

# INITIAL BUCKLING STRESS, MAXIMUM DIRECT STRESS AND SHEAR STRAIN OF SQUARE PLATES IN SHEAR WITH CENTRAL CIRCULAR HOLES

## 1. NOTATION

|               |                                                                     |                  |                     |
|---------------|---------------------------------------------------------------------|------------------|---------------------|
| $b$           | width of plate                                                      | m                | in                  |
| $d$           | diameter of central hole                                            | m                | in                  |
| $E$           | modulus of elasticity of plate material                             | N/m <sup>2</sup> | lbf/in <sup>2</sup> |
| $f_{max}$     | maximum direct stress acting at hole boundary                       | N/m <sup>2</sup> | lbf/in <sup>2</sup> |
| $K$           | elastic buckling stress coefficient defined by $q_{be} = KE(t/b)^2$ |                  |                     |
| $q$           | average shear stress applied to plate edges                         | N/m <sup>2</sup> | lbf/in <sup>2</sup> |
| $q_{be}$      | value of $q$ at which plate would buckle elastically                | N/m <sup>2</sup> | lbf/in <sup>2</sup> |
| $t$           | plate thickness                                                     | m                | in                  |
| $\gamma$      | overall shear strain of plate (see notes)                           |                  |                     |
| <i>Suffix</i> |                                                                     |                  |                     |
| 0             | relates to plates without holes                                     |                  |                     |

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

## 2. NOTES

The data provided in this Item relate to the elastic analysis of flat square isotropic plates subjected to shear and containing a central circular hole without edge reinforcement.

Figure 1 gives  $K/K_0$  plotted against  $d/b$ . The values of  $K_0$  should be determined for the appropriate edge conditions and may be obtained from Figure 1 of Item No. 71005 "Buckling of flat plates in shear". The data are based on finite element calculations for the case of a uniform shear stress along the plate edges. The data are supported by experimental results which indicate that for practical panels values of  $K$  obtained from Figure 1 are likely to be accurate to within  $\pm 10$  per cent.

Figure 2 gives  $f_{max}/q$  plotted against  $d/b$ . The stress  $f_{max}$  occurs at four points around the boundary of the hole and is either tensile or compressive as indicated by the sketch accompanying the figure.

Figure 3 gives  $\gamma/\gamma_0$  plotted against  $d/b$ . The figure is based upon the results of a finite element calculation which relates to an overall state of shear deformation in which the edge lines remain straight and unstrained.

The data of Figures 1 to 3 relate strictly to square plates. For rectangular plates  $b$  should be taken as the smaller dimension and the data may be used where the other dimension is not greater than  $1.2b$ .

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### 3. DERIVATION

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3. GROSSKURTH, J.F. Shear buckling of square perforated plates. NASA-CR-132548, 1974.  
*et al.*