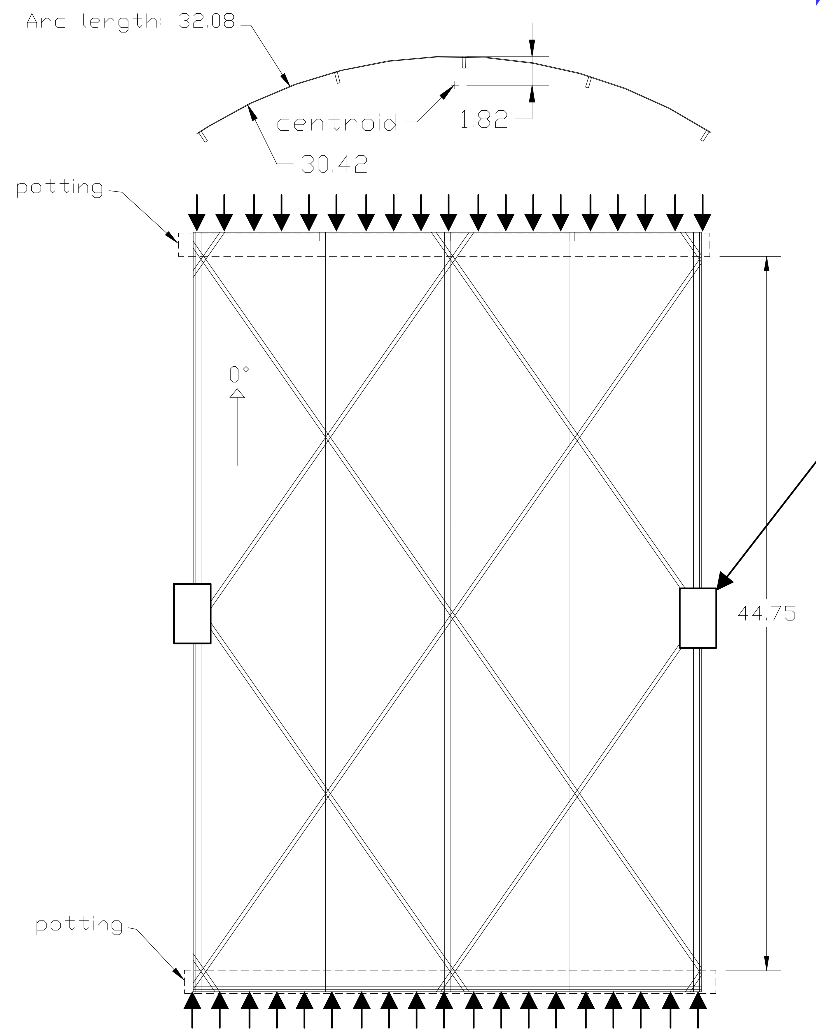
Analysis Verifications

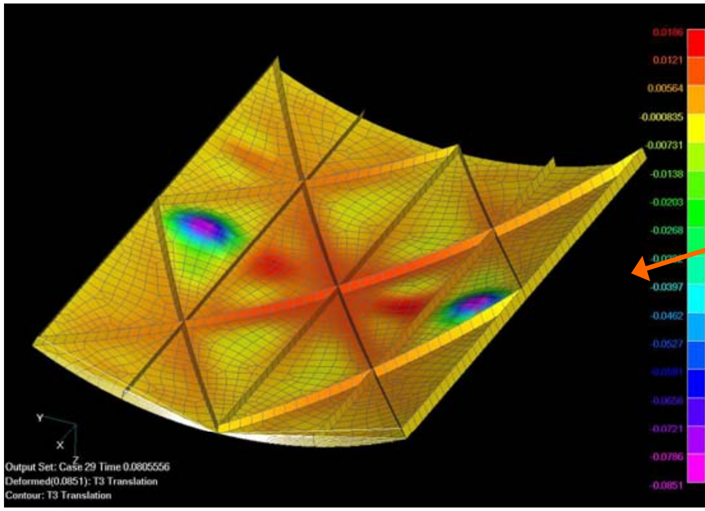
Collier Research Corporation

Pretest Prediction to Uniform Compression Load – Grid Stiffened Panel Structural Certification



