Steel Beam Analysis

2/11/20

Given:

W-section	W10X33
Fy	50KSI
Span A	19ft
Span B	10ft
Floor DL	16 PSF

① $Z_x = \boxed{38.8}$ ← Table 1-1, Pg 1-26

② $M_n = F_y(Z_x) = \underset{\text{given}}{50} \times \underset{\text{Ans}}{38.8} = \boxed{1940 \text{ K-IN}}$

③ $\phi M_n = 0.9(M_n) = 0.9 \times 1940 = \boxed{1746 \text{ K-IN}}$

④ $M_u = \frac{\phi M_n}{12} = \frac{1746}{12} = \boxed{145.5 \text{ K-FT}}$

convert to feet

⑤ $w_u = \frac{8M_u}{l^2}$ (comes from $M_u = \frac{wl^2}{8}$)

$w_u = \frac{8 \times 145.5}{(19)^2} = \boxed{3.224 \text{ KLF}}$

use longer span

⑥ factored dead load on beam, w_u → (nominal wt. of beam from table 1-1)

given floor DL = 16 PSF

Span B

$w_{DL} = \frac{\text{beam self wt} + \text{dead load}}{1000} = \frac{33 + (16 \times 10')}{1000}$

$= \boxed{0.193 \text{ KLF}}$

(F) $w_u DL = 1.2 \times w_{DL} = 1.2 \times 1.93 = \boxed{.2316 \text{ KLF}}$

(8) $w_u\text{-}LL = w_u - w_u DL = 3.224 - .2316$

Ans 5 Ans 7

$\boxed{= 2.99}$

(9) $w\text{-}LL = \dfrac{w_u LL}{1.6}$ ← Ans 8 $= \dfrac{2.99}{1.6} = \boxed{1.868}$

(10) $LL = \dfrac{w_{LL}}{\text{Span B}} = \dfrac{1.868 \times 1000}{10'}$ ← Converting to lbs

$= \boxed{186.8 \text{ psf}}$

(11) $V_{u\,max} = \dfrac{w_u l}{2} = \dfrac{3.224 \times 19}{2} = \boxed{30.628 \text{ K}}$

Ans 5 ↘ ↙ long span

(12) Web Area $A_w = d \times t_w = 9.73 \times 0.29 = \boxed{2.82 \text{ in}^2}$

(table 1-1, pg 1-26)

(13) phi $V_n = 0.6 f_y A_w = 0.6 \times 50 \times 2.82 = \boxed{84.6 \text{ K}}$

(14) $V_u < V_n$ $30.628 < 84.6$ ✓ yes

(1728 = 12^3 converting to inches)

(15) $\Delta = \dfrac{5wL^4}{384EI} = \dfrac{5(w\text{-}DL + w\text{-}LL) \times (\text{span A})^4 \times 1728}{384 \times 29{,}000 \times 171}$

$= \dfrac{5(0.193 + 1.868) \times 194 \times 1728}{384 \times 29000 \times 171} = \boxed{1.218 \text{ in}}$

(16) $l/180 = \dfrac{19 \times 12}{180} = \boxed{1.266 \text{ in}}$

(17) $1.218 < 1.266$ ✓ Yes

E for steel is always 29000. Look at beam equations.pdf, pg-2

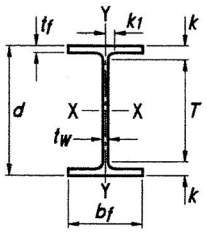
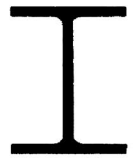


