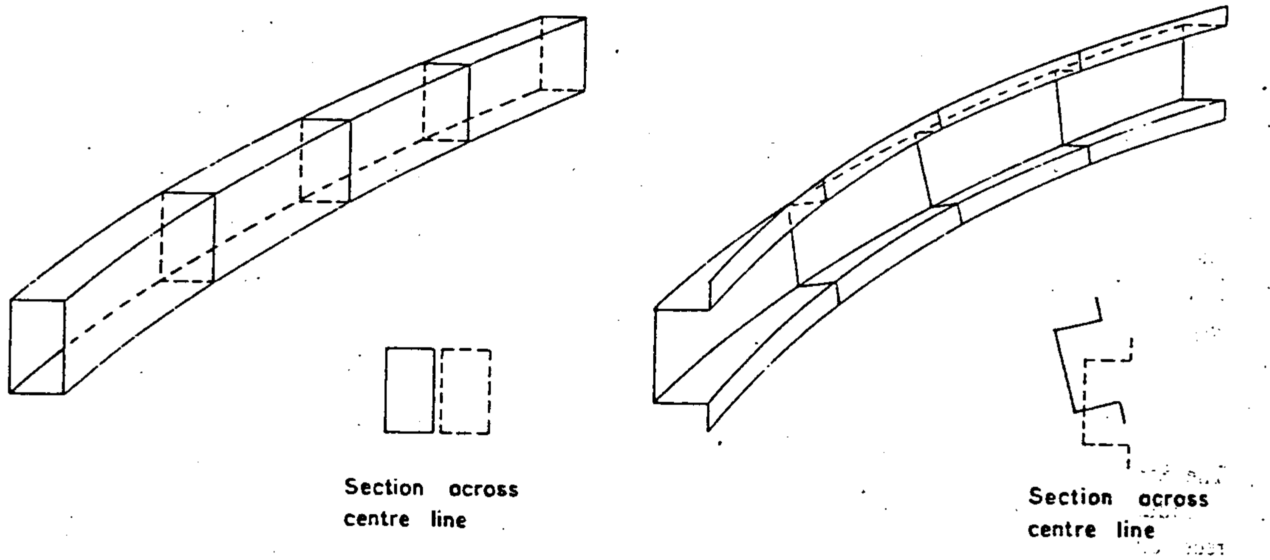
INSTABILITÀ CORRENTI

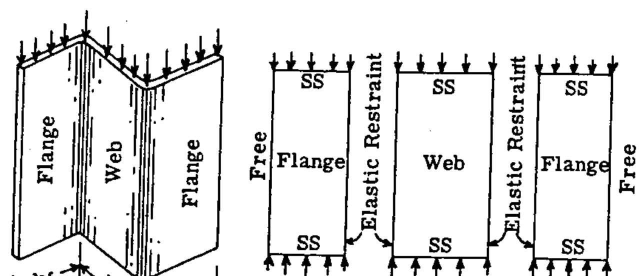


a. Flexural mode

b. Torsional-flexural mode

Instabilità globali

Instabilità Euleriana $\quad \sigma_{cr} = \dfrac{\pi^2 E}{(L/\rho)^2}$



Breakdown of Z into Flange and Web Elements.

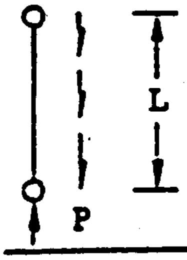
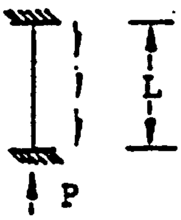
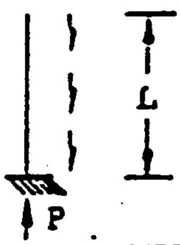
Instabilità locali

Flangia : $\sigma_{cr_f} = \dfrac{\pi^2 \cdot .43\, E}{12(1-\nu^2)} \left(\dfrac{t_f}{b_f}\right)^2$

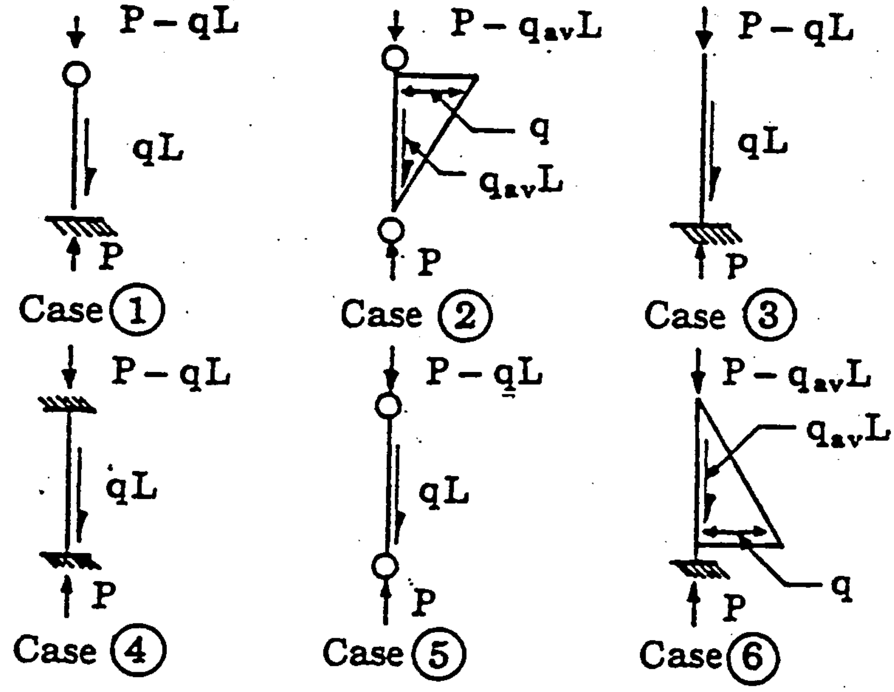
Anima : $\sigma_{cr_a} = \dfrac{\pi^2\, 4.\, E}{12(1-\nu^2)} \left(\dfrac{t_a}{b_a}\right)^2$

