction w (lb/ft)	275
Construction p (lb)	3000
1/2 of Deck Overhang Weight (lb/ft)	95.15625
ADDITIONAL CONSTRUCTION VERTICAL BENDING ON GIRDER	
Construction w (lb/ft)	275
Construction p (lb)	3000



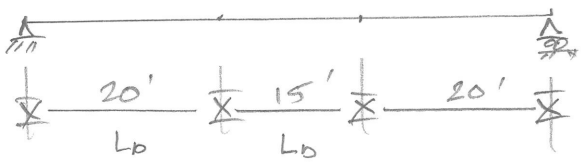
CHOOSE 7 GIRDERS
@ 9'-3" SPACING

OVERHANG 1'-9"

SHARE BARRIER
50% EXT. : 50% 1ST INT.

OVERHANG 18.9% GS

48' LANES + 8' SHOULDER



LATERAL BRACING

DC, LOADING

$$\left[\left(\frac{8\frac{1}{2}-\frac{2}{2}}{12}\right)(150)+15\right]\frac{59}{7} = 916.6\ \frac{lb}{ft}$$

IGNORE HAUNCH & OVERHANG

TOTAL $DC_1 = 916.6\ lb/ft$

DC_2 LOADING

BARRIER EXT. $\frac{250\ lb/ft}{2} = 125\ lb/ft$

INT. $\frac{250}{2} = 125\ lb/ft$

ADD'L $DC_2 = 50\ lb/ft$ 100%

TOTAL $DC_2 = 175\ lb/ft$

DW LOADING

$$\frac{25psf(56)}{7}$$

TOTAL $DW = 200\ lb/ft$

ADD'L VERTICAL BENDING FOR CONSTRUCTION LOADING

$W = 275\ lb/ft$
$P = 3000\ lb$

DO NOT CONSIDER W40 OR W44

$\frac{L}{d_{MAX}} = 30$ $d_{min} = 12"$ $d_{MAX} = 36"$

DEFLECTION LIMIT $L/800$

COMPRESSION FLANGE NOT BRACED FOR CONSTRUCTION

COMPRESSION FLANGE BRACED FOR FINAL

USE AASHTO APPENDIX A6

Yield Strength (ksi)	50
Bridge Length (ft)	55
Girder Spacing (ft)	9.25
Number of Girders	7
Overhang (18.9% of Girder Spacing) (ft)	1.75
Barrier Width (ft)	1.5
Lateral Bracing Locations in Span (ft)	
Enter Support Bracing at End of Span (ft)	
Distance from End to 1ST Brace (ft) = 0	0
Distance from End to 2nd Brace (ft)	20
Distance from End to 3rd Brace (ft)	35
Distance from End to 4th Brace (ft)	55
Distance from End to 5th Brace (ft)	
Distance from End to 6th Brace (ft)	
Distance from End to 7th Brace (ft)	
Distance from End to 8th Brace (ft)	
Use AASHTO Appendix A.6 for Strength? (No Limits Strengths to AASHTO 6.10.8)	Yes
Calculate Cb Factors or Use Cb = 1?	Calc Cb

Consider W40 & W44?		No
Limit Maximum L/D to		30 d>= 22.0
For Diaphragms	Min Depth (in) (If Want min WXX use XX)	12 >= W12
For Approach/Clearance	Max Depth (in) (If want max WXX use XX)	36 <= W36
x for Deflection Limit in L/x (If Deflections not Considered enter Low Number)		800
Is Compression Flange Fully Braced For Construction?		No
Is Compression Flange Fully Braced For Final State?		Yes
Maximum Accepted Performmance Ratio		1.00
Override Calculated Lateral Distribution Factors?		No
Single Lane Moment		
Two Lane Moment		
Fatigue Moment		
Single Lane Shear		
Two Lane Shear		

Bridge Width (ft)	**59**
Roadway Width (ft)	**56**
Shoulders (ft each side)	**4 Double for One-Sided Shoulder**

4 Striped Lanes and 4 Design Lanes

ANYTIME A VALUE IS CHANGED IN THE YELLOW, HIT RUN DESIGN FOR UPDATED RESULTS

Run Design

Lightest 10 Sections (see to the right for additional Information)

Str I, Serv II, Constr	Fatigue	Deflection	L/D	Defl	Mn/My	Weight (tons)
W30X116	W30X116	W30X116	22.0	L/1553	1.92	22.3
W33X118	W33X118	W33X118	20.1	L/1821	1.93	22.7
W30X124	W30X124	W30X124	21.9	L/1642	1.87	23.9
W27X129	W27X129	W27X129	23.9	L/1456	1.81	24.8
W33X130	W33X130	W33X130	19.9	L/1978	1.84	25.0
W24X131	W24X131	W24X131	26.9	L/1259	1.75	25.2
W30X132	W30X132	W30X132	21.8	L/1723	1.83	25.4
W36X135	W36X135	W36X135	18.5	L/2277	1.87	26.0
W33X141	W33X141	W33X141	19.8	L/2116	1.77	27.1
W27X146	W27X146	W27X146	24.1	L/1630	1.65	28.1

If No Section is Shown that Meets all the Criteria, See Sections to the Right
If No Sections are Shown to the Right, There is No W Section that Meets Design and Criteria

If Mn/My is Low (~0.70 is Elastic LTB), Lighter Section Possible with Cross-Frame Changes for Unbraced Lengths

W30X116 WORKS, BUT WANT TO USE W33X118
CAN SELECT ON SELECT A GIRDER SHEET

EXAMPLE WILL USE W33X118

Yield Strength (ksi)	50
Bridge Length (ft)	55
Girder Spacing (ft)	9.25
Number of Girders	7
Overhang (18.9% of Girder Spacing) (ft)	1.75
Barrier Width (ft)	1.5
Barrier Load on Girder (lb/ft)	125
DC Deck Only Loading (psf)	106.25
Wearing Surface (psf)	25
Additional DC1 Load on Girder (lb/ft)	0
Additional DC2 Load on Bridge (lb/ft)	50
AT OVERHANG FOR LATERAL FLANGE BENDING	
Construction w (lb/ft)	275
Construction p (lb)	3000
1/2 of Deck Overhang Weight (lb/ft)	95.15625
ADDITIONAL VERTICAL BENDING ON GIRDERS	
Exterior - Construction p (lb)	3000
Exterior - Construction w (lb/ft)	275
% Misc Stl for Diaphrams, etc	5%
DEFLECTION LIMIT (x for Deflection Limit in L/x)	800

Bridge Width (ft)	**59.00**
Roadway Width (ft)	**56.00**
Shoulders (ft) each side - Double for One Sided	**4.00**
4 Striped Lanes and 4 Design Lanes	
Composite Design	8 in Structural Deck with 2 in SIP Forms
AASHTO HL93 Loading and No User Defined Vehicle	
Strength Design Uses AASHTO Appendix A6	
Fatigue Design Life (yrs)	75
Fatigue $ADTT_{SL}$	1200 Fatigue I Controls

Consider W40 & W44 Beams?	No
L/D Limited to	30
Minimum Depth Beam (in)	W12
Maximum Depth Beam (in)	W36

