Recitation 4

Steel beam Analysis

Homework problem

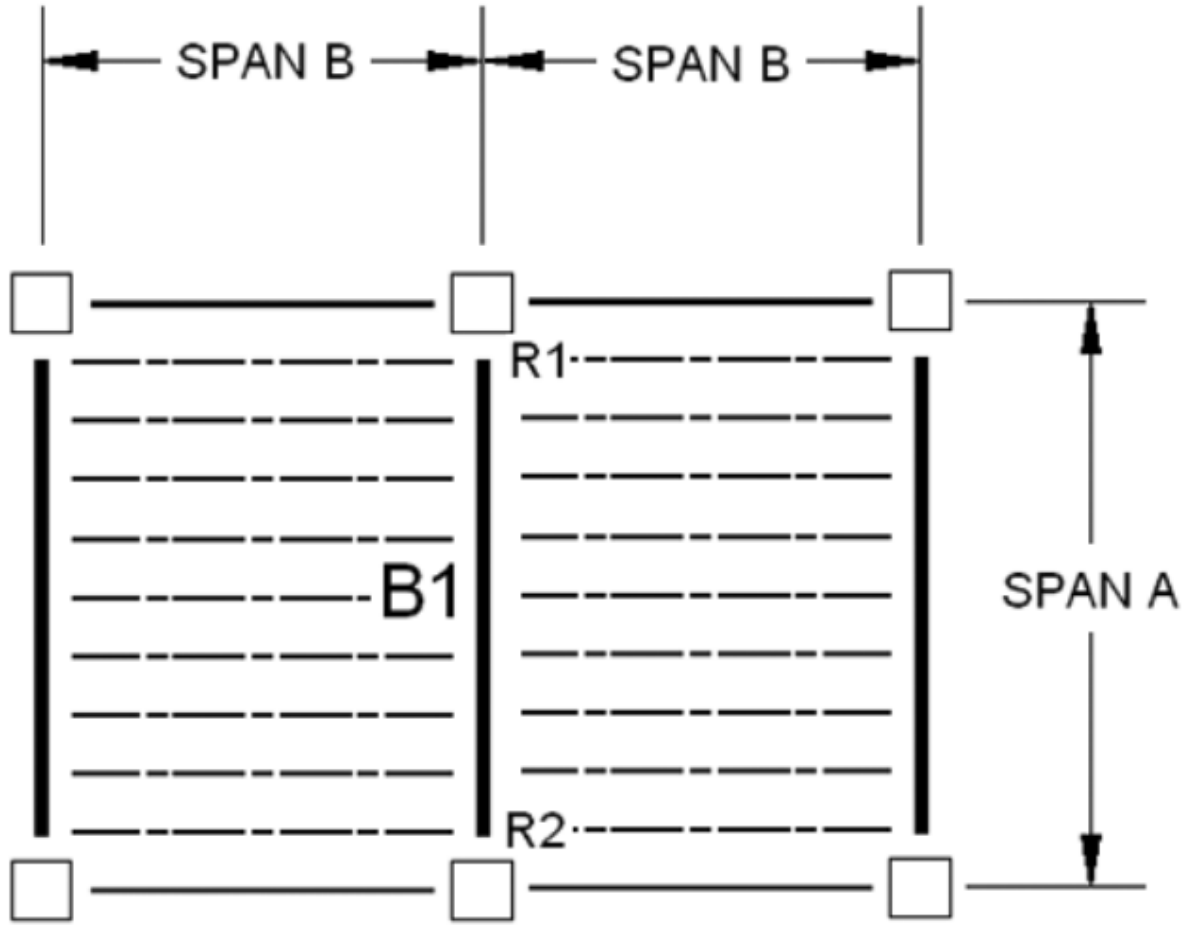
Steel Beam Analysis

4. Steel Beam Analysis

Analyze the given W-section for beam B1, to determine the maximum live load capacity the floor can carry. Determine the shear and bending forces and check the maximum deflection against an allowable of L/180. Assume the beam is fully braced, Lb < Lp (zone 1).