Table 1-1 (continued)
W-Shapes
Dimensions

Shape	Area, A	Depth, d		Web Thickness, t_w		$\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		Distance k: k_{des}	Distance k: k_{det}	Distance k_1	Distance T	Workable Gage
	in.^{2}	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W12×58	17.0	12.2	12 1/4	0.360	3/8	3/16	10.0	10	0.640	5/8	1.24	1 1/2	15/16	9 1/4	5 1/2
×53	15.6	12.1	12	0.345	3/8	3/16	10.0	10	0.575	9/16	1.18	1 3/8	15/16	9 1/4	5 1/2
W12×50	14.6	12.2	12 1/4	0.370	3/8	3/16	8.08	8 1/8	0.640	5/8	1.14	1 1/2	15/16	9 1/4	5 1/2
×45	13.1	12.1	12	0.335	5/16	3/16	8.05	8	0.575	9/16	1.08	1 3/8	15/16	↓	↓
×40	11.7	11.9	12	0.295	5/16	3/16	8.01	8	0.515	1/2	1.02	1 3/8	7/8	↓	↓
W12×35[c]	10.3	12.5	12 1/2	0.300	5/16	3/16	6.56	6 1/2	0.520	1/2	0.820	1 3/16	3/4	10 1/8	3 1/2
×30[c]	8.79	12.3	12 3/8	0.260	1/4	1/8	6.52	6 1/2	0.440	7/16	0.740	1 1/8	3/4	↓	↓
×26[c]	7.65	12.2	12 1/4	0.230	1/4	1/8	6.49	6 1/2	0.380	3/8	0.680	1 1/16	3/4	↓	↓
W12×22[c]	6.48	12.3	12 1/4	0.260	1/4	1/8	4.03	4	0.425	7/16	0.725	15/16	5/8	10 3/8	2 1/4[g]
×19[c]	5.57	12.2	12 1/8	0.235	1/4	1/8	4.01	4	0.350	3/8	0.650	7/8	9/16	↓	↓
×16[c]	4.71	12.0	12	0.220	1/4	1/8	3.99	4	0.265	1/4	0.565	13/16	9/16	↓	↓
×14[c,v]	4.16	11.9	11 7/8	0.200	3/16	1/8	3.97	4	0.225	1/4	0.525	3/4	9/16	↓	↓
W10×112	32.9	11.4	11 3/8	0.755	3/4	3/8	10.4	10 3/8	1.25	1 1/4	1.75	1 15/16	1	7 1/2	5 1/2
×100	29.3	11.1	11 1/8	0.680	11/16	3/8	10.3	10 3/8	1.12	1 1/8	1.62	1 13/16	1	↓	↓
×88	26.0	10.8	10 7/8	0.605	5/8	5/16	10.3	10 1/4	0.990	1	1.49	1 11/16	15/16	↓	↓
×77	22.7	10.6	10 5/8	0.530	1/2	1/4	10.2	10 1/4	0.870	7/8	1.37	1 9/16	7/8	↓	↓
×68	19.9	10.4	10 3/8	0.470	1/2	1/4	10.1	10 1/8	0.770	3/4	1.27	1 7/16	7/8	↓	↓
×60	17.7	10.2	10 1/4	0.420	7/16	1/4	10.1	10 1/8	0.680	11/16	1.18	1 3/8	13/16	↓	↓
×54	15.8	10.1	10 1/8	0.370	3/8	3/16	10.0	10	0.615	5/8	1.12	1 5/16	13/16	↓	↓
×49	14.4	10.0	10	0.340	5/16	3/16	10.0	10	0.560	9/16	1.06	1 1/4	13/16	↓	↓
W10×45	13.3	10.1	10 1/8	0.350	3/8	3/16	8.02	8	0.620	5/8	1.12	1 5/16	13/16	7 1/2	5 1/2
×39	11.5	9.92	9 7/8	0.315	5/16	3/16	7.99	8	0.530	1/2	1.03	1 3/16	13/16	↓	↓
×33	9.71	9.73	9 3/4	0.290	5/16	3/16	7.96	8	0.435	7/16	0.935	1 1/8	3/4	↓	↓
W10×30	8.84	10.5	10 1/2	0.300	5/16	3/16	5.81	5 3/4	0.510	1/2	0.810	1 1/8	11/16	8 1/4	2 3/4[g]
×26	7.61	10.3	10 3/8	0.260	1/4	1/8	5.77	5 3/4	0.440	7/16	0.740	1 1/16	11/16	↓	↓
×22[c]	6.49	10.2	10 1/8	0.240	1/4	1/8	5.75	5 3/4	0.360	3/8	0.660	15/16	5/8	↓	↓
W10×19	5.62	10.2	10 1/4	0.250	1/4	1/8	4.02	4	0.395	3/8	0.695	15/16	5/8	8 3/8	2 1/4[g]
×17[c]	4.99	10.1	10 1/8	0.240	1/4	1/8	4.01	4	0.330	5/16	0.630	7/8	9/16	↓	↓
×15[c]	4.41	9.99	10	0.230	1/4	1/8	4.00	4	0.270	1/4	0.570	13/16	9/16	↓	↓
×12[c,f]	3.54	9.87	9 7/8	0.190	3/16	1/8	3.96	4	0.210	3/16	0.510	3/4	9/16	↓	↓

