CVEN 446 – Fall 2020 **Exam AB** **October 15, 2020**
Dr. Brackin

Section: **501**

Name: PRELIMINARY KEY

Student UIN: ____________________

"An Aggie does not lie, cheat, or steal, or tolerate those who do." – Aggie Code of Honor

By my signature below I pledge that my conduct on this exam is consistent in every way with the Aggie Code of Honor:

Signature: ____

1. This exam consists of ***four (4)*** problems that are equally weighted
2. Some problems may have multiple parts.
3. Be sure to carefully read and properly analyze each question that is asked. Do not jump to unfounded conclusions, but also do not overlook or oversimplify problems either.
4. Be sure to show all work, including sketches, and calculations, and organize your solution procedure as clearly and systematically as possible.
5. Neatly work the problems on a separate sheet of ENGINEERING paper. **DO NOT WRITE ON THE BACK OF ANY PAGE.**
6. You need only to present your solution (i.e. Given, Required, not necessary)
7. Work efficiently, neatly, and use pencil.
8. Clearly indicate final answers by enclosing in a "box" or place answer in the blank if a blank is provided. Include any and all appropriate units.
9. **CLOSED FRIEND, CLOSED GOOGLE, AND CLOSED EVERYTHING NOT ON THE FOLLOWING LIST**. You may use the 15th Edition AISC Manual, the course textbook, and your course notes.

Problem 1: ________ / 10

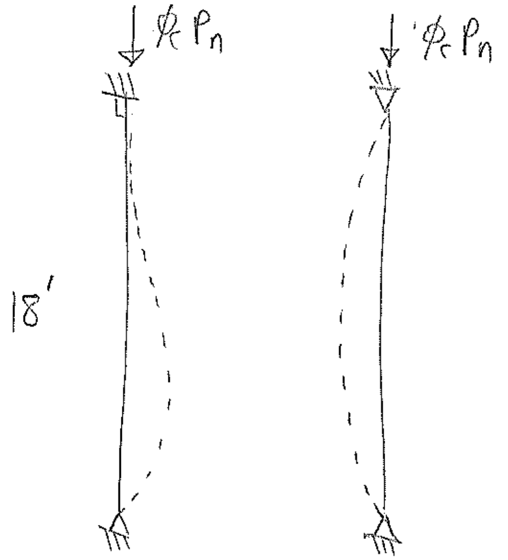
Problem 2: ________ / 10

Problem 3: ________ / 10

Problem 4: ________ / 10

TOTAL: ________ / 40

Problem 1: A **W14X211**, A572 Gr. 65 steel, is used for an 18-ft long column. The column's fixity at the top and bottom are shown for the weak and strong axes. **Determine the design compressive capacity of the member.** Consider all limit states, check local buckling explicitly, and state the mode of failure from the column response curve that controls.



Y-Y AXIS $\quad K_y = 0.8$

X-X AXIS $\quad K_x = 1.0$

A572 Gr 65: $f_y = 65^{ksi}$
$f_u = 80^{ksi}$

W14X211: $A_g = 62 \text{ in}^2$

$\frac{b_f}{2t_f} = 5.06$; $\frac{h}{t_w} = 11.6$

$r_x = 6.55$; $r_y = 4.07$

LOCAL BUCKLING:

$\frac{b_f}{2t_f} = 5.06 \le \frac{95}{\sqrt{f_y}} = \frac{95}{\sqrt{65}} = 11.8$ ✓

(CANNOT USE NOTATION, $f_y = 65^{ksi}$)

$\frac{h}{t_w} = 11.6 \le \frac{254}{\sqrt{f_y}} = \frac{254}{\sqrt{65}} = 31.5$ ✓

$$\left(\frac{KL}{r}\right)_y = \frac{0.8(18^{ft})(12)}{4.07} = 42.46 \le 200 \checkmark \; ; \; \left(\frac{KL}{r}\right)_x = \frac{1.0(18')(12)}{6.55} = 32.98 \le 200 \checkmark$$

controls, serviceability ok

$$F_e = \frac{\pi^2 E}{\left(\frac{kL}{r}\right)^2_{max}} = \frac{\pi^2 (29000^{ksi})}{(42.46)^2} = 158.8 \text{ ksi} \ge 0.44 f_y = 28.6 \text{ ksi}$$

