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

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Introduction: 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. Polymeric plates can undergo large deformation. Design leveraging geometric and material non-linear effects of polymeric sheets will increase the efficient use of these materials.

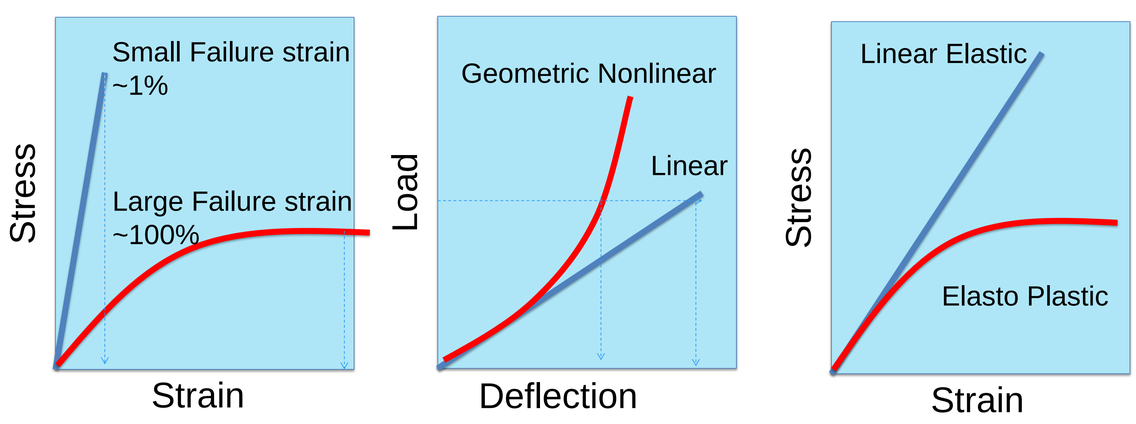

Figure 1. Schematics of building materials failure strain, Geometric and material Nonlinearity effects.

Computational Methods: Isotropic thin plate governing differntial equation including the effect of lateral loads and forces in the middle plane of the plate is shown below.

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

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

$$D = \frac{E\,t^3}{12\,(1-\upsilon^2)}, N_x, N_y, N_{xy} = N_{yx}$$

Where, E elastic modulus, t thickness, ν Poisson's ratio and N_x, N_y, N_{xy}, N_{yx} are mid plane force components. COMSOL non-linear structural mechanics module was used for the numerical DoE simulations.

Results: The simulation results shows that the deflection for the given width, load and thickness can range significantly. The analytical linear plate performance results and COMSOL model simulation results are shown. The comparison of linear vs nonlinear, effect of boundary condition, aspect ratio on the overall performance is shown. The importance of the practical installation of these sheets is also highlighted.

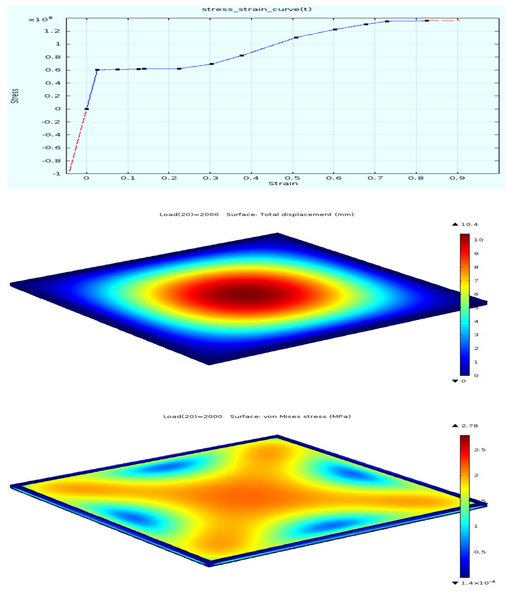

Figure 2. Typical Elasto plastic, deflection and stress contour plots.

