CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 16
COMPRESSION MEMBER

SEMESTER: SUMMER 2020

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OUTLINE

- Local buckling (cont.)

- W- section property table

- Math Problem on column design
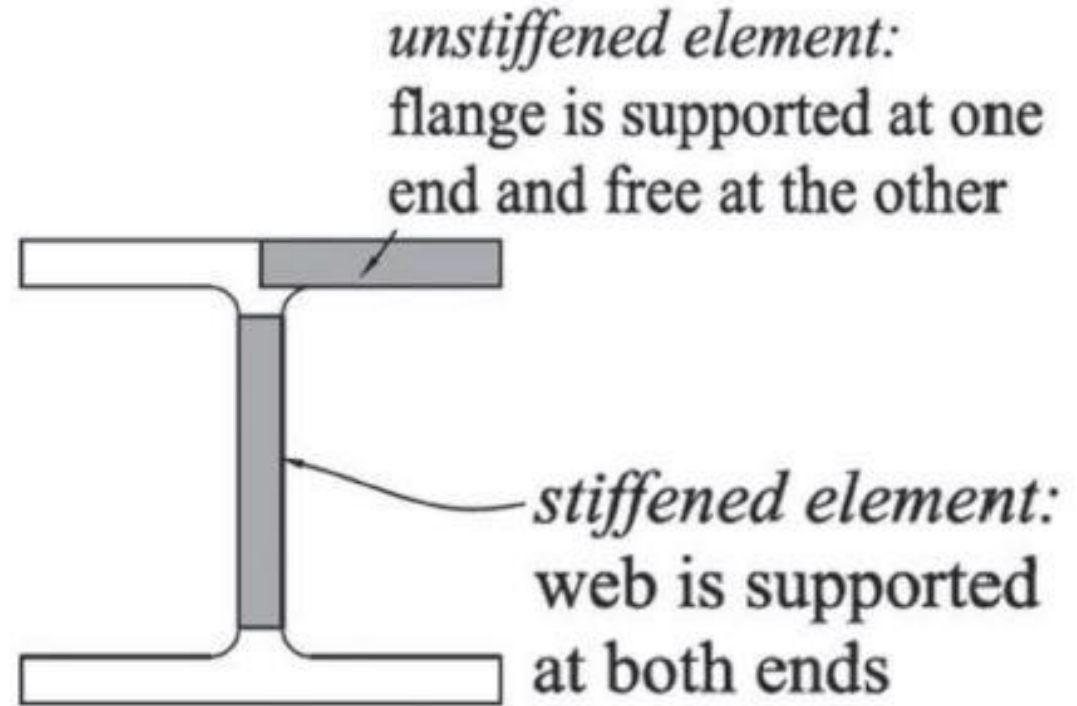
LOCAL BUCKLING

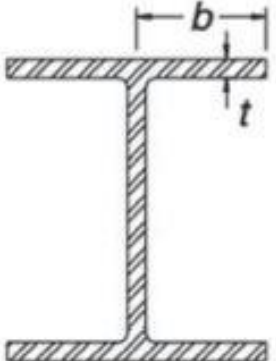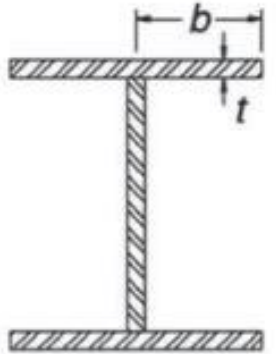There are also two type of elements of a column section :

Stiffened:
Stiffened elements are supported along both edges parallel to the applied axial load. An example of this is the web of an I-shaped column where the flanges are connected on either end of the web.
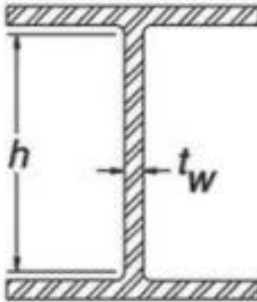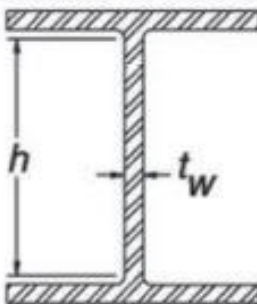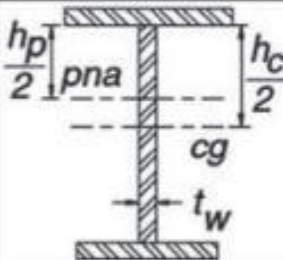
Unstiffened:
An unstiffened element has only one unsupported edge parallel to the axial load—for example, the outstanding flange of an I-shaped column that is connected to the web on one edge and free along the other edge.