Compression Flange Laterally Braced for Final State

Unbraced Length #	Lb	Cb
1	20.00	1.40
2	15.00	1.01
3	20.00	1.40

Limit States Checked

Strength I & II
Service II
Constructability
Fatigue
Deflection

7

						STRENGTH I/II SERVICE II Constructability					**Fatigue Fatigue I Controls (ADTT)SL=** 1200		**Deflection**		**Overall for all criteria Maximum**
		Uniform Load	Deflect	Girder Weight		Shear	Strength I	Service II	Constructabil	**Maximum**					Deflection	
Section	**L/D**	**w/Stl for DC1 (lb/ft)**	**L/Num**	**(tons)**	**Mn/My**	**PR**	PR	PR	PR	**PR**	Controlling	Section	PR	**Section**	PR	**PR**
W30X116	**22.0**	**1038.4**	**L/1553**	**22.3**	**1.92**	**0.44**	0.87	0.96	0.98	**0.98**	Construction	**W30X116**	**0.91**	**W30X116**	0.52	**0.98** Construction
W33X118	**20.1**	**1040.5**	**L/1821**	**22.7**	**1.93**	**0.41**	0.80	0.90	0.81	**0.90**	Service II	**W33X118**	**0.84**	**W33X118**	0.44	**0.90** Service II
W30X124	**21.9**	**1046.8**	**L/1642**	**23.9**	**1.87**	**0.42**	0.84	0.91	0.87	**0.91**	Service II	**W30X124**	**0.85**	**W30X124**	0.49	**0.91** Service II
W27X129	**23.9**	**1052.1**	**L/1456**	**24.8**	**1.81**	**0.45**	0.88	0.93	0.92	**0.93**	Service II	**W27X129**	**0.87**	**W27X129**	0.55	**0.93** Service II
W33X130	**19.9**	**1053.1**	**L/1978**	**25.0**	**1.84**	**0.39**	0.75	0.81	0.69	**0.81**	Service II	**W33X130**	**0.76**	**W33X130**	0.40	**0.81** Service II
W24X131	**26.9**	**1054.2**	**L/1259**	**25.2**	**1.75**	**0.51**	0.95	0.97	0.75	**0.97**	Service II	**W24X131**	**0.91**	**W24X131**	0.64	**0.97** Service II
W30X132	**21.8**	**1055.2**	**L/1723**	**25.4**	**1.83**	**0.40**	0.81	0.86	0.79	**0.86**	Service II	**W30X132**	**0.80**	**W30X132**	0.46	**0.86** Service II
W36X135	**18.5**	**1058.4**	**L/2277**	**26.0**	**1.87**	**0.34**	0.69	0.76	0.62	**0.76**	Service II	**W36X135**	**0.70**	**W36X135**	0.35	**0.76** Service II
W33X141	**19.8**	**1064.7**	**L/2116**	**27.1**	**1.77**	**0.37**	0.71	0.75	0.61	**0.75**	Service II	**W33X141**	**0.70**	**W33X141**	0.38	**0.75** Service II
W27X146	**24.1**	**1069.9**	**L/1630**	**28.1**	**1.65**	**0.46**	0.82	0.81	0.57	**0.82**	Strength I	**W27X146**	**0.76**	**W27X146**	0.49	**0.82** Strength I/II
W24X146	**26.7**	**1069.9**	**L/1369**	**28.1**	**1.67**	**0.48**	0.89	0.88	0.65	**0.89**	Strength I	**W24X146**	**0.81**	**W24X146**	0.58	**0.89** Strength I/II
W21X147	**29.9**	**1071.0**	**L/1146**	**28.3**	**1.71**	**0.49**	0.97	0.96	0.75	**0.97**	Strength I	**W21X147**	**0.88**	**W21X147**	0.70	**0.97** Strength I/II
W30X148	**21.5**	**1072.0**	**L/1898**	**28.5**	**1.74**	**0.38**	0.74	0.77	0.65	**0.77**	Service II	**W30X148**	**0.71**	**W30X148**	0.42	**0.77** Service II

ENTER W SECTION FOR MORE INFORMATION

W33X118 **Composite** Weight (lb/ft) 118

OVERALL PERFORMANCE FOR W33X118

Strength I/II	Service II	Construction	Fatigue	Deflection		Overall
PR	PR	PR	PR	PR		PR
0.805	0.895	0.811	0.842	0.439		0.895
In Lb #	At Centerline	In Lb #	At Critical Brace	At Centerline Equal to		Service II
2		1		L/1821		

PERFORMANCE BY UNBRACED LENGTH FOR W33X118

Compression Flange Laterally Braced for Final State			Strength I/II		
Unbraced Length #	Unbraced Length (ft)	Lb Range	PR	Mn/My	Cb
1	20	0 - 20 ft	0.757	1.934	1.401
2	15	20 - 35 ft	0.805	1.934	1.006
3	20	35 - 55 ft	0.757	1.934	1.401

SELECT W33 x 118

LIST OF ALL W SHAPES RANKED FROM STRENGTH I, SERVICE II & CONSTRUCTION

Top 20 That Meet Min Depth, Max Depth & W40 & W44 Limits

Shape	Strength I/II	Service II	Construction	Fatigue	Deflection	Overall
	PR	PR	PR	PR	PR	PR
W30X116	**0.87**	**0.96**	**0.98**	0.91	0.52	0.98
W33X118	**0.80**	**0.90**	**0.81**	0.84	0.44	0.90
W30X124	**0.84**	**0.91**	**0.87**	0.85	0.49	0.91
W27X129	**0.88**	**0.93**	**0.92**	0.87	0.55	0.93
W33X130	**0.75**	**0.81**	**0.69**	0.76	0.40	0.81
W24X131	**0.95**	**0.97**	**0.75**	0.91	0.64	0.97
W30X132	**0.81**	**0.86**	**0.79**	0.80	0.46	0.86
W36X135	**0.69**	**0.76**	**0.62**	0.70	0.35	0.76
W33X141	**0.71**	**0.75**	**0.61**	0.70	0.38	0.75
W27X146	**0.82**	**0.81**	**0.57**	0.76	0.49	0.82
W24X146	**0.89**	**0.88**	**0.65**	0.81	0.58	0.89
W21X147	**0.97**	**0.96**	**0.75**	0.88	0.70	0.97
W30X148	**0.74**	**0.77**	**0.65**	0.71	0.42	0.77
W36X150	**0.64**	**0.68**	**0.52**	0.64	0.32	0.68
W33X152	**0.68**	**0.70**	**0.54**	0.65	0.36	0.70
W36X160	**0.62**	**0.64**	**0.48**	0.60	0.31	0.64
W27X161	**0.77**	**0.74**	**0.51**	0.69	0.46	0.77
W24X162	**0.83**	**0.80**	**0.58**	0.73	0.54	0.83
W21X166	**0.90**	**0.86**	**0.64**	0.77	0.63	0.90
W33X169	**0.63**	**0.64**	**0.48**	0.59	0.33	0.64

STRENGTH I $pr = 0.80$

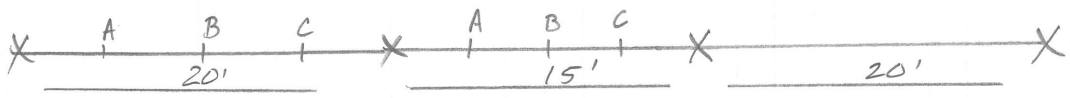
SERVICE II $pr = 0.90$

CONSTRUCTION $pr = 0.81$

FATIGUE I $pr = 084$ INFINITE

DEFLECTION $pr = 0.44$ $L/1821$

Date: Class: Assignment:

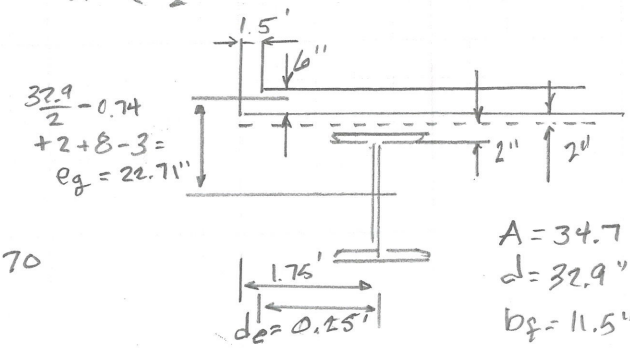


MOMENTS			REACTIONS
DC_1 (NO STL)	320.8	346.6	25.2
DC_2	61.3	66.2	4.8
DW	70	75.6	5.5
HL93+IM	1131	1194	97.1k
FATIGUE	570.3	X	
ADD'L CONST.	134.4	145.2	

LATERAL DISTRIBUTION FACTORS – DEPENDENT ON SECTION

W33x118

$b_{eff} = \left(\frac{9.25}{2} + 1.75\right)12 = 76.5"$ $n = 8$



$A = 34.7 in^2$
$d = 32.9"$
$b_f = 11.5"$
$t_f = 0.74"$
$t_w = 0.55"$
$I_x = 5900 in^4$
$S_x = 359 in^3$

MOMENT INTERIOR

$K_g = n(I + Ae_g^2)$

$= 8(5900 + 34.7(22.71)^2) = 190370$

SINGLE

$$g = 0.06 + \left(\frac{S}{14}\right)^{0.4}\left(\frac{S}{L}\right)^{0.3}\left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

$3 \le S \le 16$
$4.5 \le t_s \le 12$
$20 \le L \le 240$ ✓
$N_b > 4$
$10\times10^3 \le K_g \le 7\times10^6$

$$g_{INT} = 0.06 + \left(\frac{9.25}{14}\right)^{0.4}\left(\frac{9.25}{55}\right)^{0.3}\left(\frac{190370}{12(55)(6)^3}\right)^{0.1} = 0.571$$

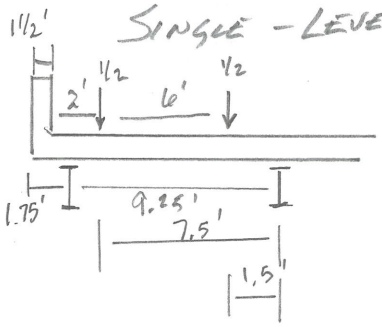
TWO OR MORE

$$g = 0.075 + \left(\frac{S}{9.5}\right)^{0.6}\left(\frac{S}{L}\right)^{0.2}\left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

$$g_{INT} = 0.075 + \left(\frac{9.25}{9.5}\right)^{0.6}\left(\frac{9.25}{55}\right)^{0.2}\left(\frac{190370}{12(55)(6)^3}\right)^{0.1} = 0.785$$

MOMENT EXTERIOR

SINGLE – LEVER RULE

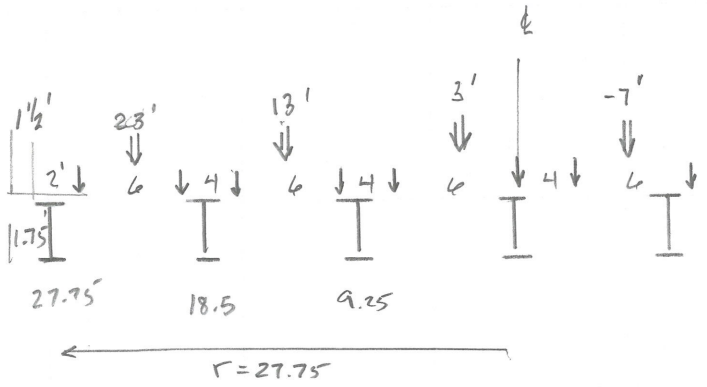


$$g_{EXT} = \frac{1}{2}\frac{(7.5+1.5)}{9.25} \times 1.2 = 0.584$$

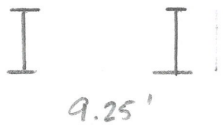
TWO OR MORE EXTERIOR $g_{EXT} = e\,g_{INT}$ $e = 0.77 + \frac{de}{9.1} = 0.77 + \frac{0.25}{9.1} = 0.797$

$g_{EXT} = 0.785(0.797) = 0.626$

RIGID ANALYSIS



$R = \frac{N_L}{N_B} + \frac{X_{EXT}\,\Sigma e_i}{\Sigma x_i^2}$



MPF
ONE 1.2
TWO 1.0
THREE 0.85
FOUR 0.65

$\Sigma r_i^2 = 2(27.75^2 + 18.5^2 + 9.25^2)$
$= 2395.75$

SINGLE $\left[\frac{1}{7} + \frac{27.75(23)}{2395.75}\right] 1.2 = 0.491$

TWO $\left[\frac{2}{7} + \frac{27.75(23+13)}{2395.75}\right] 1.0 = 0.703$

THREE $\left[\frac{3}{7} + \frac{27.75(23+13+3)}{2395.75}\right] 0.85 = 0.748$

FOUR $\left[\frac{4}{7} + \frac{27.75(23+13+3-7)}{2395.75}\right] 0.65 = 0.612$

SHEAR INTERIOR

SINGLE $g = 0.36 + \frac{S}{25} = 0.36 + \frac{9.25}{25} = 0.73$

TWO OR MORE $g = 0.2 + \frac{S}{12} - \left(\frac{S}{35}\right)^2 = 0.2 + \frac{9.25}{12} - \left(\frac{9.25}{35}\right)^2 = 0.901$

SHEAR EXTERIOR

SINGLE LEVER RULE $g = 0.584$

TWO OR MORE $g_{EXT} = e\, g_{INT}$ $e = 0.6 + \frac{de}{10} = 0.6 + \frac{6.25}{10} = 0.625$

$g_{EXT} = 0.625(0.901) = 0.563$

USE MAXIMUM FOR INT. & EXT - CONSERVATIVE

MOMENT SINGLE $g = 0.584$

TWO OR MORE $g = 0.785$

FATIGUE $g = \frac{0.584}{1.2} = 0.486$

SHEAR SINGLE $g = 0.730$

TWO OR MORE $g = 0.901$

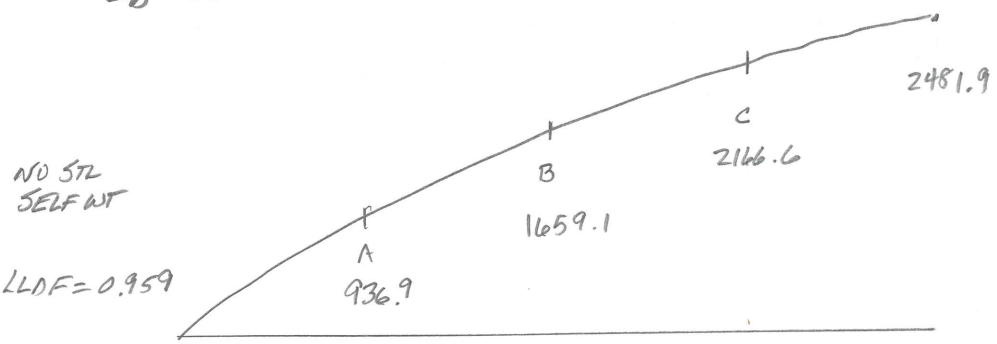
FOR C_b USE $g = 0.959$ MAX RIGID; INT. LEVER TWO OR MORE

