Structure II Recitation 2/23

Steel Column Analysis

Before we start ...

Today's Tasks

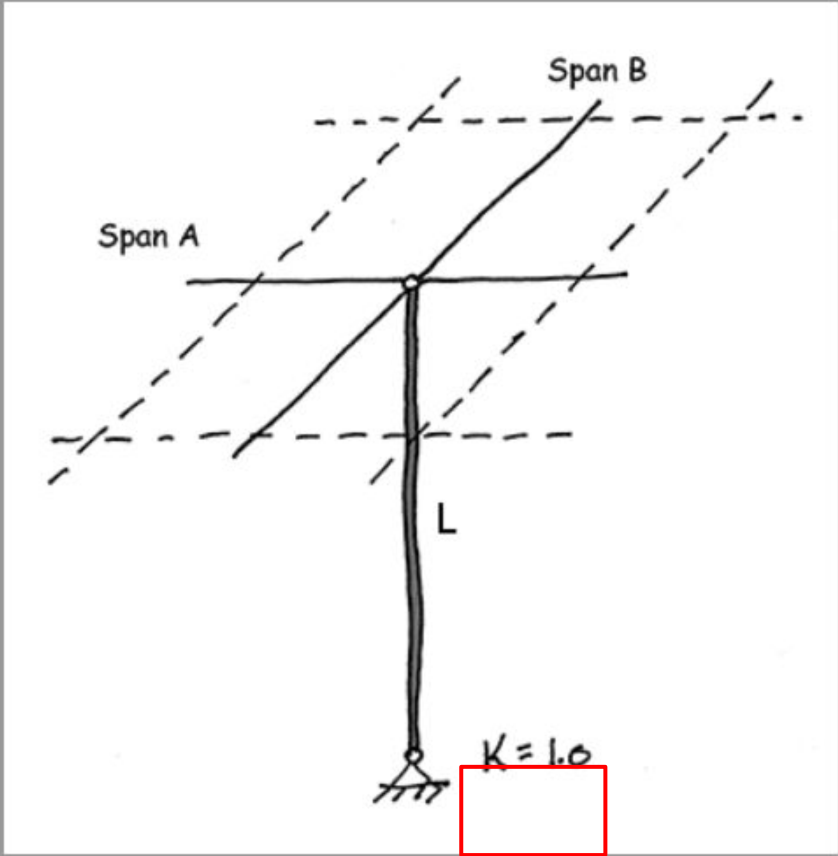
Homework Example (Steel Column Analysis) (9 Questions)

6. Steel Column Analysis

For the given axially loaded steel W-section, determine the maximum floor live load capacity, P LL. Assume the column is pinned top and bottom: K = 1.0, and there is no intermediate bracing. Use AISC-LRFD steel equations to determine phi Pn and the load. E = 29000 ksi.

DATASET: 1 -2- -3-

W-section	W8X31
Fy	50 KSI
Span A	34 FT
Span B	43 FT
Height L	13 FT
Floor Dead Load	44 PSF



Get Slenderness Ratio – Get Transition Slenderness – Decide Long or Short Column – Get ΦPn – Decide LL

Analysis of Steel Columns

pass / fail by LRFD

Data:

- Column – <u>size</u>, length
- Support conditions
- Material properties – F_y
- Factored load – P_u

Required:

- $P_u \leqq ø P_n$ (pass)

1. Calculate slenderness ratios: L_c/r_x and L_c/r_y (L_c = KL)
   The largest ratio governs.
2. Check slenderness ratio against upper limit of 200 (recommended)
3. Calculate transition slenderness $4.71\sqrt{E/Fy}$
   and determine column type (short or long)
4. Calculate F_{cr} based on slenderness
5. Determine $øP_n$ and compare to P_u
   $P_n = F_{cr}\ A_g \qquad ø = 0.9$
6. If $P_u \leqq ø P_n$, then OK

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y \quad \text{Short}$$

$$F_{cr} = 0.877 F_e \quad \text{Long}$$

Q1: The Unfactored Floor Dead Load on the Column

= Floor DL x Tributary Area

= 44 x (34 x 43) / 1000

= **64.328 kips**

Convert Unit

Q2: Controlling Slenderness Ratio

Look at Table 1-1 for the radius of gyration r, search for the weak axis (smaller one),

