Advanced Capability & Application of Genesis Software Sizing

Advanced Vehicle Development and CAE
General Motors

Acknowledgment
GM Vehicle Optimization and CAE Teams (AVD-CAE)

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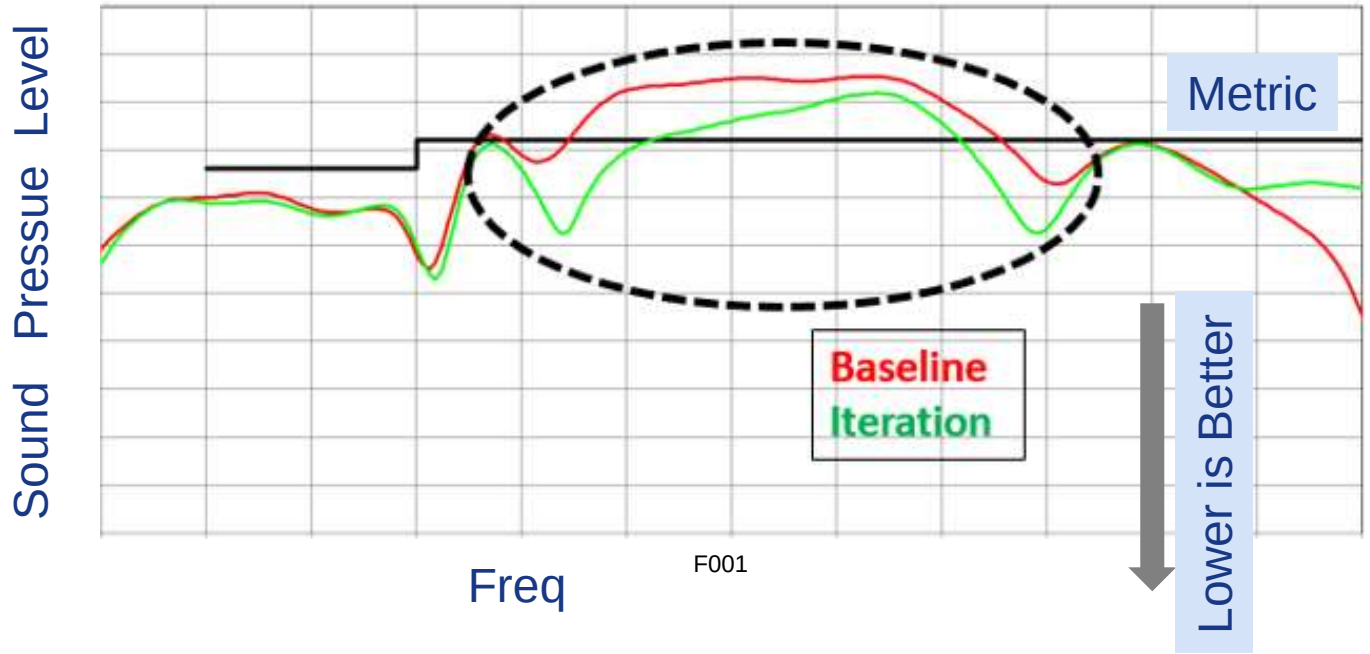
Overview

- Example 1ST: Sound Pressure Level (SPL) Optimization
- Example 2S: Handling Large number of Design Constraints