Date: Class: Assignment:

LTB C_b FACTORS USES AASHTO 10TH EDITION

$$C_b = \frac{12.5M_{MAX}}{2.5M_{MAX} + 3M_A + 4M_B + 3M_A}$$

1ST UNBRACED
$L_b = 20'$



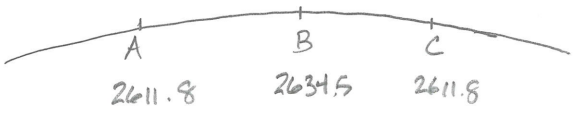
NO STL SELF WT

LLDF = 0.959

	A	B	C	
$1.25(DC_1+DC_2)$ $+1.50\,DW$	208.1	374.5	499.4	582.6
$1.75\,HL93+IM \cdot LLDF$	728.8	1284.6	1667.3	1899.3

$$C_b = \frac{12.5(2481.9)}{2.5(2481.9) + 3(936.9) + 4(1659.1) + 3(2166.6)} = 1.401$$

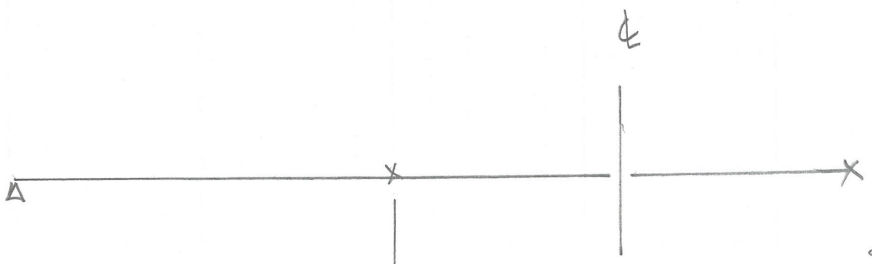
$L_b = 15'$



	A	B	C
$1.25\,(DC_1+DC_2)$ $+1.50\,DW$	617.7	629.4	617.7
$1.75\,HL93+IM \cdot LLDF$	1994.1	1992.1	1994.1

$$C_b = \frac{12.5(2634.5)}{2.5(2634.5) + 3(2611.8) + 4(2634.5) + 3(2611.8)} = 1.005$$

W 33 x 118



MOMENTS			SHEAR
DC_1 + STL + 5%	363.7	393.4	33.4
DC_2	61.3	66.2	4.8
DW	70	75.6	5.5
HL93+IM·LLDF (0.785)	1131(0.785) = 887.8	1194(0.785) = 937.3	97.1(0.901) = 87.5
C_b	1.40		1.01
FATIGUE	570.5(0.486) = 277.3		

FATIGUE CHECK AT 1st DIAPHRAM $HL93+IM^{15\%} = 570.5$

$g = 0.486$

$ADTT_{SL} > 970$

∴ INFINITE FATIGUE I

$\gamma = 1.75$

FATIGUE $M = 277.3'^k$

STIFFENER TYPE C' DETAIL

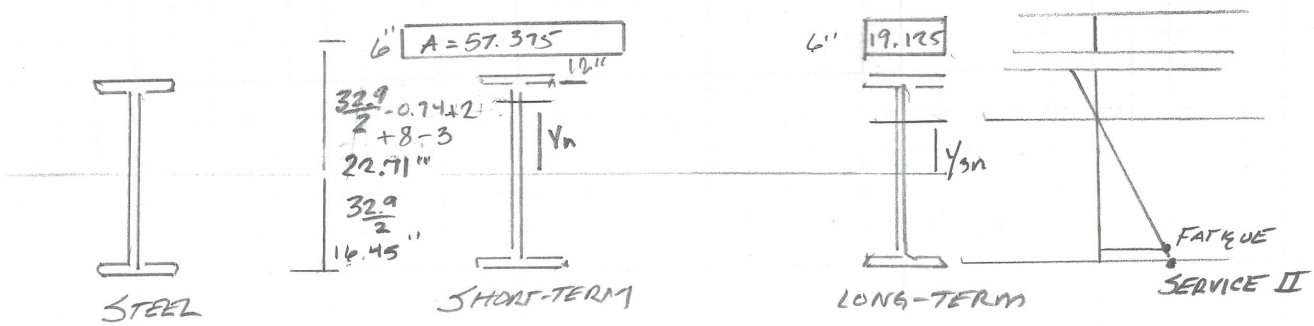
$$\Delta f = \frac{1.75M\left(\frac{d}{2} - t_f\right)}{I_n}$$

NEED TRANSFORMED SECTIONS

$b_{eff} = 76.5$
$n = 8$

$\frac{76.5}{8} = 9.5625$

$\frac{76.5}{3(8)} = 3.19$



$I_x = 5900$
$A = 34.7$
$S_x = 359$
$d = 32.9$
$t_f = 0.74"$

$\bar{Y}_n = \frac{57.375(22.71)}{34.7 + 57.375} = 14.15"$

$\bar{Y}_{3n} = \frac{19.125(22.71)}{34.7 + 57.375} = 8.07"$

$I_n = 5900 + 34.7(14.15)^2 + \frac{9.5625(6)^3}{12} + 57.375(22.71 - 14.15)^2$

$I_n = 17224\ in^4$

$I_{3n} = 5900 + 34.7(8.07)^2 + \frac{3.19(6)^3}{12} + 19.125(22.71 - 8.07)^2$

$I_{3n} = 12316\ in^4$

$S_n = \frac{17224}{16.45 + 14.15} = 562.9\ in^3$

$S_{3n} = \frac{12316}{16.45 + 8.07} = 502.3\ in^3$

FOR FATIGUE,

$$\Delta f = \frac{1.75(277.3 \times 12)(16.45 + 14.15 - 0.74)}{17224} = 10.1\ ksi$$

FOR FATIGUE I $\Delta F_{TH} = 12 ksi$ $pr = \frac{10.1}{12} = 0.84$

FATIGUE O.K.

NEED Q FOR STUD DESIGN SHORT TERM

$Q = 57.375(22.71 - 14.15) = 491.1\ in^3$

Date: Class: Assignment:

DEFLECTION CHECK

$$\text{LIVE LOAD } \Delta \pm \frac{L}{800} = 0.825"$$

BEST FIT POLYNOMIAL FOR Δ OF TWO LANE * NUMBER GIR * I_x

$$C = 2.8\times10^{-6}L^5 - 0.00094L^4 + 0.3585L^3 - 7.0859L^2 + 46.369L$$

$$C = 33568$$

MPF	
ONE	1.2
TWO	1.0
THREE	0.85
FOUR	0.65

$$\Delta = \frac{MPF * C\left(\frac{1}{2}\right)}{(\text{NUMBGIR})I_n} = \frac{0.65(33568)\left(\frac{4}{2}\right)}{7(17224)} = 0.362"$$

$$pr = \frac{0.362}{0.825} = 0.44$$

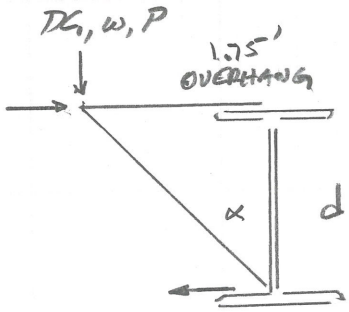
DEFLECTION O.K.