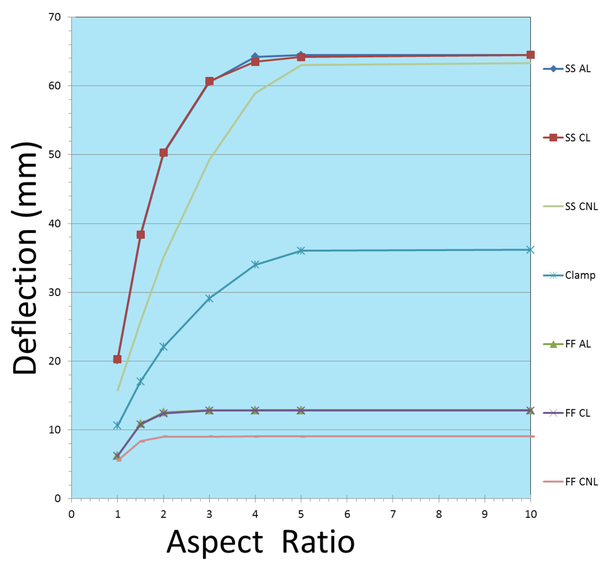

Figure 3. Effect of boundary condition and aspect ratio on sheet deflection behavior

Conclusions: Numerical DoE Results were used to develop a plate calculator for mobile phones to enable complex engineering design decisions on the Go!

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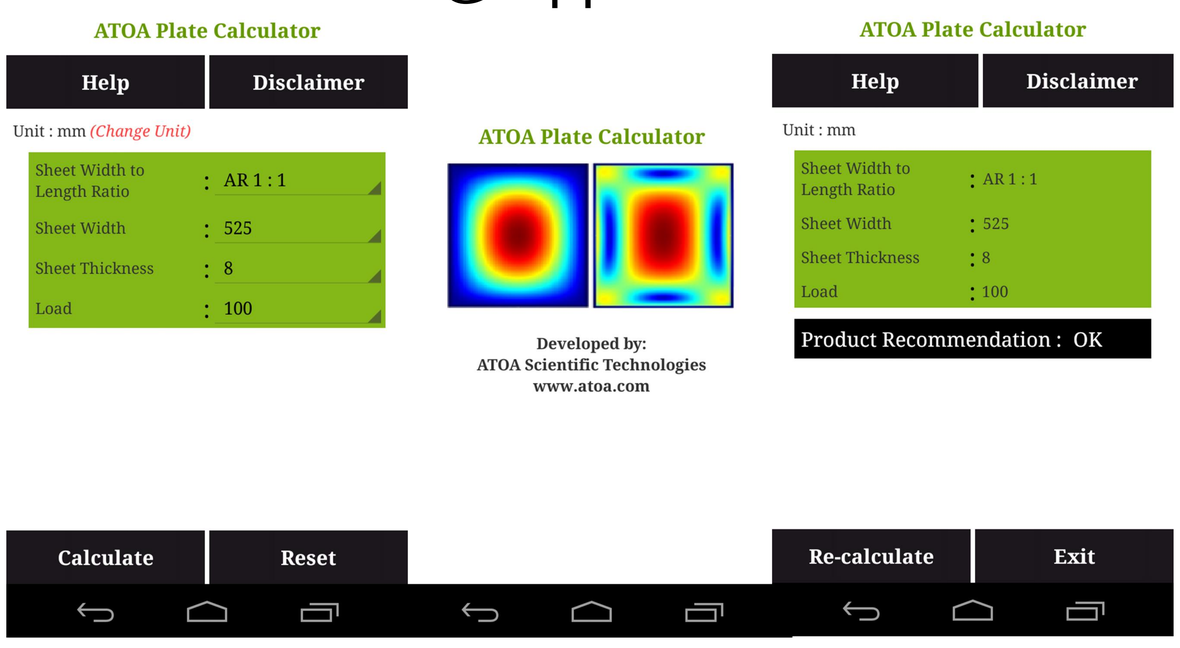

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