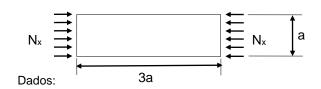
### **EST-25 ESTRUTURAS AEROESPACIAIS II**

## 1ª SÉRIE DE EXERCÍCIOS

### Exercício 1



a = 3"; t = 0.07"

Material: liga AL 7075-T6

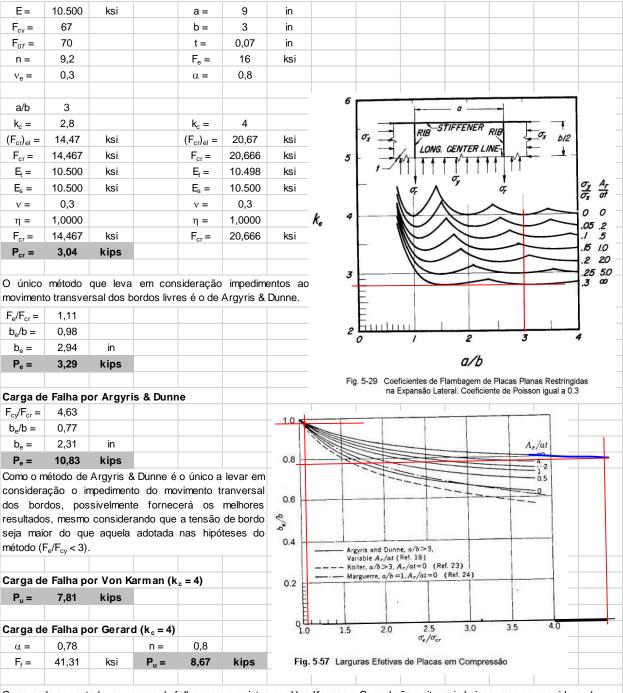
E = 10.500ksi;  $F_y = 67$ ksi;  $F_{0.7} = 70$ ksi; n = 9,2;  $\square v = 0,3$ 

Uma placa simplesmente apoiada em seus quatro bordos é carregada uniaxialmente. O reforço, nos bordos carregados, é tal a impedir, totalmente, o movimento transversal dos bordos livres. Nestas condições,

- a) qual a carga total suportada pela placa no instante da flambagem?
- b) qual a carga total suportada pela placa quando a tensão de bordo for  $f_b = 16 \ \text{ksi?}$
- c) qual a carga total suportada pela placa no momento da falha?

Neste item, calcule segundo Argyris & Dunne (com  $f_b = F_{cy}$ ), Von Karman e Gerard, e discuta os resultados.

# **SOLUÇÃO**



Como pode ser notado, as cargas de falha como previstas por Von Karman e Gerard são muito mais baixas, mesmo considerando uma tensão de flambagem sem a influência do reforço lateral. Se este reforço fosse levado em consideração, a carga de falha seria ainda menor. Os desenvolvimentos realizados por Von Karman e Gerard foram realizados sob a hipótese de Ar/at = 0 (reforço lateral nulo) de modo que a sua utilização neste caso certamente não é apropriada.

#### PROBLEMA 2

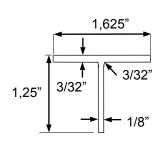
Considere o perfil da figura, extrudado em liga 7075-T6.

- a) estime a tensão de flambagem local
- b) calcule a tensão média de falha local na temperatura ambiente, usando o método da Boeing
- c) idem, usando o método de Gerard
- d) qual o diâmetro de bulbo que torna fornece condição de apoio completa para o flange horizontal?
- e) calcule a tensão média de falha local do perfil com bulbos como calculado no item c (use o método da Boeing)
- f) calcule a tensão média de falha local de ambas as seções, com e sem bulbos, sob temperatura de 450° F (método da Boeing)

### Dados do material:

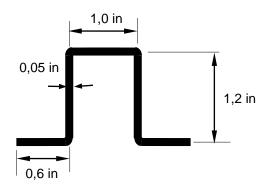
T.A.: E = 10.500 ksi ;  $F_{cy}$  = 70 ksi;  $F_{0.7}$  = 72 ksi;  $v_e$  = 0,3; n = 16,6 450° F: E = 7.800 ksi ;  $F_{cy}$  = 22,5 ksi;  $F_{0.7}$  = 21,3 ksi;  $v_e$  = 0,3; n = 7,2

