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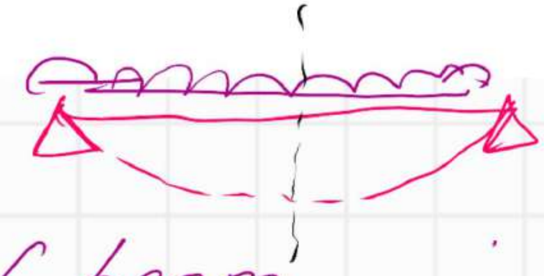
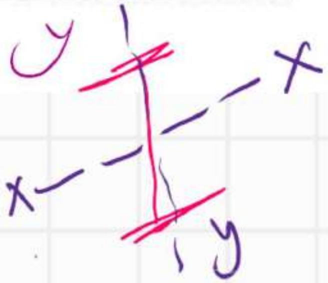
Summary of the content of posts 2-2a

3.2 COLUMN BUCKLING

- Consider a long slender compression member. If an axial load P is applied and increased slowly, it will ultimately reach a value P_{cr} that will cause buckling of the column. P_{cr} is called the critical buckling load of the column.

Any Loading





Link to post 2- compression

Case of beam

Due to Loading (any type) There will be a moment about major axis x_x and deflection

X_X is the major axis

Y-Y is the minor axis

Deflection is about major axis

movement in Y_Y direction

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The difference between beam buckling and column buckling-beam case

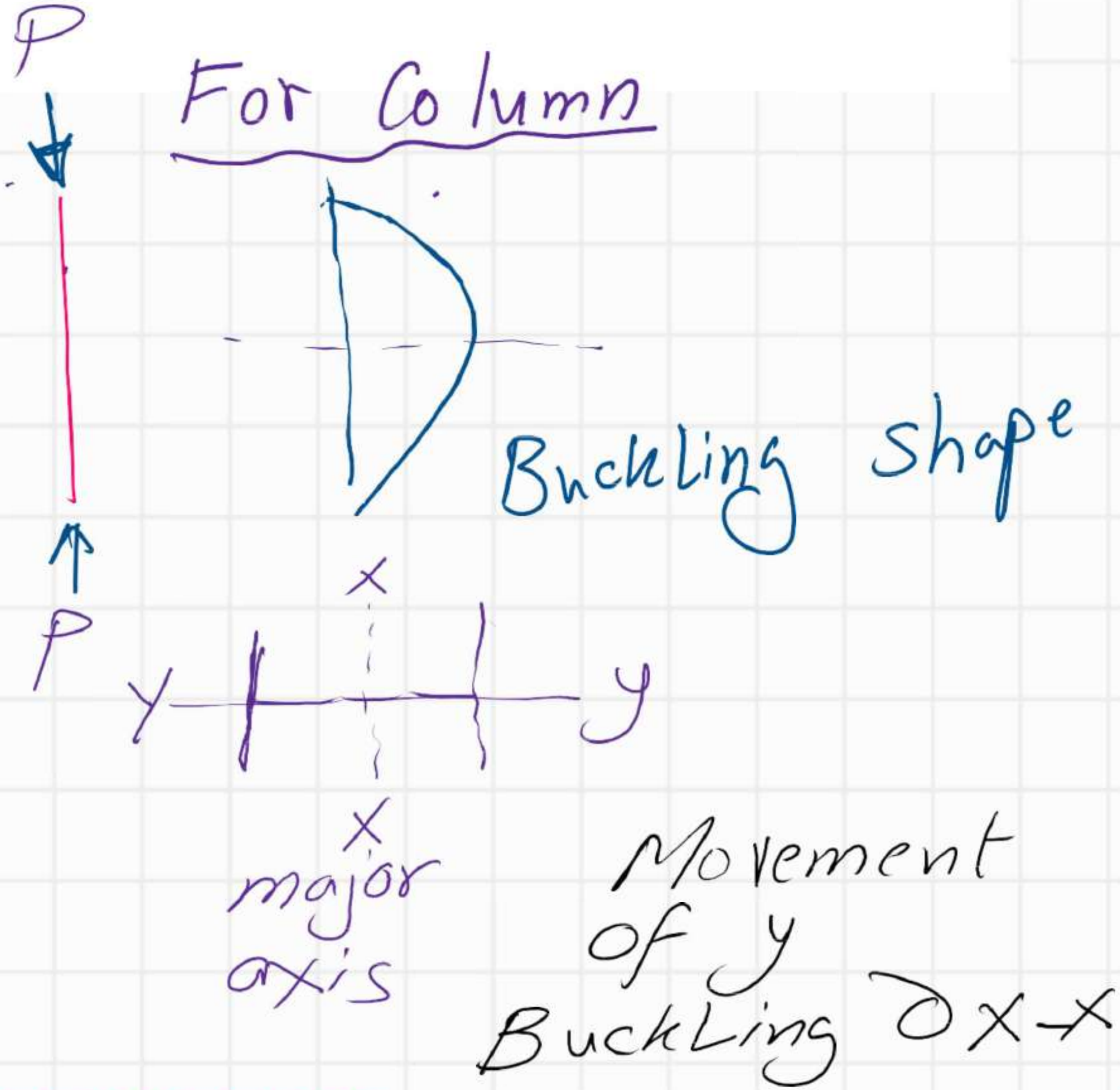
3.2 COLUMN BUCKLING

- Consider a long slender compression member. If an axial load P is applied and increased slowly, it will ultimately reach a value P_{cr} that will cause buckling of the column. <u>P_{cr} is called the critical buckling load of the column.</u>

The difference between beam buckling and column buckling-Column case.

<u>Case of Column</u>

Buckling occurs when a straight Column under axial Compression undergoes bending



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Effective length method-Appendix-7-AISC.

