THE BENDING STRENGTH

1 - INTRODUCTION

The sandwich panels are often used to bring a larger bending and buckling strength.
The core of **nidaplast** honeycomb transmits the shearing and by giving extra thickness, increases inertia.
The rigid skins are pulled, one under a tensile, the other one under a compressive strength. It means they are involved according to their resistance and their elastic modulus values.

Several parameters have to be considered in the manufacturing of sandwich panels and its calculation when it is under bending.

- Amount of deflexion
- The resistance to breaking and the core and/or skins modulus
- The way of pulling either static or dynamic

The first two points are easily determinated by calculation or trials. The last point is harder to meet by calculation only. Further alternative pulling trials under fatigue are needed to surely bring out the values.

2 - CALCULATION

The amount of deflexion and the resistance to breaking are two independent values, which can shift in different ways. We can meet a large stiffness (small deformation) with a low resistance to breaking or at the opposite a slightly lower stiffness (high deformation) with a higher resistance to breaking.

The **nidaplast** honeycomb in polypropylene, with a low G Coulomb modulus is closer to this second type. With the same thickness, they are slightly more flexible but more resistant

2.1. DEFORMATIONS

The size of a sandwich panel mostly depends on deformation and next on the shearing strength of the core, then at least of the rigid skins. Breaking is reached only under far bigger deformation and safety margins on breaking stresses are often high.

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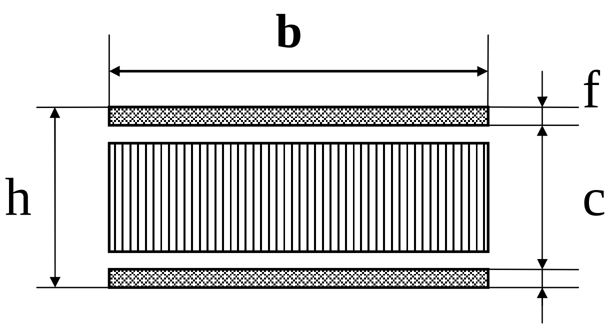
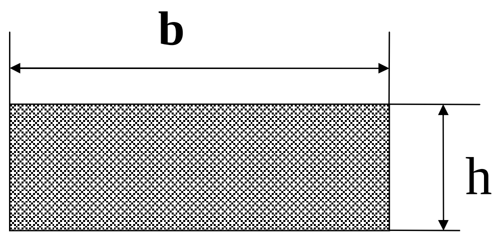
The calculation of the bending deformation, under a load, of a sandwich panel working as a beam can be studied in a similar way as a monolithic component, as shown by the following formula for a first estimation

Sandwich panel



Plain panel



E_f Elasticity modules of skins
G_c Shear modulus of the core

E Elasticity modulus of the panel

P total load, **L** bearing, **D** stiffness, **I** inertia

the bending deformation is :

Sandwich panel: $y = y_1 + y_2$

Plain panel: $y = y_1$

- with $\mathbf{y_1}$ due to the rigid skins

Sandwich panel: $y_1 = Kg\ PL^3/D$

and $D = "E"I$ with $"E" = E_f\ (1 - c^3/h^3)$

Plain panel: $y_1 = Kg\ PL^3/D$

and $D = EI$

The amount of deflexion y_1, proportional to the cube of the bearing, is generally preponderous and all the more so as the bearing between supports is wide. In a given scheme, for a quoted force and bearing**,** the way to lower its value is to increase the stiffness **D = EI**

For this purpose:
- We can increase the skins elasticity modulus E by changing the material.

Or
- Increase the inertia $I = bh^3/12$, by increasing the thickness. It is the simplest solution proper to sandwich structure.

- Y_2 is the shearing term for the core

$$Y_2 = Ks\ PL/b(c+f)Gc$$

The amount of deflexion y_2, proportional to the bearing**,** is generally less important, unless if the supports are close and the shape strength important.
Graph 1 presents the various values in relation to the different loading possibilities.

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2.2 STRESSES

The compressive or pulling stresses on the skins is given by the following formula:

$$\sigma_c = 2M/b.f(h+c)$$

The shearing stress in the core by the following formula:

$$\sigma_s = N/b(c+f)$$

Where M and N are the bending moment and the sharp strength

Check that the calculated stresses are lower than the breaking ones, divided by safety margins adapted according to requirements and to the application.

3. PULLING MODE

The simplified calculation above checks the deformation and the stresses under a static load. A classical bending test, it means a static one, allow verifying that the calculation is correct. This test does not prove the resistance to fatigue under dynamic pulling. In this last case, the resistance to damage of the different sandwich panel components is involved.

As seen above, the **nidaplast** honeycomb has a Coulomb modulus fairly low compared to their shearing resistance. It means certain flexibility, which is good for the resistance to damages. To sum up, the sandwich panel with **nidaplast** is going to accept high deformations absorbing energy without breaking.

Nota 1 :
The panel shearing resistance is closely linked to the stickiness between the skin and the core that has to be as strong as possible. It is better making a trial to bring out this figure and find the panel properties.

Nota 2 :
The deformation under a shearing strength depends on two figures. The links between these two figures depend of the importance of the trial. It is important to make trials with a bearing value very close to the one that will be applied on the panels in their common uses.
For large bearing panels, an entre-axe forty times the thickness is required.

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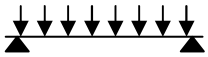
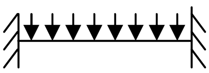
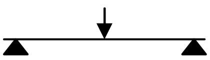
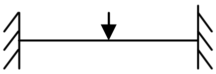
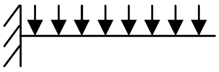
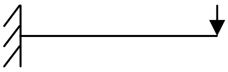
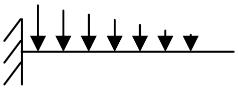
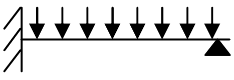
ANNEXE I

Kg and Ks coefficients, the bending moment M and the sharp strength N are given below, regarding the different loading cases :

Type of loading		N	M	Kg	Ks
2 strong points Regular load		$\frac{P}{2}$	$\frac{PL}{8}$	$\frac{5}{384}$	$\frac{1}{8}$
Built-in Regular load		$\frac{P}{2}$	$\frac{PL}{12}$	$\frac{1}{384}$	$\frac{1}{8}$
3-points bending		$\frac{P}{2}$	$\frac{PL}{4}$	$\frac{4}{192}$	$\frac{1}{4}$
Built-in Centered load		$\frac{P}{2}$	$\frac{PL}{8}$	$\frac{1}{192}$	$\frac{1}{4}$
Built-in Regular load		P	$\frac{PL}{2}$	$\frac{1}{8}$	$\frac{1}{2}$
Built-in Punctual load		P	PL	$\frac{1}{3}$	1
Built-in Decreasing load		P	$\frac{PL}{3}$	$\frac{1}{15}$	$\frac{1}{3}$
Half built-in Regular load		$\frac{5P}{8}$	$\frac{PL}{8}$	$\frac{1}{185}$	$\frac{1}{14{,}2}$

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