

FLEXIBLE CIRCULAR FRAMES SUPPORTING A SHELL. SHEAR FLOW FROM SHELL TO FRAME DUE TO CONCENTRATED LOADS AND COUPLES

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 about an axis through its centroid normal to plane of frame and including an allowance for effect of attached skin	m ⁴	in ⁴
L'	effective frame spacing (see Data Sheet 03.06.17)	m	in
M_a	applied couple, positive if tending to rotate frame anti-clockwise	N m	lbf/in
N_a	applied radial load, positive if acting outward	N	lbf
Q	shear flow from shell to frame, positive if tending to rotate frame clockwise	N/m	lbf/in
R	radius of frame measured to centroid of section	m	in
t	thickness of skin of shell to which frame is attached	m	in
T_a	applied tangential load, positive if tending to rotate frame anti-clockwise	N	lbf
θ	angle between point of application of load and section under consideration, positive if measured clockwise	degree	degree

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

2. NOTES

Three sets of curves are given showing the shear flow from the shell to a flexible circular frame when the frame is loaded by a concentrated couple, tangential load or radial load.

Figure 1 – The ratio QR^2/M_a is plotted against the angle θ for various values of the parameter GtR^4/EIL' . The curves are symmetrical about the $\theta = 0^\circ$ ordinate.

Figure 2 – The ratio QR/T_a is plotted against the angle θ for various values of the parameter GtR^4/EIL' . The curves are symmetrical about the $\theta = 0^\circ$ ordinate.

Figure 3 – The ratio QR/N_a is plotted against the angle θ for various values of the parameter GtR^4/EIL' . The curves are anti-symmetrical about the $\theta = 0^\circ$ ordinate.

The couple M_a and the loads T_a and N_a act in the plane of the frame and are assumed to be balanced entirely by tangential shear forces in the shell. Rigid connection of frames to skins is assumed. The effective value of GtR^4/EIL' is reduced when flexible connection exists between the shell and frame.

3. DERIVATION

1. WIGNOT, J.E. Analysis of circular shell-supported frames. NACA tech. Note 929,
COMBS, H. December 1943.
ENSRUD, A.F.

4. EXAMPLE

It is required to find the maximum shear flow from the shell to the frame for the circular frame described in the example of Data Sheet 03.06.17 when $M_a = 25\,000$ lbf in.

From Data Sheet 03.06.17, $GtR^4/EIL' = 8000$.

From Figure 1, at $\theta = 0^\circ$,

$$\frac{QR^2}{M_a} = -13.9$$

Therefore
$$Q = \frac{-13.9 \times 25\,000}{66^2} = -80 \text{ lbf/in.}$$