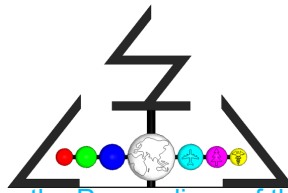


On the geometric and material nonlinearity effects of polymeric thin plates or films on structural performance.

Kiran V, Asutosh P and Raj C Thiagarajan
ATOA Scientific Technologies Pvt Ltd

COMSOL
CONFERENCE
2014 BANGALORE



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ATOA Scientific Technologies
Multiphysics CAE for Innovation™

ATOA

- **CAE Solution Provider**

- CAE (cae.atoa.com)

- Multiphysics

- Multimaterial

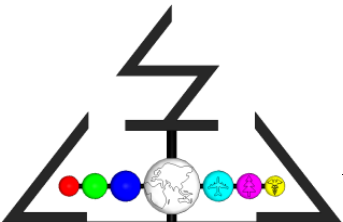
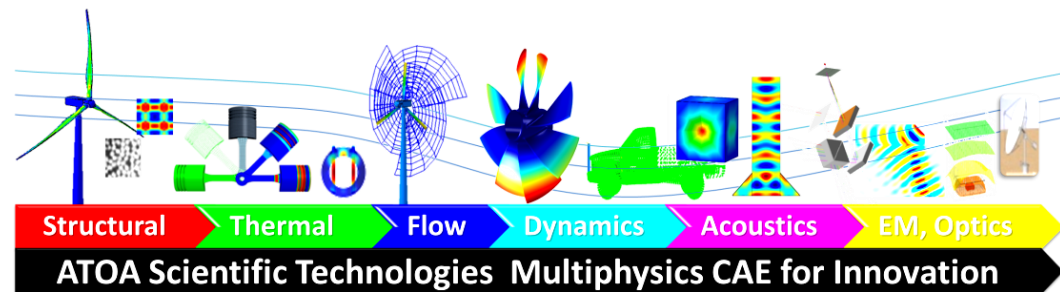
- Multiscale

- 3D Printing (3d.atoa.com)

- Engineering Apps (apps.atoa.com)

- Material Unity Vision: To solve complex problem of our clients.

- 1st COMSOL Certified Consultant from India.

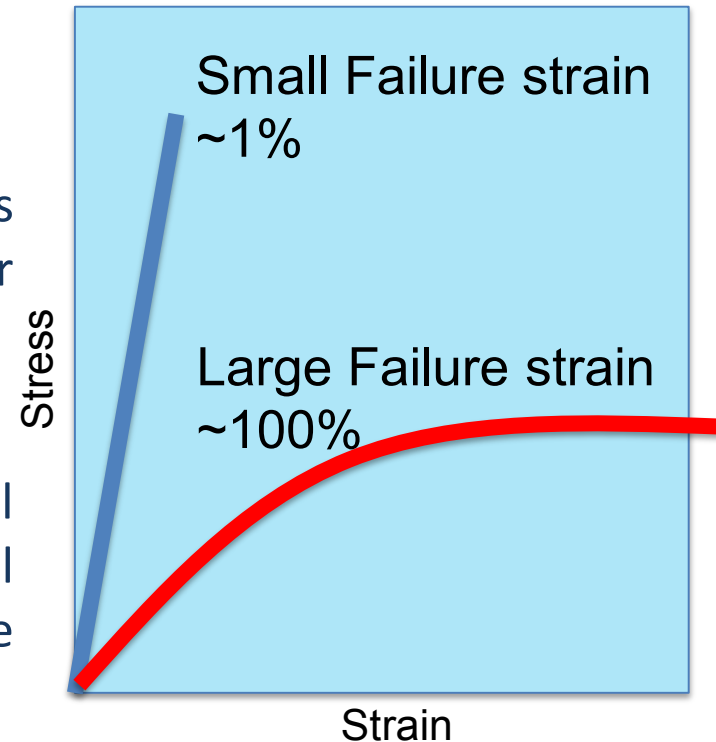


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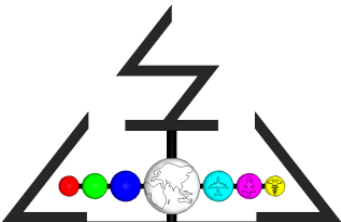
Introduction & Objectives

- Polymer sheets are widely used for glazing and roofing structural applications.
- Conventional building materials such as glass and concrete are relative stiffer compared to polymeric materials.
- Design leveraging geometric and material non-linear effects of polymeric sheets will increase the efficient use of these materials.