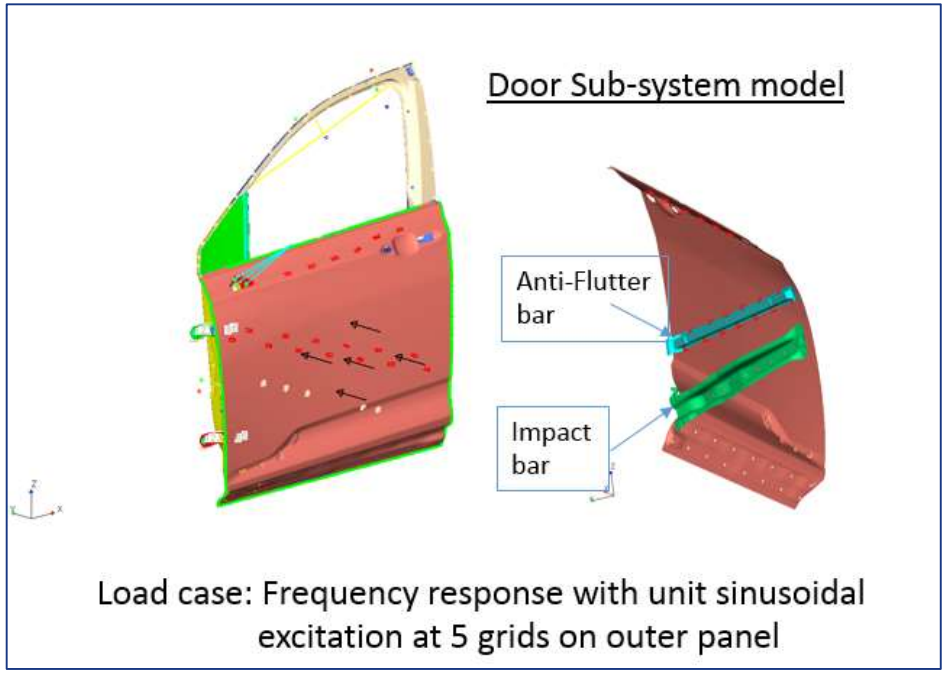
Example 1ST – SPL Optimization

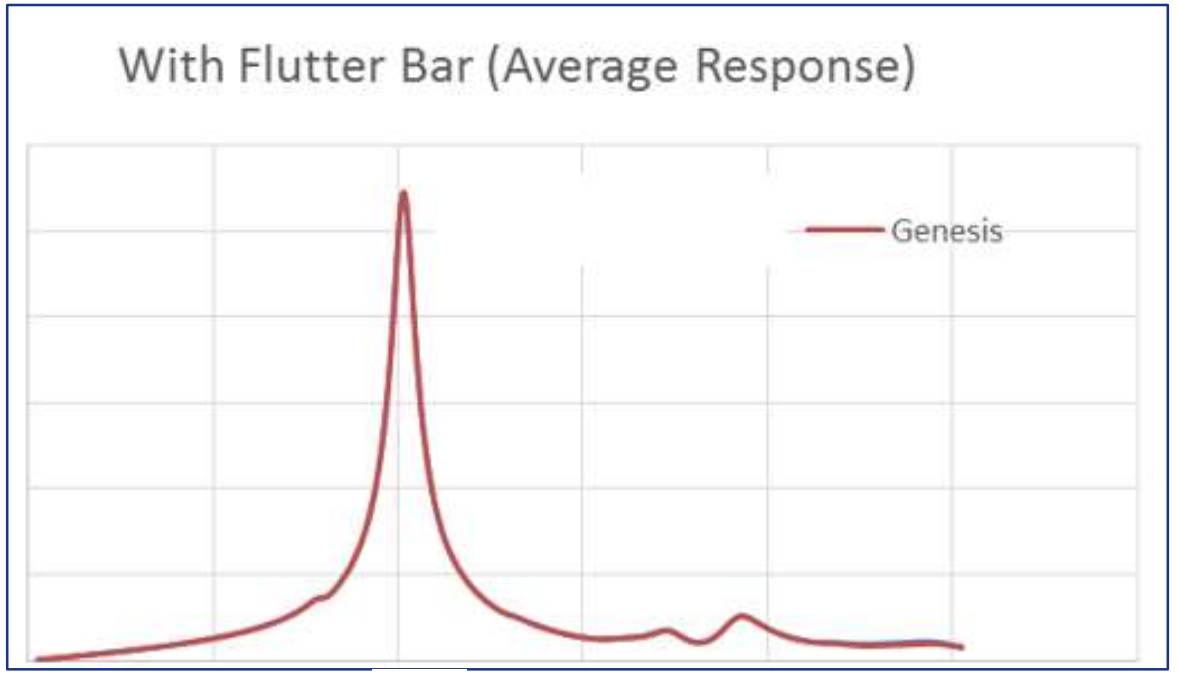
Challenge: SPL for Idle Boom (Full System Model) does not meet Metric