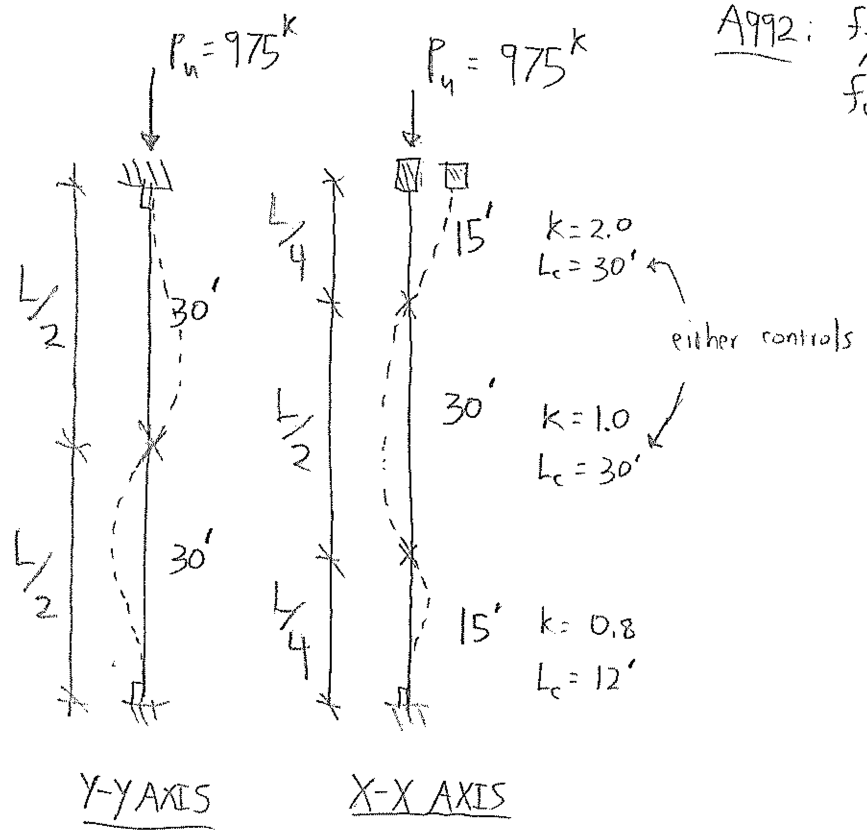
65^{ksi}

$\therefore$ Inelastic Buckling $\quad$ * MUST STATE THIS

$$F_{cr} = \left(0.658^{f_y/F_e}\right) f_y = \left(0.658^{65^{ksi}/158.8^{ksi}}\right)(65^{ksi}) = 54.77 \text{ ksi}$$

$$\phi_c P_n = \phi_c F_{cr} A_g = 0.9(54.77^{ksi})(62 \text{ in}^2) = \underline{3056.2 \text{ k}}$$

Problem 2: Select the lightest W14X_____ shape for the compression member shown. The compression member is required to carry a factored load of 975 kips and L = 60 ft. Assume A992 steel material. Be sure to verify the design capacity of your section and check all appropriate limit states and serviceability requirements. The "X" denotes a brace point.



A992: $f_y = 50$ ksi
$f_u = 65$ ksi

$K_y = 0.8$
$L_c = 0.8(30') = 24'$

$P_u = 975^k$ @ $L_{c,y} = 24'$ → estimate $\frac{r_x}{r_y} \approx 1.67$, pg 4-16

$$(kL)_{eq} = \frac{(kL)_x}{r_x/r_y} = \frac{30'}{1.67} = 18'$$

$(kL)_y = 24'$ ← CONTROLS

TRY W14X120; $\phi_c P_n = 1030^k$ @ $L = 24^{ft}$, pg 4-16
$A_g = 35.3 \text{ in}^2$
$r_y = 3.74$ in
$r_x = 6.25$ in

$$\left(\frac{kL}{r}\right)_x = \frac{30'(12)}{6.25''} = 57.6 \le 200 \ \checkmark$$

$$\left(\frac{kL}{r}\right)_y = \frac{24'(12)}{3.74''} = 77 \le 200 \ \checkmark$$