Date: Class: Assignment:

CONSTRUCTION USE 1.25DC + 1.50 CONSTR. LOADING

FLANGE LATERAL BENDING

DC, USE ½ OF OVERHANG



DC_1 $\left[\frac{8\frac{1}{2}}{12}(150)+15\right]\frac{1.75}{2} = 0.106^{k}/_{ft}$

w $0.275^{k}/_{ft}$

$$M_\ell = \frac{(1.25DC_1 + 1.50w)\tan\alpha\, L_b^2}{12} + \frac{1.50P\tan\alpha\, L_b}{8}$$

$$\tan\alpha = \frac{\text{OVERHANG}}{d}$$

$$S_{x_{fl}} = \frac{b_f^2 t_f}{6} = 16.31 in^3$$

$$\tan\alpha = \frac{21}{32.9}$$

FOR $L_b = 20'$ $\frac{[1.25(0.106)+1.5(0.275)]\left(\frac{21}{32.9}\right)(20)^2}{12}$

$+ \frac{1.50(3)\left(\frac{21}{32.9}\right)20}{8} = 18.78^{'k}$

$$f_{\ell_1} = \frac{18.78(12)}{16.31} = 13.81 ksi$$

FOR $L_b = 15'$ $\frac{[1.25(0.106)+1.5(0.275)]\left(\frac{21}{32.9}\right)(15)^2}{12}$

$+ \frac{1.50(3)\left(\frac{21}{32.9}\right)15}{8} = 11.91^{'k}$

$$f_{\ell_1} = \frac{11.91(12)}{16.31} = 8.76 ksi$$

STRONG AXIS BENDING W/ ADD'L CONSTR
1.25 DC, +1.50 CONSTRUCTION

FOR $L_b = 20$ $1.25(363.7)+1.50(134.4) = 656.2$ $f_{bu} = \frac{M}{S_x} = \frac{656.2(12)}{359} = 21.94 ksi$

FOR $L_b = 15'$ $1.25(393.4)+1.50(145.2) = 709.6$ $f_{bu} = \frac{M}{S_x} = \frac{709.6(12)}{359} = 23.72 ksi$

Date: Class: Assignment:

2nd ORDER (P-δ) LATERAL FLANGE AMPLIFICATION FACTOR

$$AF = \frac{0.85}{1 - \frac{f_{bu}}{\frac{C_b \pi^2 E}{(L_b/r_t)^2}}}$$

THEN $f_l = AF\, f_{l1}$

$r_t = r_{ts} = 2.89"$

FOR $L_b = 20$ $C_b = 1.40$ $f_{bu} = 21.94$ ksi

$$AF = \frac{0.85}{1 - \frac{21.94}{\left(\frac{1.40\pi^2 29000}{\left(\frac{20\times12}{2.89}\right)^2}\right)}} = 1.365$$

$f_l = 1.365(13.81) = 18.86$ ksi

$f_l < 0.6F_y$

FOR $L_b = 15$ $C_b = 1.01$ $f_{bu} = 23.72$

$$AF = \frac{0.85}{1 - \frac{23.72}{\left(\frac{1.01\pi^2 29000}{\left(\frac{15\times12}{2.89}\right)^2}\right)}} = 1.247$$

$f_l = 1.247(8.76) = 10.92$ ksi

$f_l < 0.6F_y$

FLANGE YIELDING DESIGN CHECK $f_{bu} + f_l < F_y$

FOR $L_b = 20'$ $21.94 + 18.86 = 40.8$ $DR = \frac{40.8}{50} = 0.816$

FOR $L_b = 15'$ $23.72 + 10.92 = 34.64$ $DR = \frac{34.64}{50} = 0.693$

Date: Class: Assignment:

LTB FLANGE BENDING $f_{bu} + \frac{1}{3} f_l \le F_{nc}$ $F_{nc} = \frac{M_{nc}}{S_x}$

W33x118

M_{nc} FOR LTB

A6.2

$$\lambda_w = \frac{2D_{cp}}{t_w} = \frac{2\left(\frac{32.9}{2} - 0.74\right)}{0.55} = 57.1 < \lambda_{pw} = \frac{\sqrt{\frac{E}{F_y}}}{\left(0.54\frac{M_p}{M_y} - 0.09\right)^2}$$

$$= \frac{\sqrt{\frac{29000}{50}}}{\left(0.54\frac{50 \cdot 415}{50 \cdot 359} - 0.09\right)^2} = 84.4$$

$$\therefore R_{PC} = \frac{M_p}{M_y} = \frac{415}{359} = 1.156$$

$$\le \lambda_{rw}\left(\frac{D_{cp}}{D_c}\right) = 5.7\sqrt{\frac{E}{F_y}} = 137$$

A6.6.3 AASHTO 10th EDITION

$$L_p = 1.1 r_t \sqrt{\frac{E}{F_y}} = 1.1(2.84)\sqrt{\frac{29000}{50}} = 76.56'' = 6.38 ft$$

$F_{yr} = 0.7F_y = 35$

$$L_r = 1.95 r_t \frac{E}{F_{yr}} \sqrt{\frac{J}{S_x h}} \sqrt{1 + \sqrt{1 + 6.76\left(\frac{F_{yr}}{E}\frac{S_x h}{J}\right)^2}}$$

$$= 1.95(2.84)\frac{29000}{35}\sqrt{\frac{5.3}{359(32.2)}}\sqrt{1 + \sqrt{1 + 6.76\left(\frac{35}{29000}\frac{359}{5.3}\frac{32.2}{}\right)^2}} = 281.3'' = 23.44 ft$$

FOR $L_b = 20' < L_r$ $C_b = 1.40$

$M_y = 359(50)\frac{1}{12} = 1495.8^{1k}$

$M_p = 415(50)\frac{1}{12} = 1729.2^{1k}$

$$M_{nc} = C_b\left[1 - \left(1 - \frac{F_{yr} S_x}{R_{pc} M_y}\right)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] R_{pc} M_y = 1.40\left[1 - \left(1 - \frac{0.7}{1.156}\right)\left(\frac{20 - 6.38}{23.44 - 6.38}\right)\right] 1.156 S_x F_y$$

$$M_{nc} = 1.40\,(0.685)\,1.156\,M_y = 1.108\,M_y < 1658.2^{1k} < M_p$$

$$F_{nc} = \frac{1658.2(12)}{359} = 55.43 ksi$$

$f_{bu} + \frac{1}{3} f_l = 21.94 + \frac{18.86}{3} = 28.2 < F_{nc}$ $\quad pr = \frac{28.2}{55.43} = 0.51$

For $L_b = 15'$ $C_b = 1.01$

$$M_{nc} = 1.01 \left[1 - \left(1 - \frac{0.7}{1.156} \right) \left(\frac{15 - 6.38}{23.44 - 6.38} \right) \right] 1.156 (1495.8)$$

$M_{nc} = 1.01(0.801)1.156(1495.8) = 0.935 M_y = 1398.3^{1k}$

$$F_{nc} = \frac{1398.3(12)}{359} = 46.74 \text{ ksi}$$

$f_{bu} + \frac{1}{3} f_l = 23.72 + \frac{10.92}{3} = 27.36$ $\quad pr = \frac{27.36}{46.74} = 0.585$

CONSTRUCTION O.K.

