

INFORMATION ON THE USE OF ITEM NO. 73007

1. INTRODUCTION

This Item describes the application of the data in Item No. 73007, "Stiffness of loaded flat strips under sinusoidally distributed bending couples at their edges (for use in local buckling calculations)", to the estimation of the local buckling* stress of stiffened panels. The data relate to thin strips of isotropic or orthotropic material under the action of a stress acting along the strip with, or without, a direct stress acting across the strip. The data are applicable to modes of deformation that involve distortion but not translation, of the cross section. Numerical examples are provided in Items Nos. 73015[†] and Struct. 02.01.34 to 37.

Data Items that provide directly the local buckling stress of particular types of construction are available. These may be located via the ESDU Index and should be used whenever applicable. Various computer programs for the calculation of local buckling stresses also exist. Where such programs are available and are sufficiently well validated it is expedient to use them. However, a knowledge of the procedures described here will be beneficial in interpreting the results of such programs.

2. NOTES

The cross section of a single stringer, or of a complete stiffened panel, may often be regarded as made up of a number of thin flat strips joined edge to edge; these strips are referred to as component flats. Where the actual junction between component flats is rounded (as in a stringer section) representation by two flats joined at a sharp corner slightly underestimates the resistance of the section to deformation.

The stiffness of a component flat to translation in its own plane is often much greater than the stiffness to rotation about the edge lines. It is then reasonable to assume that no component flat is translated in its own plane during buckling of the cross section and therefore the edge lines at the junctions between flats remain fixed in space. Then all possible modes of deformation involving only distortion of the cross section consist of pivoting of the component flats about their edge lines, and the only stiffness involved is the rotational stiffness about those edge lines.

For an isotropic component flat subjected only to a longitudinal compressive stress distributed uniformly over the cross section and bending couples distributed sinusoidally along the edges, all deformations of the flat must also vary sinusoidally with the same wavelength. All relevant stiffnesses for a particular component flat may then be presented in terms of λ , the half wavelength and f_x , the longitudinal stress. They are so presented in Item No. 73007. The curves of that Item are presented in terms of $\beta^{1/2}b/\lambda$ (b being the width of a component flat and β being unity since $f_y = 0$) up to $\beta^{1/2}b/\lambda = 2.4$; at short wavelengths considerations arise that may invalidate the present approach. The total stiffness about any edge line is the sum of the stiffnesses of the individual component flats under the conditions that λ and f_x must be the same for all component flats.

* For a description of local buckling see Section 3.1 of Item No. 72012, "Information on the use of Data Items on the buckling of plates and compression panels manufactured from isotropic materials".

[†] Data Item No. 73015 "Estimation of the local buckling stress under biaxial compression of an isotropic skin with fibre reinforced integral unflanged stiffeners".

Reference has been made previously to modes of deformation of a cross section. Any given cross section will have several possible modes of deformation satisfying the conditions that the edge lines at the junctions between component flats remain fixed in space and that the angles between component flats at the junctions are maintained constant during buckling; since the flats are joined at a sharp edge, no allowance is needed for deformation of the joint itself. All possible modes of deformation satisfying these conditions must be considered if the lowest value of the critical stress is to be obtained.

To allow for practical cases where one component flat is attached to another by means of single point fixings, such as rivets or spot-welds, it is assumed that the component flats act independently and rotate only about junctions to other component flats. When a component flat having only one edge supported (as for flat *D* on Sketch 4.3) is attached to another flat by a continuous adhesive joint, the stiffness will be increased; no allowance is made for this increase and the same conditions as for single point fixings are assumed to apply. When a component flat having both edges supported (as for flat *C* on Sketch 4.4) is attached to another flat by a continuous adhesive joint, the stiffness will be increased; allowance for this effect may be made by assuming that the component flats act as one flat of thickness equal to the sum of the thicknesses joined.

All component flats have been assumed to rotate about junctions to other component flats. In certain cases where the attachment is by rivets or spot-welds the possibility of separation of component flats at the apparent junction may necessitate the consideration of modes of deformation based on rotation about actual points of attachment. In the example of Item No. Struct. 02.01.37, any reasonable spacing of a double row of rivets attaching flats *C* and *H* would have been insufficient to prevent flat *G* from failing as a separate plate between the nearest lines of rivets; because the critical stress found for the complete cross section, taking the apparent junction of flats *A*, *G*, *H* and *C* as a point of rotation, is in fact greater than that required to buckle the widened flat *G* even if its edges were completely clamped along the rivet lines.

The process of estimating the critical longitudinal compressive stress for a panel under a particular mode of deformation consists of a search for a minimum value of the longitudinal compressive stress associated with zero values of the total stiffness at each edge line. This process will involve balancing the positive stiffnesses in one or more of the component flats against the negative stiffnesses of other component flats. Several modes may need to be investigated in order to derive the true minimum. The examples of the next section illustrate the formulae to give the resultant bending couples at junctions of component flats in various types of compression panel cross section. The application of the formulae to the balancing process is also shown.

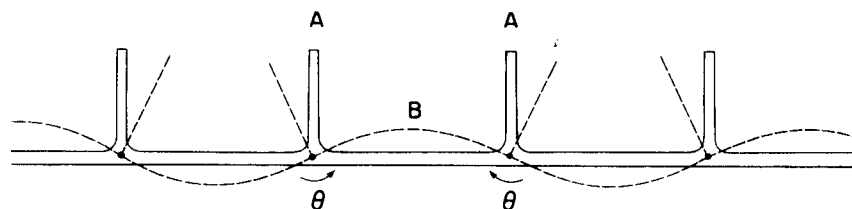
3. NOTATION

$A, B, C, \text{etc.}$	component flats		
$A_1, B_1, C_1, \text{etc.}$	stiffnesses of component flats with loaded edges simply-supported and remote edge free (designated μ_1 in Item No. 73007)	N m/m	lbf in/in
$A_2, B_2, C_2, \text{etc.}$	stiffnesses of component flats with both edges simply-supported and loaded by equal but opposed couples (designated μ_2 in Item No. 73007)	N m/m	lbf in/in
$A_3, B_3, C_3, \text{etc.}$	stiffnesses of component flats with both edges simply-supported and loaded by equal couples of the same sense (designated μ_3 in Item No. 73007)	N m/m	lbf in/in
$T_\theta, T_\psi, \text{etc.}$	resultant bending couples at junctions	N m/m	lbf in/in
$\theta, \psi, \text{etc.}$	angles of rotation at junctions	rad	rad

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

4. EXAMPLES

4.1 Panel with Integral Unflanged Stringers



Sketch 4.1

For the mode of deformation shown in Sketch 4.1, the resultant bending couple at any junction is given by

$$T_\theta = A_1\theta + 2B_2\theta$$

$$\text{or } T_\theta/\theta = A_1 + 2B_2. \quad (4.1)$$

Another mode of deformation satisfying the conditions noted in Section 2 could occur in which all the rotations θ were of the same sense. In this case B_3 would replace B_2 in Equation (4.1). Within the range of values of b/λ for which stiffnesses are provided, B_3 will always be greater than B_2 and this mode would lead to a higher value of the critical stress.