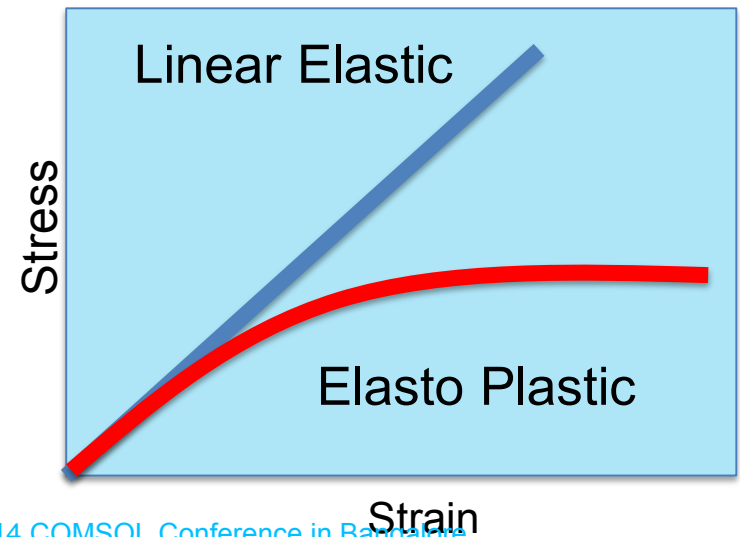
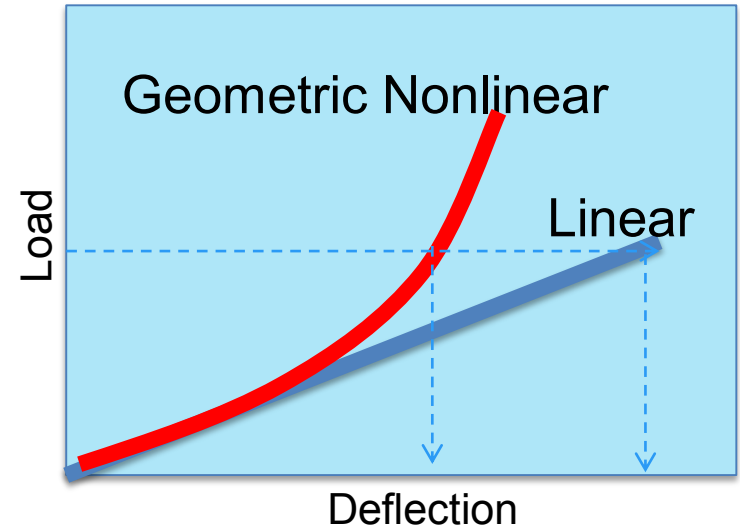
**Stress – Strain Diagram
(Conventional Vs Polymer)**

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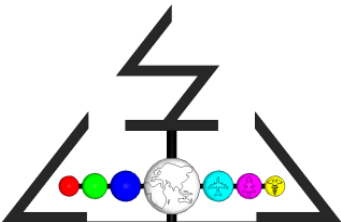


Nonlinearity Effects

- Geometric Nonlinearity.
- Material Nonlinearity.



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Governing Equations

- The general governing differential equation for an isotropic plate, relating the load, rigidity and deformation.
- Isotropic plate differential equation including the effect of lateral loads and forces in the middle plane of the plate.
- COMSOL Nonlinear Structural Mechanics module.

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

Where

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

Where,

E is elastic modulus,

t thickness and

ν is Poisson's ratio.

