CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 15
FLEXURAL MEMBER

SEMESTER: SUMMER 2021

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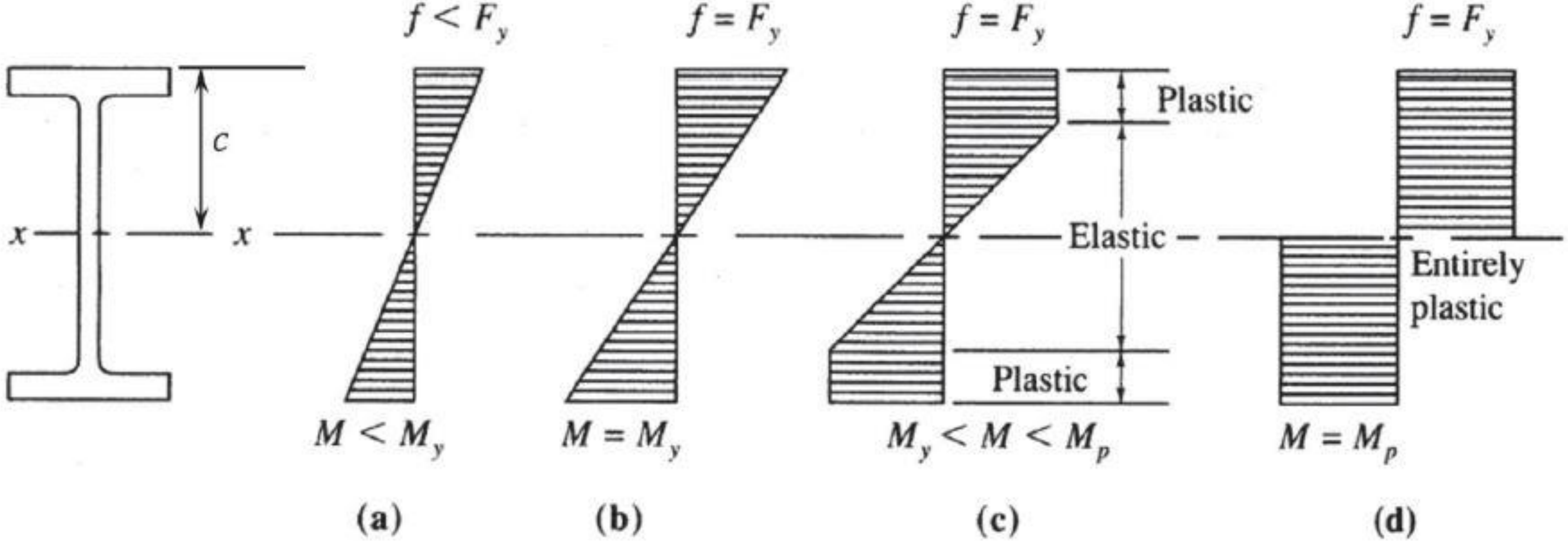
OUTLINE

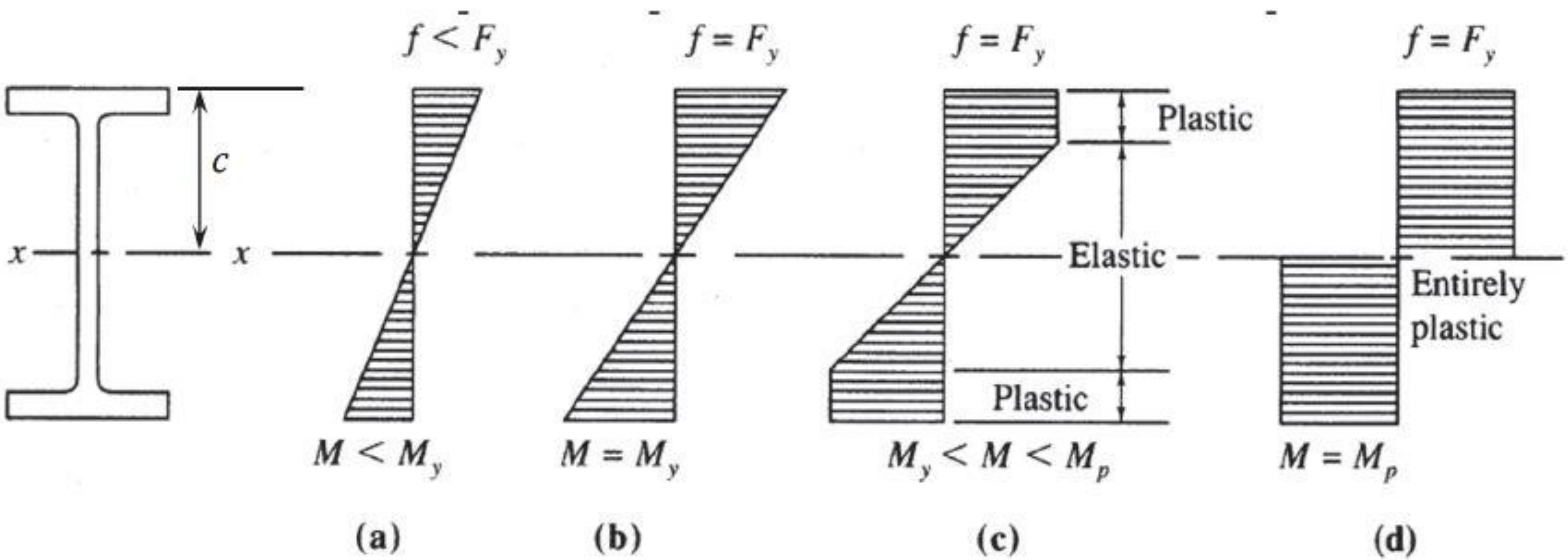
- Stress diagram-compact and non-compact section
- Moment capacity of compact section and partially compact section
- Investigate local buckling