SERVICE II AT ℄ $DC_1+DC_2+DW+1.30\,HL93+IM\cdot LLDF$

$S_x = 359$ $S_{3n} = 502.3$ $S_n = 562.9$

STRESSES LIMITED TO $0.95F_y$

$DC_1 = 393.4$

$DC_2 = 66.2$

$DW = 75.6$

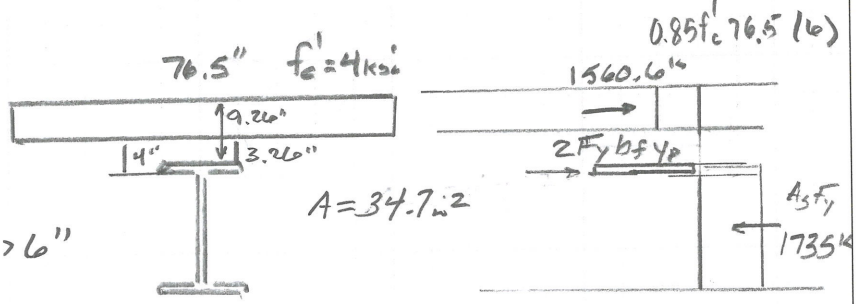
$HL93_{MV+LLDF} = 937.3$

$$f = \frac{393.4(12)}{359} + \frac{(66.2+75.76)(12)}{502.3} + 1.30\frac{(937.3)(12)}{562.9} = 42.52\ ksi \le 0.95F_y$$

$$pr = \frac{42.52}{0.95(50)} = 0.895$$

STRENGTH I CHECK COMPOSITE - ONLY CHECK ℄

FIND M_p



$$a = \frac{34.7(50)}{0.85(4)\,76.5} = 6.67 > 6"$$

PNA IN STEEL

$$1560.6 + 2(50)(11.5)y_p = 1735 \qquad y_p = 0.152" < t_f$$

PNA IN TOP FLANGE

$2F_y b_f y_p = 174.4$

$$M_p = 1560.6(9.26-3) + 1735\left(\frac{32.9}{2}\right) - 174.4\left(\frac{0.152}{2}\right) = 38297"k = 3191.4'k$$

$D_p = 9.26 + 0.152 = 9.412$ $\quad D_t = 9.26 + 32.9 = 42.16$

$\frac{D_p}{D_t} = \frac{9.412}{42.16} = 0.223 > 0.1$ $\quad M_n < M_p$ $\quad > 0.42$ DUCTILITY O.K.

$$M_n = M_p\left(1.07 - 0.7\frac{D_p}{D_t}\right) = 3191.4\left(1.07 - 0.7\frac{9.412}{42.16}\right) = 0.914\,M_p$$

$$M_n = 2916.1'k$$

$$1.25DC_1 + 1.25DC_2 + 1.50DW + 1.75\,HL93+IM \cdot LLDF \le M_n$$

$$1.25(393.4) + 1.25(66.2) + 1.50(75.6) + 1.75(937.3) = 2328.2'k < M_p$$

$$pr = \frac{2328.2}{2916} = 0.798$$

STRENGTH I O.K.

SHEAR $V_u = 1.25DC_1 + 1.25DC_2 + 1.50DW + 1.75(HL93+IM \cdot LLDF)$

$1.25(28.8) + 1.25(4.8) + 1.50(5.5) + 1.75(87.5) = 203.4^k$

$V_n = CV_p$

$\frac{D}{t_w} = \frac{32.9 - 2(0.74)}{0.55} = 57.1$ $\quad V_p = 0.58 D t_w F_y$

$V_p = 0.58(32.9 - 2(0.741))0.55(50) = 501.1^k$

IF $\frac{D}{t_w} < 1.12\sqrt{\frac{Ek}{F_y}}$ $\quad k=5$

$= 1.12\sqrt{\frac{29000(5)}{50}} = 60.3$ $\quad C = 1$

$\phi V_n = 501.1 > V_u = 203.4$

$pr = \frac{203.4}{501.1} = 0.406$

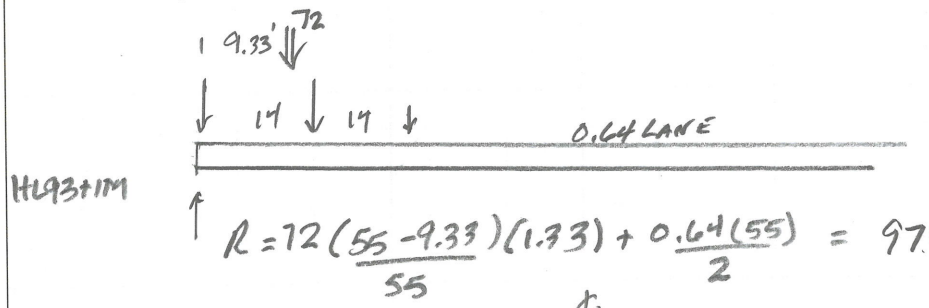
Date: Class: Assignment:

Summary - All Match Program

Strength I	pr = 0.80
Service II	pr = 0.90
Construction	pr = 0.82
Fatigue I	pr = 0.84 at Stiffener
Deflection	pr = 0.44 L/1821
Shear	pr = 0.41 Support

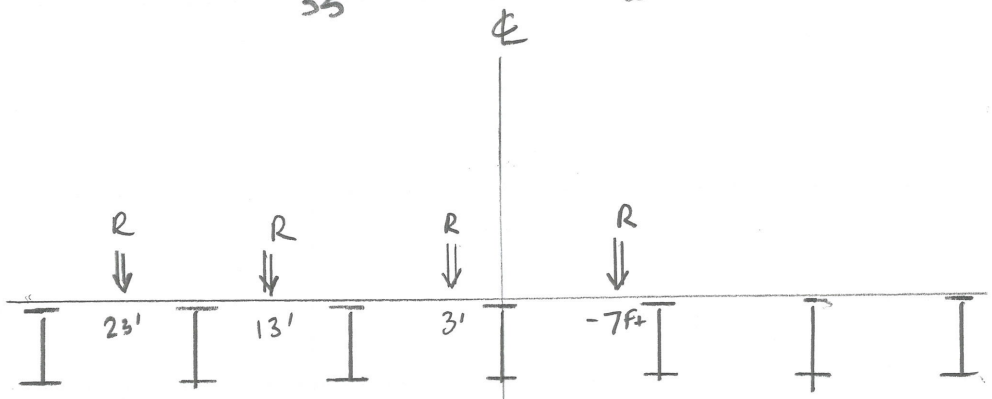
Date: Class: Assignment:

ABUTMENT LOADS



$$R = 72\left(\frac{55-9.33}{55}\right)(1.33) + \frac{0.64(55)}{2} = 97.1^{k}$$

MPF	
ONE	1.2
TWO	1.0
THREE	0.85
FOUR	0.65



SINGLE LANE $HL93+IM = 97.1(1.2) = 116.5^{k}$ @ 23'

TWO LANE $HL93+IM = 2(97.1)1 = 194.2^{k}$ @ $\frac{23+13}{2} = 18'$

THREE LANE $HL93+IM = 3(97.1)0.85 = 247.6^{k}$ @ $\frac{23+13+3}{3} = 13'$

FOUR LANE $HL93+IM = 4(97.1)0.65 = 252.5^{k}$ @ $\frac{23+13+3-7}{4} = 8'$

$$DC_1 = \left[108.75(54) + 7(133)(1.05)\right]\frac{55}{2} = 203.3$$

$$DC_2 = \left[2(250) + 50\right]\frac{55}{2} = 15.1^{k}$$

$$DW = \left[25(56)\right]\frac{55}{2} = 38.5^{k}$$

W33X118 Composite

Consider W40 & W44 Beams? No
L/D Limited to 30
Minimum Depth Beam W12
Maximum Depth Beam W36