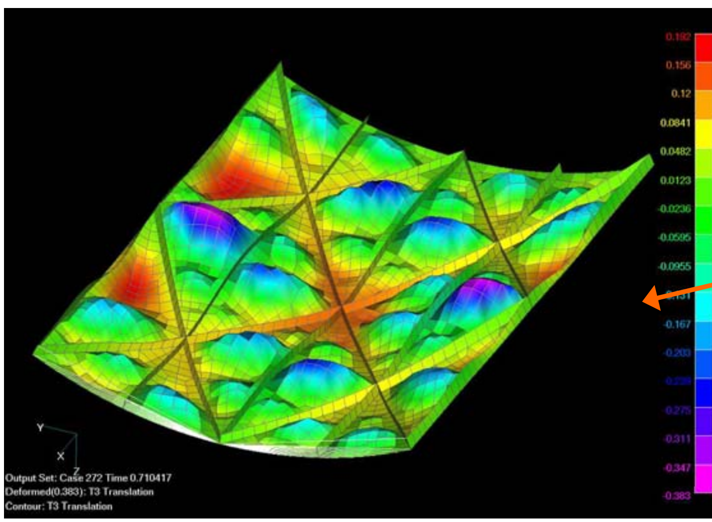
HyperSizer Grid Stiffened Panel Test

Pretest Prediction to Uniform Compression Load – Grid Stiffened Panel Structural Certification



Local buckling of the skin pockets

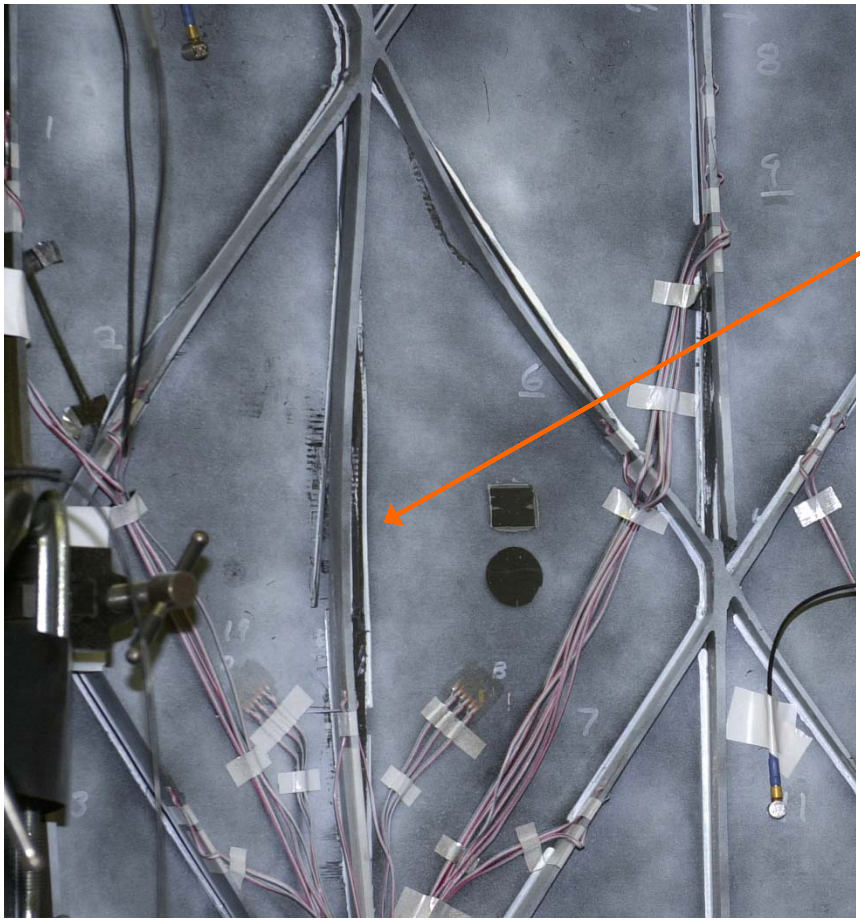
- **8500 lb, HyperSizer predicted**
- **8000 lb, Test result**



Non-linear, post-buckling full panel buckling

- **41,600 lb, HyperSizer predicted**
- **42,325 lb, Test result**

Pretest Prediction to Uniform Compression Load – Grid Stiffened Panel Structural Certification