Model Details

Background - One of the key contributor has been determined to be the Front Door.
Lower Frequencies of the Front Door directly impact the SPL



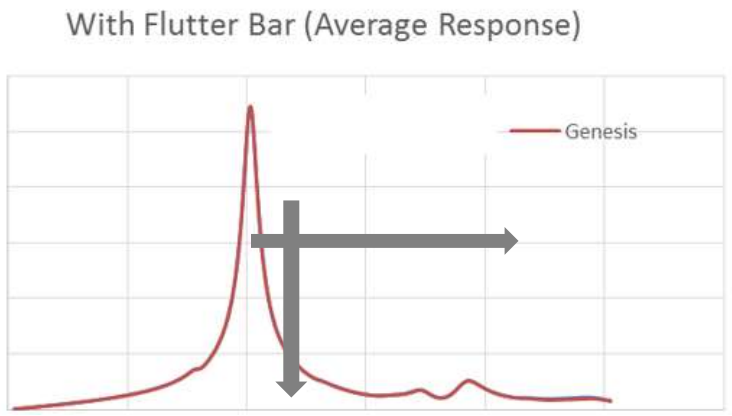


Optimization Setup

Design Variable: Orientation of the Anti-Flutter bar

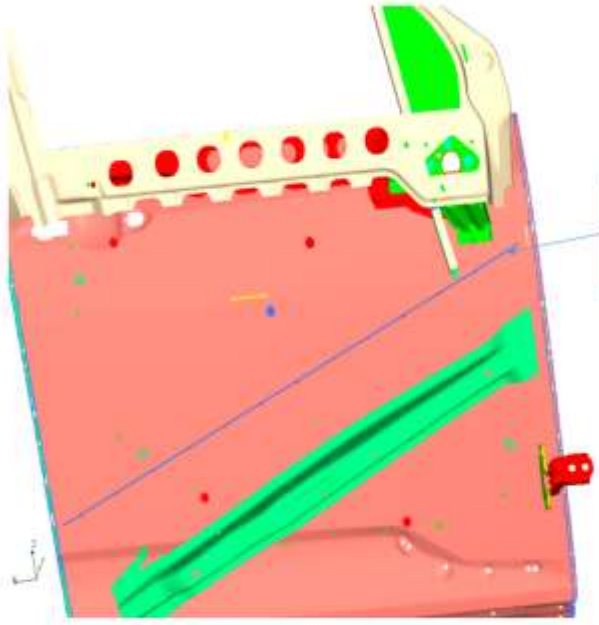
Response Tracking:

- Minimize the average of dynamic velocity magnitudes at 5 grids
- Improve Frequency > F001 Hz door mode