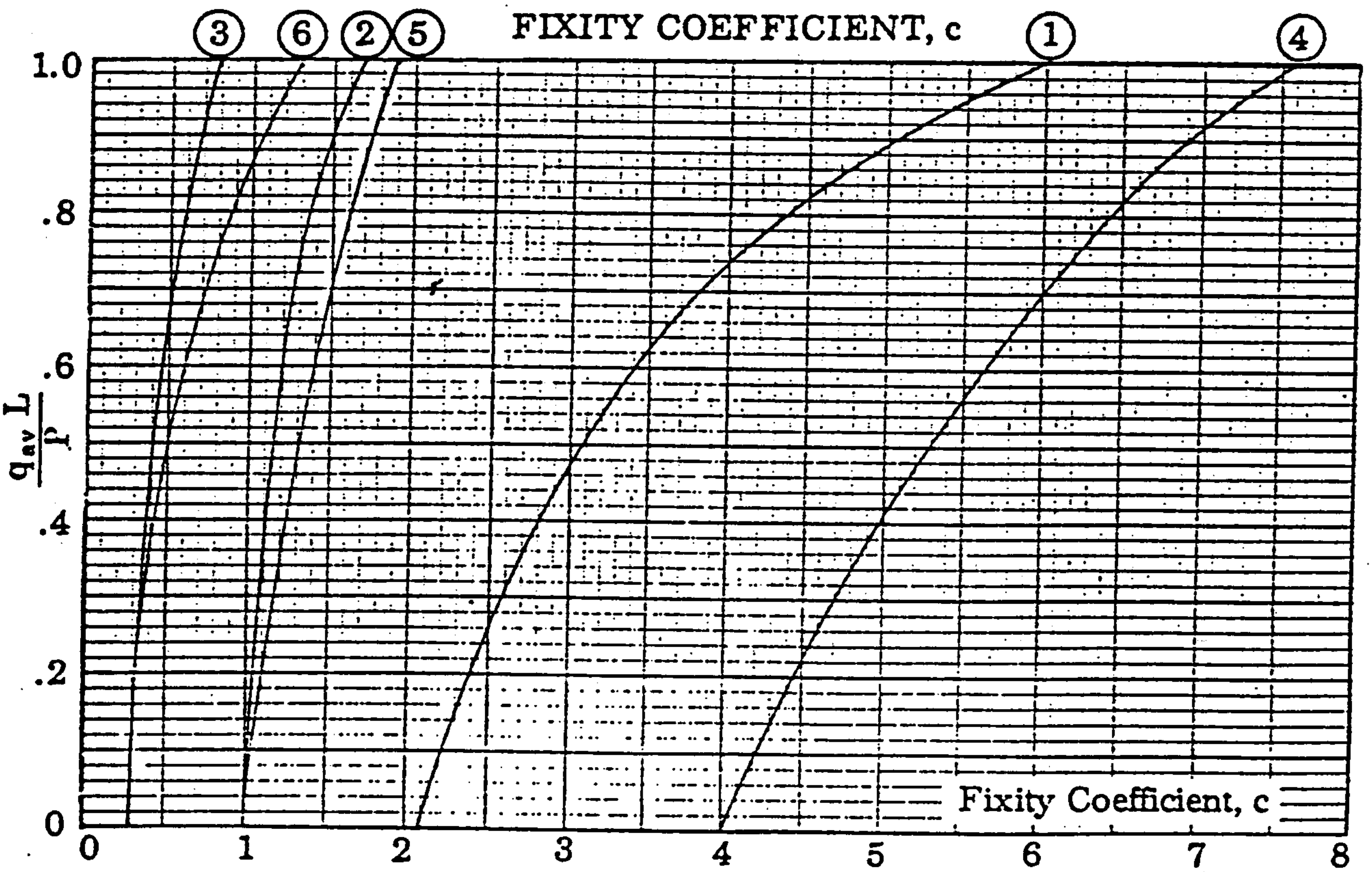
$\Rightarrow \sigma_{BUCK} = \min(\sigma_{cr_f}, \sigma_{cr_a})$

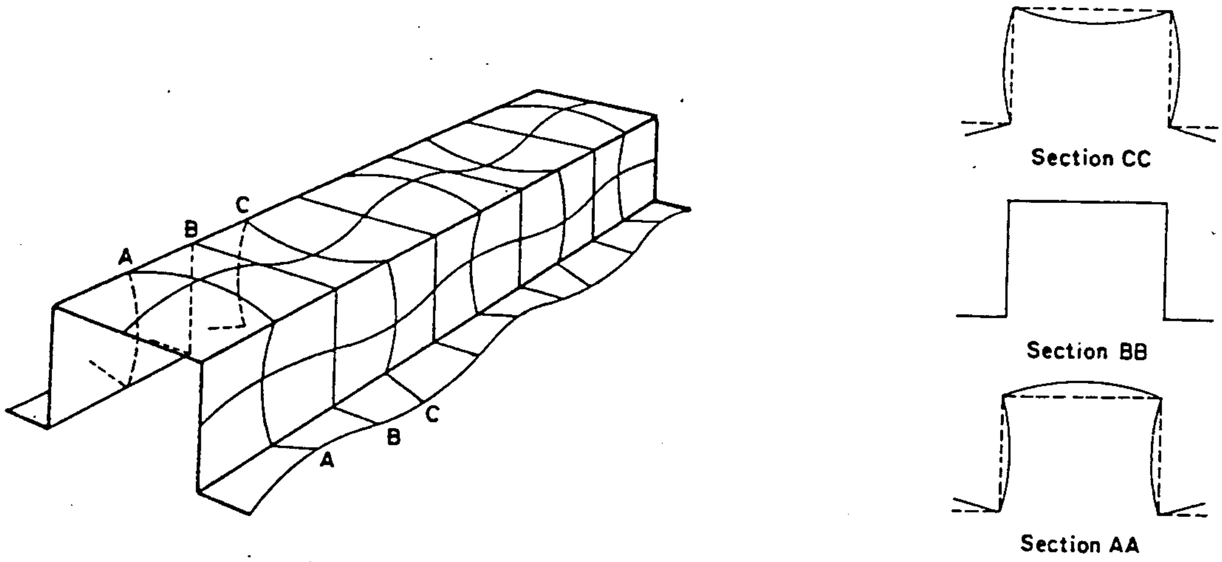
FIXITY COEFFICIENTS FOR COLUMNS WITH VARIOUS END CONDITIONS

lumn Shape and End Condition		Loading Type	End Fixity Coefficient	
			c	$1/\sqrt{c}$
	Uniform column, pinned ends	Concentrated axial load	1.0	1.0
		Distributed axial load	1.87	.732
	Uniform column, fixed ends	Concentrated axial loads	4.0	.50
		Distributed axial loads	7.5	.365
	Uniform column, one end fixed, one end pinned	Concentrated axial loads	2.05	.70
		Distributed axial loads	6.08 (approx)	.406
	Uniform column, one end fixed, one end free	Concentrated axial loads	.25	2.0
		Distributed axial loads	.794	1.12
All the above		Combination of distributed and concentrated axial loads	See Figure 2.2.1-2	