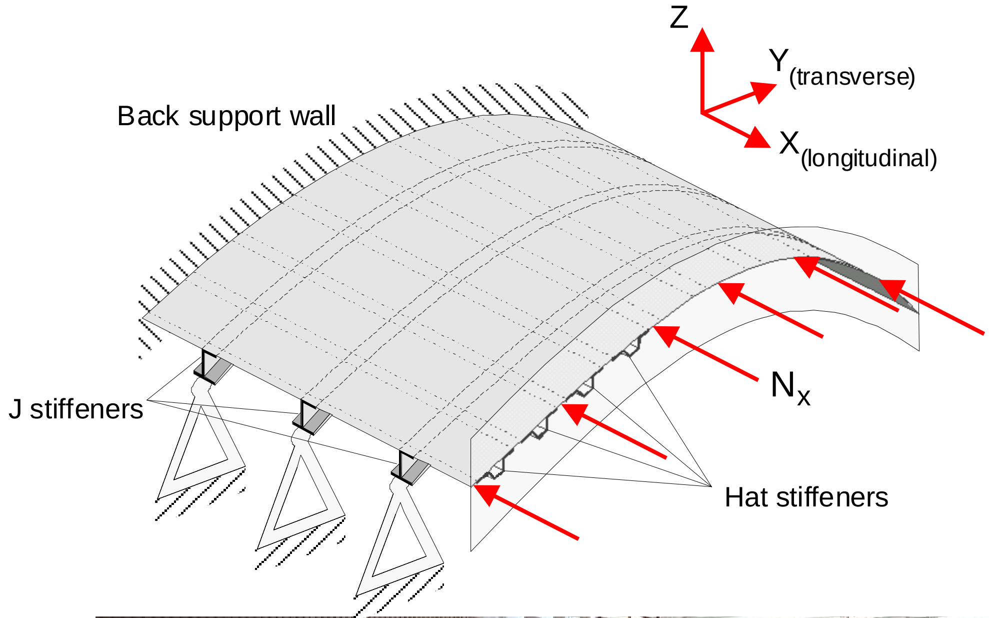


The failure location is the 0-degree (longitudinal) rib.

HyperSizer predicted failure mode and location matched the actual test failure mode and location.

Pretest Prediction to Uniform Compression Load – Hat Stiffened Panel Structural Certification

Reusable Launch Vehicle (RLV) Intertank - Failure Load Prediction for a Test Article



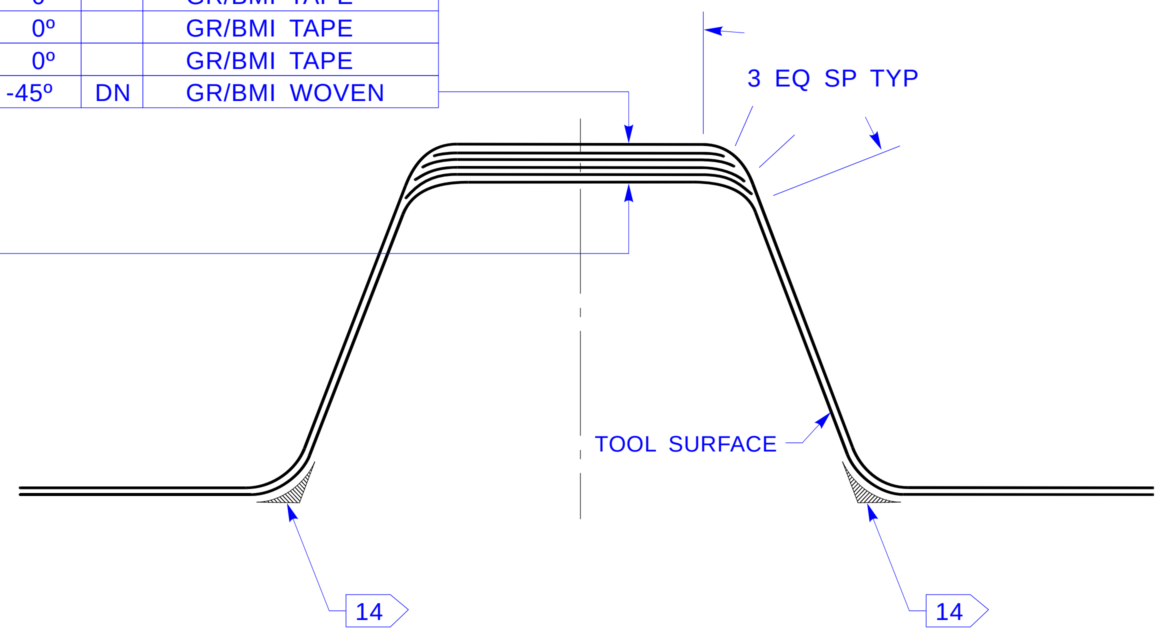
Analyze and optimize structural area in detail