SERVICEABILITY OK

CONTROLS

NO NOTATION ∴ NO LOCAL BUCKLING ISSUES

$$F_e = \frac{\pi^2 E}{\left(\frac{kL}{r}\right)^2_{max}} = \frac{\pi^2 (29000^{ksi})}{(77)^2} = 48.3^{ksi} \ge 0.44 F_y = 22^{ksi}$$

50^{ksi}

∴ Inelastic Buckling

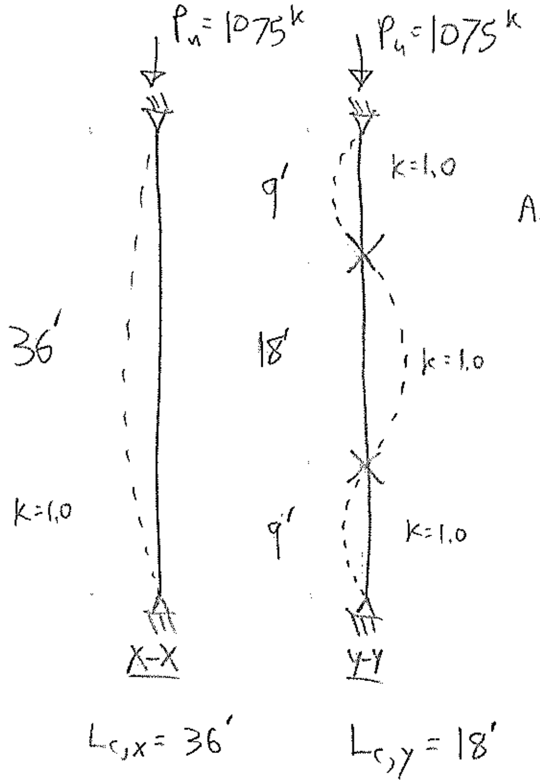
$$F_{cr} = \left(0.658^{F_e/F_y}\right) F_y = \left(0.658^{48.3/50}\right)(50 \text{ ksi}) = 33.4^{ksi}$$

$$\phi_c P_n = \phi_c F_{cr} A_g = 0.9(33.4 \text{ ksi})(35.3 \text{ in}^2) = 1061^k$$

$$\ge P_u = 975^k \ \checkmark$$

USE W14X120, A992 STEEL, 60-FT LONG

Problem 3: Select an appropriate W18X_____ shape for the compression member shown (an excel spreadsheet might be helpful and start with an initial guess of elastic buckling stress around 80 percent of yield). The compression member is required to carry a factored load of 1075 kips. Assume A992 steel material. Be sure to verify the design capacity of your section and check all appropriate limit states and serviceability requirements.



A992: $f_y = 50$ ksi
$f_u = 65$ ksi

Assume $f_{cr} \approx 0.8(50^{ksi}) = 40^{ksi}$

$$\phi_c P_n = \phi_c f_{cr} A_g \Rightarrow (A_g)_{req'd} \geq \frac{P_u}{\phi_c f_{cr}}$$

$$(A_g)_{req'd} \geq \frac{1075^k}{0.9(40^{ksi})} = 29.86 \text{ in}^2$$

TRY $\underline{W18X106} \rightarrow A_g = 31.1 \text{ in}^2 > (A_g)_{req'd} = 29.86 \text{ in}^2$