[c] Shape is slender for compression with $F_y = 50$ ksi.
[f] Shape exceeds compact limit for flexure with $F_y = 50$ ksi.
[g] The actual size, combination and orientation of fastener components should be compared with the geometry of the cross section to ensure compatibility.
[v] Shape does not meet the h/t_w limit for shear in AISC *Specification* Section G2.1(a) with $F_y = 50$ ksi.

Table 1-1 (continued)
W-Shapes
Properties



W12-W10

Nominal Wt.	Compact Section Criteria $\frac{b_f}{2t_f}$	Compact Section Criteria $\frac{h}{t_w}$	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X Z	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y Z	r_{ts}	h_o	Torsional Properties J	Torsional Properties C_w
lb/ft			in.^{4}	in.^{3}	in.	in.^{3}	in.^{4}	in.^{3}	in.	in.^{3}	in.	in.	in.^{4}	in.^{6}
58	7.82	27.0	475	78.0	5.28	86.4	107	21.4	2.51	32.5	2.81	11.6	2.10	3570
53	8.69	28.1	425	70.6	5.23	77.9	95.8	19.2	2.48	29.1	2.79	11.5	1.58	3160
50	6.31	26.8	391	64.2	5.18	71.9	56.3	13.9	1.96	21.3	2.25	11.6	1.71	1880
45	7.00	29.6	348	57.7	5.15	64.2	50.0	12.4	1.95	19.0	2.23	11.5	1.26	1650
40	7.77	33.6	307	51.5	5.13	57.0	44.1	11.0	1.94	16.8	2.21	11.4	0.906	1440
35	6.31	36.2	285	45.6	5.25	51.2	24.5	7.47	1.54	11.5	1.79	12.0	0.741	879
30	7.41	41.8	238	38.6	5.21	43.1	20.3	6.24	1.52	9.56	1.77	11.9	0.457	720
26	8.54	47.2	204	33.4	5.17	37.2	17.3	5.34	1.51	8.17	1.75	11.8	0.300	607
22	4.74	41.8	156	25.4	4.91	29.3	4.66	2.31	0.848	3.66	1.04	11.9	0.293	164
19	5.72	46.2	130	21.3	4.82	24.7	3.76	1.88	0.822	2.98	1.02	11.9	0.180	131
16	7.53	49.4	103	17.1	4.67	20.1	2.82	1.41	0.773	2.26	0.983	11.7	0.103	96.9
14	8.82	54.3	88.6	14.9	4.62	17.4	2.36	1.19	0.753	1.90	0.961	11.7	0.0704	80.4
112	4.17	10.4	716	126	4.66	147	236	45.3	2.68	69.2	3.08	10.2	15.1	6020
100	4.62	11.6	623	112	4.60	130	207	40.0	2.65	61.0	3.04	10.0	10.9	5150
88	5.18	13.0	534	98.5	4.54	113	179	34.8	2.63	53.1	2.99	9.81	7.53	4330
77	5.86	14.8	455	85.9	4.49	97.6	154	30.1	2.60	45.9	2.95	9.73	5.11	3630
68	6.58	16.7	394	75.7	4.44	85.3	134	26.4	2.59	40.1	2.92	9.63	3.56	3100
60	7.41	18.7	341	66.7	4.39	74.6	116	23.0	2.57	35.0	2.88	9.52	2.48	2640
54	8.15	21.2	303	60.0	4.37	66.6	103	20.6	2.56	31.3	2.85	9.49	1.82	2320
49	8.93	23.1	272	54.6	4.35	60.4	93.4	18.7	2.54	28.3	2.84	9.44	1.39	2070
45	6.47	22.5	248	49.1	4.32	54.9	53.4	13.3	2.01	20.3	2.27	9.48	1.51	1200
39	7.53	25.0	209	42.1	4.27	46.8	45.0	11.3	1.98	17.2	2.24	9.39	0.976	992
33	9.15	27.1	171	35.0	4.19	38.8	36.6	9.20	1.94	14.0	2.20	9.30	0.583	791
30	5.70	29.5	170	32.4	4.38	36.6	16.7	5.75	1.37	8.84	1.60	10.0	0.622	414
26	6.56	34.0	144	27.9	4.35	31.3	14.1	4.89	1.36	7.50	1.58	9.86	0.402	345
22	7.99	36.9	118	23.2	4.27	26.0	11.4	3.97	1.33	6.10	1.55	9.84	0.239	275
19	5.09	35.4	96.3	18.8	4.14	21.6	4.29	2.14	0.874	3.35	1.06	9.81	0.233	104
17	6.08	36.9	81.9	16.2	4.05	18.7	3.56	1.78	0.845	2.80	1.04	9.77	0.156	85.1
15	7.41	38.5	68.9	13.8	3.95	16.0	2.89	1.45	0.810	2.30	1.01	9.72	0.104	68.3
12	9.43	46.6	53.8	10.9	3.90	12.6	2.18	1.10	0.785	1.74	0.983	9.66	0.0547	50.9