APPENDIX 7

ALTERNATIVE METHODS OF DESIGN FOR STABILITY

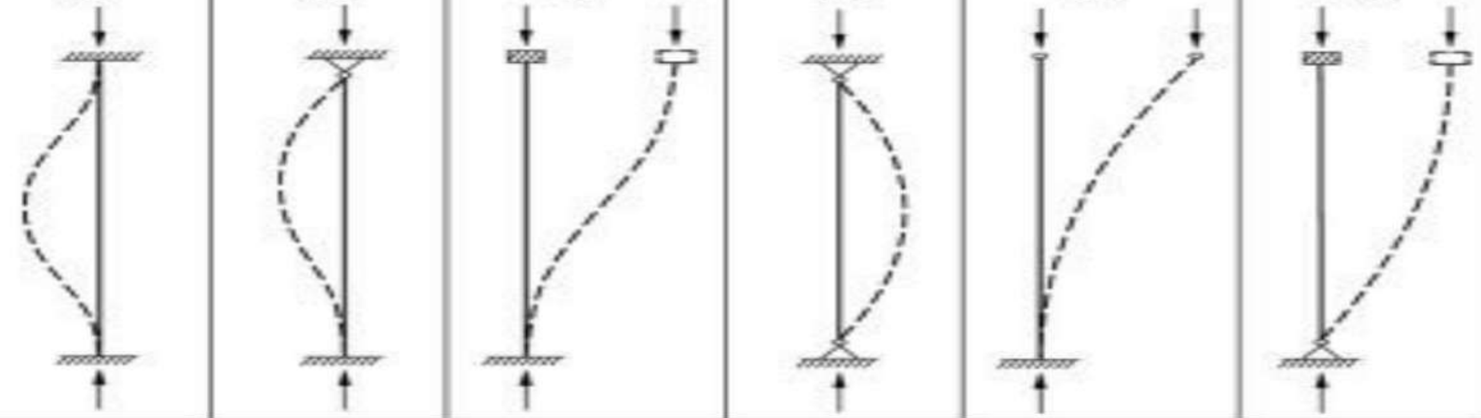
The effective length method and first-order analysis method are addressed in this Appendix as alternatives to the direct analysis method, which is presented in Chapter C. These alternative methods of design for stability can be used when the limits on their use as defined in Appendix 7, Sections 7.2.1 and 7.3.1, respectively, are satisfied.

The effective length, $L_c = KL$, for column buckling based upon elastic (or inelastic) stability theory, or alternatively the equivalent elastic column buckling stress, $F_e = \pi^2 E/(L_c/r)^2$, is used to calculate an axial compressive strength, P_c, through an empirical column curve that accounts for geometric imperfections and distributed yielding (including the effects of residual stresses). This column strength is then combined with the available flexural strength, M_c, and second-order member forces, P_r and M_r, in the beam-column interaction equations.

L_c	Effective length of member, in. (mm)	E2
L_{cx}	Effective length of member for buckling about x-axis, in. (mm)	E4
L_{cy}	Effective length of member for buckling about y-axis, in. (mm)	E4

Effective length method-Table C-A-7.1-AISC.

TABLE C-A-7.1
Approximate Values of Effective Length Factor, *K*

	(a)	(b)	(c)	(d)	(e)	(f)
Buckled shape of column is shown by dashed line						
Theoretical *K* value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design value when ideal conditions are approximated	0.65	0.80	1.2	1.0	2.1	2.0
End condition code	 Rotation fixed and translation fixed Rotation free and translation fixed Rotation fixed and translation free Rotation free and translation free					

L_c	Effective length of member, in. (mm)	E2
L_{cx}	Effective length of member for buckling about *x*-axis, in. (mm)	E4
L_{cy}	Effective length of member for buckling about *y*-axis, in. (mm)	E4

Elastic buckling stress using E, Lc, and r.

F_e = elastic buckling stress determined according to Equation E3-4, as specified in Appendix 7, Section 7.2.3(b), or through an elastic buckling analysis, as applicable, ksi (MPa)

$$= \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2} \quad \text{(E3-4)}$$