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

=

$$\frac{1}{D} \left(q + N_x \frac{\partial^2 w}{\partial x^2} + 2 N_{xy} \frac{\partial^2 w}{\partial x \partial y} + N_y \frac{\partial^2 w}{\partial y^2} \right)$$

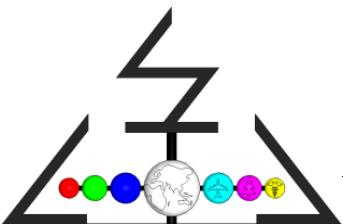
Where

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

$$N_x, N_y, N_{xy} = N_{yx},$$

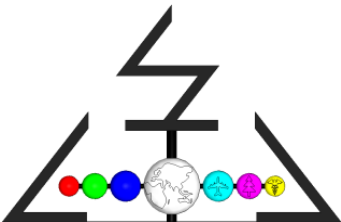
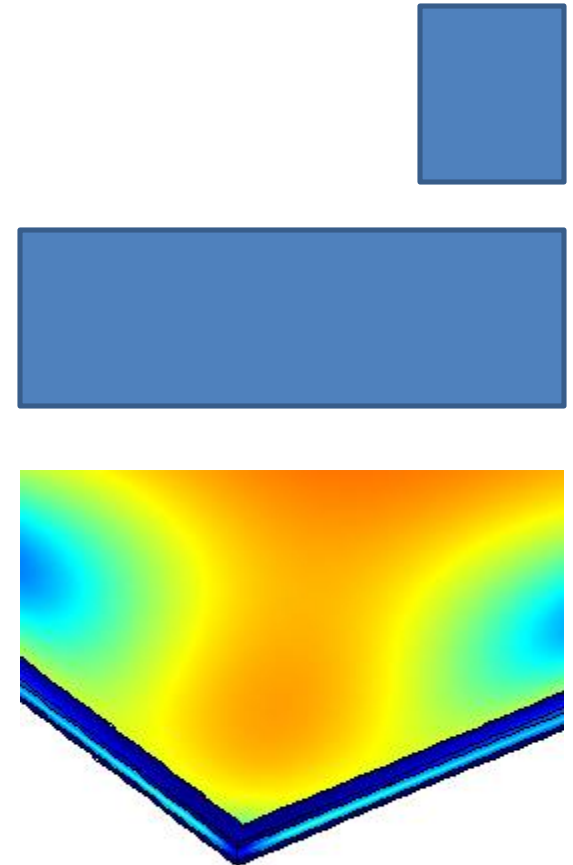
are midplane force components.

