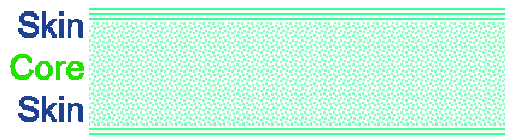
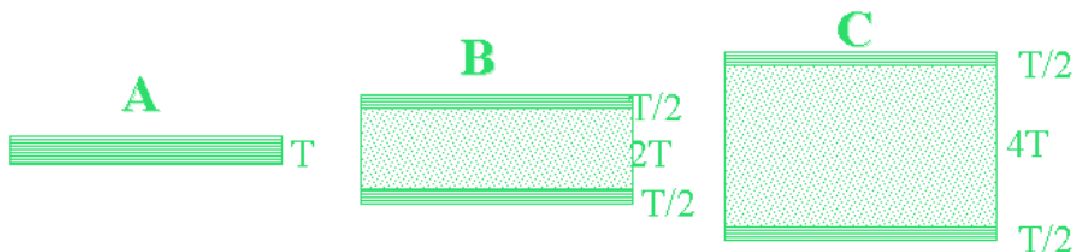


Sandwich Calculator –Pro

Sandwich Calculator is used to predict the deflection and stress of sandwich beam and plates for various load, boundary and materials. You can use this app for sandwich beam and plate design or performance prediction. Sandwich Plates are common structural elements used in many engineering applications.

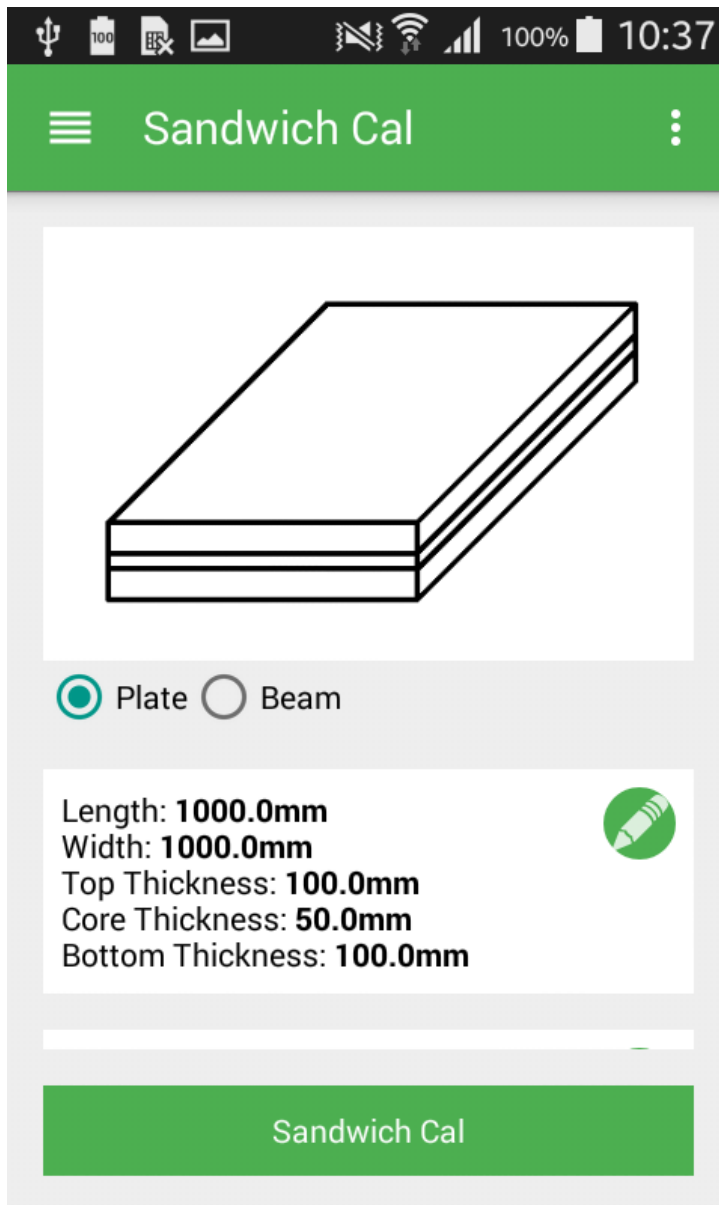


SANDWICH structures constitute, high stiff skin and low modulus core. The Face Skins are made of Metal, Non-metal, Plastics sheets. The core is made of lightweight structural element of Wood, Foam or Honeycomb. The skin and core are combined using adhesive bonding, co-extrusion or lamination process. Some of the failure modes of sandwich structures are Bond failure, Skin yielding, Skin wrinkling, Core shear and Core fracture. Sandwich structures are epitome of structural element for exceptional flexural rigidity and lower weight.