# SOLUÇÃO



b <sub>F</sub> =					T A				4E00E			
UF =	0,8125	in		E=	T.A. 10.500	ksi		E=	450°F 7.800	ksi		= 3
											g <sub>GER</sub> :	
b <sub>W</sub> =	1,2031	in		F <sub>CY</sub> =	70	ksi		F <sub>CY</sub> =	22,5	ksi	β <sub>G</sub> =	0,67
t <sub>F</sub> =	0,0938	in		F <sub>0,7</sub> =	72	ksi		F <sub>0,7</sub> =	21,3	ksi	m <sub>GER</sub>	
t <sub>W</sub> =	0,1250	in		n =	16,6			n =	7,2		F <sub>CUT</sub> /F <sub>C</sub>	, = 0,8
				ν <sub>e</sub> =	0,3			ν <sub>e</sub> =	0,3			
				m =	0,75			m=	0,75			
				B <sub>10</sub> =	0,063			B <sub>10</sub> =	0,061			
				g <sub>F</sub> =	2,3			g <sub>F</sub> =	2,3			
a)												
Um limitar	nte inferio	r é dado p	ela tensão	de flamb	agem da p	erna mais	s fraca na	condição	de borda	simplesmer	nte apoiada	
KFLANGE =	0,428											
(t/b) <sub>MIN</sub> =	0,108											
(F <sub>CR</sub> ) <sub>EL</sub> =	47,47	ksi							FLANGE	•	-	
α =	0,9					19		,			10	20/4 1 /4
F <sub>CR</sub> =	47,444	ksi				1					AT 6 = 00	
E <sub>s</sub> =	10.493	ksi				12				10.00		12
ν =	0,300					t				/		1
η =	0,99944				_	10			- 1	/		10
F <sub>CR</sub> =	47,444	ksi	regime el	ástico					FLANGE (V=0.3)		6	
I CR -	77,777	Noi	regime ei	astico	− & FLANGE	8			-03/			0 %
Im limita	nte sunei	rior é da	do pela te	ensão de	PLANOL	1					4.6.96 Are. 0	PLATE
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orda en		G 11610 111		iaição do		AT 62	0					
	_				-	k <sub>0</sub> =0.4	\$00 0					1*
fLANGE =					-	20000000						1.
(t/b) <sub>MIN</sub> =	0,108	1*			-	2						2
F <sub>CR</sub> ) <sub>EL</sub> =		ksi			_		ed visit some		- 1			1
α =	0,9				_	0 1	Z	,	10	,	100 100	10
F <sub>CR</sub> =	76,127	ksi			_				PLAT	E (		
E <sub>S</sub> =	5.192	ksi			Fig 5	-12 Coo	ficientes d	e Flambaa			lacas Infinitame	nte
ν=	0,401				i ig. 5					Rotacional r		
η =	0,53622								, ,			
F <sub>CR</sub> =	76,127	ksi	regime in	elástico								
Outro limi	tante supe	erior é da	do pela ter	nsão de fla	ambagem	da perna	mais forte	na condic	ão de bo	rda simplesi	mente apoiada	
FLANGE =	0,428											
t/b) <sub>MAX</sub> =												
F <sub>CR</sub> ) <sub>EL</sub> =		ksi										
α =	0,9											
	61,507	ksi										
F <sub>CR</sub> =												+
E <sub>S</sub> =	10.128	ksi										_
ν=	0,307											-
η =	0,96916											-
F <sub>CR</sub> =	61,507	ksi	regime in	elastico								-
			_									-
47,4	ksi	<	F <sub>CR</sub>	<	61,5	ksi						-
												-
										1		
	-	1.		۸	D.		-	_				
i	n	b	t	Area	B.L	g	F <sub>CC</sub>	P <sub>CC</sub>				
i 1	2	0,8125	0,0938	0,15234	1	1	60,13	9,161				
				0,15234 0,15039				9,161 8,359				
i 1	2	0,8125	0,0938	0,15234	1	1	60,13	9,161				
i 1	2	0,8125	0,0938	0,15234 0,15039	1	1	60,13	9,161 8,359				
i 1 2	2 1	0,8125 1,2031	0,0938	0,15234 0,15039	1	1	60,13	9,161 8,359				
i 1 2	2 1	0,8125 1,2031	0,0938	0,15234 0,15039	1	1	60,13	9,161 8,359				
i 1 2 F <sub>CC</sub> =	2 1	0,8125 1,2031	0,0938	0,15234 0,15039	1	1	60,13	9,161 8,359				
i 1 2 F <sub>CC</sub> =	2 1 57,87	0,8125 1,2031 <b>ksi</b>	0,0938	0,15234 0,15039	1	1	60,13	9,161 8,359				
i 1 2 F <sub>CC</sub> =	2 1 <b>57,87</b> 0,29688	0,8125 1,2031 <b>ksi</b> in <sup>2</sup>	0,0938	0,15234 0,15039	1	1	60,13	9,161 8,359				
i 1 2 Fcc =	2 1 <b>57,87</b> 0,29688 0,10674	0,8125 1,2031 <b>ksi</b> in <sup>2</sup> in	0,0938 0,1250	0,15234 0,15039	1	1	60,13	9,161 8,359				
i 1 2 F <sub>CC</sub> = :) A = t <sub>BARRA</sub> = F <sub>CC</sub> =	2 1 <b>57,87</b> 0,29688 0,10674	0,8125 1,2031 <b>ksi</b> in <sup>2</sup> in	0,0938 0,1250	0,15234 0,15039 0,30273	1	1 1	60,13 55,58	9,161 8,359 17,520	(n)4	h	(D)3	(n) <sup>2</sup>
i 1 2 F <sub>CC</sub> = :) A = t <sub>BARRA</sub> = F <sub>CC</sub> =	2 1 <b>57,87</b> 0,29688 0,10674	0,8125 1,2031 <b>ksi</b> in <sup>2</sup> in	0,0938 0,1250	0,15234 0,15039 0,30273	1	1 1	60,13 55,58	9,161 8,359 17,520	$\Rightarrow \left(\frac{D}{\cdot}\right)^4$	= 7,44 <sup>b<sub>f</sub></sup>	$+1.6\left(\frac{D}{L}\right)^3 + 0.3$	$74\left(\frac{D}{\cdot}\right)^2 =$