When the yield stress is reached at the extreme fiber [Fig. (b)], the nominal moment strength M_n is referred to as the yield moment M_y and is computed as

$$M_n = M_y = S_x F_y$$

Where S_x = section modulus = I_x/c



When the condition of Fig. (d) is reached, every fiber has a strain equal to or greater than $\varepsilon_y = F_y/E_s$ i.e., it is in the plastic range. The nominal moment strength M_n is therefore referred to as the plastic moment M_p, and is computed as.

$$M_p = F_y \int_A y\, dA = F_y Z$$

$$Z = \int y\, dA$$ → **Plastic section modulus**

NOMINAL MOMENT CAPACITY OF LATERALLY SUPPORTED BEAMS

Compact Sections

The nominal strength M_n for laterally stable "compact sections" according to AISC may be stated,

$$M_n = M_p = F_y Z_x$$

Where, M_p = Plastic moment capacity

Z_x = Plastic section modulus

F_y = Specified minimum yield stress.

In order to develop full plastic moment, the b/t ratio ($b=b_f/2$) for flange must be smaller than the limit λ_p defined by AISC.

Local buckling in hot-rolled I-shaped sections is, for practical purposes, only possible in the flanges.

Partially Compact Sections

The nominal strength M_n for laterally stable "noncompact sections" whose flange width/thickness ratios λ are less than λ_r but not as low as λ_p must be linearly interpolated between M_p and M_r = 0.7 $F_y S_x$

$$M_n = M_p - (M_p - 0.7F_y S_x)\left(\frac{\lambda - \lambda_{pf}}{\lambda_{rf} - \lambda_{pf}}\right)$$

where $\lambda = b_f/2t_f$ for I-shaped member flanges

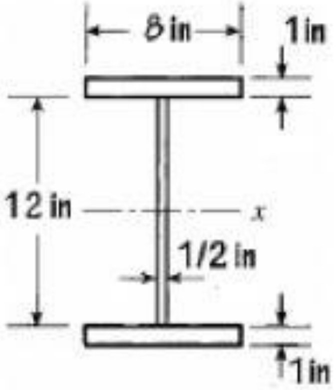
b_f = flange width

t_f = flange thickness

λ_{pf} = compact limit for reaching M_p (AISC-Table B4.1)

λ_{rf} = noncompact limit for reaching M_r (AISC-Table B4.1)

Ques. Investigate the local stability of the following section.



Flange Buckling Check

$$\lambda = \frac{b_f}{2t_f} = \frac{8}{2\times 1} = 4$$

$$\lambda_p = 0.38\sqrt{E/F_y} = 0.38\sqrt{29000/50} = 9.15$$

Since $\lambda(4) < \lambda_p(9.15)$, flange is compact.

Web Buckling Check

$$\lambda = \frac{h}{t_w} = \frac{12}{0.5} = 24$$

$$\lambda_p = 3.76\sqrt{E/F_y} = 3.76\sqrt{29000/50} = 90.6$$

Since $\lambda(24) < \lambda_p(90.6)$, web is also compact.

Ans. Section is compact.

Ques. Investigate the local stability of section W14 × 90

Solution.
From Table 1-1 of AISC Manual, we find,

Section	b_f	t_f	d	k_{des}	t_w
W14 × 90	14.5	0.71	14	1.31	0.44

Flange Buckling Check

$$\lambda = \frac{b_f}{2t_f} = \frac{14.5}{2\times 0.71} = 10.2$$

$$\lambda_p = 0.38\sqrt{E/F_y} = 0.38\sqrt{29000/50} = 9.15$$

$$\lambda_r = 1.00\sqrt{E/F_y} = 0.38\sqrt{29000/50} = 24.1$$

Since $\lambda_p(9.15) < \lambda(10.2) < \lambda_r(24.1)$, flange is noncompact.

Web Buckling Check

$$\lambda = \frac{h}{t_w} = \frac{d - 2k_{des}}{t_w} = \frac{14 - 2\times 1.31}{0.44} = 25.86$$

$$\lambda_p = 3.76\sqrt{E/F_y} = 3.76\sqrt{29000/50} = 90.6$$

Since $\lambda(25.8) < \lambda_p(90.6)$, web is compact.

Ans. Section is noncompact (flange governs).

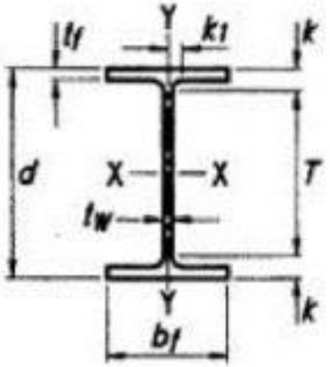


Table 1-1 (continued)
W Shapes
Dimensions

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}	Distance: k_1	Distance: T	Distance: Workable 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	↓	↓
W14×53	15.6	13.9	13 7/8	0.370	3/8	3/16	8.06	8	0.660	11/16	1.25	1 1/2	1	10 7/8	5 1/2
×48	14.1	13.8	13 3/4	0.340	5/16	3/16	8.03	8	0.595	5/8	1.19	1 7/16	1	↓	↓
×43[c]	12.6	13.7	13 5/8	0.305	5/16	3/16	8.00	8	0.530	1/2	1.12	1 3/8	1	↓	↓