

STIFFNESS AFTER BUCKLING. FLAT RECTANGULAR PLATES IN COMPRESSION (EDGES SIMPLY-SUPPORTED)

1. NOTATION

a	plate length	m	in
b	plate width	m	in
E	modulus of elasticity of plate material	N/m ²	lbf/in ²
f_a	average stress in plate = $\frac{\text{total load on plate}}{b \times t}$	N/m ²	lbf/in ²
f_e	stress at edges a of plate parallel to direction of applied load	N/m ²	lbf/in ²
N	elastic stiffness per unit length against lateral movement of edges parallel to a	(N/m)/m	(lbf/in)/in
t	plate thickness	m	in
η	stiffness ratio after buckling		
λ	half wavelength of buckles along plate	m	in
μ_L	elastic edge lateral restraint coefficient defined by $\mu_L = \frac{Nb}{Et}$		

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

2. NOTES

The ratio of the slope of the load-deflection curve after buckling to that before buckling, that is, df_a/df_e , is called the stiffness ratio after buckling; it is denoted by η , and is plotted against λ/b in Figure 1.

The plate is loaded at its edges b by a compressive strain parallel to its edges a . It is assumed that the edges of the plate are all free to rotate, although constrained to remain straight in the plane of the plate. The restraint against movement in that plane is expressed by the coefficient μ_L which is a function of N . For the determination of N , see Section 2 of Item No. 72019. It is assumed that the plate material is isotropic and that all stresses are within the elastic range of the plate material.

The direct influence of μ_L on the stiffness of the plate after buckling is small; therefore an average curve has been drawn. The main influence of μ_L is due to its effect on the wavelength, which is indicated on Figure 1 of Item No. 72019. For short plates, to which the figure mainly applies, the influence of the plate length on the value of λ cannot be neglected. An estimate of λ for such plates can be made from Item No. 72019 if the boundary conditions are sufficiently well known, but experimental information is generally desirable.

In long plates the half wavelength λ is almost wholly determined by the conditions at the edges a ; the values of η appropriate to such plates are tabulated as follows.

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Values of η Appropriate to Long Plates

μ_L	0	$\frac{1}{4}$	$\frac{1}{2}$	1	2	4	∞
Edges a held straight	0.500	0.548	0.580	0.621	0.665	0.696	0.746
Edges a free to wave in plane of plate	0.408	0.458	0.494	0.540	0.590	0.613	0.684

3. DERIVATION

COX, H.L. The buckling of a flat rectangular plate and its behaviour after buckling. R & M 2041, Aeronautical Research Council, UK, 1946.

4. EXAMPLE

It is required to determine the stiffness ratio after buckling of a plate when $a = 375$ mm, $b = 160$ mm and $\mu_L = 0.5$.

Then $a/b = 2.34$; from Figure 1 of Item No. 72019 for this value of a/b and at $\mu_L = 0.5$ the plate may be expected to buckle into two half-waves.

Therefore, $\lambda/b = a/(2b) = 1.17$.

Hence, from Figure 1, $\eta = 0.596$.

Note that a further example of the use of the data given in this Item is given in Section 7.2 of Item No. 72012.