We choose 2.02 in for my situation

Slenderness Ratio = K x L / r = 1 x 13 x 12 / 2.02 = **77.228**

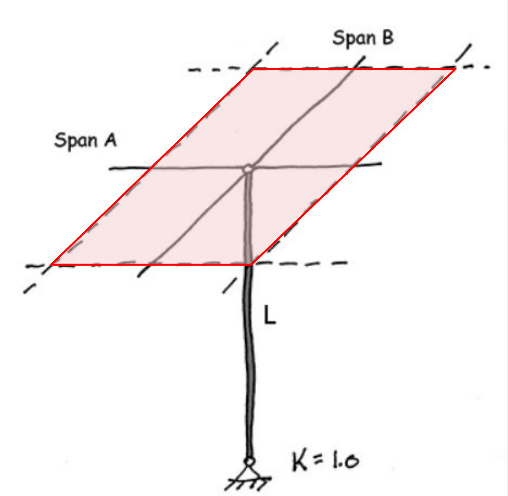
Convert Unit

Q3: Transition Slenderness Value

$4.71 \times (E/Fy)^{0.5} = 4.71 \times (29000/50)^{0.5} = \mathbf{113.432}$

Given from Question

W-section	W8X31
Fy	50 KSI
Span A	34 FT
Span B	43 FT
Height L	13 FT
Floor Dead Load	44 PSF



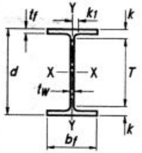


Table 1-1 (continued)
W-Shapes
Dimensions

Shape	Area, A	Depth, d		Web Thickness, t_w		$t_w/2$	Flange Width, b_f		Flange Thickness, t_f		k_{des}	k_{det}	k_1	T	Workable Gage
	in.^{2}	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W8×67	19.7	9.00	9	0.570	9/16	5/16	8.28	8 1/4	0.935	15/16	1.33	1 5/8	15/16	5 3/4	5 1/2
×58	17.1	8.75	8 3/4	0.510	1/2	1/4	8.22	8 1/4	0.810	13/16	1.20	1 1/2	7/8	↓	↓
×48	14.1	8.50	8 1/2	0.400	3/8	3/16	8.11	8 1/8	0.685	11/16	1.08	1 3/8	13/16		
×40	11.7	8.25	8 1/4	0.360	3/8	3/16	8.07	8 1/8	0.560	9/16	0.954	1 1/4	13/16		
×35	10.3	8.12	8 1/8	0.310	5/16	3/16	8.02	8	0.495	1/2	0.889	1 3/16	13/16		
×31[f]	9.13	8.00	8	0.285	5/16	3/16	8.00	8	0.435	7/16	0.829	1 1/8	3/4		

Table 1-1 (continued)
W-Shapes
Properties

W8-W4

Nominal Wt.	Compact Section Criteria $b_f/2t_f$	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}
67	4.43	11.1	272	60.4	3.72	70.1	88.6	21.4	2.12	32.7	2.43	8.07	5.05	1440
58	5.07	12.4	228	52.0	3.65	59.8	75.1	18.3	2.10	27.9	2.39	7.94	3.33	1180
48	5.92	15.9	184	43.2	3.61	49.0	60.9	15.0	2.08	22.9	2.35	7.82	1.96	931
40	7.21	17.6	146	35.5	3.53	39.8	49.1	12.2	2.04	18.5	2.31	7.69	1.12	726
35	8.10	20.5	127	31.2	3.51	34.7	42.6	10.6	2.03	16.1	2.28	7.63	0.769	619
31	9.19	22.3	110	27.5	3.47	30.4	37.1	9.27	2.02	14.1	2.26	7.57	0.536	530

$$4.71\sqrt{E/Fy}$$

Q4: Euler Stress (Fe)

π^2 x E / (K x L / r)^2 ← From Q2

= π^2 x 29000 / (77.228)^2

= π^2 x 29000 / (77.228)^2

= **47.99 ksi**

Q5: Critical Stress (Fcr)

Compare the controlling slenderness ratio to the transition slenderness value to see which formula to use:

77.228 (Q2) < 113.432 (Q3), use short column formula

Fcr = 0.658$^{(Fy/Fe)}$ x Fy = 0.658$^{(50/47.99)}$ x 50 = **32.3283 kips**

↑ From Q4

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$

Given from Question

W-section	W8X31
Fy	50 KSI
Span A	34 FT
Span B	43 FT
Height L	13 FT
Floor Dead Load	44 PSF

Short & Intermediate Columns:

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y$$

Q2 < Q3

Equation E3-2

Long Columns:

$$F_{cr} = 0.877 F_e$$

Q2 > Q3

Equation E3-3

Q6: Nominal Strength (Pn)