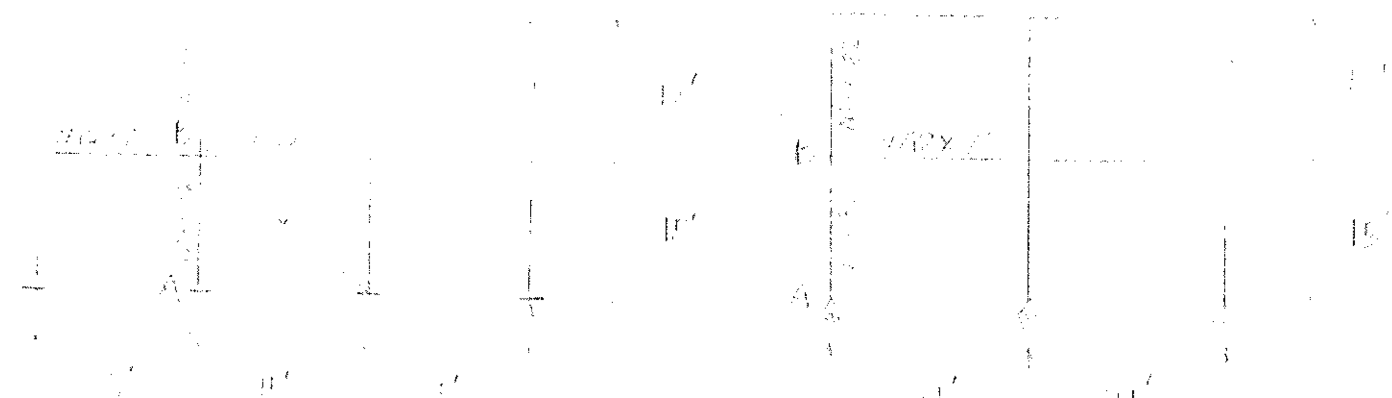
* SEE SPREADSHEET

USE W18X119, A992 STEEL, 36' LONG

fy	50	*ksi*
KLx	36	*ft*
Kly	18	*ft*

	W18X106	**W18X119**	**W18X130**	
Ag	31.10	35.10	38.30	*in.^2*
bf/2tf	5.96	5.31	4.65	
	non-slender flange	non-slender flange	non-slender flange	
h/tw	27.20	24.50	23.90	
	non-slender web	non-slender web	non-slender web	
rx	7.84	7.90	8.03	*in.*
ry	2.66	2.69	2.70	*in.*
(KL/r)x	55.10	54.68	53.80	
	Serviceability OK	Serviceability OK	Serviceability OK	
(KL/r)y	81.20	80.30	80.00	
	Serviceability OK	Serviceability OK	Serviceability OK	
fe	43.41	44.39	44.72	*KSI*
fcr	34.77	34.48	34.39	*KSI*
Design Comp. Strength	973.13	1089.27	1185.30	*Kip*

Problem 4: Consider the frame shown. Connectivity for the weak and strong axes are shown for column AB. Additionally, the W-sections specified for the columns and girders are shown and are A992 steel. The dashed lines denote tension bracing. **Determine the design axial compression capacity for column AB.**



* BRACED FRAME (ie I_y)

* MOMENT FRAME (ie I_x)

W14X132: $A_g = 38.8\ in^2$
$r_x = 6.28\ in$; $r_y = 3.76\ in$
$I_x = 1530\ in^4$; $I_y = 548\ in^4$

W14X82: $I_x = 881\ in^4$; $I_y = 148\ in^4$
W12X87: $I_x = 740\ in^4$; $I_y = 241\ in^4$
W18X71: $I_x = 1170\ in^4$; $I_y = 60.3\ in^4$

$G_A = 1.0$ "fixed"

$$G_B = \frac{\sum\left(\frac{I}{L}\right)_{col}}{\sum\left(\frac{I}{L}\right)_{gir}} = \frac{\frac{548}{18} + \frac{148}{12}}{2\left(\frac{241}{15}\right)} = 1.33$$

$G_A = 10.0$ "pinned"

$$G_B = \frac{\frac{1530}{18} + \frac{881}{12}}{\frac{1170}{21}} = 2.84$$

Braced Frame → $k_y \approx 0.79$

Moment Frame → $k_x \cong 2.25$

$$\left(\frac{KL}{r}\right)_x = \frac{2.25(18')(12)}{6.28\ in} = 77.4 \leq 200$$ CONTROLS

$$\left(\frac{KL}{r}\right)_y = \frac{0.79(18')(12)}{3.76\ in} = 45.4 \leq 200$$

SERVICEABILITY OK

NO NOTATION ∴ NO LOCAL BUCKLING

$$f_e = \frac{\pi^2 E}{\left(\frac{kL}{r}\right)^2_{max}} = \frac{\pi^2 (29000 \text{ ksi})}{(77.4)^2} = 47.8 \text{ ksi} > 22 \text{ ksi}$$

∴ Inelastic Buckling

$$f_{cr} = \left(0.658^{f_e/f_y}\right) f_y = \left(0.658^{47.8/50}\right)(50) = 33.51 \text{ KSI}$$

$$\phi_c P_n = \phi_c f_{cr} A_g = 0.9\,(33.51 \text{ ksi})(38.8 \text{ in}^2) = \underline{\underline{1170.2 \text{ k}}}$$