i 1 2 F <sub>CC</sub> = A = F <sub>CC</sub> = F <sub>CC</sub> =	2 1 57,87 0,29688 0,10674 53,81	0,8125 1,2031 <b>ksi</b> in <sup>2</sup> in	0,0938 0,1250	0,15234 0,15039 0,30273	$1$ $1$ $1$ $-1.6\left(\frac{L}{t}\right)$	$\frac{1}{1}$ $\frac{1}$	$\begin{array}{c} 60,13 \\ \hline 55,58 \\ \\ \hline \end{array}$	9,161 8,359 17,520 7,44 b <sub>f</sub> /t		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ c) $A = t_{BARRA} = F_{CC} =$ d) $\alpha = D/t)_{MN} =$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380	0,8125 1,2031 <b>ksi</b> in <sup>2</sup> in	0,0938 0,1250	0,15234 0,15039 0,30273	$1$ $1$ $1$ $-1.6\left(\frac{L}{t}\right)$	$\frac{1}{1}$ $\frac{1}$	$\begin{array}{c} 60,13 \\ \hline 55,58 \\ \\ \hline \end{array}$	9,161 8,359 17,520 7,44 b <sub>f</sub> /t		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ c) $A = t_{BARRA} = F_{CC} =$ i) $\alpha = D/t)_{MN} = D/t)_{MN} =$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 3,380	0,8125 1,2031 <b>ksi</b> in² in <b>ksi</b>	0,0938 0,1250	0,15234 0,15039 0,30273	$1$ $1$ $1$ $-1.6\left(\frac{L}{t}\right)$	$\frac{1}{1}$ $\frac{1}$	$\begin{array}{c} 60,13 \\ \hline 55,58 \\ \\ \hline \end{array}$	9,161 8,359 17,520 7,44 b <sub>f</sub> /t		$= 7.44 \frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ c) $A = t_{BARRA} = F_{CC} =$ d) $\alpha = D/t)_{MN} =$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380	0,8125 1,2031 <b>ksi</b> in <sup>2</sup> in	0,0938 0,1250	0,15234 0,15039 0,30273	$1$ $1$ $1$ $-1.6\left(\frac{L}{t}\right)$	$\frac{1}{1}$ $\frac{1}$	$\begin{array}{c} 60,13 \\ \hline 55,58 \\ \\ \hline \end{array}$	9,161 8,359 17,520		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 F <sub>CC</sub> = A = i <sub>BARRA</sub> = F <sub>CC</sub> = D/t) <sub>MN</sub> = D/t) <sub>MN</sub> =	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 3,380	0,8125 1,2031 <b>ksi</b> in² in <b>ksi</b>	0,0938 0,1250	0,15234 0,15039 0,30273	$1$ $1$ $1$ $-1.6\left(\frac{L}{t}\right)$	$\frac{1}{1}$ $\frac{1}$	$\begin{array}{c} 60,13 \\ \hline 55,58 \\ \\ \hline \end{array}$	9,161 8,359 17,520 7,44 b <sub>f</sub> /t		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3+0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ c) $A = t_{BARRA} =$ $F_{CC} =$ ii) $\alpha = D/t_{MN} =$ $D/t_{MN} =$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317	0,8125 1,2031 <b>ksi</b> in <sup>2</sup> in <b>ksi</b>	0,0938 0,1250 < FCUT	0,15234 0,15039 0,30273	$\begin{pmatrix} 1 \\ 1 \end{pmatrix} - 1,6 \left( \frac{L}{t} \right)_{MIN} = \begin{bmatrix} 7, \\ 4 \end{pmatrix}_{MIN}$	$\frac{1}{1}$ $\frac{1}$	$60.13$ $55.58$ $14\left(\frac{D}{t}\right)^{2} \ge 6\left(\frac{D}{t}\right)^{3} + 6\left(\frac{D}{t}\right)^$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$		= 7,44 b <sub>1</sub>	$+1.6\left(\frac{D}{t}\right)^3+0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ c) $A = t_{barra} = F_{CC} =$ ii) $\alpha = D/t_{MN} =$ $D/t_{MN} =$ $D_{MN} =$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317	0,8125 1,2031 ksi in² in ksi	0,0938 0,1250 < FCUT	0,15234 0,15039 0,30273  (D) (D) (I) (D) (I) (I) (I) (I) (I) (I) (I) (I) (I) (I	$ \frac{1}{1} $ $ 1$	$\left(\frac{1}{1}\right)^{3} - 0.37$ $\left(\frac{b_{f}}{t} + 1\right)$	$60.13$ $55.58$ $74\left(\frac{D}{t}\right)^{2} \ge 6\left(\frac{D}{t}\right)^{3} + F_{CC}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$		= 7,44 \(\frac{b_f}{t}\)	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ :) $A =$ $I_{BARRA} =$ $F_{CC} =$ ii) $\alpha =$ $D/t)_{MN} =$ $D_{MN} =$ :) i 1	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317	0,8125 1,2031 ksi in² in ksi	0,0938 0,1250 < FCUT	0,15234 0,15039 0,30273	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix}^{4} - 1, 6 \left(\frac{L}{t}\right)^{4} = 1, $	$\frac{1}{1}$ $\frac{1}$	$60.13$ $55.58$ $74\left(\frac{D}{t}\right)^{2} \ge 6\left(\frac{D}{t}\right)^{3} + \frac{F_{cc}}{70.00}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$		$=7.44\frac{b_f}{t}.$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ c:) A = $t_{BARRA} =$ $F_{CC} =$ di) $\alpha =$ $D/t)_{MN} =$ $D/t)_{MN} =$ $D_{MIN} =$ c:	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2	0,8125 1,2031 ksi in² in ksi in 0,8125	0,0938 0,1250 < FCUT	0,15234 0,15039 0,30273 $\frac{D}{t}$ Area 0,15774 0,15234	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix} $ $ -1,6 \left(\frac{L}{t}\right) $ $ MIN = \begin{bmatrix} 7, \\ 0 \end{bmatrix} $ B.L.	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}$	$\begin{array}{c} 60.13 \\ 55.58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \ge \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70.00 \\ 70.00 \\ \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ P <sub>CC</sub> 11,042 10,664		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3+0.3$	$74\left(\frac{D}{t}\right)^2 =$