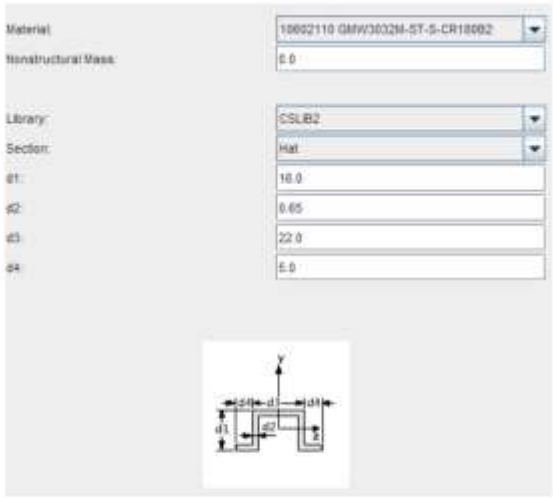


F001

Reducing Model Complexity

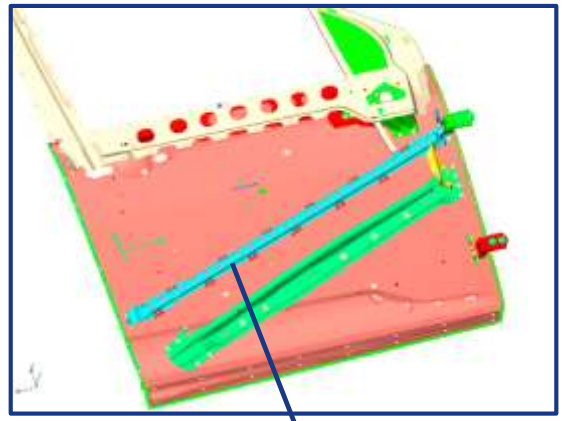


13 CBAR elements
11 RBE's connecting
to outer panel



Hat cross-section defined on PBAR property

CBAR-RBE Anti-Flutter Bar



Current Detailed Anti-Flutter Bar

Opt Sensitivity Runs
- Replace Detailed Anti-Flutter bar by beam elements

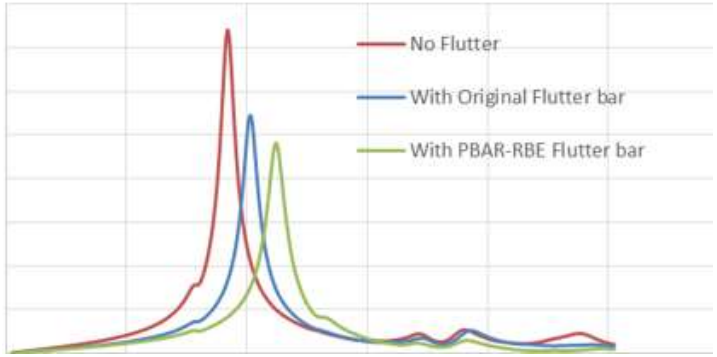
Genesis Capability
- Adding Beam Elem
- Different Cross-Section
- Picture make it easy to interpret

*Appreciate Brian Watson adding this Beam capability

Sense Checks on Reduced Model Complexity

Detailed Anti-Flutter

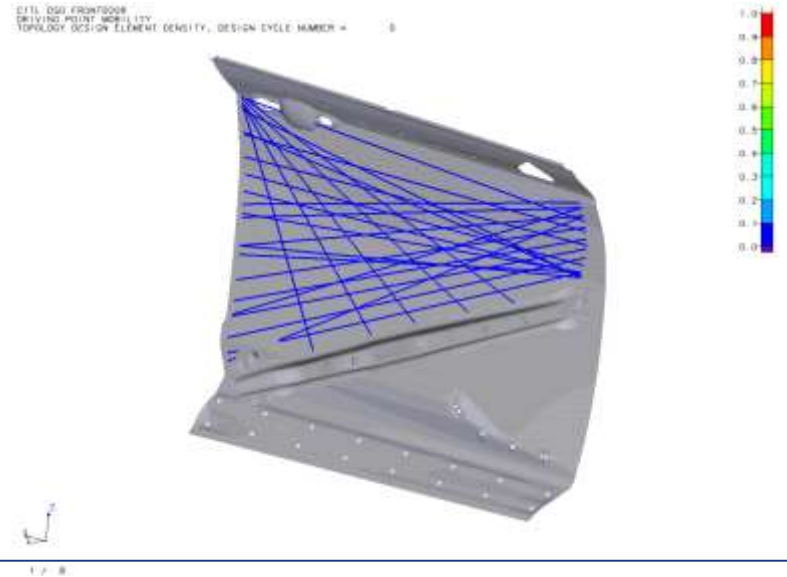
Beam-Elem Anti-Flutter



Freq

Better

Design Variables



Design Variables:

- Each blue line has 13 CBAR elements with 1 PBAR
- There are 25 blue lines, i.e. 25 PBAR

