

ESTIMATION OF THE INITIAL BUCKLING STRESS UNDER UNIAXIAL COMPRESSION OF A SKIN WITH TOP HAT SECTION STRINGERS

1. INTRODUCTION

This Item illustrates the use of Items Nos 73007 and Struct. 02.01.28 for the estimation of the initial buckling stress under uniaxial compression of a skin with top hat section stringers manufactured from an isotropic material. A diagram of a typical cross section of this type and the computation of the buckling stress are given in Section 3. Explanatory notes on this computation are given below.

Equation (4.3) of Item No. Struct. 02.01.28 gives

$$T_{\theta}/\theta = B_2 + D_1 + F_2 + \frac{\frac{1}{2}(A_2 + A_3)C_2 + A_2A_3}{\frac{1}{2}(A_2 + A_3) + C_2}.$$

The computation of the initial buckling stress, appropriate to a mode of deformation involving distortion of the cross section without translation of any of the junctions of the component flats, consists of a search for the minimum value of the longitudinal compressive stress f_x associated with a zero value of the total stiffness T_{θ}/θ .

2. EXPLANATORY NOTES

- (1) All stresses are quoted in thousands of pounds force per square inch and, in accordance with Item No. 73007, compressive stresses are positive. Since there is no transverse stress the term β_I of Item No. 73007 reduces to one so that $\beta_I^{1/2} b/\lambda$ reduces to b/λ . The stress parameter α_I similarly reduces to f_x/f_I and is a convenient means of expressing the longitudinal compressive stress in non-dimensional form. The value of the modulus of elasticity used in the calculation of f_I should be that appropriate to the stress f_x .
- (2) Since $\nu = 0.3$ stiffnesses with subscripts "1" are obtained from Figures 3 and 4, those with subscripts "2" are obtained from Figures 7 and 8 and those with subscripts "3" are obtained from Figures 9 and 10 of Item No. 73007.
- (3) The best initial choice of a value for the half wavelength λ is largely a matter of experience but a value somewhat less than the value of b for the widest component flat in the skin is suggested.
- (4) A series of values of f_x is selected until both positive and negative values of T_{θ}/θ have been obtained. Inspection of the cross section suggests that an appropriate initial choice of f_x is a value somewhat above the buckling stress for component flat B for simply-supported edge conditions.
- (5) Values of $\mu/(E't^3/(3b))$ are read from the figures of Item No. 73007 appropriate to the mode of deformation denoted by the subscript.

In the case noted,

$$\frac{f_x}{f_I} = \frac{44.5}{37.1} = 1.2 \quad \text{and} \quad \frac{b}{\lambda} = 0.833.$$

From Figure 7, $\frac{\mu_2}{E't^3/(3b)} = -0.315$,

giving $\mu_2 = -0.315 \times E't^3/(3b) = -0.315 \times 270 = -85 \text{ lbf}$.

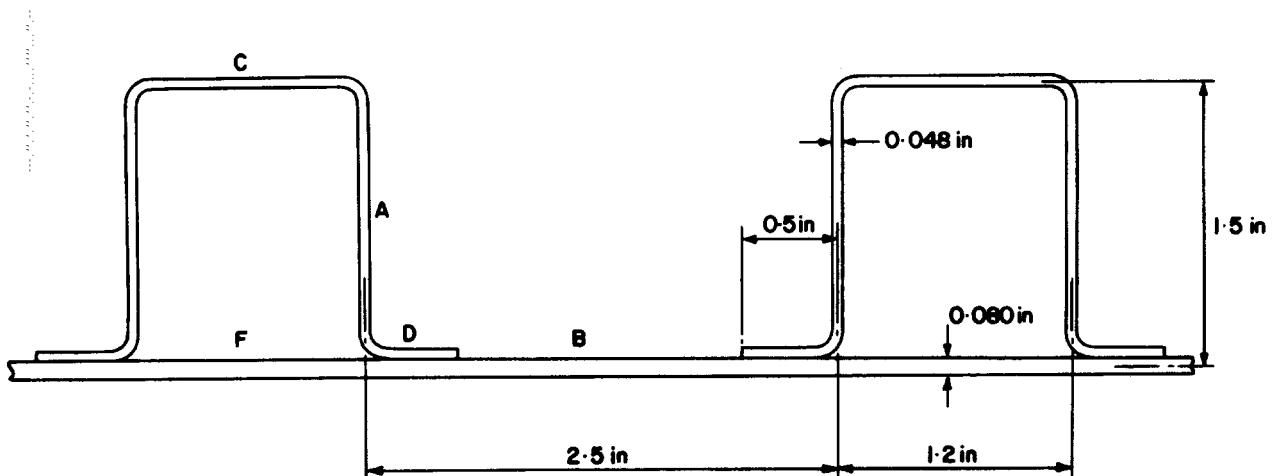
- (6) Critical f_x is the value of f_x appropriate to $T_0/\theta = 0$ and is obtained graphically.
- (7) Minimum critical f_x and the associated value of λ are obtained by plotting critical f_x against λ .

It will be noted that all the values of $\frac{1}{2}(A_2 + A_3) + C_2$ are positive, indicating that the minimum obtained occurs on the lower series of roots noted in Section 5 of Item No. Struct. 02.01.28. It is necessary to check that there is no other minimum, of this same series of roots, at a still lower value of λ . This has been done for the present example and the results are as follows.

λ in	1.7	1.5	1.3	1.1
Critical $f_x \times 10^3 \text{ lbf/in}^2$	48.7	49.4	49.8	50.7

This steady increase in critical f_x with decreasing λ indicates that the minimum value obtained at $\lambda \approx 2.0$ in is the only one.

3. EXAMPLE CALCULATION



Material Properties

Young's modulus of elasticity, E , is $10.0 \times 10^6 \text{ lbf/in}^2$ and Poisson's ratio, ν , is 0.3.

Thus, $E' = \frac{E}{(1-\nu^2)} = 11.0 \times 10^6 \text{ lbf/in}^2$ and $f_I = 3.62E\left(\frac{t}{b}\right)^2 \text{ lbf/in}^2$.

The material is assumed to be elastic within the range of stresses concerned.