$i$ 1 2 $F_{CC} = i$ $i$ $A = t_{BARRA} = i$ $F_{CC} = i$ $i$ $i$ $i$ $i$ $i$ $i$ $i$ $i$ $i$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317	0,8125 1,2031 ksi in² in ksi	0,0938 0,1250 < FCUT	0,15234 0,15039 0,30273	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix}^{4} - 1, 6 \left(\frac{L}{t}\right)^{4} = 1, $	$\frac{1}{1}$ $\frac{1}$	$60.13$ $55.58$ $74\left(\frac{D}{t}\right)^{2} \ge 6\left(\frac{D}{t}\right)^{3} + \frac{F_{cc}}{70.00}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3+0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ i \\ 1 \\ 2 $ $ F_{CC} = $ $ A = \\ A_{BARRA} = \\ F_{CC} = $ $ O(t)_{MN} = $ $ O_{MN} = $ $ O(t)_{MN} = $ $ O_{MN} = $ $ O(t)_{MN} = $ $ O(t)_$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2	in b - 0,8125 1,2031	0,0938 0,1250 < FCUT	0,15234 0,15039 0,30273 $\frac{D}{t}$ Area 0,15774 0,15234	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix} $ $ -1,6 \left(\frac{L}{t}\right) $ $ MIN = \begin{bmatrix} 7, \\ 0 \end{bmatrix} $ B.L.	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}$	$\begin{array}{c} 60.13 \\ 55.58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \ge \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70.00 \\ 70.00 \\ \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ P <sub>CC</sub> 11,042 10,664		= 7,44 <sup>b</sup> / <sub>I</sub>	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 $F_{CC} =$ c:) A = $t_{BARRA} =$ $F_{CC} =$ di) $\alpha =$ $D/t)_{MN} =$ $D/t)_{MN} =$ $D_{MIN} =$ c:	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2	0,8125 1,2031 ksi in² in ksi in 0,8125	0,0938 0,1250 < FCUT	0,15234 0,15039 0,30273	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix} $ $ -1,6 \left(\frac{L}{t}\right) $ $ MIN = \begin{bmatrix} 7, \\ 0 \end{bmatrix} $ B.L.	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}$	$\begin{array}{c} 60.13 \\ 55.58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \ge \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70.00 \\ 70.00 \\ \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 +0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 2	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2	in b - 0,8125 1,2031	0,0938 0,1250 < FCUT t - 0,0938	0,15234 0,15039 0,30273	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix} $ $ -1,6 \left(\frac{L}{t}\right) $ $ MIN = \begin{bmatrix} 7, \\ 0 \end{bmatrix} $ B.L.	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}$	$\begin{array}{c} 60.13 \\ 55.58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \ge \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70.00 \\ 70.00 \\ \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} i \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} F_{CC} = \\ ) \\ ) \\ A = \\ \\ Bearra = \\ F_{CC} = \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ \end{array} $	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1	in b - 0,8125 1,2031	0,0938 0,1250 < FCUT t - 0,0938	0,15234 0,15039 0,30273	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix} $ $ -1,6 \left(\frac{L}{t}\right) $ $ MIN = \begin{bmatrix} 7, \\ 0 \end{bmatrix} $ B.L.	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}$	$\begin{array}{c} 60.13 \\ 55.58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \ge \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70.00 \\ 70.00 \\ \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359		= 7,44 b <sub>1</sub>	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} i \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} F_{CC} = \\ ) \\ ) \\ A = \\ \\ Bearra = \\ F_{CC} = \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ \end{array} $	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1	in b - 0,8125 1,2031	0,0938 0,1250 < FCUT t - 0,0938	0,15234 0,15039 0,30273	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix} $ $ -1,6 \left(\frac{L}{t}\right) $ $ MIN = \begin{bmatrix} 7, \\ 0 \end{bmatrix} $ B.L.	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}$	$\begin{array}{c} 60.13 \\ 55.58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \ge \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70.00 \\ 70.00 \\ \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359		= 7,44 \frac{b_f}{t}	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} i \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} F_{CC} = \\ ) \\ ) \\ A = \\ \\ Bearra = \\ F_{CC} = \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ 0 \\ \end{array} $ $ \begin{array}{c} 0 \\ 0 \\ \end{array} $ $ \begin{array}$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1	in b - 0,8125 1,2031	0,0938 0,1250 < FCUT t - 0,0938	0,15234 0,15039 0,30273	$ \begin{pmatrix} 1 \\ 1 \end{pmatrix} $ $ -1,6 \left(\frac{L}{t}\right) $ $ MIN = \begin{bmatrix} 7, \\ 0 \end{bmatrix} $ B.L.	