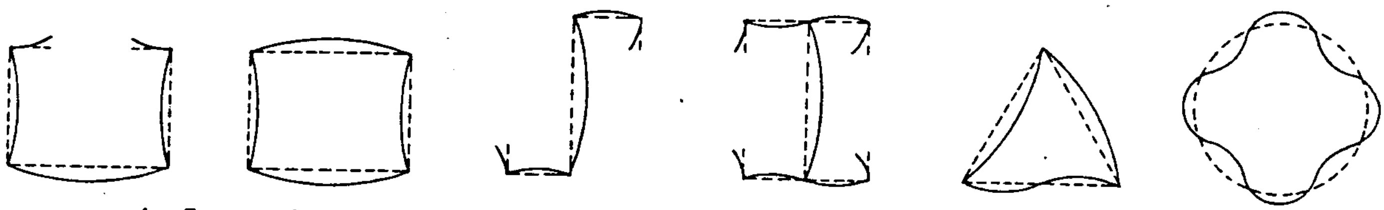
FIXITY COEFFICIENTS FOR UNIFORM COLUMNS WITH CONCENTRATED AXIAL AND DISTRIBUTED SHEAR LOADS



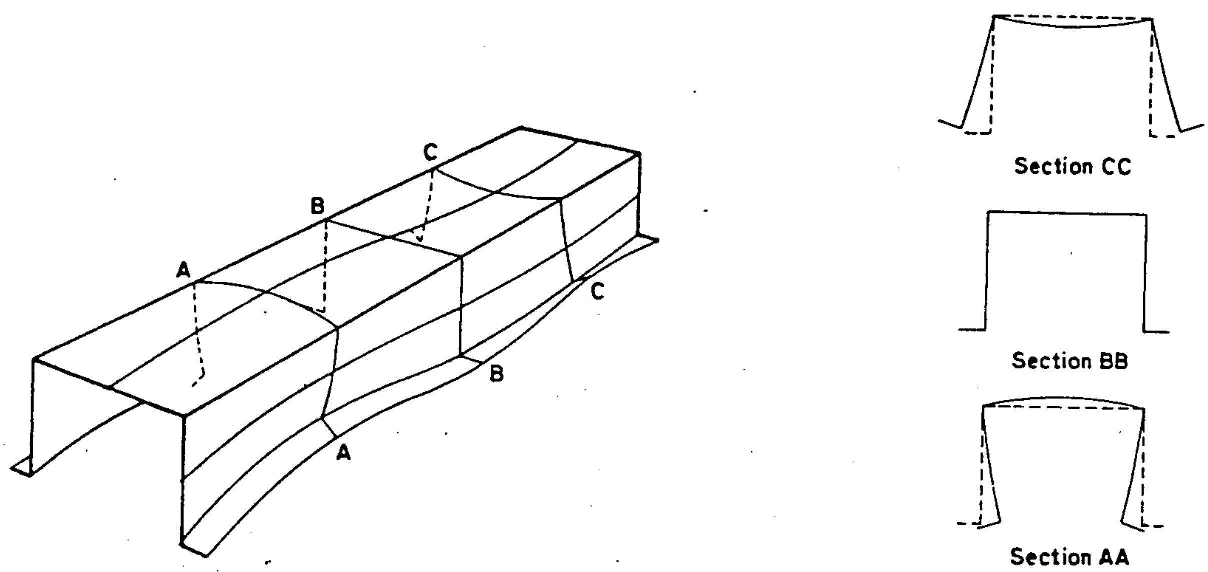




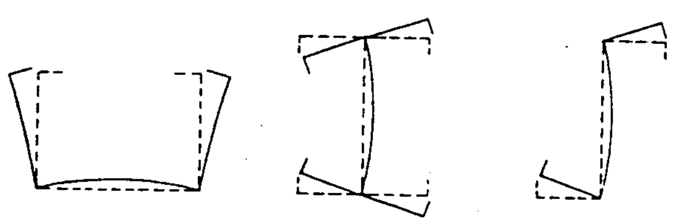
a. Local buckling of a lipped channel



b. Forms of local buckling of common sections



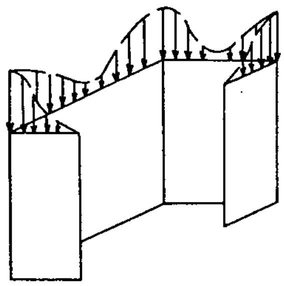
c. Flange buckling of a lipped channel



d. Forms of flange buckling of common strut sections

Instabilità locali

CRIPPLING



La sezione, dopo l'insorgere del local buckling, può sopportare ulteriore carico fino a:
- cedimento angoli (CRIPPL
- instabilità globale

METODO DI GERARD PER IL CALCOLO DELLO SFORZO DI CRIPPLING

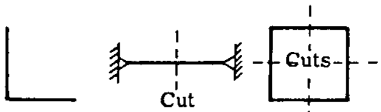
Angolari, tubi, multi-angolo :
$$\sigma_{CRP} = .56 \cdot \sigma_{SU} \left[\left(\frac{g t^2}{A} \right) \left(\frac{E}{\sigma_{SU}} \right)^{1/2} \right]^{.85}$$

Sezioni a T e H :
$$\sigma_{CRP} = .67 \, \sigma_{SU} \left[\left(\frac{g t^2}{A} \right) \left(\frac{E}{\sigma_{SU}} \right)^{1/2} \right]^{.40}$$

Sezioni a Z e [:
$$\sigma_{CRP} = 3.2 \, \sigma_{SU} \left[\left(\frac{t^2}{A} \right) \left(\frac{E}{\sigma_{SU}} \right)^{1/3} \right]^{.75}$$

Distorted Unloaded Edges

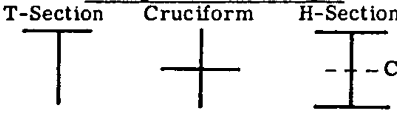
Angle	Plate	Tube



Basic Section	1 Cut	4 Cuts
g = 2	2 Flanges	8 Flanges
	3 = g	12 = g

Straight Unloaded Edges

T-Section	Cruciform	H-Section

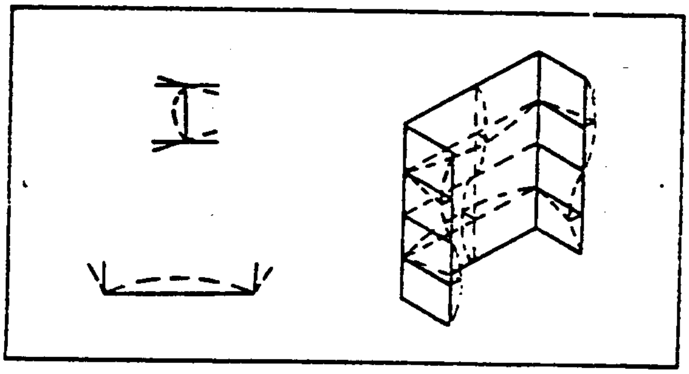


Basic Section	0 Cuts	1 Cut
g = 3	4 Flanges	6 Flanges
	4 = g	7 = g

Type of Section	Max. F_{cs}
Angles	$.7 F_{cy}$
V Groove Plates	F_{cy}
Multi-Corner Sections, Including Tubes	$.8 F_{cy}$
Stiffened Panels	F_{cy}
Tee, Cruciform and H Sections	$.8 F_{cy}$
2 Corner Sections. Zee, J, Channels	$.9 F_{cy}$