Genesis Capability

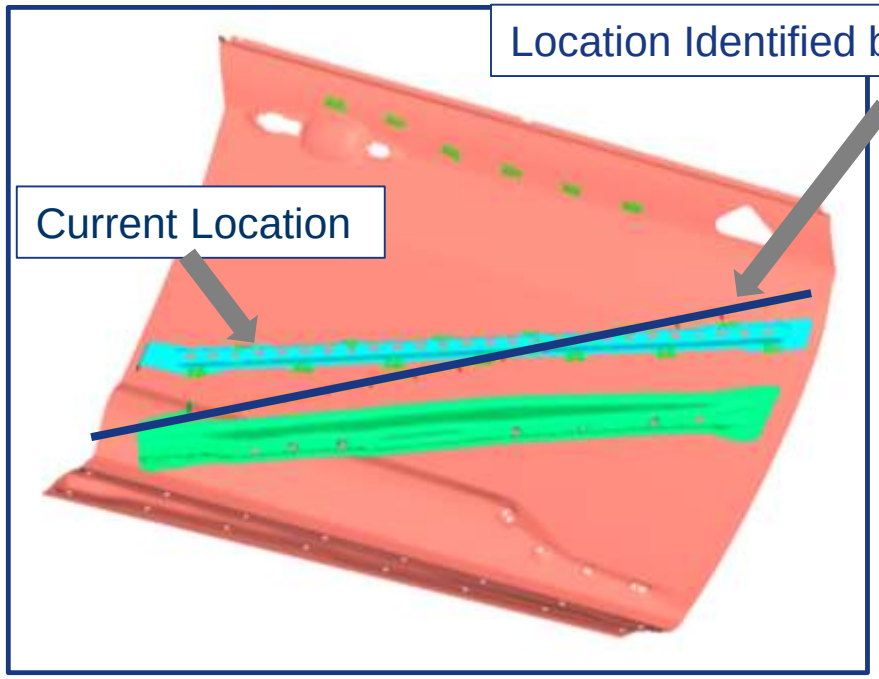
Selection of 1 out of 25 bars
TSELECT capability is very convenient

Topology optimization

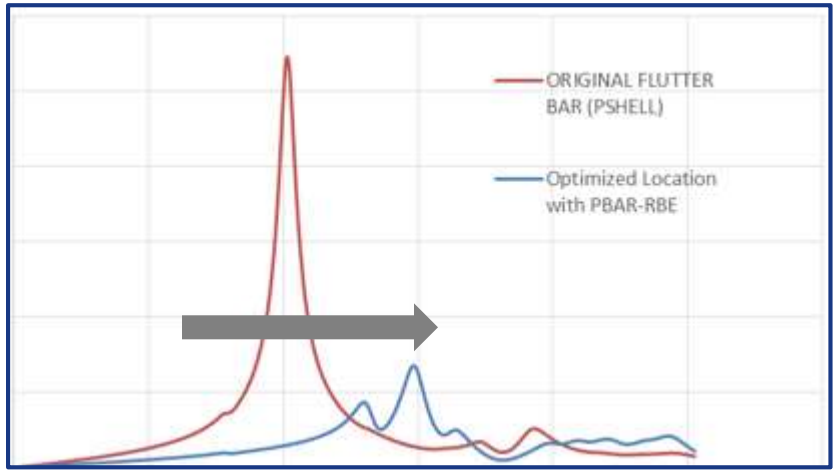
Maximizing Summation of Freq by
TINDEX is very convenient

*Appreciate J.P. Leiva adding this TSELECT capability

Results and Validation



Genesis Capability
Post-Processor
makes is easy to look at results



Validation: The CBAR above was converted to Shell Elem (actual part).
The improvement was also observed in the Detailed Model

Example 2S – Large Number of Design Constraints

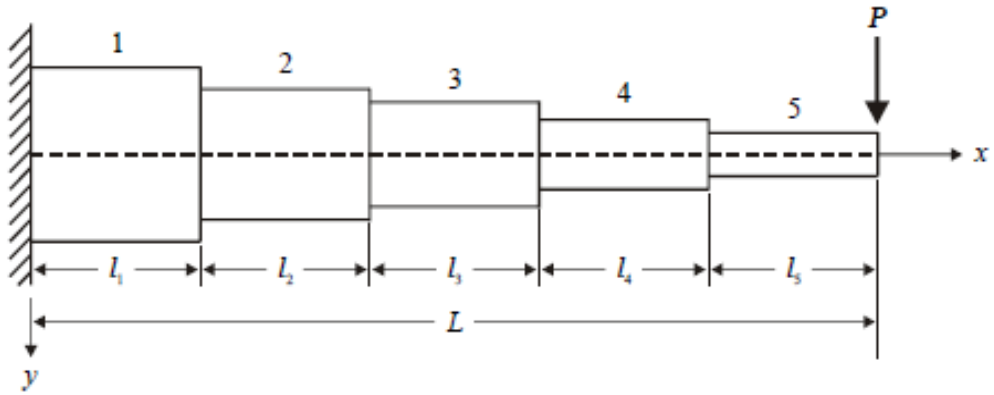
Challenge:
To benchmark a test problem with large number of active constraints

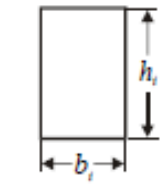
Background:
In typical optimization jobs, the number of active constraints the optimizer considers is small (of the order of a few 100s at most).