unstiffened element:
flange is supported at one end and free at the other

stiffened element:
web is supported at both ends

LOCAL BUCKLING: AISC Specification for limiting b/t ratio
Unstiffened Elements

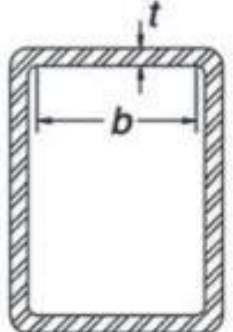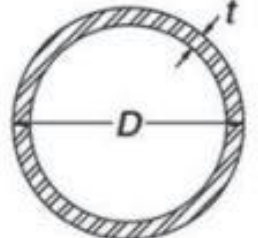| Case	Description of Element	Width Thick-ness Ratio	Limiting Width-Thickness Ratios		Example
			λ_p (compact)	λ_r (noncompact)	
1	Flexure in flanges of rolled I-shaped sections and channels	b/t	$0.38\sqrt{E/F_y}$	$1.0\sqrt{E/F_y}$	
2	Flexure in flanges of doubly and singly symmetric I-shaped built-up sections	b/t	$0.38\sqrt{E/F_y}$	$0.95\sqrt{k_c E/F_L}$ [a],[b]	

LOCAL BUCKLING: AISC Specification for limiting *b/t* ratio
Stiffened Elements

| Case | Description of Element | Width Thick- ness Ratio | Limiting Width- Thickness Ratios | | Example |
			λ_p (compact)	λ_r (noncompact)	
9	Flexure in webs of doubly symmetric I-shaped sections and channels	h/t_w	$3.76\sqrt{E/F_y}$	$5.70\sqrt{E/F_y}$	
10	Uniform compression in webs of doubly symmetric I-shaped sections	h/t_w	NA	$1.49\sqrt{E/F_y}$	
11	Flexure in webs of singly-symmetric I-shaped sections	h_c/t_w	$\dfrac{\dfrac{h_c}{h_p}\sqrt{\dfrac{E}{F_y}}}{\left(0.54\dfrac{M_p}{M_y}-0.09\right)^2} \leq \lambda_r$	$5.70\sqrt{E/F_y}$	

(left margin label: Stiffened Elements)

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LOCAL BUCKLING: AISC Specification for limiting b/t ratio
Stiffened Elements

Case	Description of Element	Width Thickness Ratio	Limiting Width-Thickness Ratios		Example
			λ_p (compact)	λ_r (noncompact)	
12	Uniform compression in flanges of rectangular box and hollow structural sections of uniform thickness subject to bending or compression; flange cover plates and diaphragm plates between lines of fasteners or welds	b/t	$1.12\sqrt{E/F_y}$	$1.40\sqrt{E/F_y}$	
15	Circular hollow sections				
	In uniform compression	D/t	NA	$0.11E/F_y$	
	In flexure	D/t	$0.07E/F_y$	$0.31E/F_y$	

Desig-nation	Nom. Weight, lb/ft	Area, A, in₂	Depth, d, in	Flange		Web Thickness tw, in	Axis X-X			Axis Y-Y		
				Width, bf, in	Thick-ness, ttf, in		I, in₄	S, in₃	r, in	I, in₄	S, in₃	r, in
W18 x 60	60	17.6	18.24	7.555	0.695	0.415	984	108	7.47	50.1	13.3	1.69
W16 x 36	36	10.6	15.86	6.985	0.43	0.295	448	56.5	6.51	24.5	7	1.52
W14 x 61	61	17.9	13.89	9.995	0.645	0.375	640	92.2	5.98	107	21.5	2.45
W14 x 53	53	15.6	13.92	8.06	0.66	0.37	541	77.8	5.89	57.7	14.3	1.92
W14 x 48	48	14.1	13.79	8.03	0.595	0.34	485	70.3	5.85	51.4	12.8	1.91
W12 x 65	65	19.1	12.12	12	0.605	0.39	533	87.9	5.28	174	29.1	3.02
W12 x 58	58	17	12.19	10.01	0.64	0.36	475	78	5.28	107	21.4	2.51
W12 x 53	53	15.6	12.06	9.995	0.575	0.345	425	70.6	5.23	95.8	19.2	2.48
W12 x 50	50	14.7	12.19	8.08	0.64	0.37	394	64.7	5.18	56.3	13.9	1.96
W10 x 54	54	15.8	10.09	10.03	0.615	0.37	303	60	4.37	103	20.6	2.56
W10 x 49	49	14.4	9.98	10	0.56	0.34	272	54.6	4.35	93.4	18.7	2.54
W10 x 45	45	13.3	10.1	8.02	0.62	0.35	248	49.1	4.32	53.4	13.3	2.01
W10 x 39	39	11.5	9.92	7.985	0.53	0.315	209	42.1	4.27	45	11.3	1.98
W8 x 48	48	14.1	8.5	8.11	0.685	0.4	184	43.3	3.61	60.9	15	2.08