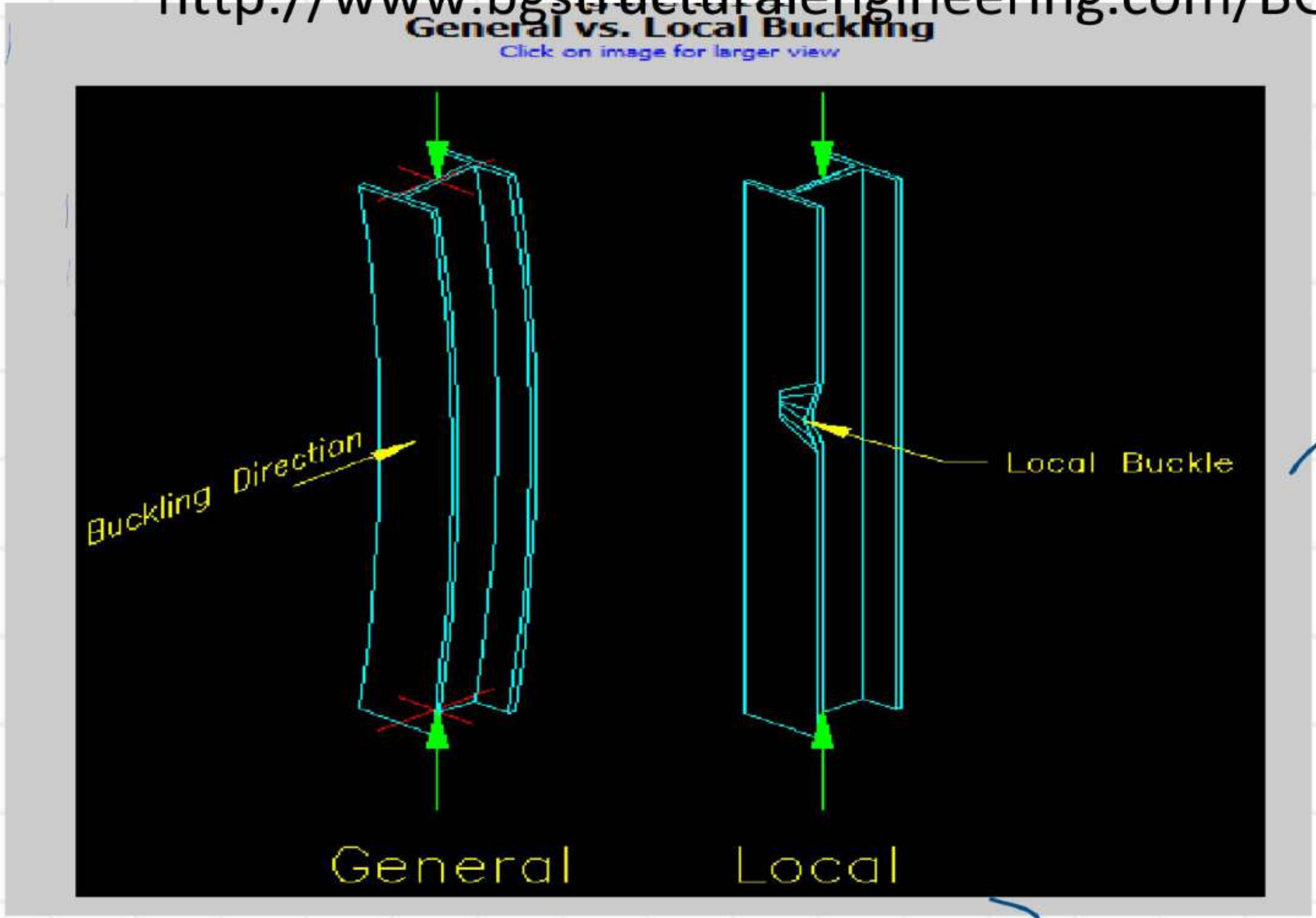
F_y = specified minimum yield stress of the type of steel being used, ksi (MPa)

r = radius of gyration, in. (mm)

Local buckling and general buckling

http://www.bgstructuralengineering.com/BGSCM15/BGSCM006/index.htm

CM #15



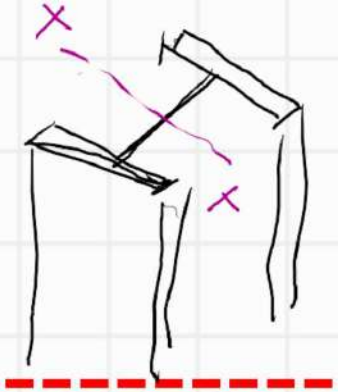
A Beginner's Guide to the Steel Construction Manual, 15th ed.

Chapter 6 - Buckling Concepts

This is a Local Buckling

This is a buckling about X - X axis

General



Difference between

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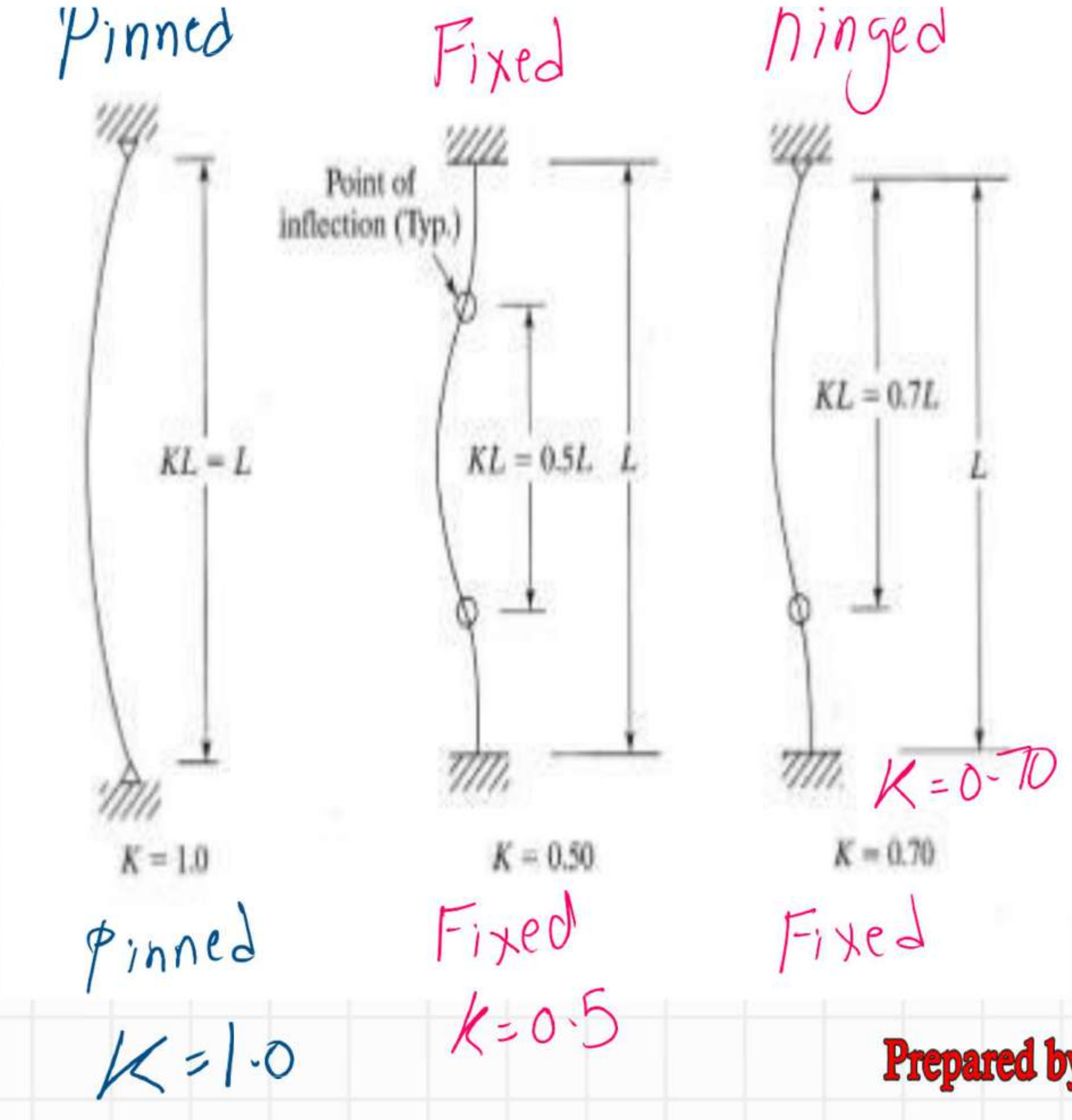
Buckling values for different end conditions