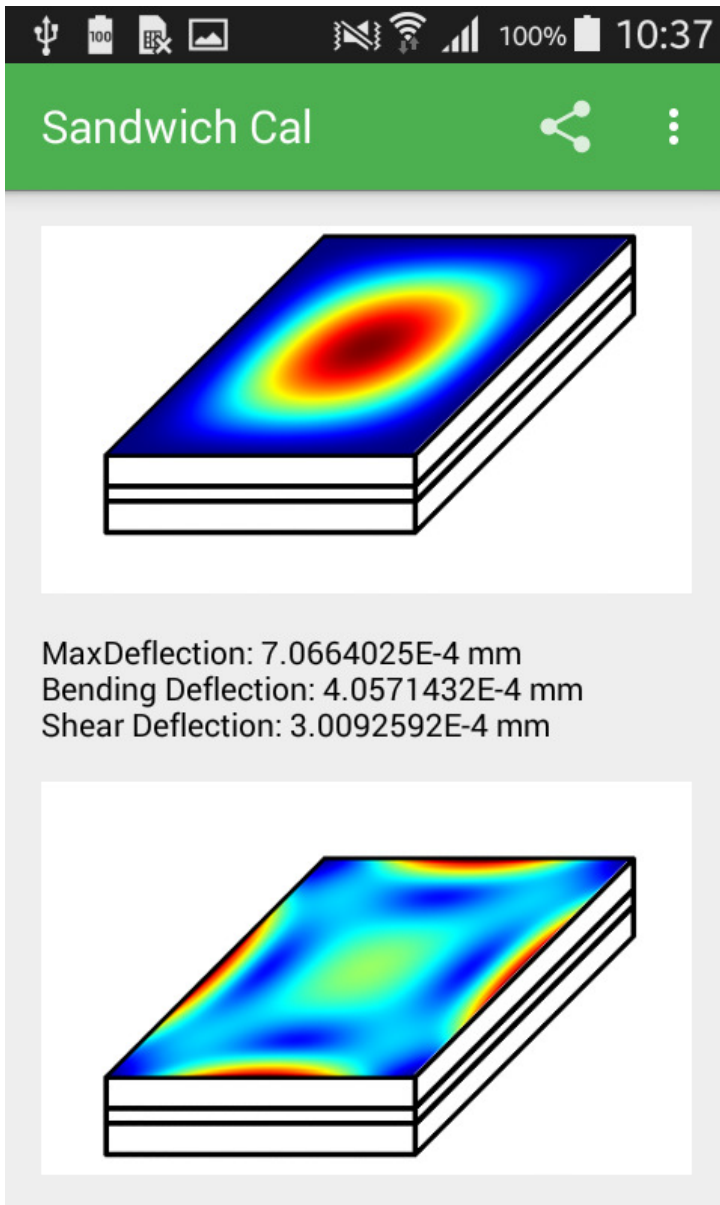


	A	B	C
RELATIVE STIFFNESS	100	700	3700
RELATIVE STRENGTH	100	350	925
RELATIVE WEIGHT	100	103	106

1) Sandwich Input for Plate



- * Select sandwich type, Plate.
- * Enter Sheet length, width and skin, core Thickness dimensions.
- * The graphics will reflect your changes to input.
- * Select material type and enter material properties.
- * Enter skin and core properties .
- * Select Boundary conditions type and enter boundary details .
- * Select type or analysis Linear .



