

BUCKLING OF FLAT PLATES IN SHEAR

1. NOTATION

a	length of plate	m	in
b	width of plate	m	in
E	Young's modulus of plate material	N/m ²	lbf/in ²
E_t	tangent modulus of plate material	N/m ²	lbf/in ²
f_n	stress at which $E_t = \frac{1}{2}E$	N/m ²	lbf/in ²
K	elastic buckling stress coefficient defined by $q_{be} = KE(t/b)^2$		
m	material characteristic for plate material (see Item No. 76016)		
q_b	shear stress at which plate buckles	N/m ²	lbf/in ²
q_{be}	elastic shear stress at which elastic plate would buckle	N/m ²	lbf/in ²
t	plate thickness	m	in
ν	Poisson's ratio of plate material		
η	plasticity reduction factor defined by $q_b = \eta q_{be}$		

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

2. NOTES

This Item gives the buckling stress of flat isotropic plates loaded in uniform shear. Figure 1 shows the elastic buckling stress coefficient K plotted against b/a for six combinations of simply-supported and clamped edges. Figure 2 shows the plasticity reduction factor plotted against q_{be}/f_n for various values of m .

Figure 1 is constructed for a value of $\nu = 0.3$. For other values of ν , q_{be} should be obtained by multiplying the value obtained from the figure by $0.91/(1 - \nu^2)$. Figure 2 is also based upon a value of $\nu = 0.3$ below the limit of proportionality; for other values of ν the use of Figure 2 is unlikely to introduce errors exceeding 2 per cent.

Data on the effect on shear buckling of restraint against edge rotation of the sides of long plates are provided in Item No. 80023 "Buckling of rectangular specially orthotropic plates".

The elastic buckling loads provided by this Data Item may be computed using the program of ESDUpac A8147. The program is available in two formats: (a) a Fortran source code with example input and output files, and (b) an executable program for PCs. Both versions can be found on the Compact Disc and on disk in the Sub-series Software Volume.

Issued February 1971
With Amendments A to D

In addition to shear loading the program deals with any combination of in-plane loads acting on panels with symmetrical combinations of clamped and simply-supported edges. Up to 50 loading cases can be examined in a single run. ESDUpac A8147 is associated with Data Item No. 81047 "Buckling of flat rectangular plates (Isotropic, orthotropic and laminated composite plates and sandwich panels)".

3. DERIVATION

1. STEIN, M.
NEFF, J. Buckling stress of simply-supported rectangular flat plates in shear. NACA tech. Note 1222, 1946.
2. BUDIANSKY, B.
CONNOR, R.W. Buckling stresses of clamped rectangular flat plates in shear. NACA tech. Note 1559, September 1947.
3. GERARD, G. Critical shear stress of plates above the proportional limit. *J. appl. Mech.*, Vol. 15, No. 1, pp. 7-12, March 1948.
4. KUHN, P.
PETERSON, J.P.
LEVIN, L.R. A summary of diagonal tension. Part II - experimental evidence. NACA tech. Note 2662, January 1952.
5. COOK, I.T.
ROCKEY, K.C. Shear buckling of rectangular plates with mixed boundary conditions. *Aeronaut. Q.*, Vol. XIV, Part 4, pp. 349-356, November 1963.
6. PIFKO, A.
ISAKSON, G. A finite-element method for the plastic buckling analysis of plates. *AIAA JI*, Vol. 7, No. 10, pp. 1950-1957, October 1969.

4. EXAMPLE

It is required to find the shear stress at which a rectangular plate 200 mm wide by 260 mm long and 4.5 mm thick buckles. The short sides of the plate are clamped and the long sides simply-supported. The plate material properties are $f_n = 340 \text{ MN/m}^2$, $m = 16$, $E = 73\,000 \text{ MN/m}^2$ and $\nu = 0.34$.

The plate aspect ratio $b/a = 200/260 = 0.769$. Therefore, from Figure 1, using the curve for short sides clamped, long sides simply-supported, $K = 8.08$.

Therefore,

$$q_{be} = 8.08 \times 73\,000 \times (4.5/200)^2 = 299 \text{ MN/m}^2.$$

Correcting q_{be} for the given value of Poisson's ratio gives

$$q_{be} = 299 \times \frac{0.91}{[1 - 0.34^2]} = 308 \text{ MN/m}^2.$$

Correcting for plasticity, with $q_{be}/f_n = 308/340 = 0.906$ and at $m = 16$, Figure 2 gives $\eta = 0.642$; therefore,

$$q_b = 0.642 \times 308 = 198 \text{ MN/m}^2.$$