

ESTIMATION OF THE INITIAL BUCKLING STRESS UNDER UNIAXIAL COMPRESSION OF A SKIN WITH INTEGRAL UNFLANGED STIFFENERS

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 integral unflanged stiffeners 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 (4.1) of Item No. Struct. 02.01.28 gives

$$T_{\theta}/\theta = A_1 + 2B_2.$$

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 of Item No. 73007. Those with subscripts "2" are obtained from Figures 7 and 8 of Item No. 73007.
- (3) The best initial choice of a value for the buckle half wavelength, λ , is largely a matter of experience but a value somewhat less than the value of b for the widest component flat is suggested.
- (4) A series of values of f_x is selected until both negative and positive values of T_{θ}/θ have been obtained. The initial choice will be guided by consideration of component flats A and B. Inspection of the cross section suggests that an appropriate initial choice of f_x is a value between the buckling stress for component flat A if the edge at the junction to flat B were simply-supported and the buckling stress if that edge were fully fixed against rotation. Figure 5 of Item No. 72019 gives the buckling stress for these two types of edge support as $0.106(\pi^2 E/3(1-\nu^2))(t/b)^2$ and $0.313(\pi^2 E/3(1-\nu^2))(t/b)^2$, or 11 000 lbf/in² and 32 500 lbf/in², respectively, in the case of a flat with the dimensions given for A.

The initial choice of f_x is made at the upper end of the range between 11 000 lbf/in² and 32 500 lbf/in².
- (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,

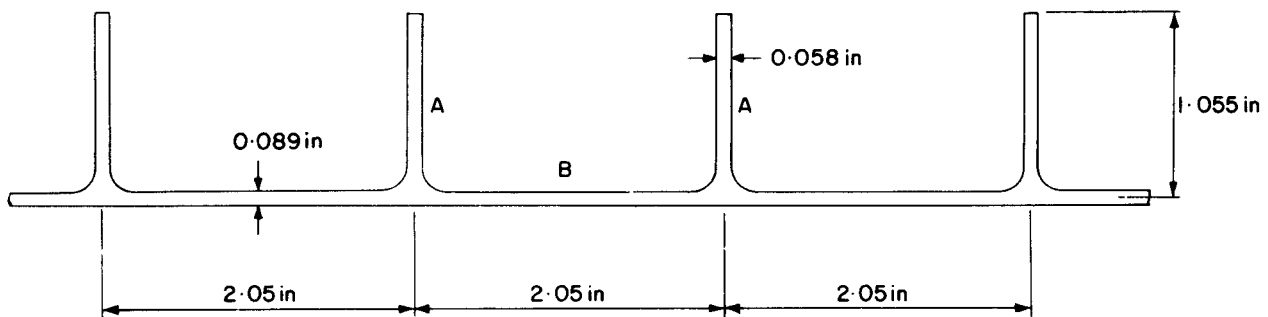
$$\frac{f_x}{f_I} = \frac{23.4}{103.9} = 0.225 \quad \text{and} \quad \frac{b}{\lambda} = 0.659.$$

From Figure 3, $\frac{\mu_1}{E't^3/(3b)} = -0.17,$

giving $\mu_1 = -0.17 \times E't^3/(3b) = -0.17 \times 644 = -110 \text{ lbf}.$

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

3. EXAMPLE CALCULATION



Material Properties

Young's modulus of elasticity, E , is $9.5 \times 10^6 \text{ lbf/in}^2$ and Poisson's ratio, ν , is 0.3.

Thus, $E' = \frac{E}{(1-\nu^2)} = 10.4 \times 10^6 \text{ lbf/in}^2$ 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 stress concerned.