Pretest Prediction to Uniform Compression Load – Hat Stiffened Panel Structural Certification

Coresheet Layup Schedule, Hybrid Woven and Tape Forms, Ply drop-offs in the Crown

PLY LAYUP TABLE: -005

PLY SEQ NUMBER	DETAIL PLY NO.	PLY OREN. WARP/FILL (+)/(-)	WARP DIRECT	MAKE FROM
2	P2	+45º	UP	GR/BMI WOVEN
3	P3	0º		GR/BMI TAPE
4	P4	0º		GR/BMI TAPE
6	P6	0º		GR/BMI TAPE
7	P7	0º		GR/BMI TAPE
8	P2	-45º	DN	GR/BMI WOVEN

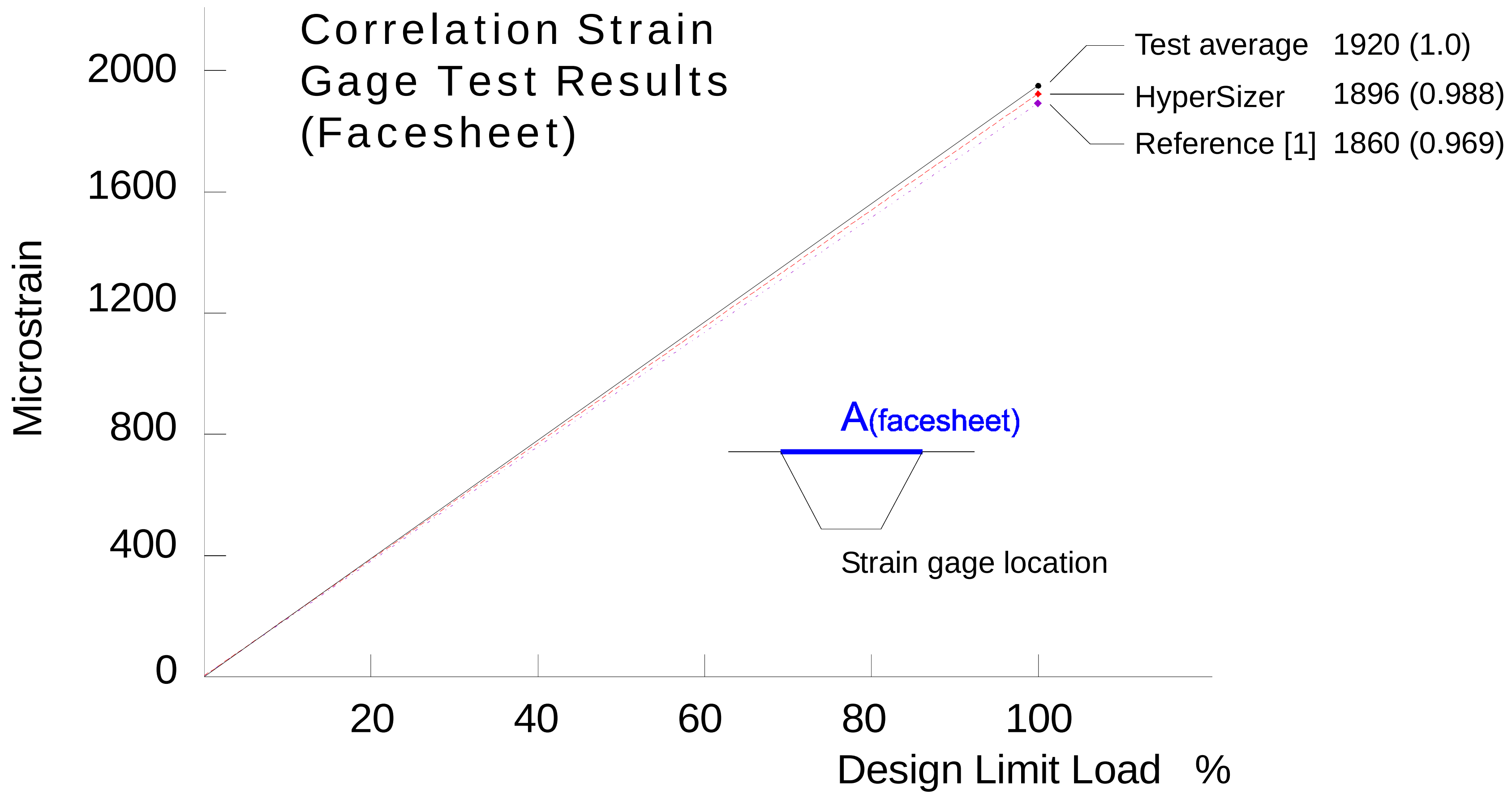


SECTION R-R E36

PLY SCHEMATIC FOR -005

NO SCALE

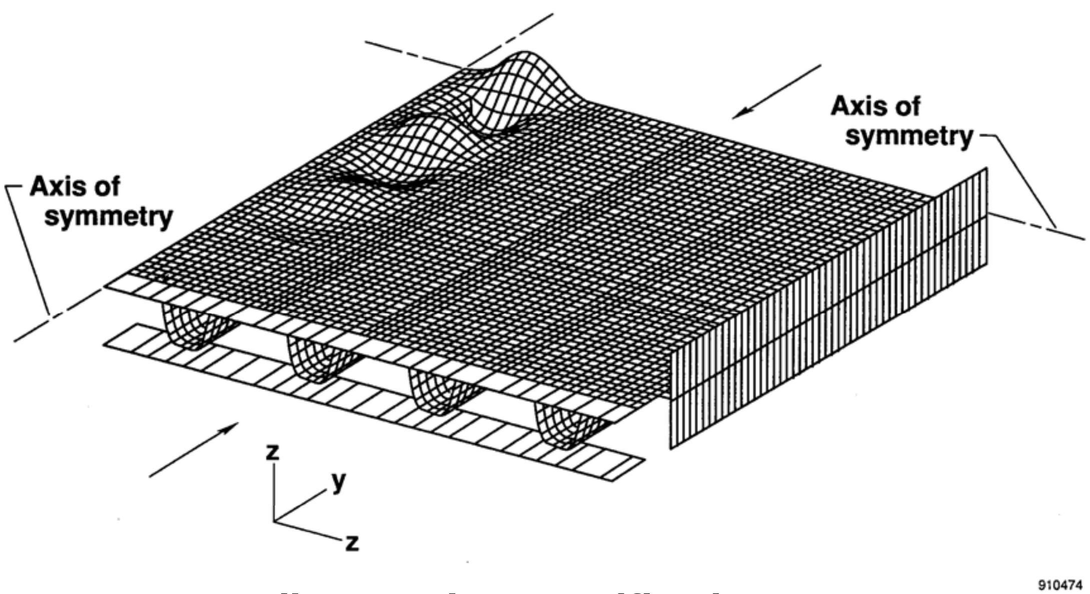
Pretest Prediction to Uniform Compression Load – Hat Stiffened Panel Structural Certification



RLV HyperSizer Customers

Local Buckling Load Comparison Between Analyses and an Experimental Test

Analysis Type		Nx_{cr} (lb/in)
NASA Dryden Research Center independent analyses:		
Elastically supported		1600
Simply supported		1601
HyperSizer	[without frame included]	**1638**
Finite Element Analysis	[without frame included]	1654
Experimental test	[with frame included]	1725*



Failure Analyses Verifications

Honeycomb Sandwich Anisotropic Panel Buckling Load Comparison to Published Data

#	A (in) X span	B (in) Y span	Layup	HyperSizer without TSF	HyperSizer with TSF	Published Data AIAA-98-2084
1	19.685	39.37	[0/90/0/90/core]s	694	634	652
2	39.370	39.37	[0/90/0/90/core]s	352	335	343
3	78.740	39.37	[0/90/0/90/core]s	352	335	343
4	39.37	39.37	[45/-45/45/-45/core]s	597	549	571
5	39.37	78.74	[0/0/0/0/core]s	297	285	287

"Free Vibration and Buckling Analysis of Anisotropic Sandwich Plates with Edges Elastically Restrained Against Rotation", Pierre Marcellier and Masoud Rais-Rohani, 39TH AIAA/ASME/ASCE/AHS/ASC Structures, Dynamics, & Materials Conference April 1998 AIAA-98-2084