Difference between X-X & Y-Y axes

Figure 6.2.1
Compression Member Principle Axis
Click on image for larger view

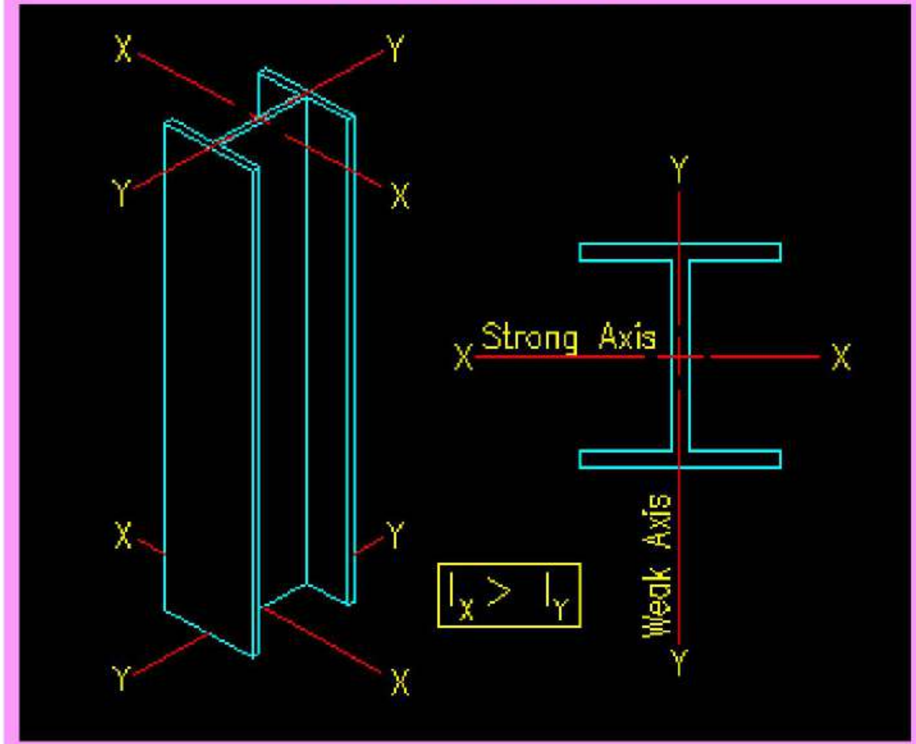


Figure 6.2.2
Compression Member Principle Planes

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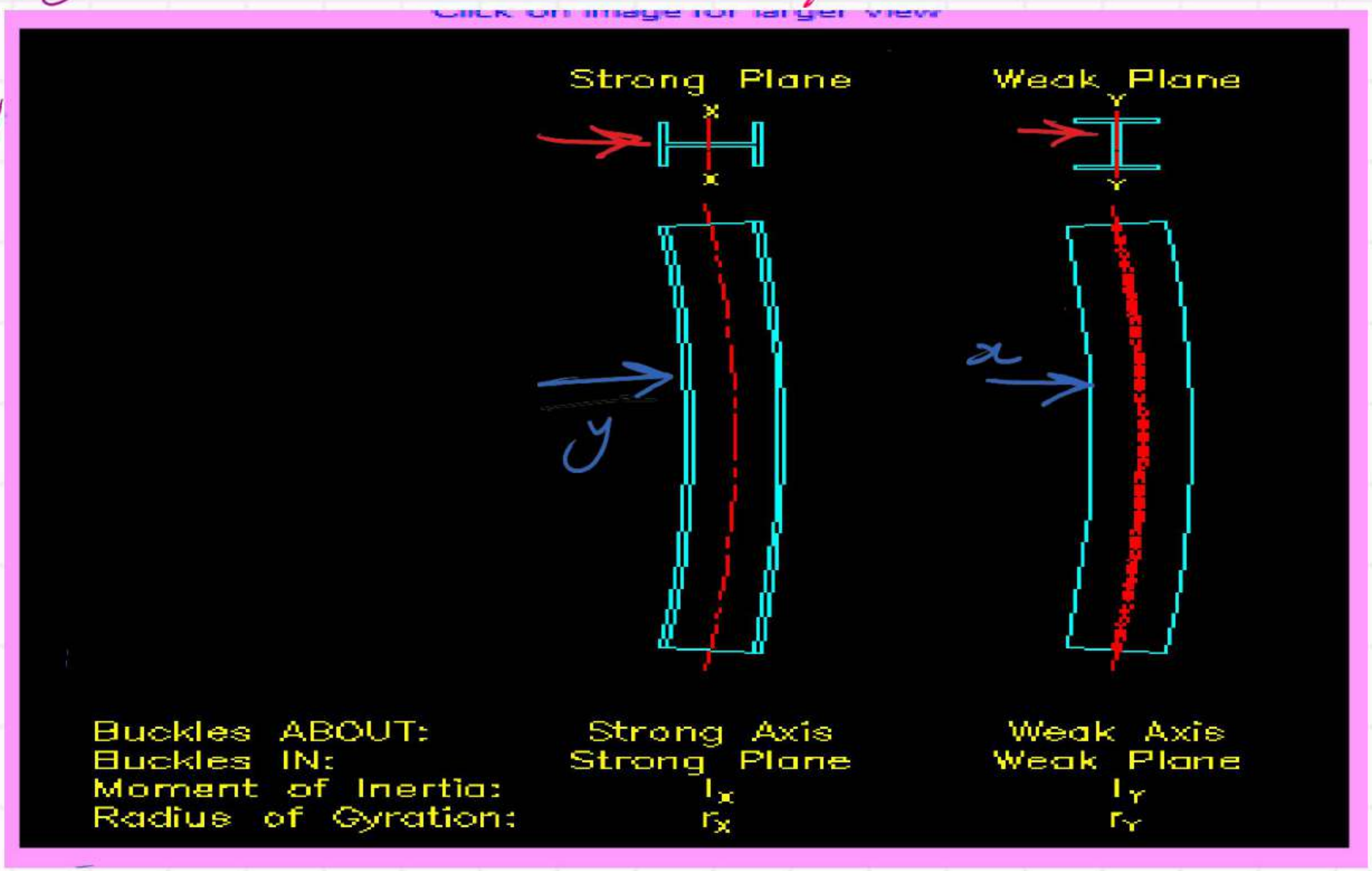
X-X major
Y-Y minor

