

LOCAL BUCKLING AND CRIPPLING OF RECTANGULAR TUBE SECTION STRUTS

1. NOTATION

d	width of short end wall	m	in
E_t	tangent modulus of strut material	N/m ²	lbf/in ²
f_b	compressive stress at onset of local buckling	N/m ²	lbf/in ²
f_c	crippling stress	N/m ²	lbf/in ²
f_p	0.2 per cent proof stress of strut material	N/m ²	lbf/in ²
h	width of long side wall	m	in
K	buckling of stress coefficient defined by $f_b = KE_t(t_h/h)^2$		
t_d	thickness of short end wall	m	in
t_h	thickness of long side wall	m	in

Both SI and British units are quoted but any coherent system of units may be used.

2. NOTES

In Figure 1 the coefficient K is plotted against the ratio d/h for various values of t_d/t_h .

The figure is divided into two parts by a dotted line. For points above the dotted line, the long side wall is primarily responsible for the instability and requires some restraint from the short end wall in order to delay buckling until that load is reached for which the cross section as a whole becomes unstable; the half wavelength of the buckle will be comparable with h . For points below the dotted line the short end wall is primarily responsible for the instability; in this case the half wavelength will be comparable with d .

The onset of local buckling will result in a reduction of stiffness which is usually of the order of 50 per cent for this type of section. If the crippling stress is appreciably greater than the buckling stress, then the reduction of stiffness may be greater and should be taken into consideration for overall flexural failure.

After buckling the section may continue to carry more load before crippling finally occurs. The crippling stress is given by the expression

$$f_c = (f_p f_b)^{1/2}$$

Values so obtained are within 10 per cent of those given by test results.

The liability of the strut to flexural and torsional-flexural instability must be examined.

3. DERIVATION

This section lists selected sources that have assisted in the preparation of this Item.

1. SECHLER, E.E. The ultimate strength of thin flat sheets in compression. California Institute of Technology. Publication No. 27, 1933.
2. KROLL, W.D. Charts for calculation of the critical stress for local instability of columns with I, Z, channel and rectangular-tube section. NACA ARR 3K04, 1943.
FISHER, G.P.
HEIMERL, G.J.

4. EXAMPLE

To investigate the local buckling and crippling of a strut of rectangular tube section when

$$t_d = t_h = 0.036 \text{ in, } d = 0.8 \text{ in, } h = 1.0 \text{ in,}$$

and the material has values of

$$\begin{aligned} E &= 10.7 \times 10^6 \text{ lbf/in}^2, \\ \text{the 0.5 per cent proof stress} &= 48\,700 \text{ lbf/in}^2 \\ \text{and the 0.2 per cent proof stress} &= 45\,000 \text{ lbf/in}^2. \end{aligned}$$

Then $d/h = 0.8$, $t_d/t_h = 1.0$ and from Figure 1 $K = 4.18$.

$$\text{Therefore } f_b/E_t = 4.18 \left(\frac{0.036}{1.0} \right)^2 = 0.005\,42$$

Now, using Item No. 76016,

$$\begin{aligned} \epsilon_R &= 0.005, & f_R &= 48\,700 \text{ lbf/in}^2, \\ \epsilon_R' &= 0.002, & f_R' &= 45\,000 \text{ lbf/in}^2, \\ \epsilon_R/\epsilon_R' &= 2.5 & \text{and } f_R/f_R' &= 1.082, \end{aligned}$$

and thus, from Figure 5 of Item No. 76016, $m = 11.5$ so that

$$\frac{m\epsilon_R E}{f_R} = 12.6.$$

Hence, from Figure 6 of Item No. 76016,

$$\begin{aligned} f_n/f_R &= 0.786 \\ \text{and } f_n &= 38\,300 \text{ lbf/in}^2 \\ \text{giving } \frac{f_b E}{E_t f_n} &= 1.515. \end{aligned}$$