* The results window will display the sandwich

Deflection

- Max deflection
- Bending Deflection
- Shear Deflection

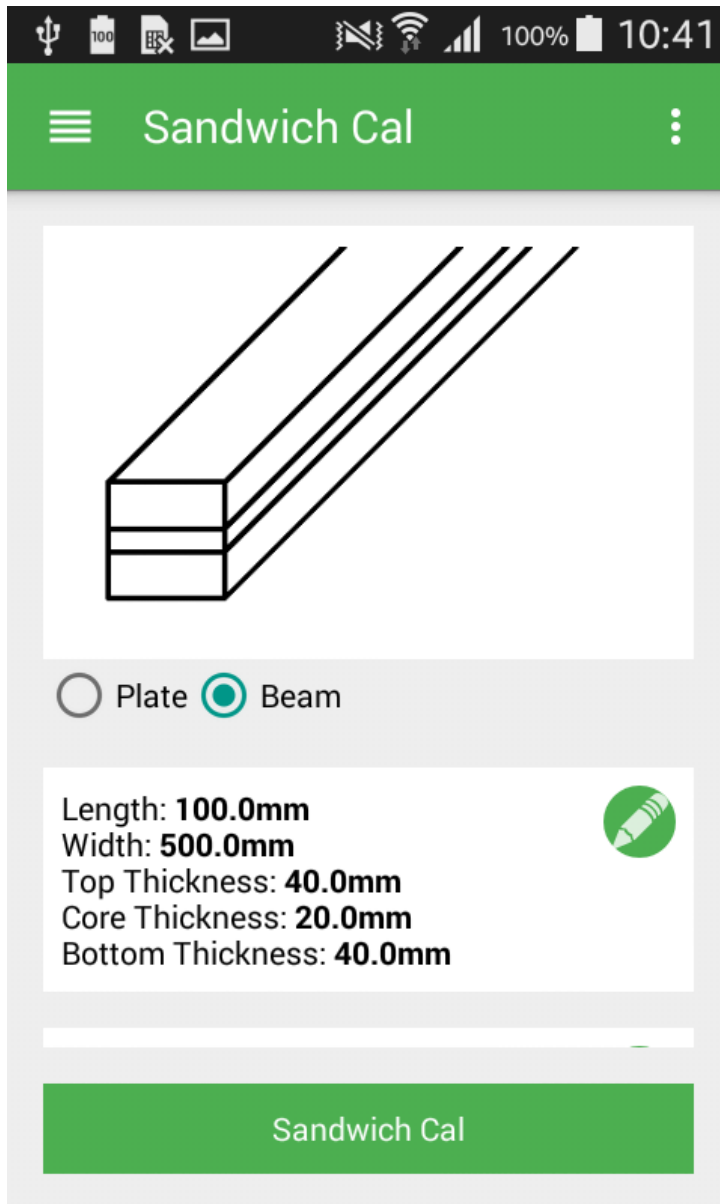
Stress

- Top Skin Stress
- Core Shear Stress
- Bottom Skin Stress

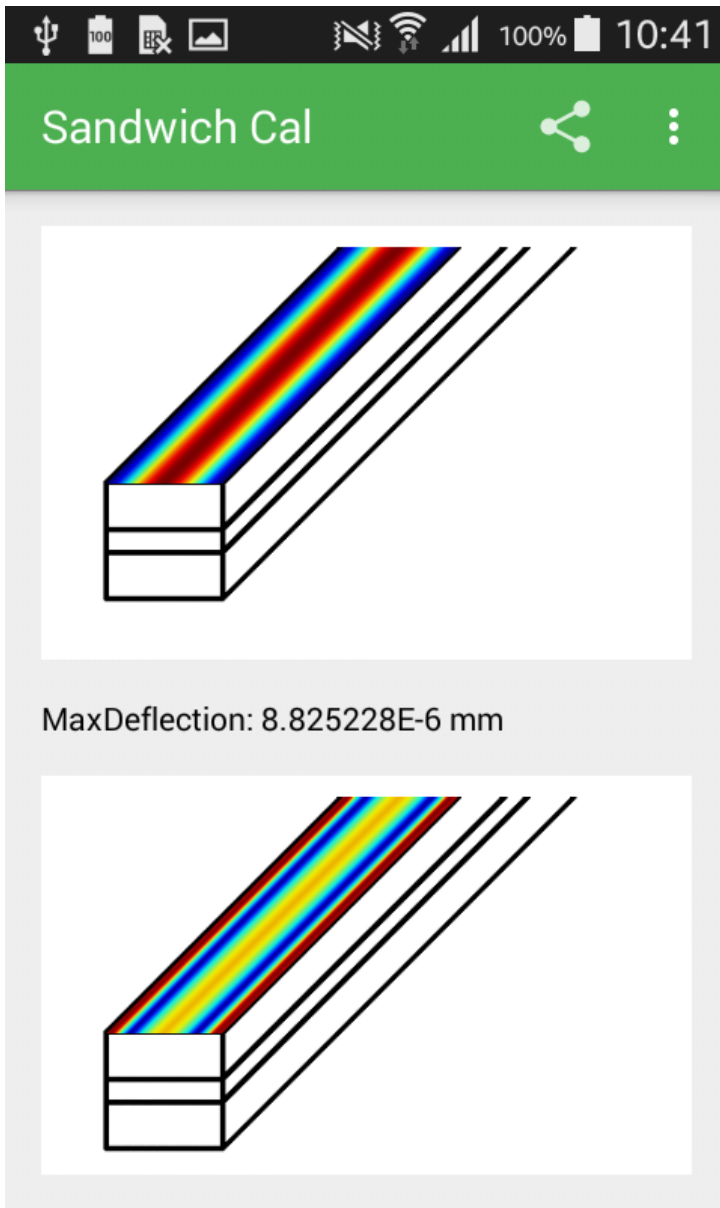
Flexural Rigidity

Shear Stiffness

2) Sandwich input for Beam



- * Select sheet type, Beam .
- * * Enter Sheet length, width and skin, core Thickness dimensions.
- * The graphics will reflect your changes to input.
- * Select material type and enter material properties.
- * Enter skin and core properties
- * Select Boundary conditions type and enter boundary details (**more in Pro**) .
- * Select type or analysis Linear .



- * The results window will display the sandwich
- Deflection
 - Max deflection
 - Stress
 - Top Skin Stress
 - Core Shear Stress
 - Bottom Skin Stress
 - Flexural Rigidity
 - Shear Stiffness

Assumptions:

1. The beam/plates are flat with uniform thickness.
2. The length is greater than width
3. All forces, loading and reactions are acting normal to the plate surface.

Theory:

The general governing differential equation for an isotropic plate with refined shear deformation theory, relating the load, rigidity and deformation is shown below, and is used for linear isotropic plate performance prediction.

$$\frac{\partial^4 w}{\partial x^4} + 2 \frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} = \frac{q}{D}$$

Where

$$D = \frac{E t^3}{12(1-\nu^2)}$$

Where, E is elastic modulus, t thickness and ν is Poisson's ratio. Isotropic plate differential equation including the effect of lateral loads and forces in the middle plane of the plate is shown below for geometrical nonlinear performance prediction.