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}$	$\begin{array}{c} 60.13 \\ 55.58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \ge \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70.00 \\ 70.00 \\ \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} F_{\text{CC}} = \\ \end{array} ) $ $ \begin{array}{c} A = \\ A = \\ \end{array} $ $ \begin{array}{c} A = \\ \end{array} $ $ \begin{array}{c} \Delta = \\ D/t)_{\text{MN}} = \\ D/t)_{\text{MN}} = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ 3 \\ \end{array} $ $ \begin{array}{c} F_{\text{CC}} = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ \text{i} \\ \text{for } = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ \text{for } = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ \text{for } = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ \text{for } = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ \text{for } = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ \text{for } = \\ \end{array} ) $ $ \begin{array}{c} \text{i} \\ \text{for } = \\ \end{array} ) $ $ \begin{array}{c} fo$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1	in b - 0,8125 1,2031 ksi	0,0938 0,1250 < FCUT t - 0,0938 0,1250	0,15234 0,15039 0,30273  \[ \begin{array}{c} array	$ \begin{vmatrix} 1 & 1 \\ 1 & 1 \end{vmatrix} $ $ -1,6\left(\frac{L}{t}\right)_{MIN} = \begin{bmatrix} 7, \\ 0 \\ 1 \end{bmatrix} $	$\frac{1}{1}$ $\frac{1}{2}$ $\frac{2}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{44}{t}$ $\frac{b_f}{t}$ $\frac{1}{t}$ $\frac{9}{t}$ $\frac{2}{t}$ $\frac{2}{t}$ $\frac{3}{t}$	$60,13$ $55,58$ $74\left(\frac{D}{t}\right)^{2} \ge 66\left(\frac{D}{t}\right)^{3} + 6\left(\frac{D}{t}\right)^{3} + \frac{1}{2}$ $70,00$ $70,00$ $55,58$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359 30,065		= 7,44 <sup>b</sup> / <sub>1</sub>	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} F_{\text{CC}} = \\ \end{array} $ $ \begin{array}{c} A = \\ F_{\text{CC}} = \\ \end{array} $ $ \begin{array}{c} A = \\ F_{\text{CC}} = \\ \end{array} $ $ \begin{array}{c} A = \\ D/t)_{\text{MN}} = \\ D/t)_{\text{MN}} = \\ \end{array} $ $ \begin{array}{c} A = $	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1	in b - 0,8125 1,2031 ksi	t - 0,0938 0,1250	0,15234 0,15039 0,30273  \[ \begin{array}{c} \D \\ \ \ \ \ \ \end{array} \] \[ \begin{array}{c} \D \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	$ \begin{vmatrix} 1 & 1 \\ 1 & 1 \end{vmatrix} $ $ -1,6\left(\frac{L}{t}\right)_{MIN} = \begin{bmatrix} 7, \\ 0 \\ 1 \end{bmatrix} $ B.L.	$\begin{pmatrix} 1 \\ 1 \end{pmatrix}^{3} - 0.37 \\ 44 \frac{b_{f}}{t} + 1. \\ \frac{9}{2.3} \\ 1 \\ 9$	$60,13$ $55,58$ $14\left(\frac{D}{t}\right)^{2} \ge 6\left(\frac{D}{t}\right)^{3} + \frac{F_{cc}}{70,00}$ $70,00$ $55,58$ $F_{cc}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ = 11,042 11,042 10,664 8,359 30,065		= 7,44 b <sub>1</sub>	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 Fcc = ) A = BBARRA = Fcc = D/t)_MN = D/t0,MN =  1 2 3 Fcc = 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 65,29	0,8125 1,2031  ksi  in² in  ksi  in  b - 0,8125 1,2031  ksi	t - 0,0938 0,1250 t 0,0938 0,1250	0,15234 0,15039 0,30273	$\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} -1 \\ 6 \end{vmatrix} \left( \frac{L}{I} \right)$ B.L. $\begin{vmatrix} 0 \\ 1 \end{vmatrix}$ B.L. $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{2}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{9}{t}$ $\frac{9}{t}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70,00 \\ 55,58 \\ \hline \\ F_{CC} \\ 22,50 \\ \hline \end{array}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 10,664 8,359 30,065		= 7,44 \frac{b_f}{t}	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