In order to generate large number of active constraints,
the constraints need to be enforced at element level.(stress)

There is limited experience on software capability with very large number of active constraints.

Test Case*





Cross section

$P = 50{,}000$ N
$E = 2.0 \times 10^7$ N/cm^2
$L = 500$ cm
$\bar{\sigma} = 14{,}000$ N/cm^2
$\bar{y} = 2.5$ cm

Minimize: $V = \sum_{i=1}^{N} b_i h_i l_i$ $\bar{\sigma}$ is the allowable bending stress

Subject to:

$$\frac{\sigma_i}{\bar{\sigma}} - 1 \le 0 \qquad i = 1, N$$

$$h_i - 20 b_i \le 0 \qquad i = 1, N$$

$$b_i \ge 1.0 \qquad i = 1, N$$

$$h_i \ge 5.0 \qquad i = 1, N$$

- The optimal solution is a fully stressed tapered beam design
- Number of active constraints is 2 * number_of_elements

*Appreciate Gary Vanderplaats for providing this model. It allowed us to explore capability of BIGDOT

Results

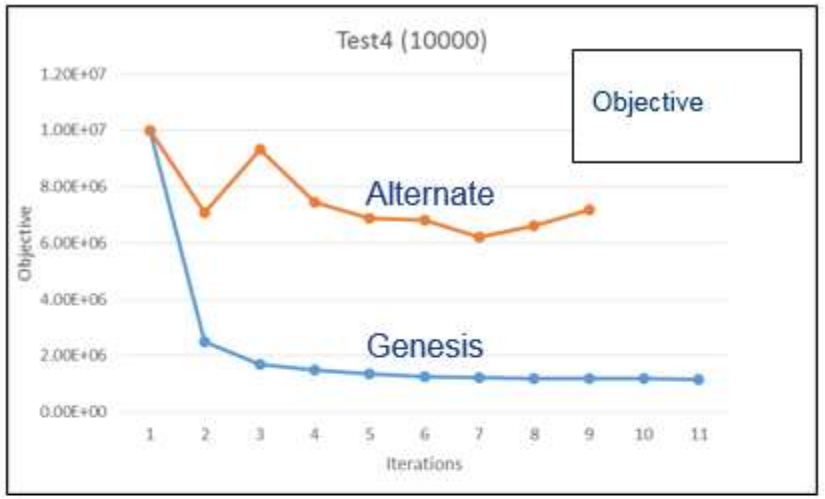
Problem	Length	No of Beams	NDOF	Stress Cons Value	Section Cons Value (hi/bi)	Potential # of Active constraints	GENESIS			
							Optimizer	Final Objective	# of Active constraints	Elapsed time
Test2	5000	1000	6000	140,000	20	2,000	DOT	542380	1964	15 minutes
Test4	50000	10000	60000	1,400,000	20	20,000	BIGDOT	1169213	19445	13.8 hours
Test6	62500	12500	75000	1,750,000	20	25000	BIGDOT	6744036	24780	23.9 hours
Test8	75000	15000	90000	2,100,000	20	30,000	BIGDOT	8088700	29846	60.73 hours