6.1 INTRODUCTION

Compression crippling is defined as an inelastic distortion of the cross-section of a structural element in its own plane resulting in permanent deformation of the section.



The maximum crippling strength of a structural element is calculated as a function of its cross-section rather than its length.

The crippling stress for a particular section is calculated as if the stress were uniform over the entire section. In reality, parts of the section buckle at a stress below the crippling stress with the result that the more stable areas, such as intersections and corners reach a higher stress than the buckled elements. At failure the stress in corners and intersections is always above the material yield stress although the crippling stress may be considerably less than the yield stress. Since there is not sufficient data to permit an exact solution for most materials, the compression yield strength is used as the crippling strength cutoff.

6.2 METHOD OF ANALYSIS

Since there is no proven analytical method for the prediction of the crippling strength, empirical techniques have been developed using coefficients derived from tests.

Formed and extruded sections are analyzed in the same manner, although different values for the coefficients are used for each. The sections are analyzed by the following procedures:

A. The section is broken down into individual segments as shown in Figures 6.2.1-1 and 6.2.2-1.

B. The allowable crippling stress for each segment is found from the applicable material curve: Figure 6.2.1-4 through 6.2.1-13 for formed sections and 6.2.2-4 through 6.2.2-9 for extruded sections. If no curve is available for the material in question a value within 10 to 15 percent may be obtained from the curves of the general solution Figures 6.2.1-3 or 6.2.2-3. The Structures Allowables Group should be consulted when more accurate values are required.

C. The allowable crippling stress for the entire section is computed by taking a weighted average of the allowables for each segment.

$$F_{cc} = \frac{b_1 t_1 F_{cc_1} + b_2 t_2 F_{cc_2} + \cdots}{b_1 t_1 + b_2 t_2 + \cdots} = \frac{\Sigma b_n t_n F_{cc_n}}{\Sigma b_n t_n}$$

where,

$b_1, b_2 \ldots$	Lengths of the individual segments
$t_1, t_2 \ldots$	Individual segment thickness
$F_{cc_1}, F_{cc_2} \ldots$	Allowable crippling stresses corresponding to computed b/t values of the individual segments.

6.2.1- FORMED SECTIONS

FORMED SECTION

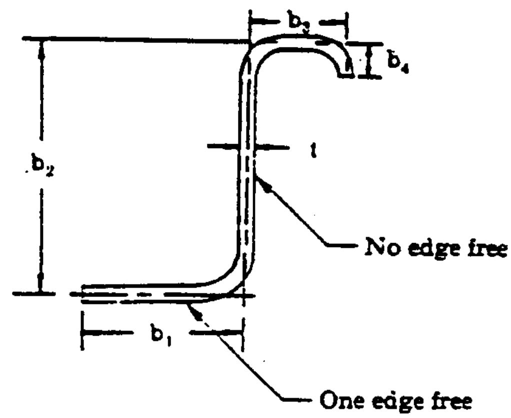


Figure 6.2.1-1

For formed sections, Figure 6.2.1-1, the bend radii are ignored, and only the idealized flat segments are considered. In a lipped section, Figure 6.2.1-2 should be consulted to determine whether the lip provides sufficient stability to the adjacent segment so that it acts like a no edge free element.

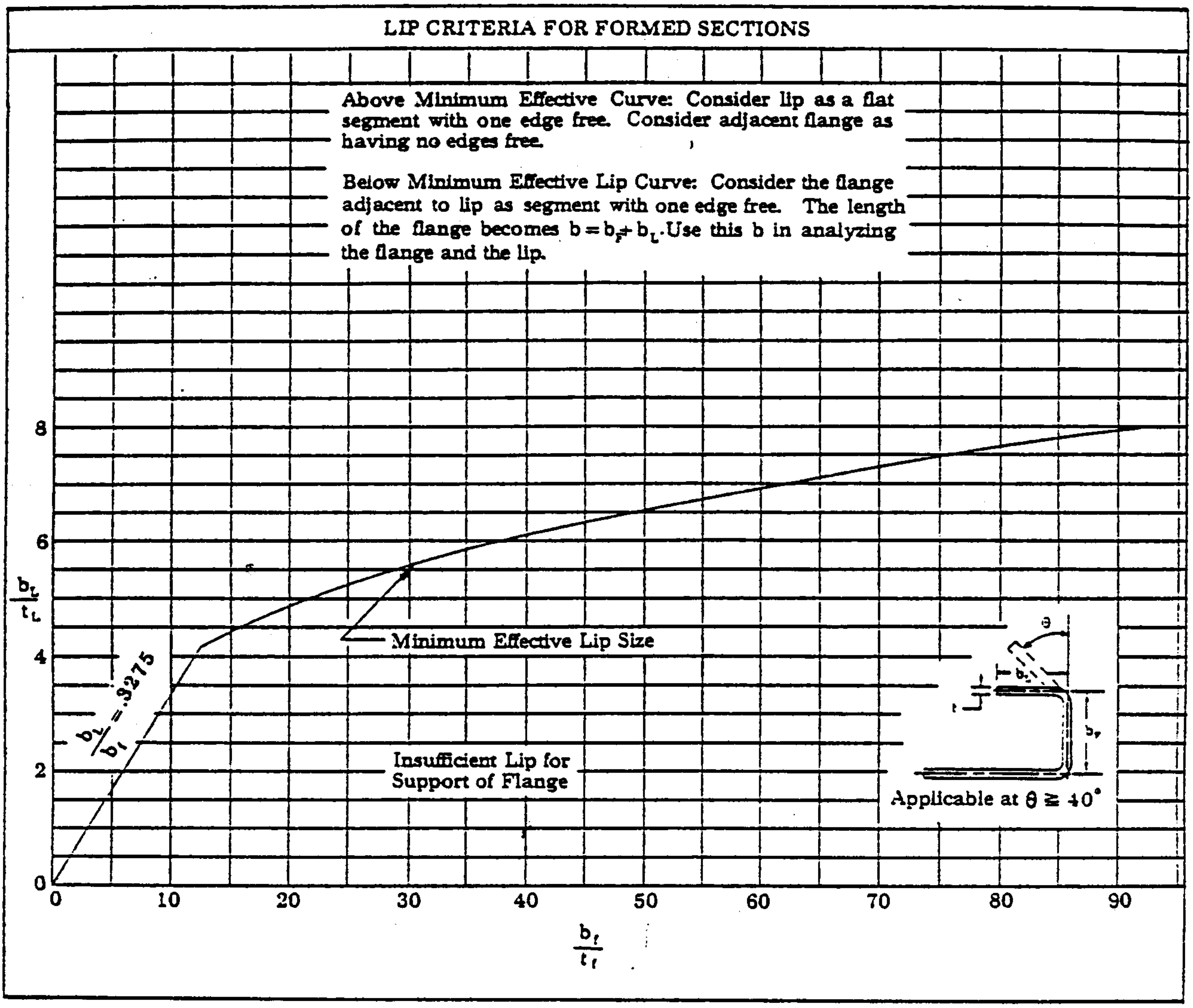
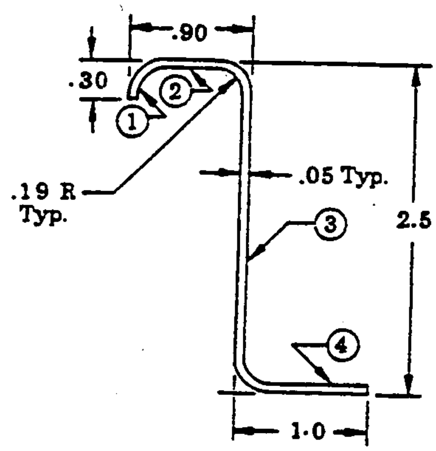