$$\begin{aligned} & \frac{\partial^4 w}{\partial x^4} + 2 \frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} \\ & = \\ & \frac{1}{D} \left(q + N_x \frac{\partial^2 w}{\partial x^2} + 2N_{xy} \frac{\partial^2 w}{\partial x \partial y} + N_y \frac{\partial^2 w}{\partial y^2} \right) \end{aligned}$$

Where

$$D = \frac{E t^3}{12(1-\nu^2)}$$

$$N_x, N_y, N_{xy} = N_{\bar{x}}$$

are midplane force components .

This equation includes the effect of stress stiffening and geometric nonlinearity.

Similarly, plate governing equation for orthotropic plates is also considered as follows, and used for orthotropic plate performance prediction. The general differential equation for anisotropic plate,

$$D_x \frac{\partial^4 w}{\partial x^4} + 2H \frac{\partial^4 w}{\partial x^2 \partial y^2} + D_y \frac{\partial^4 w}{\partial y^4} = q$$

$$D_x = \frac{E_x t^3}{12(1-\nu_x \nu_y)}$$

$$D_y = \frac{E_y t^3}{12(1-\nu_x \nu_y)}$$

$$H = D_x \nu_y + 2D_{xy}$$

The D_x and D_y are anisotropic flexural rigidity. D_{xy} is torsion rigidity. Where, E_x , E_y , longitudinal and transverse elastic modulus, t thickness and ν is Poisson's ratio.

Analytical solution for the above type of plate governing equations with thick beam/plate shear deformation theory was compiled for various type of plate, boundary, loading conditions and is used for the beam/plate performance prediction app. The results predicted by Sandwich Calculator are also compared with numerical simulations. The analytical results predicted by app matches closely with the industry standard numerical finite element analysis solver results.