Yield Strength (ksi)	50		
Bridge Length (ft)	55	Bridge Width (ft)	59.00
Girder Spacing (ft)	9.25	Roadway Width (ft)	56.00
Number of Girders	7	Shoulders (ft) each side - Double for One Sided	4.00
Overhang (18.9% of Girder Spacing) (ft)	1.75	4 Striped Lanes and 4 Design Lanes	
Barrier Width (ft)	1.5		
Barrier Load on Girder (lb/ft)	125	8 in Structural Deck with 2 in SIP Forms	
DC Deck Only Loading (psf)	106.25	Deck f'c (psi)	4000
Wearing Surface (psf)	25	Haunch from Top of Web (in)	2
Additional DC1 Load on Girder (lb/ft)	0	Nominal Girder DC1 (lb/ft)	865.5
Additional DC2 Load on Bridge (lb/ft)	50	Nominal Girder DC2 (lb/ft)	175.0
		Nominal Girder DW (lb/ft)	200.0
AT OVERHANG FOR LATERAL FLANGE BENDING	0		
Construction w (lb/ft)	275	AASHTO HL93 Loading and	
Construction p (lb)	3000	No User Defined Vehicle	
1/2 of Deck Overhang Weight (lb/ft)	95.15625		
ADDITIONAL VERTICAL BENDING ON GIRDERS			
Exterior - Construction p (lb)	3000		
Exterior - Construction w (lb/ft)	275		
% Misc Stl for Diaphrams, etc	5%		
DEFLECTION LIMIT (x for Deflection Limit in L/x)	800		
Fatigue Design Life (yrs)	75		151463.75
Fatigue ADTTSL	1200	Fatigue I Controls	

Lateral Distribution Factors
Single Lane/Multi-Lane
Moment LLDF = 0.584 , 0.785
Fatigue LLDF = 0.486
Shear LLDF = 0.730 , 0.901

SERVICE II near Centerline

DC1 (ft-k)	327.3	Sx=359.0 in^3
DC2 (ft-k)	66.2	S3n=502.0 in^3
DW (ft-k)	75.6	S3n=502.0 in^3
HL93 LL+IM (ft-k) LLF = 1.75	937.0	Sn=562.6 in^3
Serv II Stress	42.5	
Serv II Allow	47.5	

LIVE LOAD DEFLECTION In=17199.7 in^4

LL Defl (in)	0.36	= L/1821
Allowable (in)	0.825	=L/800

FATIGUE Cat C' at Critical Brace

Fat Moment (ft-k) LLF = 1.75	277.5	Sfat=576.6 in^3
Fat Stress (ksi)	10.11	
Fat Allow (ksi)	12.00	

STRENGTH I/II SHEAR at Support

DC1 (k)	28.6
DC2 (k)	4.8
DW (k)	5.5
HL93 LL+IM (k) LLF = 1.75	87.5
Vu (k)	203.2
Vn (k)	501.1

STRENGTH I/II Compression Flange Laterally Braced for Final LLF = 1.75

	Lb (ft)	DC1 (ft-k)	DC2 (ft-k)	DW (ft-k)	HL93 LL+IM (ft-k)	Mu (ft-k)	Cb	Mn (ft-k)	Perf Ratio
1	20	364.2	61.25	70.0	887.5	2189.9	1.40	2892.2	0.757
2	15	393.4	66.171875	75.6	937.0	2327.6	1.01	2892.2	0.805
3	20	364.2	61.25	70.0	887.8	2190.4	1.40	2892.2	0.757

Strength Design Uses AASHTO Appendix A6 **CONSTRUCTION** <0.60Fy RpcFy=1.16*50

	Lb (ft)	Mconstr (ft-k)	Mlat (ft-k)	AF	Affl (ksi)	Perf Ratio	fbu+Affl (ksi)	Perf Ratio	fbu+1/3Affl (ksi	Fnc (ksi)	Perf Ratio
1	20	656.9	18.5	1.4	18.6	0.62	40.5	0.81	28.2	55.5	0.51
2	15	709.7	11.7	1.2	10.8	0.36	34.5	0.69	27.3	46.5	0.59
3	20	656.9	18.5	1.4	18.6	0.62	40.5	0.81	28.1	55.5	0.51

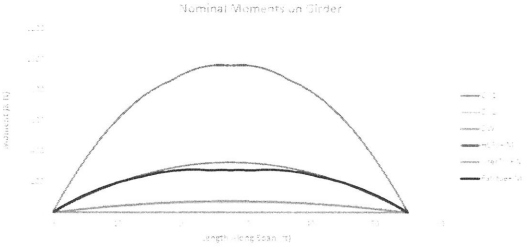
DEAD LOAD DEFLECTIONS (Max Loaded Girder)

Ix (in^4) = 5900.0
I3n (in^4) = 12293.3
I3n (in^4) = 12293.3

	0	0.10L	0.20L	0.30L	0.40L	0.50L	0.60L	0.70L	0.80L	0.90L	L
Distance (ft)	0	5.5	11	16.5	22	27.5	33	38.5	44	49.5	55
DC1 (in)	0.000	0.327	0.619	0.847	0.992	1.041	0.992	0.847	0.619	0.327	0.000
DC2 (in)	0.000	0.032	0.060	0.082	0.096	0.101	0.096	0.082	0.060	0.032	0.000
DW (in)	0.000	0.036	0.069	0.094	0.110	0.116	0.110	0.094	0.069	0.036	0.000
Total (in)	0.00	0.39	0.75	1.02	1.20	1.26	1.20	1.02	0.75	0.39	0.00

NOMINAL ABUTMENT REACTIONS

DC1 (k)	207.2	At Centerline
DC2 (k)	15.1	At Centerline
DW (k)	38.5	At Centerline
Single Lane LL+IM (k)	116.5	At 23.00 From Centerline
Two Lane LL+IM (k)	194.2	At 18.00 From Centerline
Three Lane LL+IM (k)	247.6	At 13.00 From Centerline
Four Lane LL+IM (k)	252.5	At 8.00 From Centerline



Date: Class: Assignment:

SHEAR STUD DESIGN 10th EDITION

USE FATIGUE TRUCK SINGLE LANE IM = 15%

SHEAR LLDF SINGLE = $\frac{0.73}{1.2} = 0.608$

STRENGTH DESIGN

$Q_r = \phi Q_n$ $\phi = 1$

$Q_n = 0.70 A_{sc} F_u = 0.7\pi\left(\frac{7/8}{4}\right)^2 60 = 25.25^k/\text{STD}$

$n = \frac{P}{Q_r}$ $P = 0.85 f_c' b_{eff} t_s = 1560.6^k$

PNA IN STL

$n = \frac{1560.2}{25.25'} = 61.8^k / \frac{1}{2}\text{ SPAN}$

TOTAL STUDS = 124 STUDS

FATIGUE $ADTT_{SL} = 1000 <$ 75 yr LIMIT OF 11320

FINITE LIFE $(\Delta F)_n = \left(\frac{A}{N}\right)^{1/m} = \left(\frac{1040\times10^8}{N}\right)^{1/5}$

$N = 365(75)(1)(1200) = 3.29\times10^7$

$\gamma_{LL} = 0.80$ $(\Delta F)_n = 5.01$ $Z_r = A_{sc}(\Delta F)_n = 3.614^k/\text{STD}$