Strong axis Buckling

Movement in y



Weak axis buckling

Accompanied by movement in X-direction

General buckling

The difference between the week and the strong column buckling.

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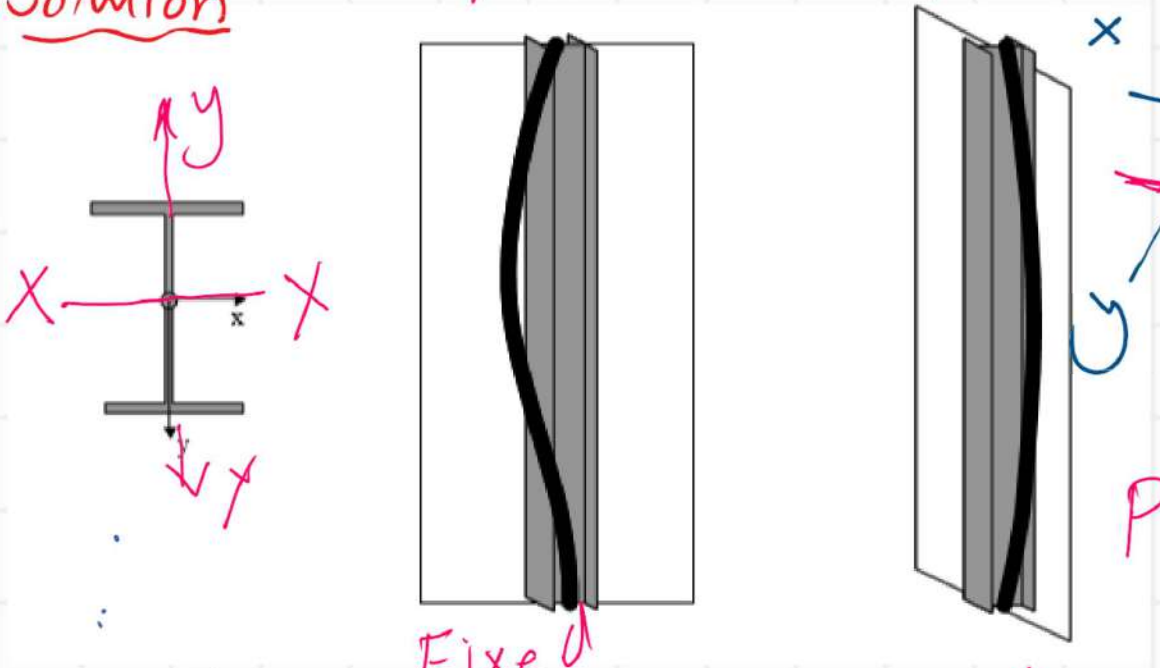
Determine the buckling strength of a W 12 x 50 column. Its length is 20 ft. For minor-axis buckling, it is pinned at both ends. For major buckling, is it pinned at one end and fixed at the other end?

Solution

W12x50 $h = 20'$



movement in x-direction → Bending about y-y

minor buckling

A solved problem for the column's buckling.

$K = 0.70 \Rightarrow K = 0.80$

$K = 1$

$(KL)_x = 0.8(20) = 16'$

$(KL)_y = 1(20) = 20'$

Prepared by Eng.Maged Kamel.

Table 1-1 (continued)
W-Shapes
Properties

W12 X 50

W14-W12

Nom-inal Wt.	Compact Section Criteria		Axis X-X				Axis Y-Y				r_{ts}	h_o	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	I	S	r	Z	I	S	r	Z			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}
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

From Table 1-1

$A = 14.60$ inch^2

$I_x = 391$ inch^4

$I_y = 56.3$ inch^4

$A r_x^2 = I_x$

$L = 20'$

E value = 29000 ksi

$$P_{cr_x} = \frac{\pi^2 E I_x}{(KL)_x^2}$$

Buckling about X–X major

$K = 0.80$ $\quad (KL)_x = (0.8)(20)(12) = 192''$

$P_{cr\,x} = (3.14159)^2 (29)(10^3)(391) / (192)^2 = 3035.90$ kips

The value of the compression force for buckling in the x-direction

Prepared by Eng.Maged Kamel.