Select the lightest W section of A992 (F_y = 50 ksi) steel to serve as a pinned-end main member column 16 ft long to carry an axial compression load of 115 kips dead load and 125 kips live load in a braced structure, as shown in Fig. Use ASD approach.

SOLUTION:

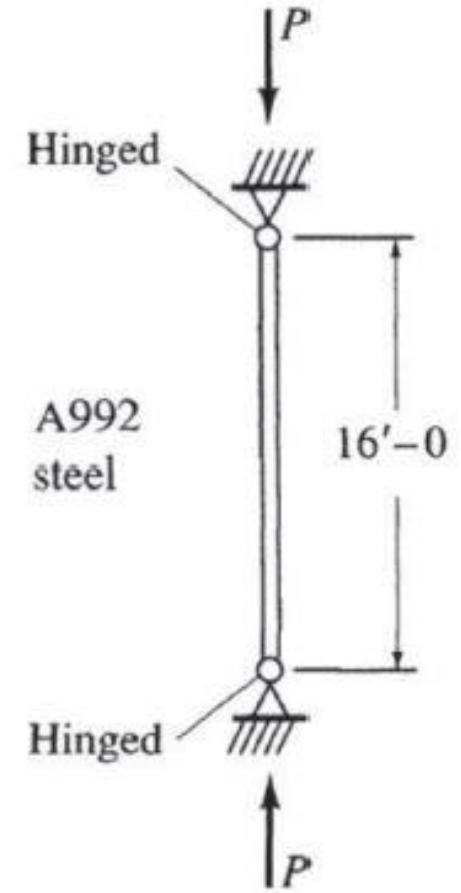P= 115+125= 240 kip, L = 16' = 192"
Both ends hinged, therefore K = 1.0

Nominal strength $P_n = F_{cr} A_g$

1. $F_{cr} = \left[0.658^{\frac{F_y}{F_e}} \right] F_y$ For $\dfrac{KL}{r} \leq 4.71 \sqrt{\dfrac{E}{F_y}}$ or $F_e \geq 0.44 F_y$ (6.7.7)

2. $F_{cr} = 0.877 F_e$ For $\dfrac{KL}{r} > 4.71 \sqrt{\dfrac{E}{F_y}}$ or $F_e < 0.44 F_y$ (6.7.8)

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

$4.71\sqrt{(E/F_y)} = 4.71 \sqrt{(29000/50)} = 113.4$

Hinged

A992 steel

Hinged

P

P

16'-0

TRIAL-1

Assume $KL/r = 90$, $\therefore r = KL/90 = 192/90 = 2.133$ in.

$F_e = \pi^2 E/(KL/r)^2 = 3.14^2 \times 29000/(90)^2 = 35.33$ ksi.

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}} \right] F_y = [0.658^{(50/35.33)}]50 = 27.65 \text{ ksi} \quad \text{For } \frac{KL}{r} \leq 4.71\sqrt{\frac{E}{F_y}}$$

Nominal strength $P_n = \Omega P = 1.67 \times 240 = 400.8$ kip

But $P_n = F_{cr} A_g$

$\therefore A_g = P_n/F_{cr} = 400.8/27.63 = 14.5$ in^2.

Now go to W section charts of AISC Manual and find a section having $r \geq 2.133$ and $A_g \geq 14.5$.