i 1 2 Fcc = ) A = BBARRA = Fcc = D/t)_MN = D/t0,MN =  1 2 3 Fcc = 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 65,29	0,8125 1,2031  ksi  in² in  ksi  in  b - 0,8125 1,2031  ksi	t - 0,0938 0,1250 t 0,0938 0,1250	0,15234 0,15039 0,30273  \[ \begin{array}{c} array	$\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} -1 \\ 6 \end{vmatrix} \left( \frac{L}{I} \right)$ B.L. $\begin{vmatrix} 0 \\ 1 \end{vmatrix}$ B.L. $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{2}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{9}{t}$ $\frac{9}{t}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70,00 \\ 55,58 \\ \hline \\ F_{CC} \\ 22,50 \\ \hline \end{array}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 10,664 8,359 30,065		= 7,44 \frac{b_f}{t}	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} F_{\text{CC}} = \\ \end{array} ) $ $ \begin{array}{c} A = \\ \\ Barran = \\ F_{\text{CC}} = \\ \end{array} ) ) $ $ \begin{array}{c} \alpha = \\ \\ DO(1)_{\text{MN}} = \\ \end{array} ) $ $ \begin{array}{c} 1 \\ \\ 2 \\ \end{array} $ $ \begin{array}{c} 3 \\ \\ \end{array} $ $ \begin{array}{c} F_{\text{CC}} = \\ \end{array} ) $ $ \begin{array}{c} \text{eem bulb} \\ \text{i} \\ \\ 1 \\ 2 \\ \end{array} $	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 65,29	in b - 0,8125 1,2031 ksi b 0,8125 1,2031	t - 0,0938 0,1250 t 0,0938 0,1250	0,15234 0,15039 0,30273  \[ \begin{array}{c} array	$\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} -1 \\ 6 \end{vmatrix} \left( \frac{L}{I} \right)$ B.L. $\begin{vmatrix} 0 \\ 1 \end{vmatrix}$ B.L. $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{2}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{9}{t}$ $\frac{9}{t}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70,00 \\ 55,58 \\ \hline \\ F_{CC} \\ 22,50 \\ \hline \end{array}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 10,664 8,359 30,065		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} F_{CC} = \\ \end{array} $ $ \begin{array}{c} A = \\ \\ F_{CC} = \\ \end{array} $ $ \begin{array}{c} \alpha = \\ \\ D/t)_{MN} = \\ \end{array} $ $ \begin{array}{c} D/t)_{MN} = \\ \end{array} $ $ \begin{array}{c} 0 \\ \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} 0 \\ \\ 3 \\ \end{array} $ $ \begin{array}{c} F_{CC} = \\ \end{array} $ $ \begin{array}{c} 0 \\ \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} 0 \\ \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} 0 \\ \\ 1 \\ 2 \\ \end{array} $	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 65,29	in b - 0,8125 1,2031 ksi b 0,8125 1,2031	t - 0,0938 0,1250 t 0,0938 0,1250	0,15234 0,15039 0,30273  \[ \begin{array}{c} array	$\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} -1 \\ 6 \end{vmatrix} \left( \frac{L}{I} \right)$ B.L. $\begin{vmatrix} 0 \\ 1 \end{vmatrix}$ B.L. $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{2}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{9}{t}$ $\frac{9}{t}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{CC} \\ 70,00 \\ 55,58 \\ \hline \\ F_{CC} \\ 22,50 \\ \hline \end{array}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 10,664 8,359 30,065		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} \textbf{F}_{\text{CC}} = \\ \\ \end{array} $ $ \begin{array}{c} \text{A} = \\ \\ \text{BBARRA} = \\ \end{array} $ $ \begin{array}{c} \text{BBARRA} = \\ \\ \text{FCC} = \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \text{CC} \\ \end{array} $ $ \begin{array}{c} \text{CC} \\ \text{CC} \\ \end{array} $	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 1 65,29	0,8125 1,2031  ksi  in² in ksi  in  b - 0,8125 1,2031  ksi  b 0,8125 1,2031	t 0,0938 0,1250 < FCUT t 0,0938 0,1250 t 0,0938 0,1250	0,15234 0,15039 0,30273 0,30273 0,30273 0,15774 0,15234 0,46048 Area 0,15234 0,15039 0,30273	$ \begin{vmatrix} 1 & 1 \\ 1 & 1 \end{vmatrix} $ $ -1,6\left(\frac{L}{t}\right)_{MIN} = \begin{bmatrix} 7, \\ 0 & 1 \end{bmatrix} $ B.L. $ 1 & 1 $	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{2}{t}$ $\frac{3}{t} - 0.37$ $\frac{9}{t}$ $\frac{2.3}{1}$ $\frac{9}{1}$ $\frac{1}{1}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \\ 74 \left(\frac{D}{t}\right)^2 \geq \\ 6 \left(\frac{D}{t}\right)^3 + \\ \\ F_{CC} \\ 70,00 \\ 70,00 \\ 55,58 \\ \\ \\ F_{CC} \\ 22,50 \\ 22,50 \\ \end{array}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ P <sub>CC</sub> 11,042 10,664 8,359 30,065  P <sub>CC</sub> 3,428 3,384 6,812		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \end{array} $ $ \begin{array}{c} \text{F}_{\text{CC}} = \\ \text{)} \\ \text{A} = \\ \text{BBARRA} = \\ \end{array} $ $ \begin{array}{c} \text{G} = \\ \text{F}_{\text{CC}} = \\ \end{array} $ $ \begin{array}{c} \text{O} \\ \text{O} \\ \text{MN} = \\ \end{array} $ $ \begin{array}{c} \text{O} \\$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 65,29	in b - 0,8125 1,2031 ksi in² in ksi  b - 0,8125 1,2031 ksi b 0,8125 1,2031	t - 