Panel and Beam Crippling Methods for Metallic and Composite Materials

Crippling stress comparisons for a metallic Z beam

Analysis Type	Crippling Stress (ksi)
Text book reference [3]*	63
HyperSizer with Niu log-log test curves**	63
HyperSizer with LTV log-log test curves	63.6

References

1. Mil-Hdbk-17-3E, DOD Coordination Working Draft, 1998.
2. Fogarty, J.H., "Crippling of Titanium Matrix Composite Stiffeners", Journal of Composite Materials, Vol 26, No. 7, 1998
3. Niu, C. Y., Airframe Stress Analysis and Sizing, 1st edition October 1997. ISBN 962-712-07-4, p. 444

HyperSizer includes all A_{ij}, B_{ij}, D_{ij} in the Crippling Analysis

Correlation to Hexcel Methods for Honeycomb Sandwich

Analysis Type	Benchmark Data	HyperSizer
Beam buckling*	0.52	0.52
Beam buckling, transverse shear flexibility	0.51	0.51
Facesheet yielding stress	10.5	10.5
Facesheet wrinkling	45.8	45.8
Facesheet dimpling	30.0	30.0
Core shear strength	12.1	11.6**
Core crushing	NA	29.0
Core shear crimping	254	254

** HyperSizer analysis performed beam buckling with panel methods*

*** different correction factor used*

Anisotropic Panel Buckling to Shear Loads

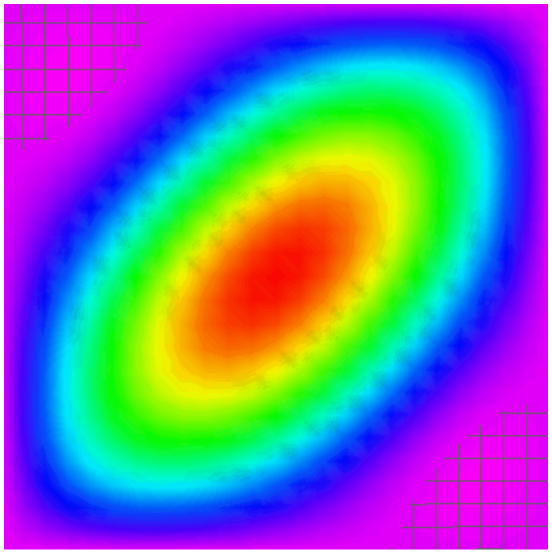


Figure 1.a, Left Image. HyperSizer computed mode shape using Raleigh Ritz 3 series displayed in HyperSizer graphics. Buckling safety factor equal to **3.437**

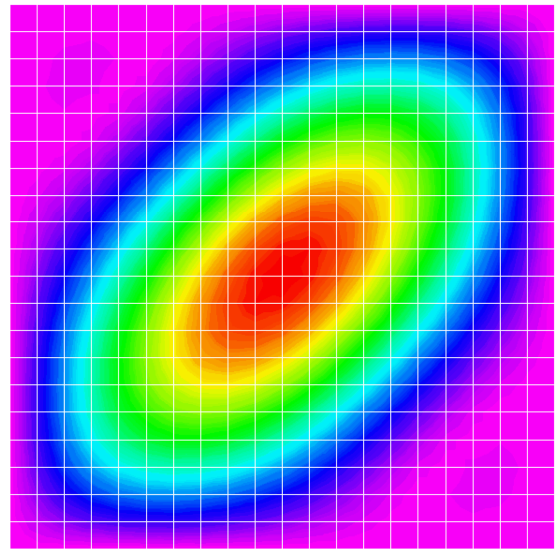
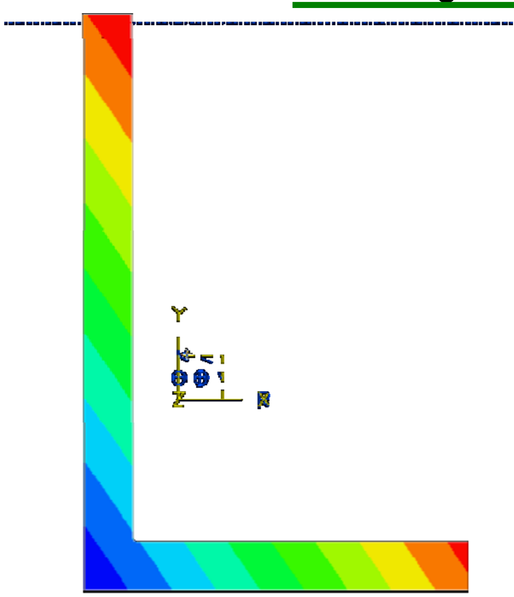