From AISC Manual Chart on Pages 1-24 and 1-25,
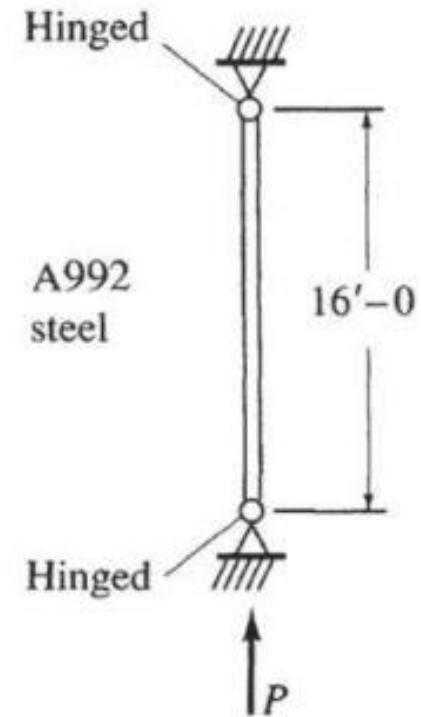
Select W12x53 with $A=15.6$ in^2 and $r = 2.48$ in

TRIAL-2

Assume $KL/r = 80$, $\therefore r = KL/80 = 192/80 = 2.4$ in.

$F_e = \pi^2 E/(KL/r)^2 = 3.14^2 \times 29000/(80)^2 = 44.72$ ksi.

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}} \right] F_y = [0.658^{(50/44.72)}]50 = 31.31 \text{ ksi}$$

But $P_n = F_{cr} A_g$ $\therefore A_g = P_n/F_{cr} = 400.8/31.31 = 12.8$ in^2.

Hinged

A992 steel

16'−0

Hinged

P

From AISC Manual Chart on Pages 1-24 and 1-25, Select W10x49 with $A=14.4$ in^2 and $r = 2.54$

TRIAL-3

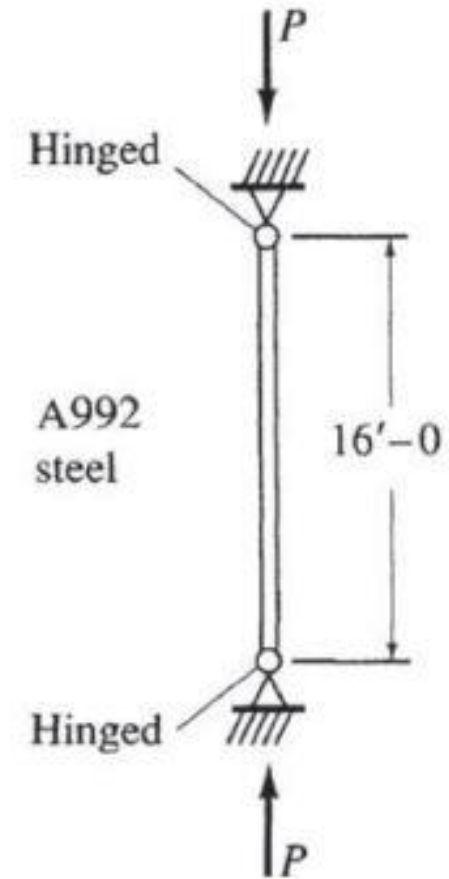Assume $KL/r = 70$, $\therefore r = KL/70 = 192/70 = 2.743$ in.

$F_e = \pi^2 E/(KL/r)^2 = 3.14^2 \times 29000/(70)^2 = 58.35$ ksi. ($> F_y$, Note)

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}} \right] F_y = [0.658^{(50/58.35)}]50 = 34.93 \text{ ksi}$$

But $P_n = F_{cr} A_g$ $\therefore A_g = P_n/F_{cr} = 400.8/34.93 = 11.45$ in^2.

Now go to W section charts of AISC Manual and find
a section having $r \geq 2.743$ and $A_g \geq 11.45$

From AISC Manual Chart on Pages 1-22 and 1-23,
Select W12x65 with $A=19.1$ in^2 and $r = 3.02$

Hinged

A992 steel

Hinged

P

$16'-0$

P

Based on above three trials, the finally chosen section is W10x49

SB- Q&A on lecture 16

Column local buckling

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Column local buckling
by Saurav Barua - Saturday, 18 July 2020, 11:39 AM

What are compact, non-compact and slender section? Answer this question and ask another question. [2 marks]
🔎 Turnitin status: Queued