DATASET: 1 -2- -3-

W-section	W14X61
Fy	50 KSI
Span A	28 FT
Span B	13 FT
Floor DL	18 PSF



F_y = 50 ksi

Table 3-2 (continued)
W-Shapes
Selection by Z_x

Z_x

Shape	Z_x	M_{px}/Ω_b	$\phi_b M_{px}$	M_{rx}/Ω_b	$\phi_b M_{rx}$	BF/Ω_b	$\phi_b BF$	L_p	L_r	I_x	V_{nx}/Ω_v	$\phi_v V_{nx}$
		kip-ft	kip-ft	kip-ft	kip-ft	kips	kips				kips	kips
	in.^{3}	ASD	LRFD	ASD	LRFD	ASD	LRFD	ft	ft	in.^{4}	ASD	LRFD
W21×55	**126**	**314**	**473**	**192**	**289**	**10.8**	**16.3**	**6.11**	**17.4**	**1140**	**156**	**234**
W14×74	126	314	473	196	294	5.31	8.05	8.76	31.0	795	128	192
W18×60	123	307	461	189	284	9.62	14.4	5.93	18.2	984	151	227
W12×79	119	297	446	187	281	3.78	5.67	10.8	39.9	662	117	175
W14×68	115	287	431	180	270	5.19	7.81	8.69	29.3	722	116	174
W10×88	113	282	424	172	259	2.62	3.94	9.29	51.2	534	131	196
W18×55	**112**	**279**	**420**	**172**	**258**	**9.15**	**13.8**	**5.90**	**17.6**	**890**	**141**	**212**
W21×50	**110**	**274**	**413**	**165**	**248**	**12.1**	**18.3**	**4.59**	**13.6**	**984**	**158**	**237**
W12×72	108	269	405	170	256	3.69	5.56	10.7	37.5	597	106	159
W21×48[f]	**107**	**265**	**398**	**162**	**244**	**9.89**	**14.8**	**5.86**	**16.5**	**959**	**144**	**216**
W16×57	105	262	394	161	242	7.98	12.0	5.65	18.3	758	141	212
W14×61	102	254	383	161	242	4.93	7.48	8.65	27.5	640	104	156
W18×50	101	252	379	155	233	8.76	13.2	5.83	16.9	800	128	192
W10×77	97.6	244	366	150	225	2.60	3.90	9.18	45.3	455	112	169
W12×65[f]	96.8	237	356	154	231	3.58	5.39	10.7	35.1	533	94.4	142

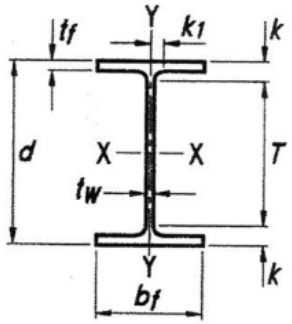


Table 1-1 (continued)
W-Shapes
Dimensions

Shape	Area, A	Depth, d		Web Thickness, t_w		Web $\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		Distance k k_{des}	Distance k k_{det}	k_1	T	Work-able Gage
	in.^{2}	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W14×132	38.8	14.7	14 5/8	0.645	5/8	5/16	14.7	14 3/4	1.03	1	1.63	2 5/16	1 9/16	10	5 1/2
×120	35.3	14.5	14 1/2	0.590	9/16	5/16	14.7	14 5/8	0.940	15/16	1.54	2 1/4	1 1/2	↓	↓
×109	32.0	14.3	14 3/8	0.525	1/2	1/4	14.6	14 5/8	0.860	7/8	1.46	2 3/16	1 1/2		
×99[f]	29.1	14.2	14 1/8	0.485	1/2	1/4	14.6	14 5/8	0.780	3/4	1.38	2 1/16	1 7/16		
×90[f]	26.5	14.0	14	0.440	7/16	1/4	14.5	14 1/2	0.710	11/16	1.31	2	1 7/16	↓	↓
W14×82	24.0	14.3	14 1/4	0.510	1/2	1/4	10.1	10 1/8	0.855	7/8	1.45	1 11/16	1 1/16	10 7/8	5 1/2
×74	21.8	14.2	14 1/8	0.450	7/16	1/4	10.1	10 1/8	0.785	13/16	1.38	1 5/8	1 1/16	↓	↓
×68	20.0	14.0	14	0.415	7/16	1/4	10.0	10	0.720	3/4	1.31	1 9/16	1 1/16		
×61	17.9	13.9	13 7/8	0.375	3/8	3/16	10.0	10	0.645	5/8	1.24	1 1/2	1	↓	↓

