

NOMOGRAM FOR STRENGTH OF STRINGERS IN PANEL IN COMPRESSION

1. NOTATION

A_s	area of section of stringer	m^2	in^2
b	plate width between stringers, measured as distance between adjacent rivet lines	m	in
E_{edge}	tangent modulus of stringer material at stress f_{edge}	N/m^2	lbf/in^2
E_s	tangent modulus of stringer material at stress f_s	N/m^2	lbf/in^2
f_b	stress at which plate first buckles in compression, deduced from Item No. 72019*	N/m^2	lbf/in^2
f_{edge}	edge stress at failure of stiffened panel	N/m^2	lbf/in^2
f_s	failing stress of stringer alone, constrained to fail by flexure in direction normal to sheet	N/m^2	lbf/in^2
I_s	second moment of area of stringer section about axis through stringer centroid parallel to sheet	m^4	in^4
I_x	second moment of area of stringer section about axis in median plane of sheet	m^4	in^4
t	sheet thickness	m	in

* Data Item No. 72019 "Buckling of flat isotropic plates under uniaxial and biaxial loading".

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

2. NOTES

Figure 1 provides a nomogram for calculating the failing edge stress of stiffened panels and represents the formula of Data Item No. Struct 02.01.16 (see Section 3) using the $f_{average}/f_{edge}$ relation corresponding to the conditions of Data Item No. Struct 02.01.03[†], but without the particular approximations introduced in Data Item No. Struct 02.01.16 that were necessary for the presentation of data in that form.

The procedure to be followed in using the nomogram is as follows.

- (1) Calculate for the panel I_s , I_x , f_s , $A_s/(bt)$ and f_b .
- (2) Assume $f_{edge} = f_s$. Draw a straight line from the given value of I_x/I_s to the point of intersection of the $A_s/(bt)$ curve with the estimated f_b/f_{edge} curve.

[†] Data Item No. Struct 02.01.03 "Average and edge stresses for thin flat aluminium alloy plates in compression".

- (3) This line will intersect the f_{edge}/f_s scale, and a value of f_{edge} is thereby obtained. The process under (2) is repeated to give a second approximation to f_{edge} and so on.

The nomogram applies only to failure of stringers due to flexural instability. Their failure due to local or torsional instability must also be considered. The effect of buckling of the sheet on its contribution to the flexural stiffness of the stringer has been taken into account, but the effects of any tendency for the stringer and plate to buckle into different forms when acting separately and of inter-rivet buckling along the length of the stringer have been ignored; this will be permissible if the stringer is of greater wall thickness than the sheet, but may not apply to heavy-gauge sheet with relatively light stringers.

The curves have been plotted for stresses in the elastic range; as a first approximation they may be used in the plastic range by replacing the ratio f_{edge}/f_s by $(f_{edge}/f_s)(E_s/E_{edge})$.

3. DERIVATION

1. ESDU Strength of stringers in panel in compression. Engineering Sciences Data Item No. Struct 02.01.16, London, August 1977.

Leading to the equation

$$\frac{f_{edge}}{f_s} = \frac{\frac{A_s}{bt} \left[1 + \left(\frac{I_x - I_s}{I_s} \right) \left(\frac{0.405(f_b/f_{edge})^{1/2} + 0.19}{A_s/(bt) + 0.405(f_b/f_{edge})^{1/2} + 0.19} \right) \right]}{A_s/(bt) + 0.81(f_b/f_{edge})^{1/2} + 0.19}. \quad (3.1)$$

2. REDSHAW The design of a nomogram for an equation occurring in stressed skin analysis. (Unpublished.)

4. EXAMPLE

It is required to find the edge stress at failure of a stiffened panel for which $A_s = 65 \text{ mm}^2$, $b = 125 \text{ mm}$, $I_s = 9160 \text{ mm}^4$, $I_x = 24\,200 \text{ mm}^4$, and $t = 0.8 \text{ mm}$. The length of panel and of stringer is 725 mm, and both use material 2L73 with properties as given in Data Item No. 76016*.

From the given data $I_x/I_s = 2.64$ and $A_s/(bt) = 0.65$.

From Item No. Struct 01.01.01† with the above data, and assuming no eccentricity and pinned ends, $f_s = 169 \text{ MN/m}^2$.

From Item No. 72019, for a long simply-supported panel, $f_b = 9.4 \text{ MN/m}^2$.

* Data Item No. 76016 "Generalisation of smooth continuous stress-strain curves for metallic materials".

† Data Item No. Struct. 01.01.01 "The strength of struts".