LIP CRITERIA FOR FORMED SECTIONS
Above Minimum Effective Curve: Consider lip as a flat segment with one edge free. Consider adjacent flange as having no edges free.
Below Minimum Effective Lip Curve: Consider the flange adjacent to lip as segment with one edge free. The length of the flange becomes $b = b_f + b_L$. Use this b in analyzing the flange and the lip.
Minimum Effective Lip Size
$b_L / b_f = .3275$
Insufficient Lip for Support of Flange
Applicable at $\theta \geq 40°$
b_L / t_L
b_f / t_f
0
2
4
6
8
10
20
30
40
50
60
70
80
90

Figure 6.2.1–2

EXAMPLE PROBLEM

Determine the crippling stress for the section shown below. The material is 2024–T3, clad, $F_{cy} = 36$ ksi.



First determine whether the lip segment, (1), provides sufficient stability to adjacent flange segment.

$$\frac{b_L}{t} = \frac{.275}{.05} = 5.5 \qquad \frac{b_f}{t} = \frac{.85}{.05} = 17$$

These values lie within the acceptable range in Figure 6.2.1–2.

The solution of crippling stress lends itself to a tabular format:

Segment	Free Edges	b_n	t_n	b_n/t_n	$b_n t_n$ (A_n)	F_{cc_n}*	$t_n b_n \cdot F_{cc_n}$
1	1	.275	.05	5.5	.01375	36	.495
2	0	.85	.05	17.	.04250	36	1.53
3	0	2.45	.05	49	.12250	24.5	3.001
4	1	.975	.05	19.5	.04875	19	.926
				A_t	.22750		5.952

$$F_{cc} = \frac{\sum t_n b_n F_{cc_n}}{\sum t_n b_n} = \frac{5.95}{.2275} = 26.16 \text{ ksi}$$

