

BUCKLING STRESS RATIOS FOR PLATES UNDER UNIFORM COMPRESSION AND SHEAR

1. NOTATION

f	compression stress at which plate first buckles when shear stress in plate is q	N/m ²	lbf/in ²
f_b	stress at which plate first buckles in compression alone	N/m ²	lbf/in ²
q	shear stress at which plate first buckles when compression stress in plate is f	N/m ²	lbf/in ²
q_b	stress at which plate first buckles in shear alone	N/m ²	lbf/in ²

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

2. NOTES

The ratio f/f_b is plotted against the ratio q/q_b in Figure 1. Two curves are shown, the upper one referring primarily to flat plates and the lower one to curved plates. The values of f_b and q_b to be used must be based on the appropriate edge conditions.

Most of the results available refer to thin plates in which initial irregularities of the order of the plate thickness may arise. In consequence test results on curved plates show a large amount of scatter. The average for curved plates approximates to the curve shown for flat plates and the straight line shown dotted corresponds approximately to the lowest test results for curved plates. For thicker plates, where the ratio of the initial irregularities to the thickness of the plate is likely to be smaller, test results will probably show less scatter.

3. DERIVATION

1. HOPKINS, H.G. The initial buckling of flat rectangular panels under combined shear and compression. ARC R & M 1965, March 1943.

4. EXAMPLE

A flat simply-supported plate 550 mm long by 300 mm wide and 5 mm thick is subjected to a shear stress of 78 MN/m². It is required to find the uniform compressive load that if applied to the shorter sides will buckle the plate. The modulus of elasticity of the plate material is $E = 73\,000\text{ MN/m}^2$ and Poisson's ratio $\nu = 0.3$.

From Item No. 71005, and in the notation of that Item, $\frac{a}{b} = \frac{300}{550} = 0.545$ and, from Figure 1 of that

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Item, $K = 6.02$.

Thus, $q_b = 6.02 \times 73\,000 \times 10^6 \times (5/300)^2 = 122 \text{ MN/m}^2$.

From Item No. 72019, and in the notation of that Item, $\frac{a}{b} = \frac{550}{300} = 1.83$, $\frac{f_{ye}}{f_0} = 0$ and, from Figure 6 of that Item,

$$\frac{f_{xe}}{f_0} = 1.00.$$

Thus, $f_b = \frac{1.00 \times \pi^2 \times 73\,000 \times 10^6 \left(\frac{5}{300}\right)^2}{3 \times (1 - 0.3^2)} = 73.3 \text{ MN/m}^2$.

Now $\frac{q}{q_b} = \frac{78}{122} = 0.64$,

so that, from Figure 1, $f/f_b = 0.59$.

Hence $f = 0.59 \times 73.3 = 43.2 \text{ MN/m}^2$

which will be produced by the application of a load of

$$43.2 \times 10^6 \times 300 \times 10^{-3} \times 5 \times 10^{-3} = 64.8 \text{ kN}.$$