Notes

BEAM DIAGRAMS AND FORMULAS

Nomenclature

E = Modulus of Elasticity of steel at 29,000 ksi.
I = Moment of Inertia of beam, in.^{4}.
L = Total length of beam between reaction points ft.
M_{max} = Maximum moment, kip in.
M_1 = Maximum moment in left section of beam, kip-in.
M_2 = Maximum moment in right section of beam, kip-in.
M_3 = Maximum positive moment in beam with combined end moment conditions, kip-in.
M_x = Moment at distance x from end of beam, kip-in.
P = Concentrated load, kips
P_1 = Concentrated load nearest left reaction, kips.
P_2 = Concentrated load nearest right reaction, and of different magnitude than P_1, kips.
R = End beam reaction for any condition of symmetrical loading, kips.
R_1 = Left end beam reaction, kips.
R_2 = Right end or intermediate beam reaction, kips.
R_3 = Right end beam reaction, kips.
V = Maximum vertical shear for any condition of symmetrical loading, kips.
V_1 = Maximum vertical shear in left section of beam, kips.
V_2 = Vertical shear at right reaction point, or to left of intermediate reaction point of beam, kips.
V_3 = Vertical shear at right reaction point, or to right of intermediate reaction point of beam, kips.
V_x = Vertical shear at distance x from end of beam, kips.
W = Total load on beam, kips.
a = Measured distance along beam, in.
b = Measured distance along beam which may be greater or less than a, in.
l = Total length of beam between reaction points, in.
w = Uniformly distributed load per unit of length, kips/in.
w_1 = Uniformly distributed load per unit of length nearest left reaction, kips/in.
w_2 = Uniformly distributed load per unit of length nearest right reaction and of different magnitude than w_1, kips/in.
x = Any distance measured along beam from left reaction, in.
x_1 = Any distance measured along overhang section of beam from nearest reaction point, in.
Δ_{max} = Maximum deflection, in.
Δ_α = Deflection at point of laod, in.
Δ_x = Deflection at any point x distance from left reaction, in.
Δ_{x1} = Deflection of overhang section of beam at any distance from nearest reaction point, in.