*From Figure 6.2.1–5

FORMED SECTION ALLOWABLE CRIPPLING STRESS–GENERAL SOLUTION

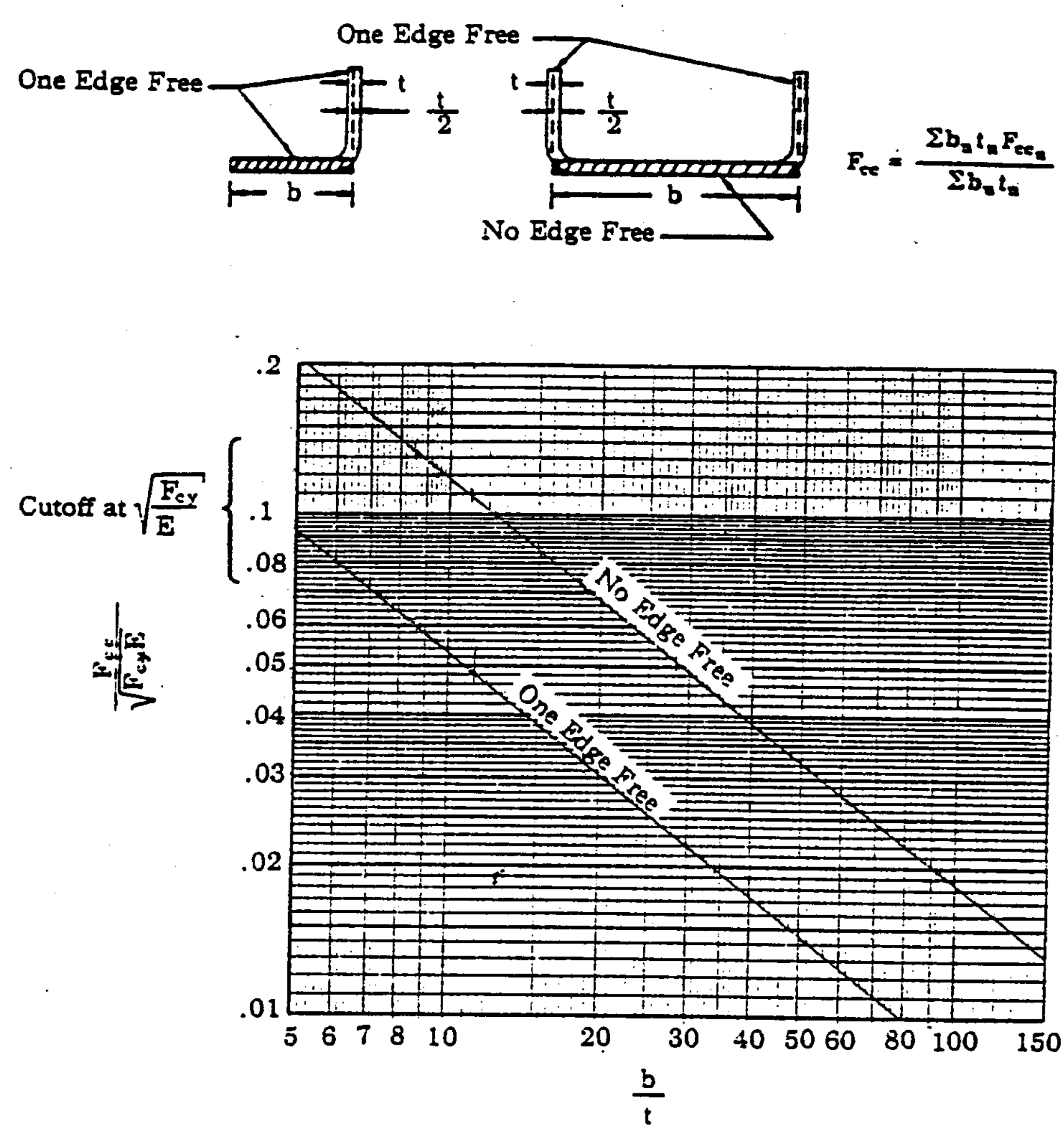


Figure 6.2.1–3

COMPRESSIVE CRIPPLING OF FORMED SECTIONS
2024–T3, – T351, –T42 CLAD

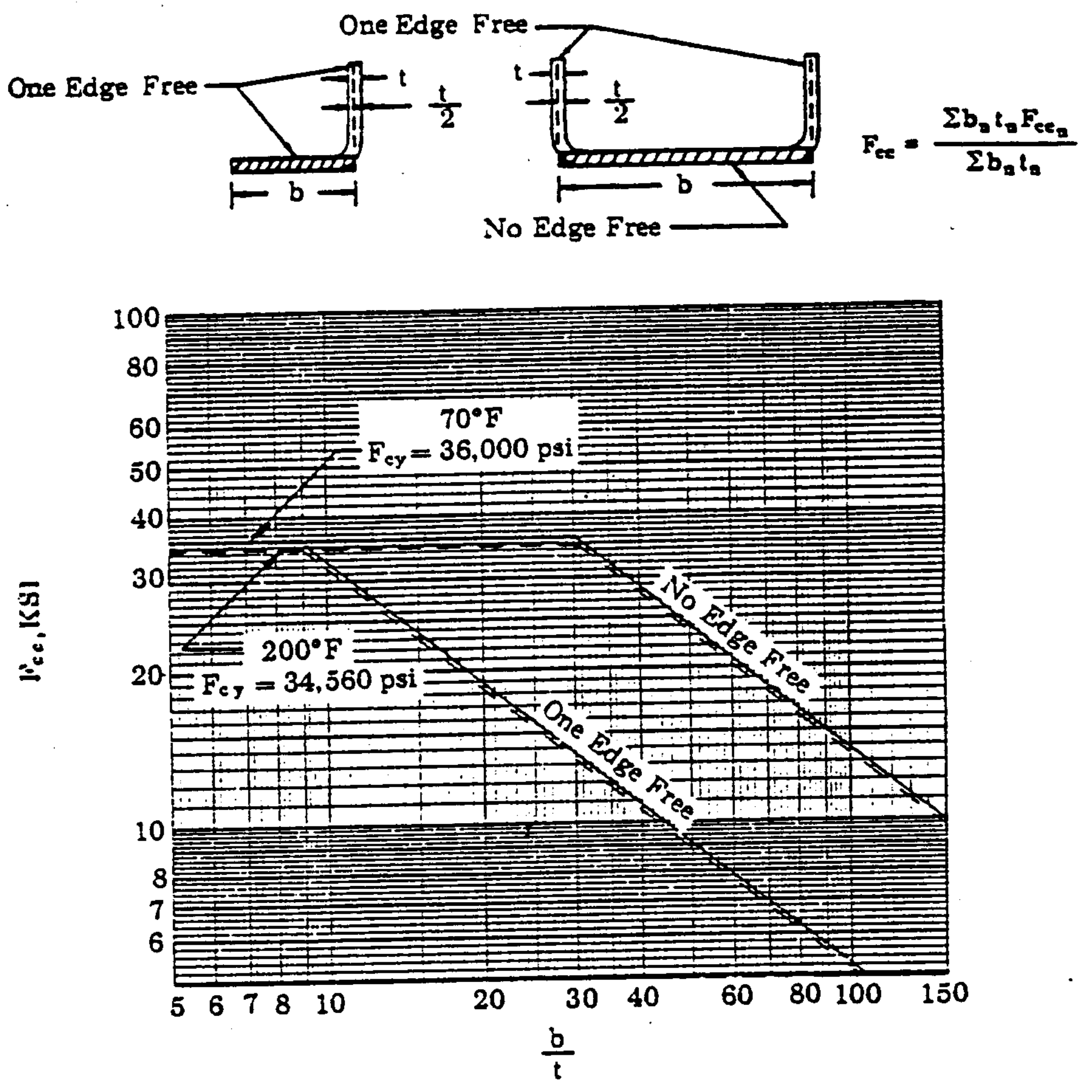
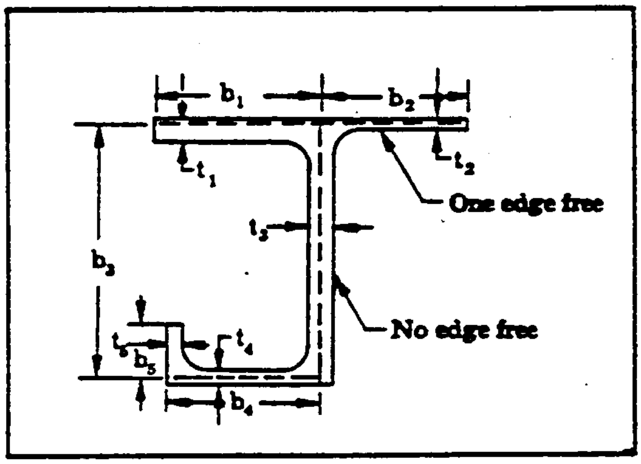


Figure 6.2.1–5



EXTRUDED SECTION

Figure 6.2.2–1

Judgment must be used in breaking down an unbalanced section. Whenever the thicknesses in a section differ by a factor of more than 3.0, the excess thickness should be discounted in calculating both the crippling stress and the section area effective in carrying load. In addition an unbalanced section should be checked for flexural or torsional instability (See section 2.4 or 2.5)

In a bulb section, Figure 6.2.2– 2 should be consulted to determine whether the bulb provides sufficient stability to the adjacent flange.