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Structural Analysis DoE

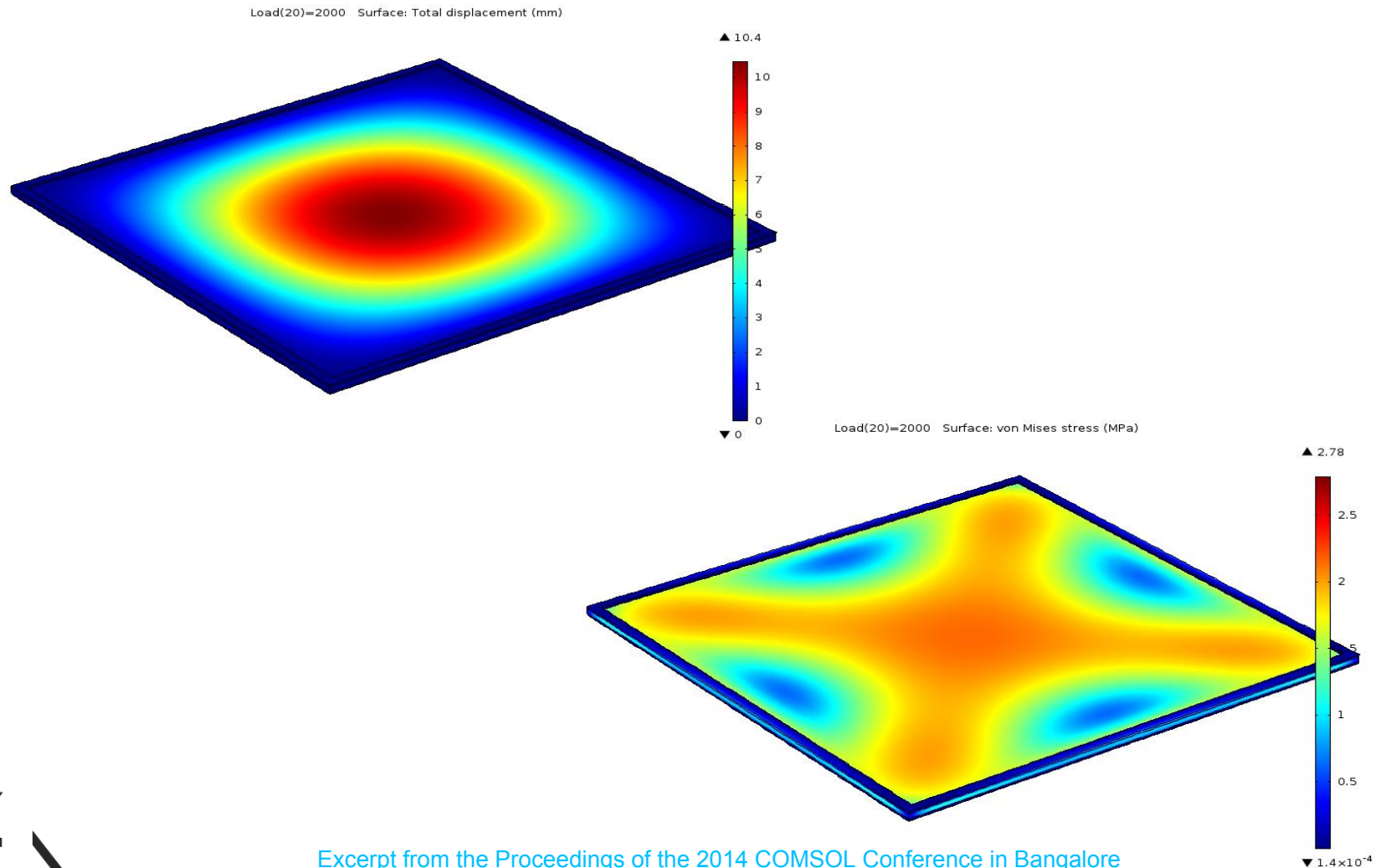
- Geometry
 - Thickness
 - Width
 - Length
 - Aspect Ratio
- Boundary Conditions
 - Fixed
 - Simply Supported
 - Clamped
- Nonlinearity effects
- Analytical Vs. Numerical



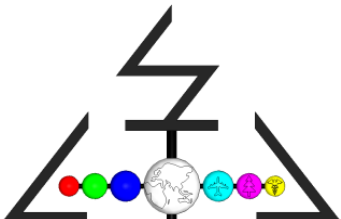
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Simulation Results

- Typical Elastoplastic deflection and stress contour plots.



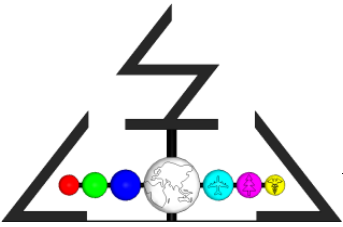
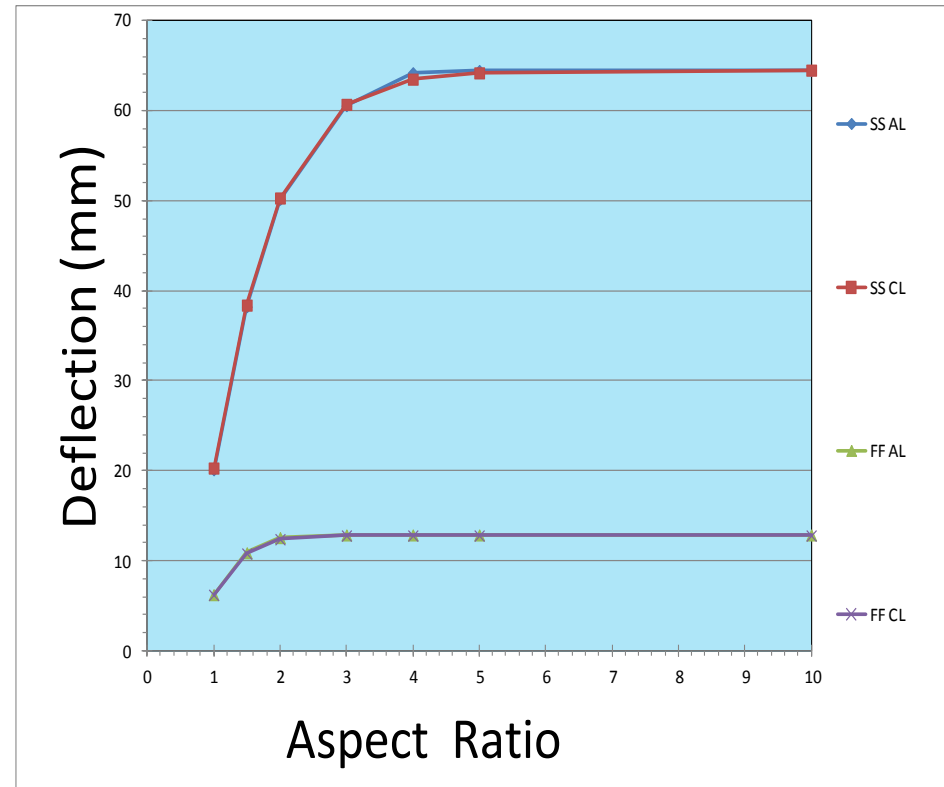
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Simulation Results