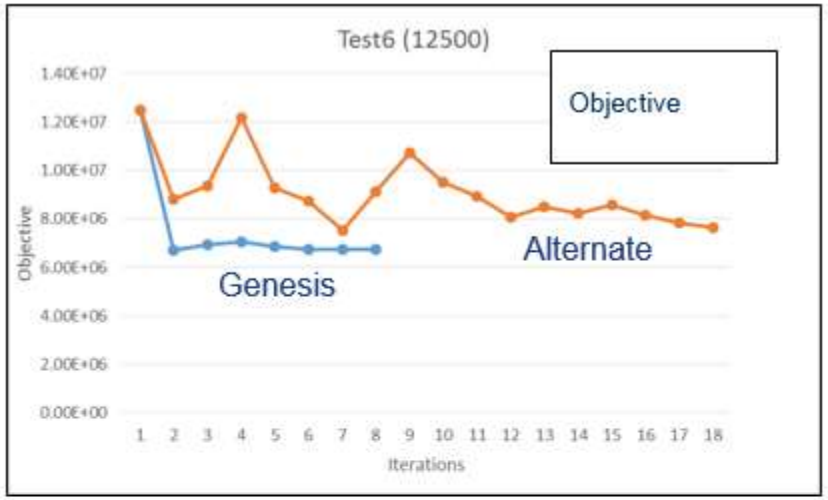
* Beam element formulation works best for reasonable D/L aspect ratios

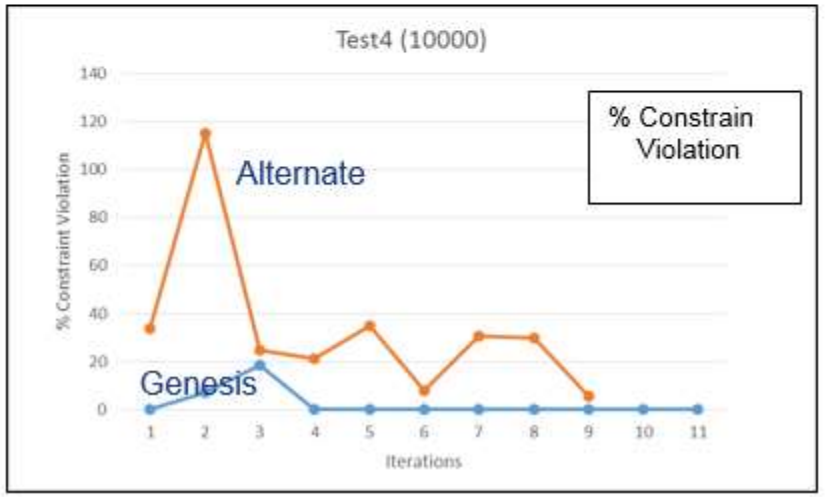
Alternative Options

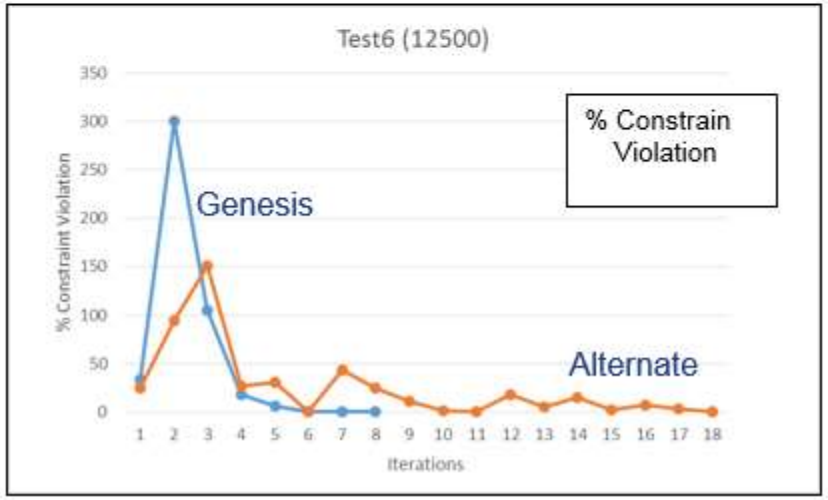
Problem Size	Potential # of Active Constraints	GENESIS			Alternate Software		
		Optimizer	Final Mass	Elapsed time	Optimizer	Final Mass	Elapsed time
Test 2	2,000	DOT	54	6 sec	UNK	54	2 sec
Test 4	20,000	BIGDOT	1,169	½ day	UNK	7,183 (iter8)	7+ days & running
Test 6	25000	BIGDOT	6,744	1 day	UNK	7,636 (iter17)	14+ days & running
Test 8	30,000	BIGDOT	8,088	2 ½ days	UNK	-	FAILED

Performance Plots









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