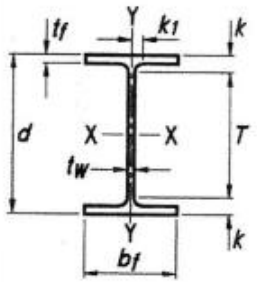


Table 1-1 (continued)
W-Shapes
Dimensions

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}	k k_{det}	k_1	T	Work-able Gage
	in.^{2}	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W14×132	38.8	14.7	14 5/8	0.645	5/8	5/16	14.7	14 3/4	1.03	1	1.63	2 5/16	1 9/16	10	5 1/2
×120	35.3	14.5	14 1/2	0.590	9/16	5/16	14.7	14 5/8	0.940	15/16	1.54	2 1/4	1 1/2	↓	↓
×109	32.0	14.3	14 3/8	0.525	1/2	1/4	14.6	14 5/8	0.860	7/8	1.46	2 3/16	1 1/2	↓	↓
×99[f]	29.1	14.2	14 1/8	0.485	1/2	1/4	14.6	14 5/8	0.780	3/4	1.38	2 1/16	1 7/16	↓	↓
×90[f]	26.5	14.0	14	0.440	7/16	1/4	14.5	14 1/2	0.710	11/16	1.31	2	1 7/16	↓	↓
W14×82	24.0	14.3	14 1/4	0.510	1/2	1/4	10.1	10 1/8	0.855	7/8	1.45	1 11/16	1 1/16	10 7/8	5 1/2
×74	21.8	14.2	14 1/8	0.450	7/16	1/4	10.1	10 1/8	0.785	13/16	1.38	1 5/8	1 1/16	↓	↓
×68	20.0	14.0	14	0.415	7/16	1/4	10.0	10	0.720	3/4	1.31	1 9/16	1 1/16	↓	↓
×61	17.9	13.9	13 7/8	0.375	3/8	3/16	10.0	10	0.645	5/8	1.24	1 1/2	1	↓	↓

Table 1-1 (continued)
W-Shapes
Properties

W14-W12

Nominal Wt.	Compact Section Criteria $\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	Axis X-X I	S	r	Z	Axis Y-Y I	S	r	Z	r_{ts}	h_o	Torsional Properties J	C_w
lb/ft			in.^{4}	in.^{3}	in.	in.^{3}	in.^{4}	in.^{3}	in.	in.^{3}	in.	in.	in.^{4}	in.^{6}
132	7.15	17.7	1530	209	6.28	234	548	74.5	3.76	113	4.23	13.7	12.3	25500
120	7.80	19.3	1380	190	6.24	212	495	67.5	3.74	102	4.20	13.6	9.37	22700
109	8.49	21.7	1240	173	6.22	192	447	61.2	3.73	92.7	4.17	13.4	7.12	20200
99	9.34	23.5	1110	157	6.17	173	402	55.2	3.71	83.6	4.14	13.4	5.37	18000
90	10.2	25.9	999	143	6.14	157	362	49.9	3.70	75.6	4.10	13.3	4.06	16000
82	5.92	22.4	881	123	6.05	139	148	29.3	2.48	44.8	2.85	13.4	5.07	6710
74	6.41	25.4	795	112	6.04	126	134	26.6	2.48	40.5	2.83	13.4	3.87	5990
68	6.97	27.5	722	103	6.01	115	121	24.2	2.46	36.9	2.80	13.3	3.01	5380
61	7.75	30.4	640	92.1	5.98	102	107	21.5	2.45	32.8	2.78	13.3	2.19	4710