A lipped section should be checked to determine whether the lip provides sufficient stability to the adjacent flange. This may be done using Figure 6.2.1–2 in the same manner as for formed sections.

EXTRUDED SECTION ALLOWABLE CRIPPLING STRESS– GENERAL SOLUTION
(Except Titanium Extrusions)

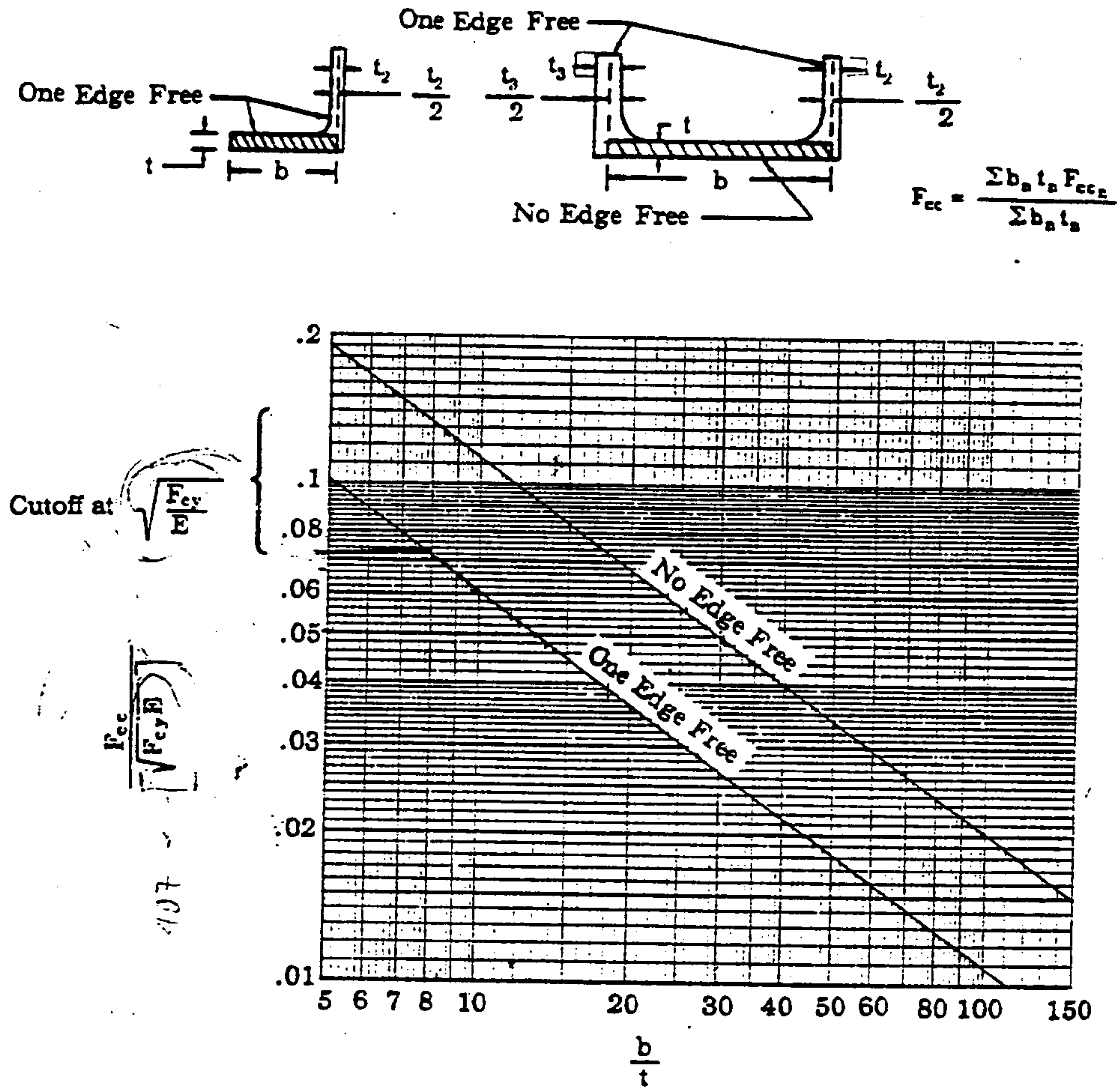


Figure 6.2.2–3

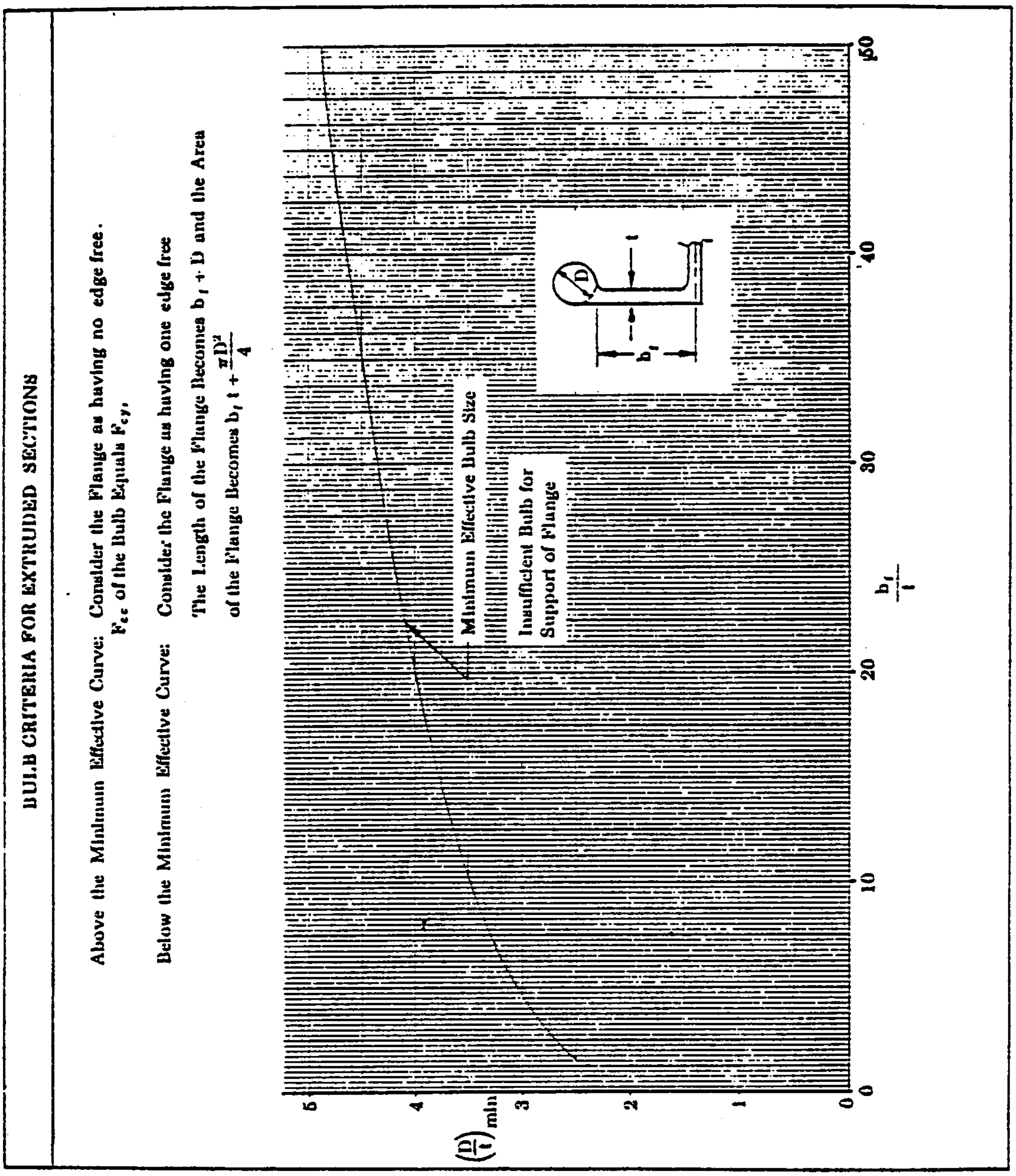
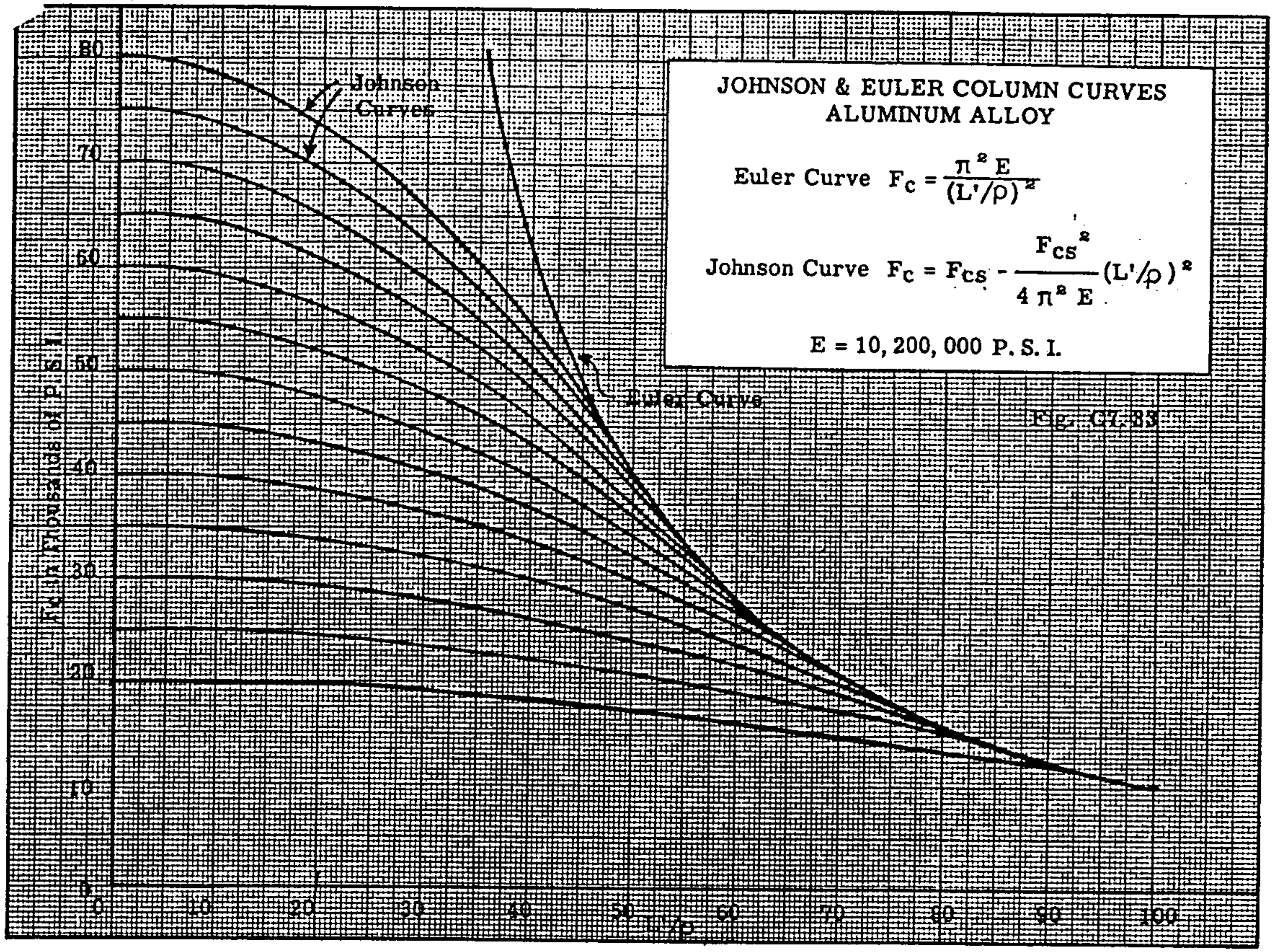

BULB CRITERIA FOR EXTRUDED SECTIONS
Above the Minimum Effective Curve: Consider the Flange as having no edge free. F_{cc} of the Bulb Equals F_{cy}.
Below the Minimum Effective Curve: Consider the Flange as having one edge free
The Length of the Flange Becomes $b_f + D$ and the Area of the Flange Becomes $b_f t + \frac{\pi D^2}{4}$
Minimum Effective Bulb Size
Insufficient Bulb for Support of Flange
D
t
b_f
$\left(\frac{D}{t}\right)_{min}$
$\frac{b_f}{t}$
0
1
2
3
4
5
10
20
30
40
50

Figure 6.2.2-2



JOHNSON & EULER COLUMN CURVES
ALUMINUM ALLOY
Euler Curve $F_c = \frac{\pi^2 E}{(L'/\rho)^2}$
Johnson Curve $F_c = F_{cs} - \frac{F_{cs}^2}{4\pi^2 E}(L'/\rho)^2$
E = 10, 200, 000 P. S. I.
Johnson Curves
Euler Curve
Fc in Thousands of P. S. I.
L'/ρ
0
10
20
30
40
50
60
70
80
90
100

Fig. C7.33