0,0938 0,1250 t 0,0938 0,1250	0,15234 0,15039 0,30273  \[ \begin{array}{c} array	$\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$ $\begin{vmatrix} -1 \\ 6 \end{vmatrix} \left( \frac{L}{I} \right)$ B.L. $\begin{vmatrix} 0 \\ 1 \end{vmatrix}$ B.L. $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{2}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{2}{t}$ $\frac{3}{t}$ $\frac{9}{t}$ $\frac{9}{t}$ $\frac{9}{t}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \\ F_{CC} \\ 70,00 \\ 55,58 \\ \\ F_{CC} \\ 22,50 \\ \\ 22,50 \\ \\ \end{array}$	9,161 8,359 17,520  7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ Pcc 11,042 10,664 8,359 30,065  Pcc 3,428 3,384 6,812		= 7,44 \(\frac{b_f}{t}\)	$+1.6\left(\frac{D}{t}\right)^{3}+0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \\ \end{array} $ $ \begin{array}{c} \text{F}_{\text{CC}} = \\ \text{:} \\ \text{:} \\ \end{array} $ $ \begin{array}{c} \text{A} = \\ \text{A}_{\text{BARRA}} = \\ \text{F}_{\text{CC}} = \\ \end{array} $ $ \begin{array}{c} \text{d} \\ \end{array} $ $ \begin{array}{c} \text{D}_{\text{MM}} = \\ \text{D}_{\text{MM}} = \\ \text{D}_{\text{MM}} = \\ \text{D}_{\text{MM}} = \\ \end{array} $ $ \begin{array}{c} \text{D}_{\text{MMM}} = \\ \text$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 65,29	in ksi b 0,8125 1,2031 ksi b 0,8125 1,2031 ksi b -	t - 0,0938 0,1250 < FCUT t - 0,0938 0,1250 t -	0,15234 0,15039 0,30273  \[ \begin{array}{c} \ldot \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	$ \frac{1}{1} $ B.L. $ \frac{1}{1} $ B.L. $ \frac{1}{1} $	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{3}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{4}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{cc} \\ 70,00 \\ 70,00 \\ 55,58 \\ \hline \\ F_{cc} \\ 22,50 \\ \hline \\ 22,50 \\ \hline \\ F_{cc} \\ 22,50 \\ \hline \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 10,664 8,359 30,065 P <sub>CC</sub> 3,428 3,484 6,812 P <sub>CC</sub> 3,549		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} & \text{i} \\ & 1 \\ 2 \\ & 2 \\ \\ & \\ & \\ & \\ & \\ & \\ & \\ &$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 1 65,29	0,8125 1,2031  ksi  in² in ksi  b - 0,8125 1,2031  ksi  b 0,8125 1,2031  ksi	t t - 0,0938 0,1250 t t - 0,0938 0,1250	0,15234 0,15039 0,30273  \[ \begin{array}{c} array	$ \frac{1}{1} $ B.L. $ \frac{1}{1} $ B.L. $ \frac{1}{1} $ B.L. $ \frac{1}{1} $	$ \frac{1}{1} $ $ \frac{1}{1} $ $ \frac{2}{2} $ $ -0.37 $ $ \frac{9}{1} $ $ \frac{9}{1} $ $ 1 $ $ \frac{9}{2} $ $ \frac{9}{2} $ $ \frac{1}{2} $ $ \frac{9}{2} $	$\begin{array}{c} 60,13 \\ 55,58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{cc} \\ 70,00 \\ 70,00 \\ 55,58 \\ \hline \\ F_{cc} \\ 22,50 \\ 22,50 \\ \hline \\ 22,50 \\ 22,50 \\ \hline \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 11,042 10,664 8,359 30,065 P <sub>CC</sub> 3,428 3,384 6,812 P <sub>CC</sub> 3,549 3,428 3,428		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$
$ \begin{array}{c} \text{i} \\ 1 \\ 2 \\ \\ \end{array} $ $ \begin{array}{c} \text{F}_{\text{CC}} = \\ \text{:} \\ \text{:} \\ \end{array} $ $ \begin{array}{c} \text{A} = \\ \text{A}_{\text{BARRA}} = \\ \text{F}_{\text{CC}} = \\ \end{array} $ $ \begin{array}{c} \text{d} \\ \end{array} $ $ \begin{array}{c} \text{D}_{\text{MM}} = \\ \text{D}_{\text{MM}} = \\ \text{D}_{\text{MM}} = \\ \text{D}_{\text{MM}} = \\ \end{array} $ $ \begin{array}{c} \text{D}_{\text{MMM}} = \\ \text$	2 1 57,87 0,29688 0,10674 53,81 0,9 3,380 0,317 n 2 2 1 65,29	in ksi b 0,8125 1,2031 ksi b 0,8125 1,2031 ksi b -	t - 0,0938 0,1250 < FCUT t - 0,0938 0,1250 t -	0,15234 0,15039 0,30273  \[ \begin{array}{c} \ldot \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	$ \frac{1}{1} $ B.L. $ \frac{1}{1} $ B.L. $ \frac{1}{1} $	$\frac{1}{1}$ $\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{3}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{44}$ $\frac{1}{2}$ $\frac{1}{4}$	$\begin{array}{c} 60,13 \\ 55,58 \\ \hline \\ 74 \left( \frac{D}{t} \right)^2 \geq \\ 6 \left( \frac{D}{t} \right)^3 + \\ \hline \\ F_{cc} \\ 70,00 \\ 70,00 \\ 55,58 \\ \hline \\ F_{cc} \\ 22,50 \\ \hline \\ 22,50 \\ \hline \\ F_{cc} \\ 22,50 \\ \hline \end{array}$	9,161 8,359 17,520 7,44 $\frac{b_f}{t}$ = 0,374 $\left(\frac{D}{t}\right)$ 10,664 8,359 30,065 P <sub>CC</sub> 3,428 3,484 6,812 P <sub>CC</sub> 3,549		$=7.44\frac{b_f}{t}$	$+1.6\left(\frac{D}{t}\right)^3 + 0.3$	$74\left(\frac{D}{t}\right)^2 =$