Steel Beam Ananlysis

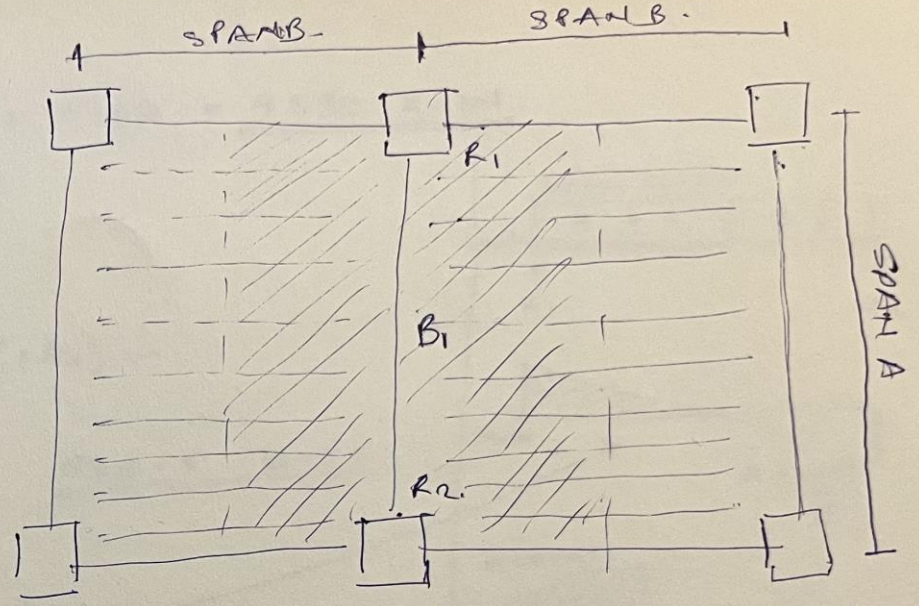
To determine the maximum live load capacity the floor can carry.

Determine shear and bending forces.

check maximum deflection against an allowable L/180.

Assume the beam is folly braced.

$L_b < L_p$ (zone 1).



W-section → W14X61 ; F_y = 50 KSI ; Span A = 28 ft ; Span B = 13 ft ; Floor DL = 18 PSF

Q1) The plastic modulus of the section, (Z_x) :- (see AISC 14 - Table 3.2)

for given section – W14X61 = Z_x = 102 IN^3.

Q2) The nominal bendy moment :- (M_n) :-

Because $L_B < L_P$ we can assume full plastic moment, so $M_n = M_p = F_y \times Z_x$.

$$M_n = \underset{\substack{\downarrow \\ \text{given} \\ \text{in question}}}{F_y} \times Z_x = 50 \times 102 = 5100 \text{ K-IN.}$$

Q3) The factored bending resistance, phi Mn :-

$$\phi M_n = 0.9 \times M_n = 0.9 \times 5100 = \underline{4590 \text{ K-IN}}.$$

ϕ ↓ constant = 0.9

Q4) The factored Design Moment (M_u) :-

$$M_u = \frac{\phi M_n}{12} = \frac{4590}{12} = \underline{382.5 \text{ K-Ft}}$$

Q5) Total factored design load. (w_u) :-

$$w_u = \frac{8 M_u}{l^2} = \frac{8(382.5)}{(28)^2} = \underline{8.903061224 \text{ KLF}}.$$

↑ long span.

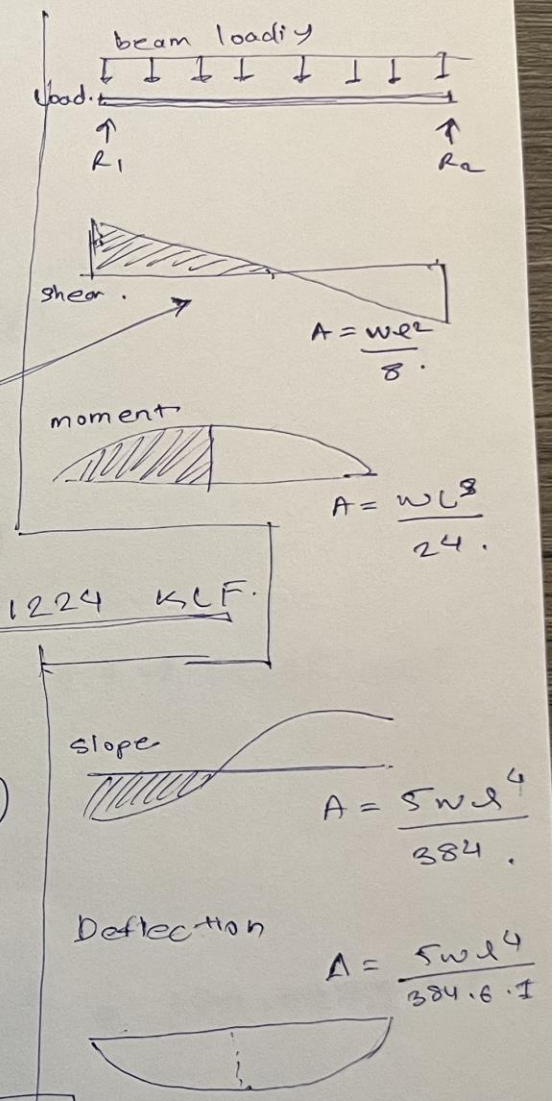
Q6) The total unfactored dead load on the beam :(w_{DL})