Pn = Fcr x Ag = 32.3283 x 9.13 = **295.157 kips**

From Q5 (Fcr) — From Table 1-1 (Ag)

Q7: Factored Nominal Strength (ΦPn)

ΦPn = 0.9 x 295.157 = **265.6416 kips**

$$P_n = F_{cr} A_g$$

$$\phi_c P_n = \phi_c F_{cr} A_g$$

$$(\phi_c = 0.90)$$

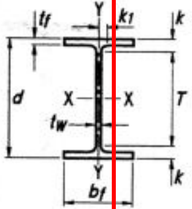


Table 1-1 (continued)
W-Shapes
Dimensions

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	Workable Gage
	in.^{2}	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W8×67	19.7	9.00	9	0.570	9/16	5/16	8.28	8 1/4	0.935	15/16	1.33	1 5/8	15/16	5 3/4	5 1/2
×58	17.1	8.75	8 3/4	0.510	1/2	1/4	8.22	8 1/4	0.810	13/16	1.20	1 1/2	7/8	↓	↓
×48	14.1	8.50	8 1/2	0.400	3/8	3/16	8.11	8 1/8	0.685	11/16	1.08	1 3/8	13/16		
×40	11.7	8.25	8 1/4	0.360	3/8	3/16	8.07	8 1/8	0.560	9/16	0.954	1 1/4	13/16		
×35	10.3	8.12	8 1/8	0.310	5/16	3/16	8.02	8	0.495	1/2	0.889	1 3/16	13/16		
×31[f]	9.13	8.00	8	0.285	5/16	3/16	8.00	8	0.435	7/16	0.829	1 1/8	3/4		

Table 1-1 (continued)
W-Shapes
Properties

W8-W4

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}
67	4.43	11.1	272	60.4	3.72	70.1	88.6	21.4	2.12	32.7	2.43	8.07	5.05	1440
58	5.07	12.4	228	52.0	3.65	59.8	75.1	18.3	2.10	27.9	2.39	7.94	3.33	1180
48	5.92	15.9	184	43.2	3.61	49.0	60.9	15.0	2.08	22.9	2.35	7.82	1.96	931
40	7.21	17.6	146	35.5	3.53	39.8	49.1	12.2	2.04	18.5	2.31	7.69	1.12	726
35	8.10	20.5	127	31.2	3.51	34.7	42.6	10.6	2.03	16.1	2.28	7.63	0.769	619
31	9.19	22.3	110	27.5	3.47	30.4	37.1	9.27	2.02	14.1	2.26	7.57	0.536	530

Q8: Unfactored Live Load on Column (LL)

Assume ΦPn = Pu,

ΦPn = 1.2 DL + 1.6 LL

From Q7 From Q1

265.6416 = 1.2 x 64.328 + 1.6 x LL

LL = (265.6416 - 1.2 x 64.328) / 1.6 = **117.78 kips**

Q9: Actual Unfactored Floor Live Load (Floor LL)

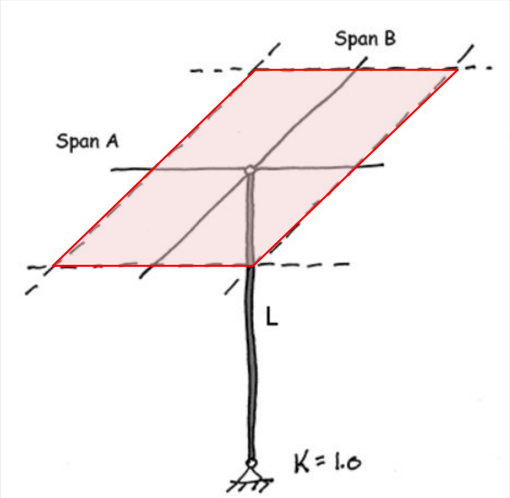
Floor LL = LL / Tributary Area

= 117.78 x 1000 / (34 x 43) = **80.5608 psf**

Convert Unit

Given from Question

W-section	W8X31
Fy	50 KSI
Span A	34 FT
Span B	43 FT
Height L	13 FT
Floor Dead Load	44 PSF



2.3 LOAD COMBINATIONS FOR STRENGTH DESIGN

1. $1.4D$
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.5W)$
4. $1.2D + 1.0W + L + 0.5(L_r \text{ or } S \text{ or } R)$
5. $0.9D + 1.0W$

$$w_u = 1.2w_{DL} + 1.6w_{LL}$$


I'M OUTTA HERE!
SPRING BREAK HAS
ARRIVED!!!
memeshappen.com