THE FUNDAMENTAL BENDING FREQUENCY OF A PLATE WITH FIXED-FREE-FREE-FREE BOUNDARY CONDITIONS

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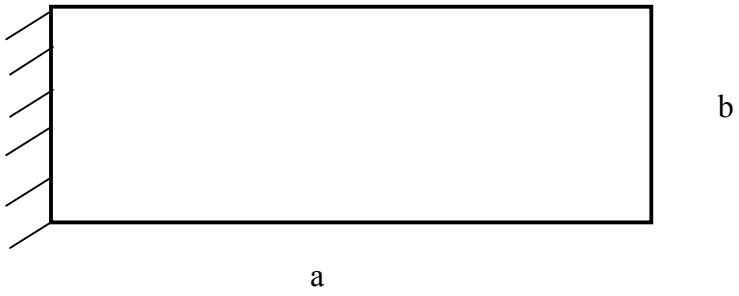

The fundamental bending frequency fn of a plate fixed at one edge but free at the other three edges is approximately:

$$fn = \frac{0.56}{a^2}\sqrt{\frac{D}{\rho}} \tag{1}$$

where

$$D = \frac{E h^3}{12\left(1-\mu^2\right)} \tag{2}$$

where

E	is the modulus of elasticity
a	is the length
b	is the width
h	is the thickness
ρ	is the mass density (mass/area)

Equation (1) is taken from Reference 1. Note that the natural frequency formula is an approximation which does not directly depend on the width b.

Reference 2 gives more detailed equations that explicitly include the width.

Example

A plate is 30 cm long and 30 cm wide. The thickness is 1.27 mm.

The material is aluminum.

The plate is fixed along one edge but free along each other edge.

The mass per area is

$$\rho = (2700\ \text{kg/m\^3})(1.27\text{e}-03\ \text{m})$$

$$\rho = 3.43\ \text{kg/m\^2}$$

The plate stiffness factor is

$$D = \frac{(70\text{e}+09\ \ \text{N/m\^2})(1.27\text{e}-03\ \ \text{m})^3}{12\left(1-0.33^2\right)}$$

$$D = 13.4\ \text{N m} \quad (\text{or kg m\^2/sec\^2})$$

The fundamental frequency is

$$fn = \frac{0.56}{(0.30\ \text{m})^2}\sqrt{\frac{13.4\ \text{kg m\^2/sec\^2}}{3.43\ \text{kg/m\^2}}}$$

$$fn = 12.3\ \text{Hz}$$

Reference

1. Dave Steinberg, Vibration Analysis for Electronic Equipment, Second Edition, Wiley-Interscience, New York, 1988.
2. A. Leissa, Vibration of Plates, NASA SP-160, Washington D.C., 1969.