The value of the compression force for buckling in the Y-direction

Table 1-1 (continued)
W-Shapes
Properties

W12 X 50

W14-W12

Nominal Wt.	Compact Section Criteria		Axis X-X				Axis Y-Y				r_{ts}	h_o	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	I	S	r	Z	I	S	r	Z			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
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

From Table 1-1

$A = 14.60$ inch^2

$I_x = 391$ inch^4

$I_y = 56.3$ inch^4

$A r_x^2 = I_x$

$L = 20'$

E value $= 29000$ ksi

$$P_{cr_y} = \frac{\pi^2 E I_y}{(KL)_y^2}$$

Buckling about Y-Y minor

$K = 1$ $\quad (KL)_y = 1\,(20)(12) = 240''$

$P_{cry} = (3.14159)^2 (29)(10^3)(56.3) / (240)^2 = 279.76$ kips

$P_{c_F} = \min(3035.90, 279.76) = 279.75$ kips

Buckling ∂ Y governs

Prepared by Eng.Maged Kamel.

Case of yielding prior to buckling

Yielding prior to buckling

W 12 x 50

In the previous Example $P_{cry} = 279.76$ kips

Area = 14.60 inch²

$(F_E)_y = 279.76 / 14.60 = 19.60$ ksi $< F_y$

where $F_y = 50$ ksi Buckling occurs prior to Buckling

But if Column is reduced to 10' For same problem

$$F_E = \frac{\pi^2 E I_y}{(KL)^2 A} = \frac{\pi^2 (29000)(56.30)}{(120)^2 (14.6)} = 76.65 \text{ ksi} > 50 \text{ ksi}$$

Case of yielding prior to buckling

- **Notes:**

- *Minor axis buckling usually governs for all doubly symmetric cross-sections. However, for some cases, major (x) axis buckling can govern.*
- *Note that the steel yield stress was irrelevant for calculating this buckling strength.*

3.3 INELASTIC COLUMN BUCKLING

Prof. varma notes

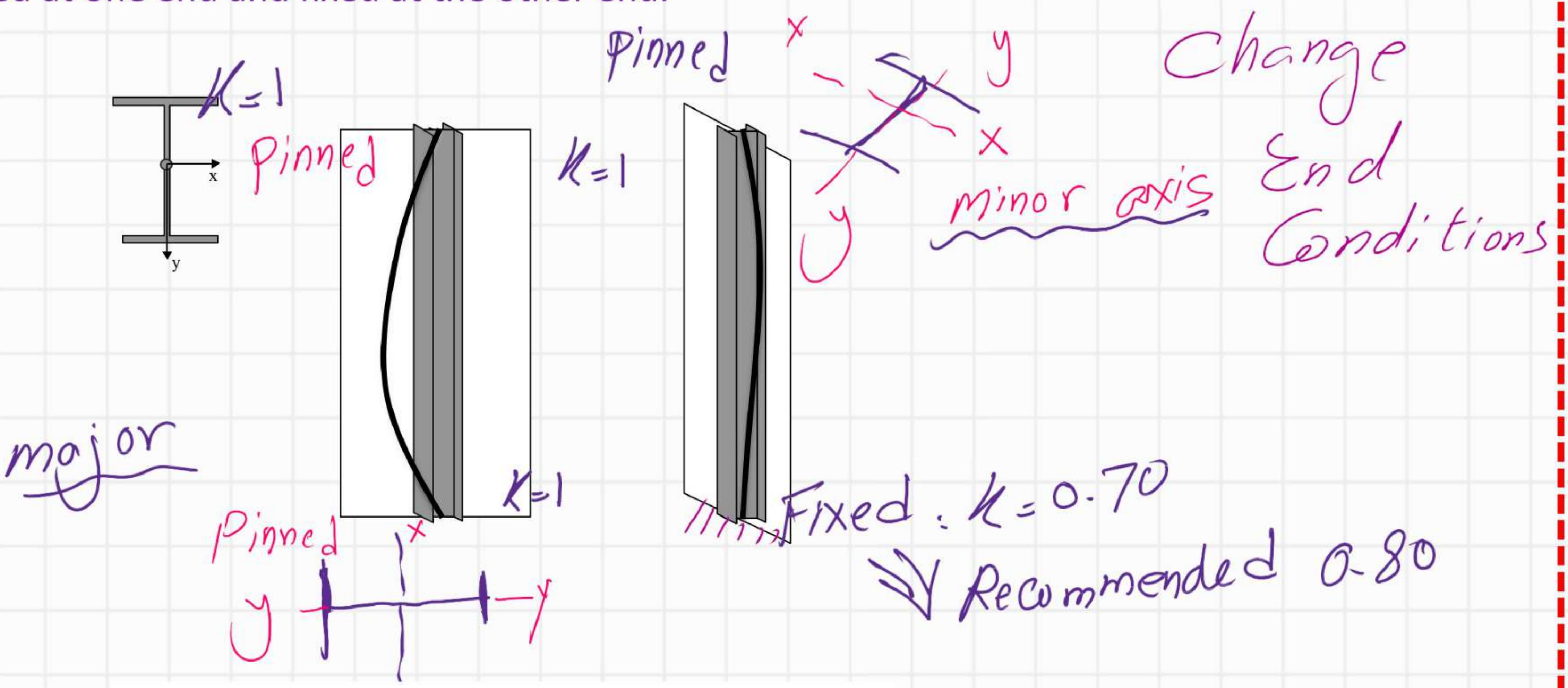
- Let us consider the previous example. According to our calculations P_{cr} = 279.8 kips. This will cause a uniform stress $f = P_{cr}/A$ in the cross-section
- For W12 x 50, A = 14.6 in^2. Therefore, for P_{cr} = 279.8 kips; f = 19.16 ksi

  The calculated value of f is within the elastic range for a 50 ksi yield stress material.
- However, if the unsupported length was only 10 ft., $P_{cr} = \frac{\pi^2 E I_y}{(K_y\ L_y)^2}$ would be calculated as 1119 kips, and f = 76.6 kips.

