

PLASTICITY CORRECTION FACTORS FOR PLATE BUCKLING

1. NOTATION

C	ratio of tensile yield stress to shear yield stress (note: for Tresca criterion $C = 2$, for von Mises criterion $C = 1.73$)		
E	modulus of elasticity	N/m ²	lbf/in ²
E_s	secant modulus	N/m ²	lbf/in ²
E_t	tangent modulus	N/m ²	lbf/in ²
f	stress	N/m ²	lbf/in ²
f_b	compressive stress at which buckling occurs	N/m ²	lbf/in ²
$(f_b)_e$	compressive stress at which elastic buckling would occur	N/m ²	lbf/in ²
f_n	stress at which $E_t = \frac{1}{2}E$	N/m ²	lbf/in ²
m	material characteristic (see Data Item No. 76016, Derivation 3)		
q_b	shear stress at which buckling occurs	N/m ²	lbf/in ²
$(q_b)_e$	shear stress at which elastic buckling would occur	N/m ²	lbf/in ²
η	plasticity reduction factor defined by $f_b = \eta(f_b)_e$ or $q_b = \eta(q_b)_e$		
ν	Poisson's ratio at stress level considered		
ν_e	fully elastic value of Poisson's ratio		
ν_p	fully plastic value of Poisson's ratio		

Suffixes

1. 6 Suffixes indicate particular plate forms in Table 5.1.

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

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2. NOTES

Curves are given that enable the plasticity reduction factors to be obtained for flat plates or flanges with various edge conditions, loaded in compression or shear. In Figures 1 to 6 the plasticity reduction factors, η , are plotted against the stress ratios $(f_b)_e/f_n$ or $C(q_b)_e/f_n$ for plate elements with various edge conditions, grouped for particular values of the material characteristic, m . In each figure a curve is also given for the values of η when $m = \infty$ for comparison. In Table 5.1 the equations on which the curves are based are given and in Table 5.2 the relationships required to relate these equations to the equations for the generalised stress-strain curves of Data Item No. 76016 are presented.

3. USE OF THE CURVES

Data Items that give the buckling stresses for combinations of plate elements enable the average elastic stress at which buckling would first occur, $(f_b)_e$ or $(q_b)_e$, to be calculated. When this stress exceeds the limit of proportionality for the material the buckling stress determined (and therefore the buckling load) will be too high. In such a case it is necessary to consider the form of the stress-strain curve in order to obtain the correct, reduced, buckling stress. This Item enables an assessment of this reduction to be made in terms of a reduction factor, η , for the particular values of $(f_b)_e$ or $(q_b)_e$, related to the material stress-strain curve as represented by the material characteristic, m , and stress, f_n (see also Data Item No. 76016).

The structures considered here are made up of either plate elements (where both long, unloaded, edges are supported by other elements) or flange elements (where one long, unloaded, edge is supported and one is free). It will be seen from Table 5.1 and the figures that the different forms of elements represented there have different values of η for a particular value of m . Since the structure is likely to comprise more than one such element it is necessary to exercise judgement as to which form represents the best idealisation of the structure under consideration. Guidance on this choice is given in Derivation 2. Typically it may be decided that either one element is the dominant factor or that the η values of more than one form can be combined.

An example of the first assumption is given by Data Item No. 71014* (Figure 10) for which η_3 was adopted on the assumption that since the stiffener flange was less than 10 per cent of the stiffener/panel cross-sectional area the simply-supported plate elements of the panel and stiffener web represented the dominant factors. An example of combining the reduction factors for two forms is given by Data Item No. 70003† (Figure 2) where, since both the unflanged stiffener and the simply-supported panel were considered important, it was assumed that $\eta = (\eta_1 \eta_3)^{1/2}$.

The curves have been calculated for values of the Poisson's ratios $\nu_e = 0.3$ and $\nu_p = 0.5$. The variation of η for the range $0.25 \leq \nu_e \leq 0.35$ is negligible.

* Data Item No. 71014 "Local buckling of compression panels with flanged stringers".

† Data Item No. 70003 "Local buckling of compression panels with unflanged integral stiffeners".

4. DERIVATION

The derivation lists selected sources that have assisted in the preparation of this Item.

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| 1. | GERARD, G.
BECKER, H. | Handbook of structural stability. Part 1 – Buckling of flat plates. NACA tech. Note 3781, October 1954. |
| 2. | BECKER, H. | Handbook of structural stability. Part II – Buckling of composite elements. NACA tech. Note 3782, October 1954. |
| 3. | ESDU | Generalisation of smooth continuous stress-strain curves for metallic materials. Item No. 76016, August 1976. |