# DML : material caracteristic measurements

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The knowledge of some parameters linked to the membrane material of the bending wave loudspeaker might help to predict the frequency response.

Those parameters should at least help in comparing materials or designs.

## A bit of theory

From NXT When a Little Chaos is Good For You by Henry Azima :

> Provided you know a few key parameters - the size and shape of the panel (it can be curved in one or more plane), the position of the exciter(s) and the bending stiffness, surface density and internal damping of the panel material - it is possible to predict the acoustic performance with a high degree of accuracy.

## Material parameters

The performances are lead by 2 main parameters :

- D (or B) : the bending bending stiffness in Nm
- μ (or m) : the arial density (mass per unit area) in kg/m2

## Aerial density μ kg/m2

Just put on a balance the membrane or a sample of material and divide its mass m by the area A of the sample.

$$\mu = m/A$$

μ in $kg/m^2$ with m the membrane mass in kg and A the membrane surface in $m^2$ or also

$$\mu = \rho * h$$

with $\rho$ the membrane density in $kg/m^3$ and h the membrane thickness in m.

## Bending stiffness D Nm

$$D = Eh^3/12$$

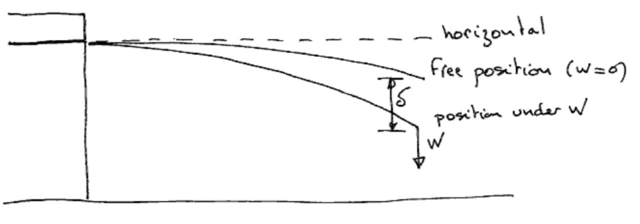
D in Nm for a plain homogeneous material with E the Young's modulus of the material in Pa and h the membrane thickness in m.

2 methods can give the bending stiffness :

- the cantilever beam
- the three-point bend test

### The cantilever beam

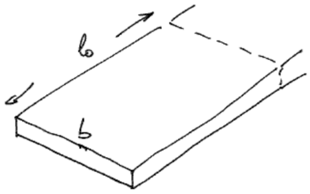
/!\ Check the quality of the embedding



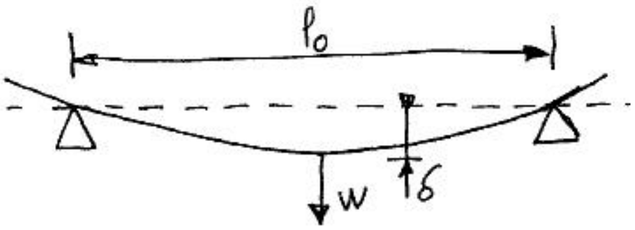

$$D = W.l_0^3/3\delta.b$$

With :

- $W$ the force in N at the free end of the beam. If W results from an additionnal mass M : $W = M.g, g = 9.81m/s^2$
- $l_0$ the beam length in m
- $b$ the beam width in m
- $\delta$ the deviation under the force $W$




## The three-point bend test




$$D = W.l_0^3/48\delta.b$$

With :

- $W$ the force in N at the center of the beam. If W results from an additionnal mass M : $W = M.g, g = 9.81m/s^2$
- $\delta$ the deviation under the force $W$
- $l_0, b$ same as above

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