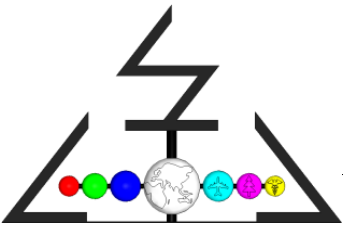
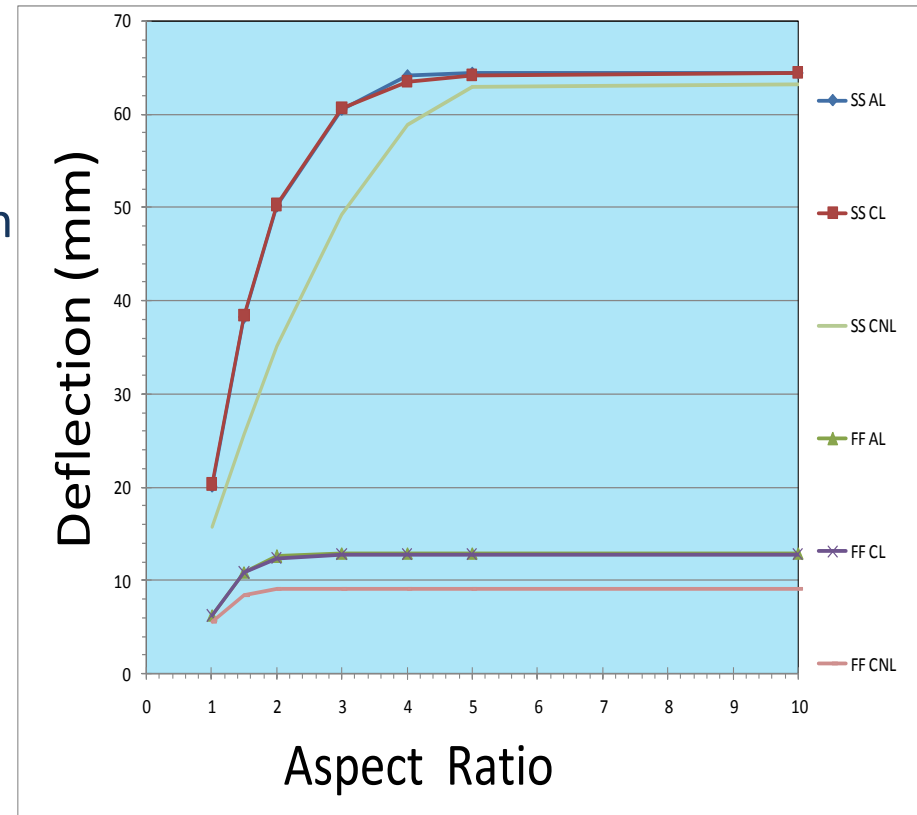
Effect of boundary conditions and aspect ratio on polymeric sheet deflection behavior.

