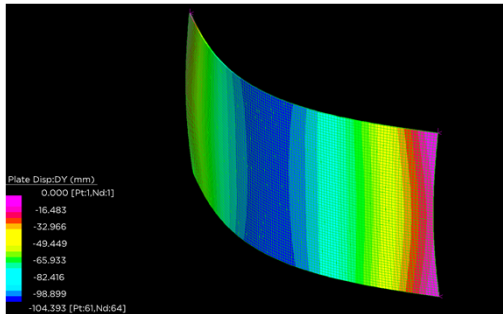


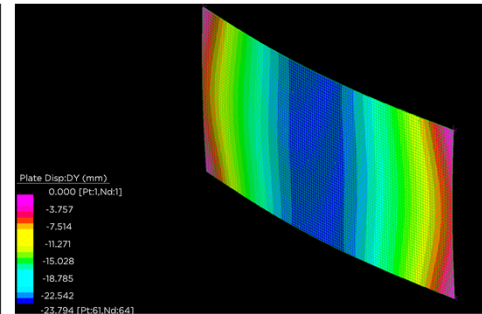
Structural Design of Glass – Modeling Pitfalls

DETAILS AND BOUNDARY CONDITIONS ARE CRITICAL – cannot make typical modeling assumptions

EXAMPLE: 3m x 1.5m x 12mm Lite, Point-Supports @ Corners; 1kPa Wind load



Linear Analysis – 104mm



Non-Linear Analysis – 24mm

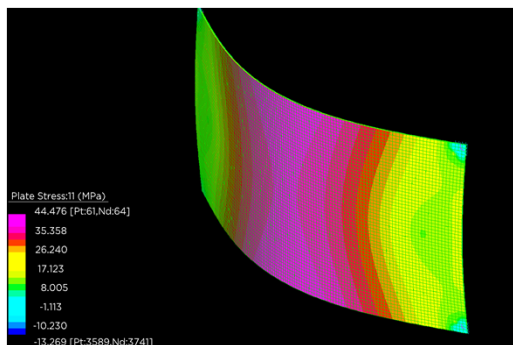
What's going on?

4x decrease in deflections?

Significant Membrane Action if corners are not free to slide

Structural Design of Glass – Modeling Pitfalls

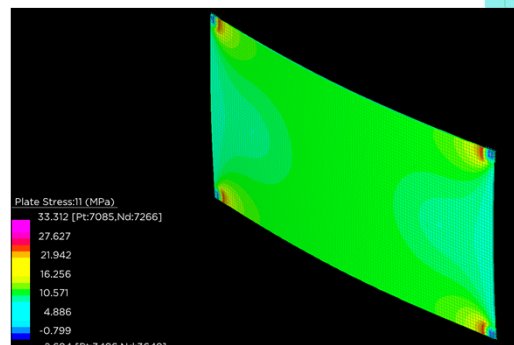
Grab 75mm of corners with rigid links



Linear Analysis

S11 = 44.476mPa

D = 92.72mm



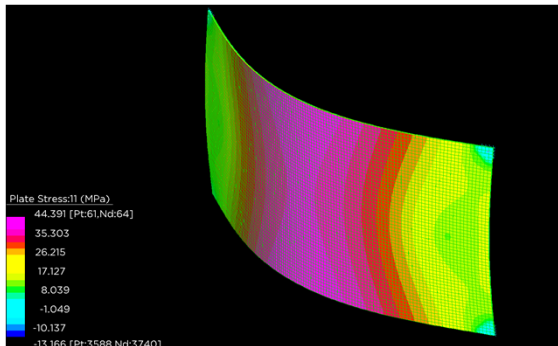
Non-Linear Analysis

S11 = 33.312mPa

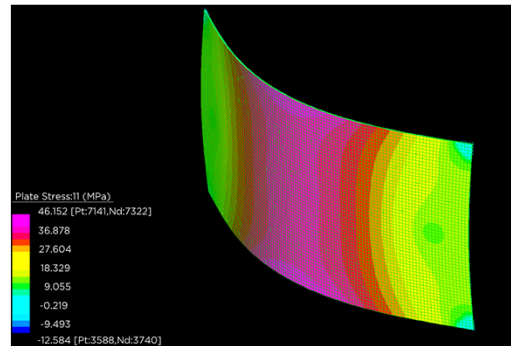
D = 18.356mm

Significant Membrane Action if Corners are not free to slide

Structural Design of Glass – Modeling Pitfalls



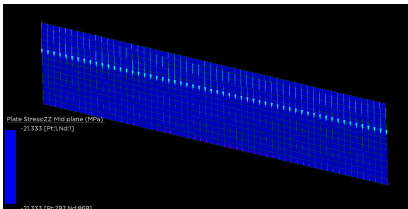
Linear Analysis
 $S_{11} = 44.391 \text{ mPa}$
 $D = 92.719 \text{ mm}$



