

FLEXIBLE CIRCULAR FRAMES SUPPORTING A SHELL. THE EFFECT OF ADJACENT FRAMES AND THE LONGITUDINAL FLEXIBILITY OF THE SHELL

1. NOTATION

E	Young's modulus of elasticity for material of frame	N/m ²	lbf/in ²
G	shear modulus for material of shell	N/m ²	lbf/in ²
I	effective moment of inertia of cross section of frame including an allowance for effect of attached skin	m ⁴	in ⁴
L	distance between adjacent frames	m	in
L'	effective frame spacing	m	in
R	radius measured to centroid of frame section	m	in
t	thickness of shell skin effective in shear	m	in
t'	equivalent thickness of shell skin effective in carrying longitudinal stress	m	in

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

2. NOTES

The effective skin-frame stiffness ratio GtR^4/EIL' is plotted against GtR^4/EIL for various values of R^6t'/IL^3 in Figure 1.

The curves have been calculated to give values of GtR^4/EIL' appropriate to Items Nos. 03.06.08 and 03.06.16, but also give good results when used with Items Nos. 03.06.06 and 07 and 09 to 15.

It is assumed that the end load carrying material of the shell is uniformly distributed longitudinally and circumferentially and that the frames are identical and are spaced equidistantly along the shell.

Non-uniformity of frame spacing may be allowed for by taking L to be $2L_1L_2/(L_1 + L_2)$ where L_1 and L_2 are the distances to the nearest frames on either side of the loaded frame.

Non-uniformity of frame stiffnesses in the form of rigid frames or bulkheads in the vicinity of the loaded frame may however have an overriding effect on the magnitude of effective frame spacing, L' . Thus, it is suggested that when the distance to rigid frames (calculated on the basis $L = 2L_1L_2/(L_1 + L_2)$ as above) is less than the value of effective frame spacing, L' , determined from the diagram of this Data Item, then the effective frame spacing should be taken as the distance to the rigid frames. When there is a rigid frame on one side only of the loaded frame, it can be assumed that L is twice the distance to the rigid frame.

The effect of loading adjacent frames in a similar manner is generally to reduce considerably the effective value of GtR^4/EIL' . The magnitude of this reduction depends upon the geometric and elastic parameters of the shell and the particular loading conditions. Loads and displacements in frames adjacent to the loaded

Issued October 1962

With Amendment A, February 1973

frame are given in Derivation 1, from which the effect of loading adjacent frames may be estimated by super-position.

3. DERIVATION

- | | | |
|----|-------------------------------|--|
| 1. | KEMPNER, J.
DUBERG, J.E. | Charts for stress analysis of reinforced circular cylinders under lateral loads. NACA tech. Note. 1310, May 1947. |
| 2. | HADCOCK, R.N.
POLAND, G.A. | The analysis of a circular cylindrical fuselage with flexible non-uniform frames of varying section. De Havilland Aircraft Company Ltd, Stress Office Report No. 29, March 1960. |
| 3. | MacNEAL, R.H.
BAILIE, J.A. | Analysis of frame-reinforced cylindrical shells. Part III - Applications. NASA tech. Note D-402, May 1960. |

4. EXAMPLE

It is required to find the value of GtR^4/EIL' for a fuselage frame supporting a stringer-stiffened skin when

$$R = 250 \text{ mm}, \quad I = 200 \text{ mm}^4, \quad E = 68\,900 \text{ MN/m}^2,$$

$$t = 0.25 \text{ mm}, \quad G = 26\,200 \text{ MN/m}^2, \quad L = 100 \text{ mm}$$

and the skin is stiffened by 72 stringers, each of cross-sectional area 11 mm^2 , equally spaced around the circumference.

$$\text{Then} \quad GtR^4/EIL = \frac{26\,200 \times 10^6 \times 0.25 \times 10^{-3} \times (250 \times 10^{-3})^4}{68\,900 \times 10^6 \times 200 \times 10^{-12} \times 100 \times 10^{-3}} = 18\,600,$$

$$t' = 0.25 \times 10^{-3} + \frac{72 \times 11 \times 10^{-6}}{2\pi \times 250 \times 10^{-3}} = 0.75 \text{ mm}$$

$$\text{and} \quad \frac{R^6 t'}{IL^3} = \frac{(250 \times 10^{-3})^6 \times 0.75 \times 10^{-3}}{200 \times 10^{-12} \times 100 \times 10^{-3}} = 9.2 \times 10^5.$$

From Figure 1, $GtR^4/EIL' = 8000$.