$$w_{DL} = \frac{\text{Beam self wt. + dead load}}{1000}$$

short span.

$$= \frac{61 + (18 \times 15)}{1000} = \frac{61 + 234}{1000}$$

$$= \frac{295}{1000} = 0.295 \text{ KLF}$$



Q7) The total factored dead load on the beam (w_u_DL) :-

$$w_u\_DL = 1.2 \times W_{DL}$$
$$= 1.2 \times 0.295$$
$$= 0.354 \text{ KLF}$$

Q8) The factored live load on the beam, (w_u_LL) :-

$$w_u\_LL = W_u - w_u\,DL$$

from Q(5).

$$= 3.903061224 - 0.354$$

from Q(7).

$$= 3.549061224 \text{ KLF}$$

Q9) The actual beam live load (capacity), (w_LL)

$$w\_LL = \frac{w_u\_LL}{1.6} = \frac{3.549061224}{1.6} = 2.218163265 \text{ KLF}$$

Q10) The actual floor live load, (LL) :-

$$LL = \frac{W_{LL}}{\text{Span } B} = \frac{2.218163}{13} \times \frac{1000 \text{ LB}}{1 \text{ K}} = 170.6279 \text{ PSF}$$

Q11) The maximum factored design beam shear force :- (V_{u_max}) :-

$$V_{max} = \frac{W_u \times l}{2} = \frac{3.90306124 \times 28}{2}$$ → long span.

$$= 54.642857136 \text{ K}.$$

Q12) The web area, (A_w) :-

from table 1.1 AISC

$$A_w = d \times t_w = 13.9 \times 0.375$$

$$= 5.2125 \text{ IN}^2.$$

Q13) The factored shear resistance, (phi V_n) :-

Because $L_B < L_p$ we can assume full plastic moment (zone 1), so,

(can be found in class notes).

$$\phi V_n = 0.6 f_y A_w$$

$$\text{phi } V_n = 0.6 f_y A_w = 0.6 \times 50 \times 5.2125$$

$$= 156.375 \text{ K}.$$

Q14) Is the section safe for shear? :-

check that $V_{u,max} < V_n$.

$V_{umax} = 54.6428 \overline{57136} < V_n = 156.375$.

$\therefore$ pass (1 = yes)

Q15). The actual (unfactored) deflection due to total load DL + LL :-

$$\Delta = \frac{5wL^4}{384EI}$$

$$= \frac{5(w_{DL} + w_{LL})(\text{span } A)^4 \times 1728 \, (IN^3/FT^3)}{384 \times 29000 \text{ psi} \times I}$$

$$= \frac{5(\overset{(0.6)}{0.295} + \overset{(0.9)}{2.2101})(28)^4 \times 1728}{384 \times \underset{(1)}{29000} \times 640}$$

Table 1.1

(1) E = 29000 PSI for steel see Beam equations sheet on canvas.

$= 1.872653276$ IN

Q16) The deflection limit :- L/180

$$L/180 = \frac{\text{span } A}{180} = \frac{28 \times 12}{180} = \frac{336}{180}$$

$$= 1.866666667 \text{ IN.}$$

Q17). Is the actual deflection less than the limit L/180 ?

$\Delta = 1.8726.$ ← (Q8)

$L/180 = 1.8666$

$\Delta > L/180,$ ∴ Fail (o = no)

Thankyou !!!