Non-Linear Analysis
 $S_{11} = 46.152 \text{ mPa}$
 $D = 90.519 \text{ mm}$

↕ Restraint / releases ↕
 pattern to provide
 stability but avoid
 ⦿ membrane action ↔

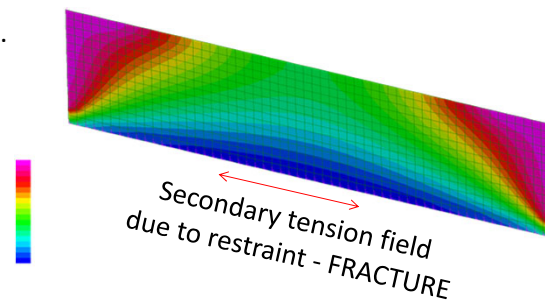
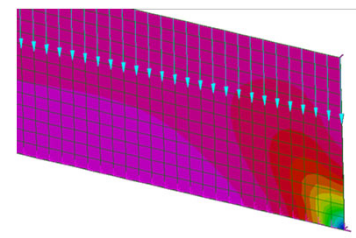
Structural Design of Glass – Modeling Pitfalls



Uniform in-plane edge load: -128 mPa compression, OK?

NOT OK: "Secondary" effects can cause failure. Primary stress field does not always govern.

Consider effects of confinement, restraint, and tolerance.