Figure 1.b, Right Image. MSC/NASTRAN computed mode shape displayed with FEMAP. Buckling safety factor equal to **3.442**

Angle Beam Flange Tip Stress Verification

Flange tip location	HyperSizer	I-DEAS
Pt A, left upper tip of long leg	4.35 ksi	4.35 ksi
Pt B, right upper tip of long leg	6.27 ksi	6.27 ksi
Pt C, OML corner of leg intersection	-11.31 ksi	-11.31 ksi
Pt D, IML corner of leg intersection	-8.09 ksi	-8.09 ksi
Pt E, right upper tip of short leg	5.34 ksi	5.34 ksi
Pt F, right lower tip of short leg	4.03 ksi	4.03 ksi

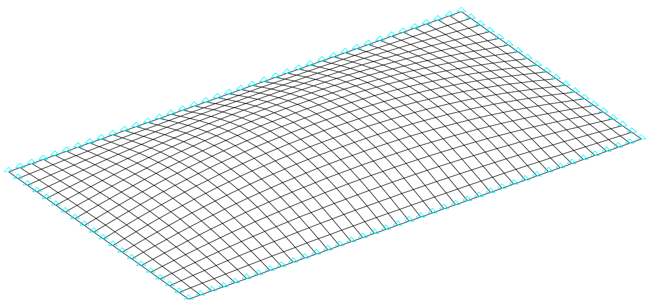


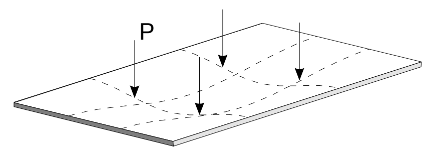
Verification of Thermal Stress Including Residual Strain Effects

CASE 2: ΔT and ΔG, a uniform temperature increase of 68º F and a linear through-the-thickness temperature gradient of 50º F in/in

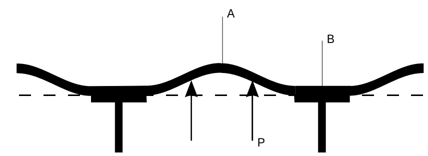
Location	Benchmark Residual strain (μ-in)	HyperSizer Residual strain (μ-in)	Benchmark Thermal stress (psi)	HyperSizer Thermal stress (psi)
Steel top face				
Top surface	983.2	983.2	4193	4193
Midplane	100.1	100.1	4268	4268
Bottom surface	101.8	101.8	4342	4342
Aluminum middle				
Top surface	-228.8	-228.8	-3585	-3585
Midplane	-107.8	-107.8	-1689	-1689
Bottom surface	13.2	13.2	207	207
Steel bottom face				
Top surface	115.8	115.8	4940	4940
Midplane	116.7	116.7	4978	4978
Bottom surface	117.6	117.6	5014	5014

Panel Response to a Uniform Pressure - Comparison of HyperSizer to FEA





Panel Level Pressure Effects



Local Level Pressure Effects

Simple boundary conditions

Analysis Type	Frequency Hz.	ΔZ in.	Mx lb-in/in	My lb-in/in	Qx lb/in	Qy lb/in
HyperSizer	**11.08**	**0.998**	**-78.35**	**-39.60**	**-8.25**	**-6.82**
FEA 800 elements	**11.05**	**1.005**	**-78.67**	**-41.40**	**-7.83**	**-7.16**
FEA 3200 elements	**11.07**	**1.007**	**-78.62**	**-41.49**	**-8.12**	**-6.65**

Fixed boundary conditions

Analysis Type	ΔZ in.	Mx lb-in/in	My lb-in/in	Qx lb/in	Qy lb/in
HyperSizer	0.263	67.54	48.33	-8.25	-6.82
FEA 800 elements	0.265	56.62*	39.32*	-9.01	-7.52
FEA 3200 elements	0.265	62.03*	43.33*	-9.32	-8.2