

INITIAL BUCKLING OF SQUARE PLATES IN SHEAR WITH CENTRAL FLANGED CIRCULAR HOLES (TENTATIVE)

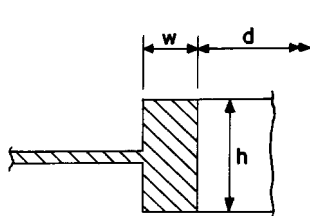
1. NOTATION

b	width of plate	m	in
d	diameter of central hole (see Sketches 2.1 to 2.4)	m	in
E	modulus of elasticity of plate material	N/m ²	lbf/in ²
h	effective height of hole reinforcement (see Sketches 2.1 to 2.4)	m	in
K	elastic buckling stress coefficient defined by $q_{be} = KE(t/b)^2$		
q_{be}	average edge shear stress at which plate would buckle elastically	N/m ²	lbf/in ²
t	plate thickness	m	in
w	effective width of hole reinforcement (see Sketches 2.1 to 2.4)	m	in
<i>Suffix</i>			
0	relates to plates without holes		

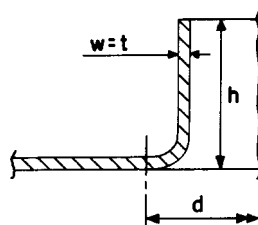
Both SI and British Units are quoted but any coherent system of units may be used.

2. NOTES

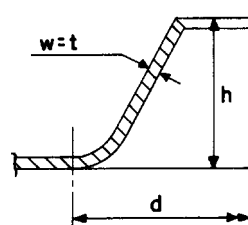
This Item gives data for calculation of the initial elastic buckling stress of a flat square isotropic plate in shear with a central circular hole, the boundary of which is reinforced or flanged.



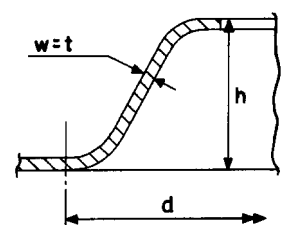
Sketch 2.1



Sketch 2.2



Sketch 2.3



Sketch 2.4

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Figures 1, 2 and 3 give, for values of d/b , curves of K/K_0 plotted against h/t for values of d/w . Values of K_0 may be determined from Figure 1 of Item No. 71005 "Buckling of flat plates in shear". The figures are based on two separate sources of data; firstly, finite element calculations for square panels having $d/b = 1/3$ and symmetrical reinforcement of the type shown in Sketch 2.1 and, secondly, experimental results on nearly square panels having flanged holes of the types shown in Sketches 2.2, 2.3 and 2.4. Agreement with experiment is adequate provided that d/t is 100 or more. The few test results available below this value of d/t show serious disagreement. For that reason and because of the limited amount of data available this Item is designated tentative.

The data relate strictly to the elastic buckling of 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 $1.25b$.

3. DERIVATION

1. ROBERTS, J.M. Comparative shear tests on two magnesium alloy panels with flanged lightening holes. Test Report No. 841, Sir W.G. Armstrong Whitworth Aircraft Ltd.
2. KROLL, W.D. Instability in shear of simply-supported square plates with reinforced hole. U.S. Department of Commerce, National Bureau of Standards, Research paper RP 2037, Vol. 43, November 1949.
3. FLOOR, W.K.G. Shear tests on 24T unstiffened and stiffened webs with flanged holes, Part 1. NLL Report S 413, July 1953.
4. BOTMAN, M. Shear tests on 24S-T unstiffened and stiffened webs with flanged holes, Part 2. NLL Report S 446, November 1954.
5. COLES, B. The buckling strength of web plates with lipped circular holes and web plates with swages when subjected to shear. Thesis submitted in part candidature for B.Sc. Degree of Wales. No. C/P/59/66.
6. ROCKEY, K.C.
ANDERSON, R.G.
CHEUNG, Y.K. The behaviour of square shear webs having a circular hole, pp. 148-174. In: *Thin walled steel structures, their design and use in building*. Edited by Rockey, K.C. and Hill, H.V., Published by Crosby Lockwood and Son Ltd, London, 1969.

4. EXAMPLE

It is required to determine the initial buckling stress of the square plate shown in Sketch 4.1 under the action of uniform shear. The modulus of elasticity of the panel material is $73\,000\text{ MN/m}^2$.

From Item No. 71005, Figure 1, $K_0 = 11.35$. The reinforcement height will be taken as the total height of the lip of 10 mm, w will be taken as equal to t and, as shown in Sketch 2.3, d will be taken as the diameter where the lip commences so that $\frac{d}{t} = \frac{180}{1.7} = 106$ and $\frac{h}{t} = \frac{10}{1.7} = 5.88$. Also $d/b = 180/300 = 0.6$.