### PROBLEMA 3



Considere o perfil da figura, conformado em chapa AL 7075-T6.

- a) Calcule a tensão média de falha local pelo método de Needham;
- b) Calcule a tensão média de falha local pelo método da Boeing;
- c) Calcule a tensão média de falha local pelo método de Gerard;
- d) Comente os resultados.

Dados do material: E = 10.500 ksi ;  $F_{cy}$  = 67 ksi;  $F_{0.7}$  = 70 ksi; v = 0,3; n = 9,2

# **SOLUÇÃO**

b <sub>F</sub> =	0,60	in		E=	10.500	ksi		C <sub>1BORDA</sub> =	0,342	g <sub>GER</sub> =	11
b <sub>W</sub> =	1,20	in		F <sub>CY</sub> =	67	ksi		C <sub>OBORDA</sub> =	0,366	$\beta_{G} =$	0,55
b <sub>T</sub> =	1,00	in		F <sub>0,7</sub> =	70	ksi		m=	0,8	m <sub>GER</sub> =	0,85
t =	0,05	in		n =	9,2			B <sub>10</sub> =	0,05275	$F_{CUT}/F_{CY} =$	0,75
				ν <sub>e</sub> =	0,3			g <sub>F</sub> =	2,65		
							6				
Cálculos F	Preliminare	es						1	1		
$b_F/b_W =$	0,5						5	_	4-1-12	<b>—</b>	
$b_W/b_T =$	1,2							1	1///	11/1	
k <sub>T</sub> =	2,3	SI	DE WEB FI	RST			4	BUCKLES TO	NST \ TEN	1-1-1	EE BOOKES FIRST
(F <sub>CR</sub> ) <sub>EL</sub> =	54,57	ksi						T SIDE H	20	1/1/	
α =	0,9						A. 3	AUCKLES	10057	1/1/	
F <sub>CR</sub> =	51,000	ksi								$\wedge \wedge \wedge$	2
E <sub>T</sub> =	8.116	ksi					2	TOP WEB. D.	SOF MER O	-1-1	- a
E <sub>s</sub> =	10.175	ksi						1	7	11	1:1
ν =	0,306						1	11.	L,		
η =	0,935							T. PLANSE	1.07		
F <sub>CR</sub> =	51,000	ksi	regime in	elástico			ساوه	اسا		8 92	
										0.70,	
a)										* *	
i	n	а	b	b'/t	Area	B.L.	CE	F <sub>CC</sub>	Pcc		
1	2	0,60	0,6	12	0,12	1	0,342	44,491	5,33892		
2	2	0,6	0,5	11	0,11	0	0,366	50,824	5,59064		
					0,23				10,9296		
F <sub>CC</sub> =	47,52	ksi	< Fcr	$\rightarrow$	F <sub>cc</sub> =	51,00	ksi				
b)											
i	n	b	t	Area	B.L.	g	F <sub>CC</sub>	Pcc			
1	2	0,60	0,05	0,06	1	1	38,2393	2,294			
2	2	1,20	0,05	0,12	0	2,65	47,8941	5,747			
3	1	1,00	0,05	0,05	0	2,65	55,415	2,771			
				0,23				10,812			
F <sub>CC</sub> =	47,01	ksi	< Fcr	$\rightarrow$	F <sub>cc</sub> =	51,00	ksi				
c)											
c) A =	0,23	in <sup>2</sup>									

d) Neste exemplo, a tensão de flambagem local resultou maior do que a tensão de falha local calculada por Needham e Boeing e só um pouco menor do que o valor fornecido por Gerard, que resultou maior do que Fcut. Como conseqüência, a tensão de flambagem local deveria ser tomada como igual à tensão de falha local, qualquer que seja o método de cálculo. Não fosse este fato, as tensões calculadas por Needham e Boeing praticamente coincidem, com valores conservativos se comparados com o valor fornecido por Gerard.