

REFERENCE FREQUENCY OF PANEL WITH FLEXIBLE STIFFENERS

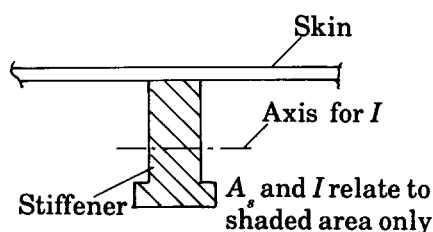
1. NOTATION

		SI	British
A_s	cross-sectional area of stiffener (see Sketch 1.1)	m^2	in^2
a	length of longer side of plate	m	in
b	length of shorter side of plate	m	in
D	flexural rigidity of plate, $E_p t^3 / \{12(1 - \nu^2)\}$	N m	lbf in
E	Young's modulus	N/m ²	lbf/in ²
f_{ref}	reference frequency of plate	Hz	Hz
I	second moment of area of stiffener (without skin) about its neutral axis parallel to plate (see Sketch 1.1)	m ⁴	in ⁴
K	reference frequency parameter	m/s	in/s
t	thickness of plate	m	in
V	velocity parameter for plate material*		
ν	Poisson's ratio for plate material		
ρ	density	kg/m ³	†
<i>Suffixes</i>			
p	denotes plate		
s	denotes stiffener		

* The velocity parameter is defined in SI units by $V = (E/\rho)^{1/2}/5080$ or in British units by $V = (E/\rho)^{1/2}/200\,000$. It is approximately unity for all common structural metallic materials.

† A density value expressed in British units as pounds per cubic inch has to be divided by 386.4 before being used to calculate parameters defined in this Item. (A force of 1 lbf acting on a mass of 1 lb produces an acceleration of 386.4 in/s².) For example, if the material density is 0.097 lb/in³, the value used in the calculation should be 2.51×10^{-4} lb s²/in⁴.

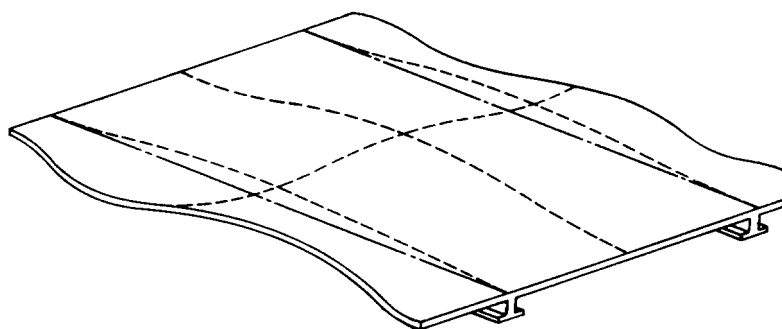
Both SI and British units are quoted but any coherent system of units may be used.



Sketch 1.1 Stiffener geometric parameters

2. NOTES

This Data Item gives the reference frequency of initially unstressed, flat, uniform, rectangular plates in a panel with flexible stiffeners. The reference frequency is the fundamental natural frequency, obtained from the model used to represent the panel, where an assumed mode shape has been employed in a Rayleigh-Ritz analysis. This frequency may be used as a first approximation to the fundamental natural frequency of the panel with edges fixed against rotation. The reference frequency is intended for use in calculating the stress response of panels with flexible stiffeners under the action of acoustic loading. In the vibration mode considered, the stiffeners are assumed to be free to bend in a plane normal to the plate and be fixed against rotation (see Sketch 2.1).



Sketch 2.1 Assumed deflected shape

The reference frequency is given by

$$f_{ref} = VK \frac{t}{b^2}. \quad (2.1)$$

In Figures 1 to 4 values of K are plotted against $E_s I / Db$ for a range of values of a/b . Each of these figures is drawn for a particular value of $\rho_s A_s / \rho_p b t$.

The plates are assumed to be separated by flexible stiffeners along their longer sides and fully fixed along their shorter sides. In the derivation, stiffener bending is considered but stiffener torsion is neglected.

The use of the second moment of area of the stiffener (without skin) about its neutral axis parallel to the plate has been found to give the closest correlation with limited test data. It is possible with certain configurations that the effective neutral axis could lie closer to the skin but as yet there is insufficient evidence to clarify this point.

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In deriving the curves the value of ν was assumed to be 0.3. This value gives sufficiently accurate frequencies for all common structural metallic materials.

A computer program, based on this procedure, to calculate both the reference frequency and stress response is provided on a diskette which is located in the Sub-series Software Volume. The use of the program, referred to as ESDUpac A7314, is described in Appendix A of Data Item No. 73014.

3. COMPARISON WITH MEASURED DATA

Figure 5 shows a comparison of calculated reference frequency and lowest measured natural frequencies of flat stiffener panels. For some of the data for integrally-machined panels, where measured frequencies were obtained using broad band excitation, frequency bands covering the predominant response frequencies are shown.

It should be noted that, when estimating frequency, the plate edge-fixing approximates to the fully-fixed condition since all edges are fixed against rotation and only the longer plate edges are free in translation. With the restriction on plate edge rotation, the estimated frequencies are expected to be greater than the lowest measured values which correspond with modes involving stringer torsion.

4. DERIVATION

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