

LOCAL BUCKLING OF COMPRESSION PANELS WITH UNFLANGED INTEGRAL STIFFENERS

1. NOTATION

b	stiffener pitch	m	in
E	Young's modulus of panel material	N/m ²	lbf/in ²
E_T	tangent modulus of panel material at stress f_b	N/m ²	lbf/in ²
f_b	average compressive stress in panel at which local buckling first occurs	N/m ²	lbf/in ²
$(f_b)_e$	average elastic compressive stress in panel at which local buckling first occurs	N/m ²	lbf/in ²
f_n	stress at which $E_T = \frac{1}{2}E$	N/m ²	lbf/in ²
h	depth of stiffener measured from skin centre-line	m	in
K	elastic buckling stress coefficient defined by $(f_b)_e = KE(t/b)^2$		
m	material characteristic (see Item No. 76016)		
t	thickness of skin	m	in
t_s	thickness of stiffener	m	in
η	plasticity reduction factor defined by $f_b = \eta (f_b)_e$		
λ	half wavelength of panel buckle at stress $(f_b)_e$	m	in
ν	Poisson's ratio for panel material		

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

2. NOTES

Figure 1 shows K plotted against h/b for various values of t_s/t for panels with unflanged integral stiffeners loaded in compression. Also shown in Figure 1 are curves of constant λ/b . Figure 2 shows η plotted against $(f_b)_e/f_n$ for various values of m .

The interaction between the skin and the stiffener has been taken into account and the data are sufficiently accurate for design, provided that both b/t and h/t_s are greater than about 5. A value of $\nu = 0.3$ has been assumed for calculating the elastic deformation of the panel material. It is sufficiently accurate to factor the buckling stress by $0.91/(1 - \nu^2)$ to obtain results for other values of ν between 0.25 and 0.35.

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The value of λ for t_s/t less than about 1.98 varies continuously and smoothly with variations of the panel geometry. When t_s/t is greater than about 1.98 two distinct regions are discernible and these are separated by the chain-dotted line shown on Figure 1 at which λ changes discontinuously. In practice either wave form may appear in the vicinity of the chain-dotted line, depending upon the form of the initial irregularities present in the panel.

If $(f_b)_e$ is outside the elastic range of the panel material the appropriate values of f_n and m together with $(f_b)_e$ may be used to estimate η from Figure 2. In this case the value of λ is slightly less than that predicted by Figure 1. It should be noted that local instability does not necessarily lead to total collapse of the panel.

3. DERIVATION

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| 1. | ESDU | Estimation of the initial buckling stress under compression of a skin with integral unflanged stiffeners. Engineering Sciences Data Item No. Struct. 02.01.34, 3 pages, June 1954. |
| 2. | COX, H.L. | Computation of initial buckling stress for sheet-stiffener combinations. <i>J. R. aeronaut. Soc.</i> , Vol. 58, pp. 634-638, September 1954. |
| 3. | GERARD, G.
BECKER, H. | Handbook of structural stability. Part I – Buckling of flat plates. NACA Tech. Note 3781, October 1954. |

4. EXAMPLE

It is required to find the local buckling stress of a panel having unflanged integral stiffeners with the dimensions $t = 0.080$ in, $t_s = 0.150$ in, $b = 2.500$ in and $h = 1.550$ in. The panel is to be manufactured from D.T.D. 5020 aluminium alloy.

Checking the skin and stiffener thickness to width ratios, $b/t = 31.25 (> 5)$ and $h/t_s = 10.33 (> 5)$. Therefore, the data are applicable.

Then,
$$\frac{t_s}{t} = \frac{0.150}{0.080} = 1.875 \text{ and } \frac{h}{b} = \frac{1.550}{2.500} = 0.62$$

giving, from Figure 1, $K = 4.51$ and $\lambda/b = 2.0$.

From Item No. 76016 for D.T.D. 5020, $E = 10.6 \times 10^6$ lbf/in², $f_n = 46\,000$ lbf/in² and $m = 15$.

Therefore,

$$(f_b)_e = 4.51 \times 10.6 \times 10^6 \times (1/31.25)^2 = 49\,000 \text{ lbf/in}^2.$$

Now
$$\frac{(f_b)_e}{f_n} = \frac{49\,000}{46\,000} = 1.065.$$

Therefore, from Figure 2 at $m = 15$, $\eta = 0.917$.

Hence,

$$f_b = 0.917 \times 49\,000 = 44\,900 \text{ lbf/in}^2.$$