- Linear Analytical Vs. Numerical
- Exact



Simulation Results

- Linear (L) Vs Non Linear (NL)
- Significant Reduction in deflection

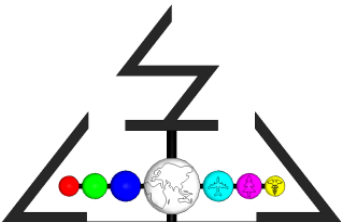
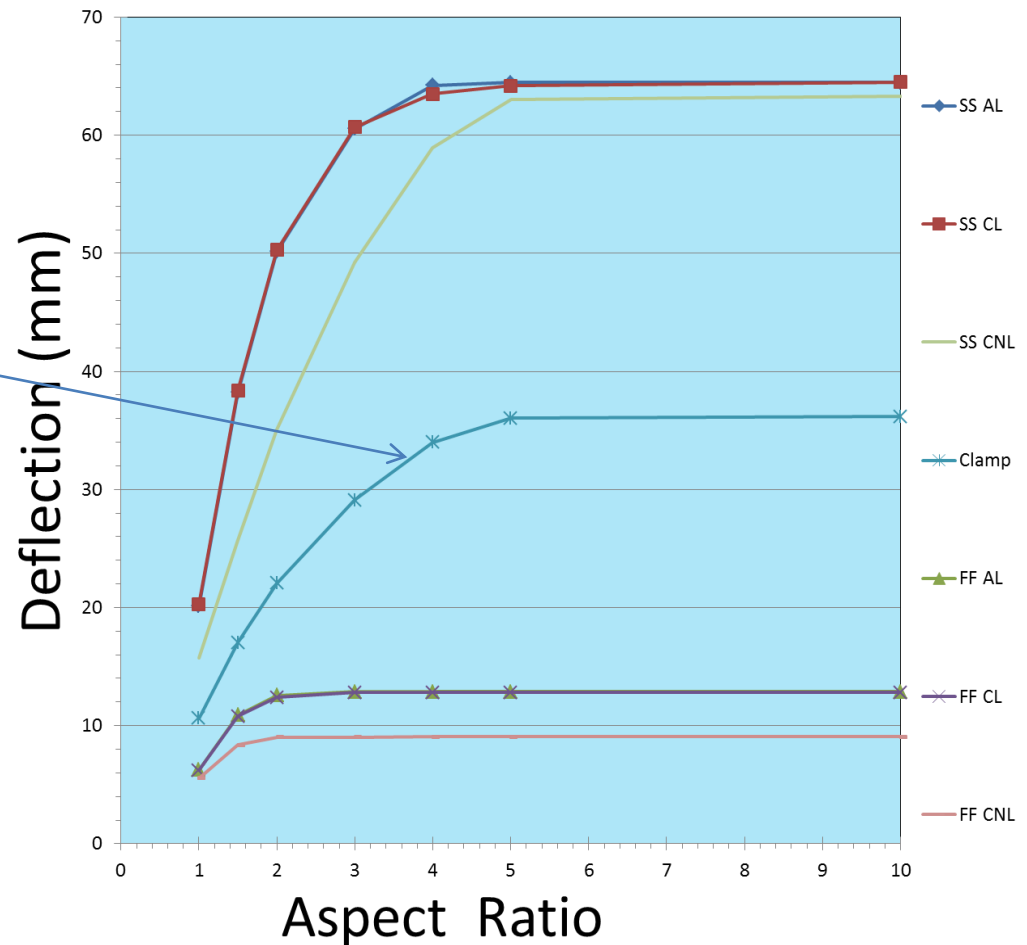