Yielding prior to buckling

Determine the buckling strength of a W12 x 50 steel column.

Its length is 20 ft. For major axis buckling, it is pinned at both ends. For minor buckling, is it pinned at one end and fixed at the other end.



A solved problem, the same as the previous but with a change of column orientation

Table 1-1 (continued)
W-Shapes
Properties

W12 X 50

W14-W12

Nom-inal Wt.	Compact Section Criteria		Axis X-X				Axis Y-Y				r_{ts}	h_o	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	I	S	r	Z	I	S	r	Z			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}
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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

From Table 1-1

$I_x = 391$ inch^4

$I_y = 56.3$ inch^4

$A = 14.60$ inch^2

$Ar_x^2 = I_x$

$L = 20'$

E value = 29000 ksi

$$P_{cr_x} = \frac{\pi^2 E I_x}{(KL)_x^2}$$

Buckling about X–X major

$K = 1$ $\quad (KL)_x = (1)(20)(12) = 240''$

$P_{cr\,x} = (3.14159)^2 (29)(10^3)(391) / (240)^2 = 1942.90$ kips

The value of the compression force for buckling in the X-direction

Prepared by Eng.Maged Kamel.

The value of the compression force for buckling in the Y-direction

d)

W-Shapes

Properties

W14-W12

W12 X 50

Nom-inal Wt.	Compact Section Criteria		Axis X-X				Axis Y-Y				r_{ts}	h_o	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	I	S	r	Z	I	S	r	Z			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
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
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From Table 1-1

$I_x = 391$ inch^4

$I_y = 56.3$ inch^4

$A = 14.60$ inch^2

$A r_x^2 = I_x$

$L = 20'$

E value = 29000 ksi

$$P_{cr_y} = \frac{\pi^2 E I_y}{(KL)_y^2}$$

Buckling about Y-Y minor

$K = 0.80$ $(KL)_y = 0.8(20)(12) = 192''$

$P_{cry} = (3.14159)^2(29)(10^3)(56.3) / (192)^2 = 437.12$ K

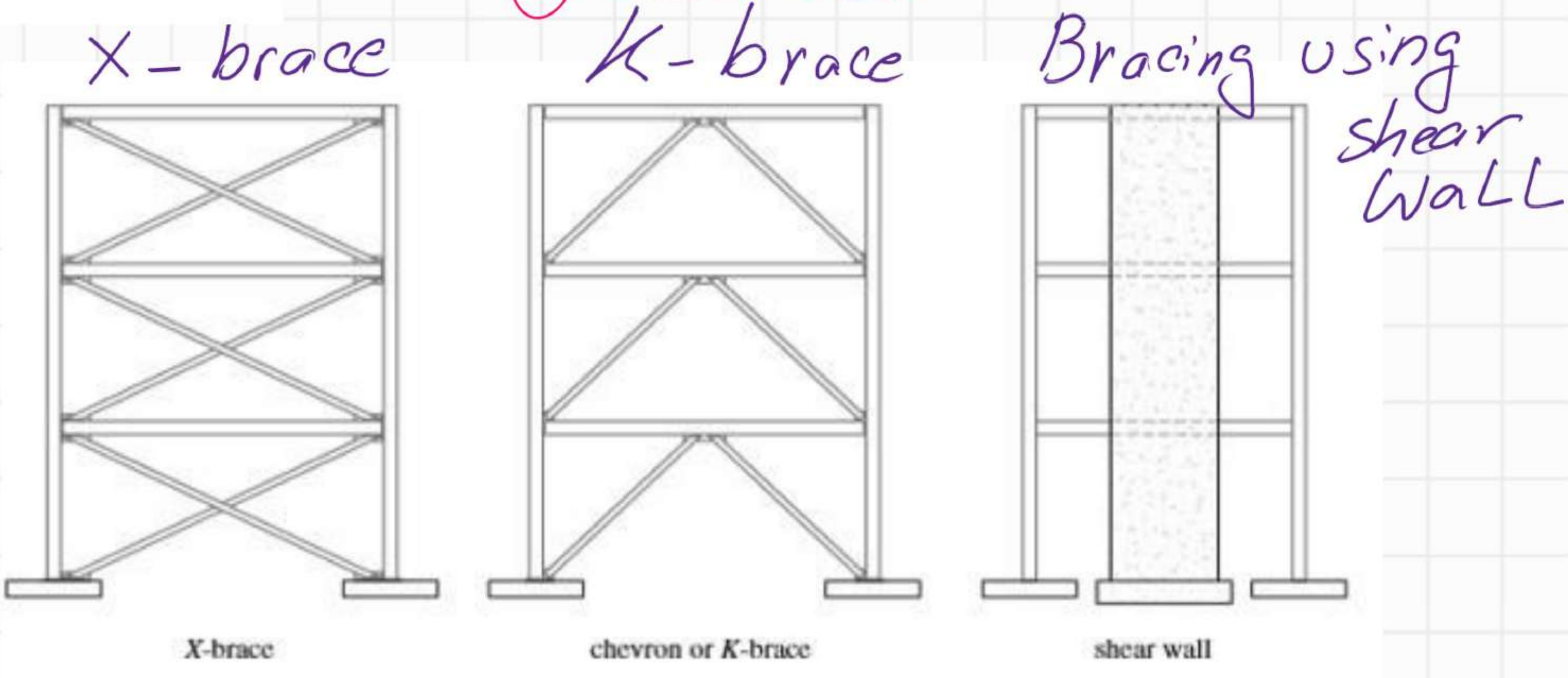
$P_{c_F} = \min(1942.9, 437.12) = 437.12$ K

Buckling @ Y governs

Prepared by Eng.Maged Kamel.