$p \le \frac{n Z_r}{V_{sr}}$ $V_{sr} = \frac{V_f Q}{I} = V_f \frac{491.1}{17224} = 0.0285 V_f$

$p \le \frac{n(3.014)}{0.0285 V_f} = \frac{105.8 n}{V_f}$

$V_f = 0.80(0.608)\Delta V$ CHECK FOR $n = 1, 2, 3$

$p \le \frac{217.9}{\Delta V} = \frac{132.5}{0.608\Delta V}$ — TABLES NEXT PG

LLDFΔV

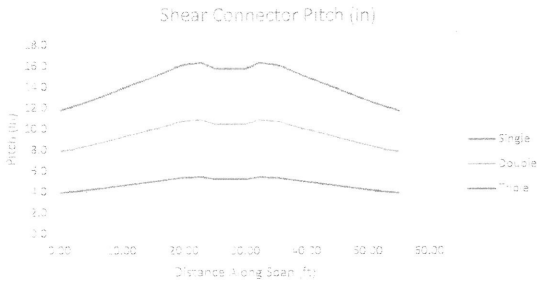
Shear Range	Location	Vsr	pitch n=1	pitch n=2	pitch n=3
33.68	0.00	0.77	3.9	7.8	11.8
33.51	0.34	0.76	3.9	7.9	11.8
33.33	0.69	0.76	4.0	7.9	11.9
33.16	1.03	0.76	4.0	8.0	12.0
32.98	1.38	0.75	4.0	8.0	12.0
32.81	1.72	0.75	4.0	8.1	12.1
32.63	2.06	0.74	4.1	8.1	12.2
32.46	2.41	0.74	4.1	8.1	12.2
32.28	2.75	0.74	4.1	8.2	12.3
32.11	3.09	0.73	4.1	8.2	12.3
31.93	3.44	0.73	4.1	8.3	12.4
31.76	3.78	0.72	4.2	8.3	12.5
31.58	4.13	0.72	4.2	8.4	12.6
31.41	4.47	0.72	4.2	8.4	12.6
31.23	4.81	0.71	4.2	8.5	12.7
31.06	5.16	0.71	4.3	8.5	12.8
30.88	5.50	0.70	4.3	8.6	12.8
30.71	5.84	0.70	4.3	8.6	12.9
30.53	6.19	0.70	4.3	8.7	13.0
30.36	6.53	0.69	4.4	8.7	13.1
30.18	6.88	0.69	4.4	8.8	13.1
30.01	7.22	0.68	4.4	8.8	13.2
29.83	7.56	0.68	4.4	8.9	13.3
29.66	7.91	0.68	4.5	8.9	13.4
29.48	8.25	0.67	4.5	9.0	13.4
29.31	8.59	0.67	4.5	9.0	13.5
29.13	8.94	0.66	4.5	9.1	13.6
28.96	9.28	0.66	4.6	9.1	13.7
28.78	9.63	0.66	4.6	9.2	13.8
28.61	9.97	0.65	4.6	9.2	13.9
28.43	10.31	0.65	4.6	9.3	13.9
28.26	10.66	0.64	4.7	9.4	14.0
28.09	11.00	0.64	4.7	9.4	14.1
27.95	11.34	0.64	4.7	9.5	14.2
27.81	11.69	0.63	4.8	9.5	14.3
27.67	12.03	0.63	4.8	9.6	14.3
27.53	12.38	0.63	4.8	9.6	14.4
27.39	12.72	0.62	4.8	9.7	14.5
27.25	13.06	0.62	4.9	9.7	14.6
27.11	13.41	0.62	4.9	9.8	14.6
26.97	13.75	0.62	4.9	9.8	14.7
26.83	14.09	0.61	4.9	9.9	14.8
26.69	14.44	0.61	5.0	9.9	14.9
26.55	14.78	0.61	5.0	10.0	14.9
26.41	15.13	0.60	5.0	10.0	15.0
26.27	15.47	0.60	5.0	10.1	15.1
26.13	15.81	0.60	5.1	10.1	15.2
25.99	16.16	0.59	5.1	10.2	15.3
25.85	16.50	0.59	5.1	10.2	15.3
25.71	16.84	0.59	5.1	10.3	15.4
25.57	17.19	0.58	5.2	10.3	15.5
25.43	17.53	0.58	5.2	10.4	15.6
25.29	17.88	0.58	5.2	10.5	15.7
25.15	18.22	0.57	5.3	10.5	15.8
25.01	18.56	0.57	5.3	10.6	15.9
24.87	18.91	0.57	5.3	10.6	15.9
24.73	19.25	0.56	5.3	10.7	16.0
24.59	19.59	0.56	5.4	10.8	16.1
24.53	19.94	0.56	5.4	10.8	16.2
24.49	20.28	0.56	5.4	10.8	16.2
24.46	20.63	0.56	5.4	10.8	16.2
24.42	20.97	0.56	5.4	10.8	16.2
24.39	21.31	0.56	5.4	10.8	16.3
24.36	21.66	0.56	5.4	10.9	16.3
24.32	22.00	0.55	5.4	10.9	16.3
24.29	22.34	0.55	5.4	10.9	16.3
24.25	22.69	0.55	5.5	10.9	16.4
24.33	23.03	0.55	5.4	10.9	16.3
24.47	23.38	0.56	5.4	10.8	16.2
24.61	23.72	0.56	5.4	10.7	16.1
24.75	24.06	0.56	5.3	10.7	16.0
24.89	24.41	0.57	5.3	10.6	15.9
25.03	24.75	0.57	5.3	10.6	15.8
25.13	25.09	0.57	5.3	10.5	15.8
25.13	25.44	0.57	5.3	10.5	15.8
25.13	25.78	0.57	5.3	10.5	15.8
25.13	26.13	0.57	5.3	10.5	15.8
25.13	26.47	0.57	5.3	10.5	15.8
25.13	26.81	0.57	5.3	10.5	15.8
25.13	27.16	0.57	5.3	10.5	15.8
25.13	27.50	0.57	5.3	10.5	15.8

7 1/2

9 1/2

10 1/2

℄ BRIDGE



TRANSVERSE MIN = 4d = 3.5"

LONGITUDINAL MIN = 4d = 3.5"

CLEAR = 1" b_f = 11½"

CAN DO UP TO n=3

CAN USE 1, 2 or 3

Pmin = ~~3.94"~~ 7.8" 11.8"

BREAK SPAN INTO 1/5 (20%)

USING DOUBLES

11 ft 7½"

22 ft 9½"

33 ft 10½"

44 ft 9½"

55 ft 7½"

≈ 152 TOTAL STUDS

ONLY IF COMPOSITE

0.875 (in) SHEAR STUDE SPACING	Minimum Spacing (in) 3.5				Maximum Spacing (in) 48
	0 - 11.0 ft	11.0 - 22.0 ft	22.0 - 33.0 ft	33.0 - 44.0 ft	44.0 - 55.0 ft
Singles Pitch (in)	3.92	4.71	5.26	4.71	3.92
Doubles Pitch (in)	7.85	9.41	10.52	9.41	7.85
Triples Pitch (in)	11.77	14.12	15.78	14.12	11.77

Minimum Transverse Spacing (in) 3.5

d (in) 32.9
bf (in) = 11.5

Doubles Transverse Spacing OK
Triples Transverse Spacing OK

Strength Minimum Number of Studs	124
Fatigue Singles Estimated Number of Studs	149.4810147
Fatigue Doubles Estimated Number of Studs	150.4810147
Fatigue Triples Estimated Number of Studs	151.4810147