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Simulation Results

Boundary Conditions

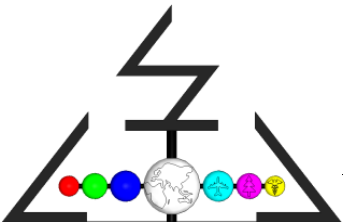
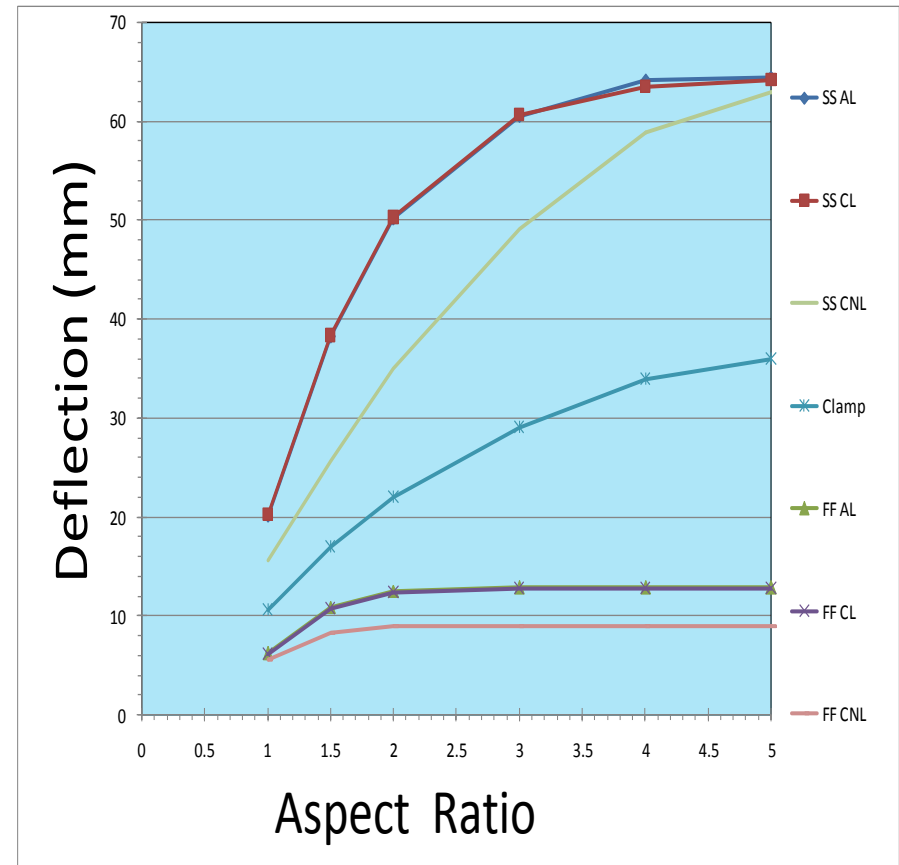
- Fixed (F)
- Simply supported (SS)
- Clamped
- Aspect Ratio effect insignificant (SS >5, FF >2)



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PLATE CALCULATOR

- DoE for Geometric + material Nonlinearity + Range of AR, Th, Load, BC.
- Database of results for smart sheet selection tool.
- Engineering apps to process complex FEA results for use by Field engineers to enable Design Decision on the Go!



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PLATE CALCULATOR

ATOA Plate Calculator

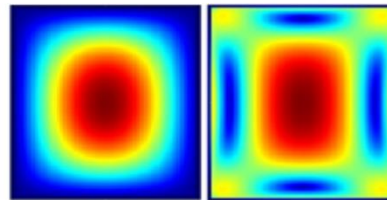
Help

Disclaimer

Unit : mm *(Change Unit)*

Sheet Width to Length Ratio : AR 1 : 1
Sheet Width : 525
Sheet Thickness : 8
Load : 100

ATOA Plate Calculator



Developed by:
ATOA Scientific Technologies
www.atoa.com

ATOA Plate Calculator

Help

Disclaimer

Unit : mm

Sheet Width to Length Ratio : AR 1 : 1
Sheet Width : 525
Sheet Thickness : 8
Load : 100

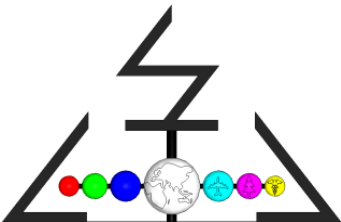
Product Recommendation : OK

Calculate

Reset

Re-calculate

Exit



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