Types of bracing for frames

Types of bracing



a. braced frames

Prepared by Eng.Maged Kamel.

Braced and unbraced frames

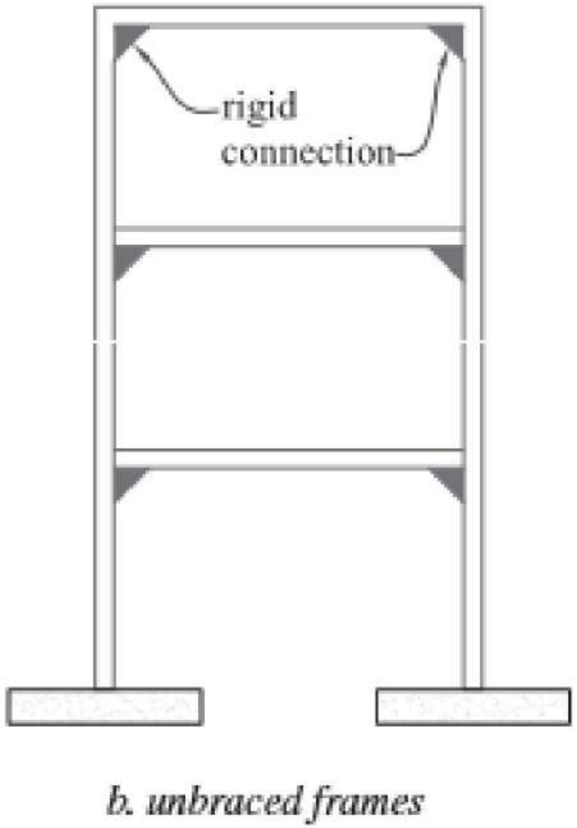
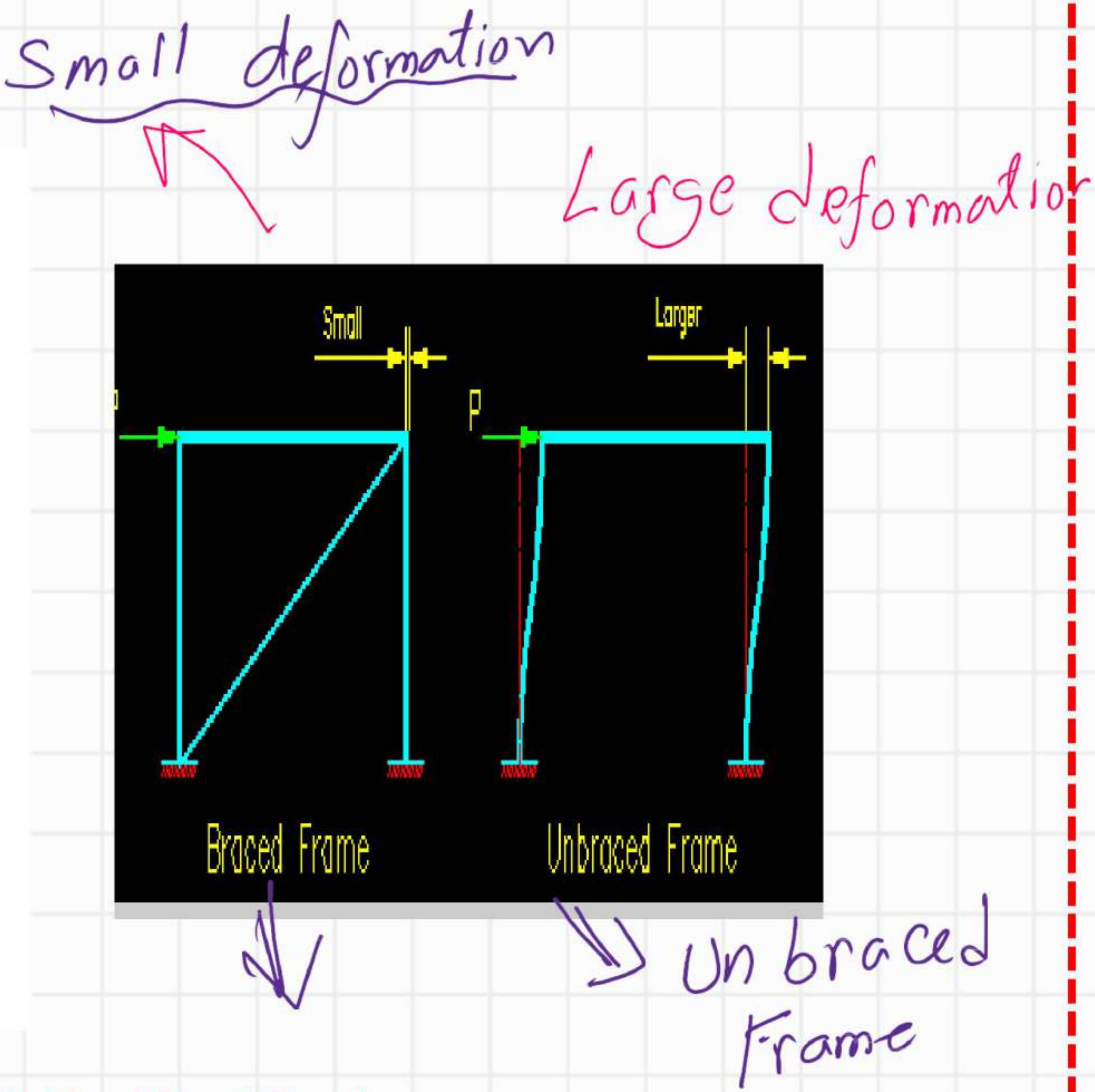


Figure 5-4 Braced and unbraced frames.



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