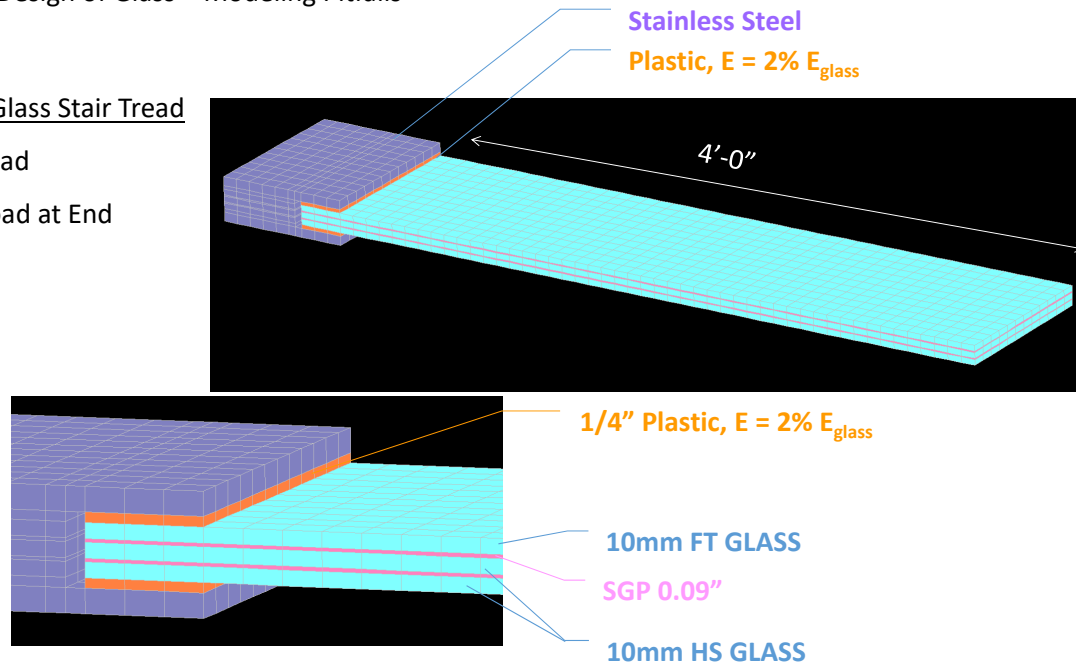


Structural Design of Glass – Modeling Pitfalls

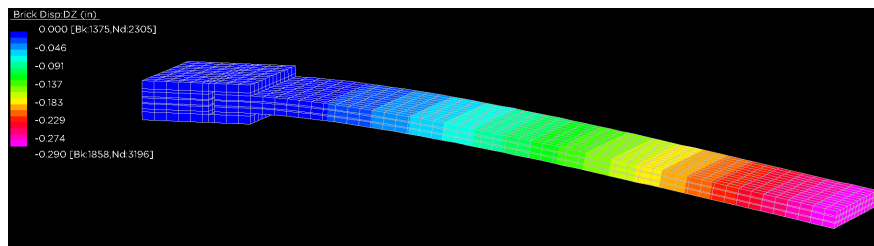
Cantilevered Glass Stair Tread

100psf Live Load

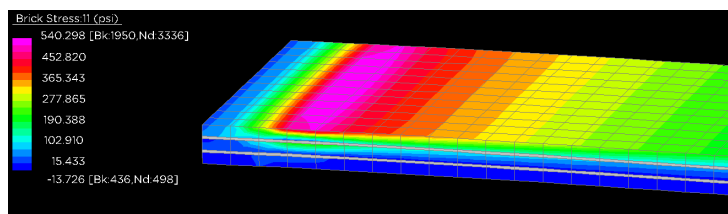
300lb Point Load at End



Structural Design of Glass – Modeling Pitfalls

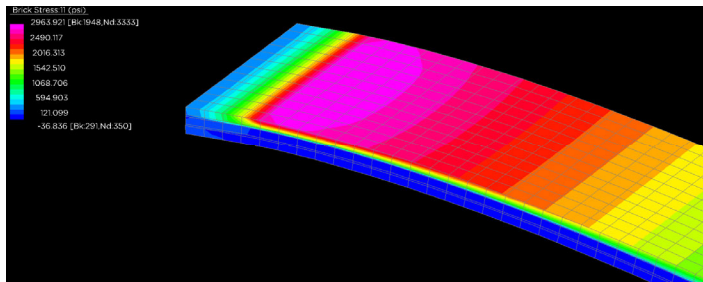


100psf LL Deflection ~ 0.29" (L/165) OK



Self-Weight (long-term load) Maximum S11 stress ~ 0.54ksi < 0.31 x 5.3ksi = 1.64ksi, OK

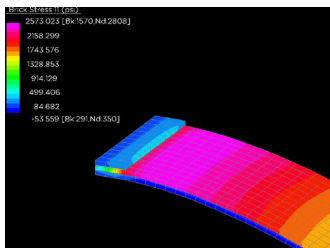
Structural Design of Glass – Modeling Pitfalls



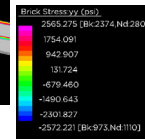
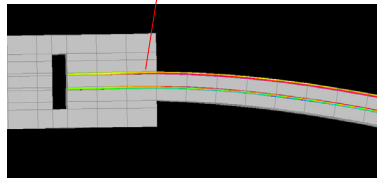
D:+300lb Point Load
S11 Stress ~ 2,964psi

ASTM E 1300: 5.3ksi Maximum Allowable
Edge Stress (OK)

POST-BREAKAGE ANALYSIS



Inner-layer in membrane
mode, subsequent to
top-lite failure



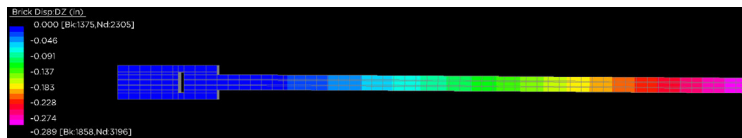
DL+40psf Post-Failure Live
Load

Max Glass Stress
(excluding top lite):
2,573psi (OK);

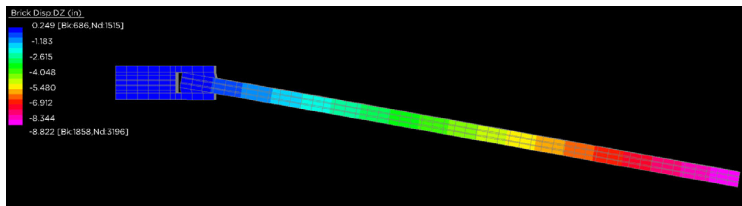
Interlayer Max Stress:
2.565ksi (5ksi ultimate
strength, OK)

Structural Design of Glass – Modeling Pitfalls

- Large (orders of magnitude) differences in stiffness between primary structure (e.g., glass, steel) and connection materials (e.g., plastic, neoprene, rubber).
- Effects of connection material stiffness are usually small for simply supported applications.
- Effects can be HUGE in clamp connections that resist bending (i.e., when compression of shim causes rotation of balustrade or cantilever)



$E_{\text{shims}} - 2\% E_{\text{glass}}$: 100psf Live Load Deflection = 0.29";



$E_{\text{shims}} - 192\text{psi}$ (Dow Corning 995 Silicon Adhesive); Deflection ~ 8.8" !