Section 1

IMPACT TESTING SETUP AND RIGID IMPACTOR STUDY

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TRIDYNAMIC SOLUTIONS

Recommendations

- Require impact using soft impactors.
- Soft impactors shall have characteristics similar to the wing of a small aircraft.

Rigid vs Soft Impactors

- Rigid Impactors tend to yield energy measurements that are lower than soft impactors.
- Energy measurements are not equivalent over the contact period.

Rigid vs Soft Impactors

Simulation Results

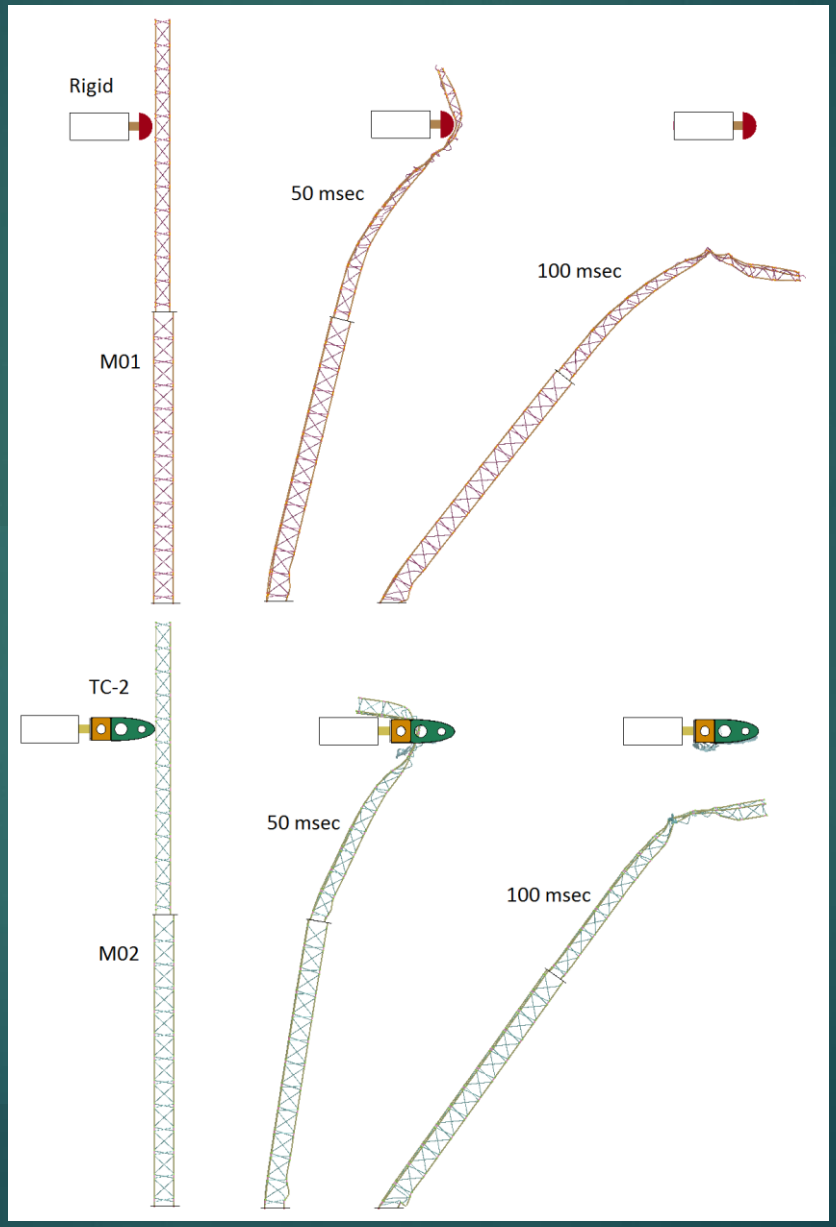
Device Type	Maximum Energy (kN-m)		Comment
	Rigid	TC2	
Aluminum Lattice	13.6	16.7	Variation in Energy is the Result of Variations in Failure Modes
Aluminum Pipe	23.6	17.2	
Composite Lattice	14.8	18.5	
Composite Pipe	4.6	14.2	

Load Cell Energy Lower in 3 of 4 Cases

68% Low

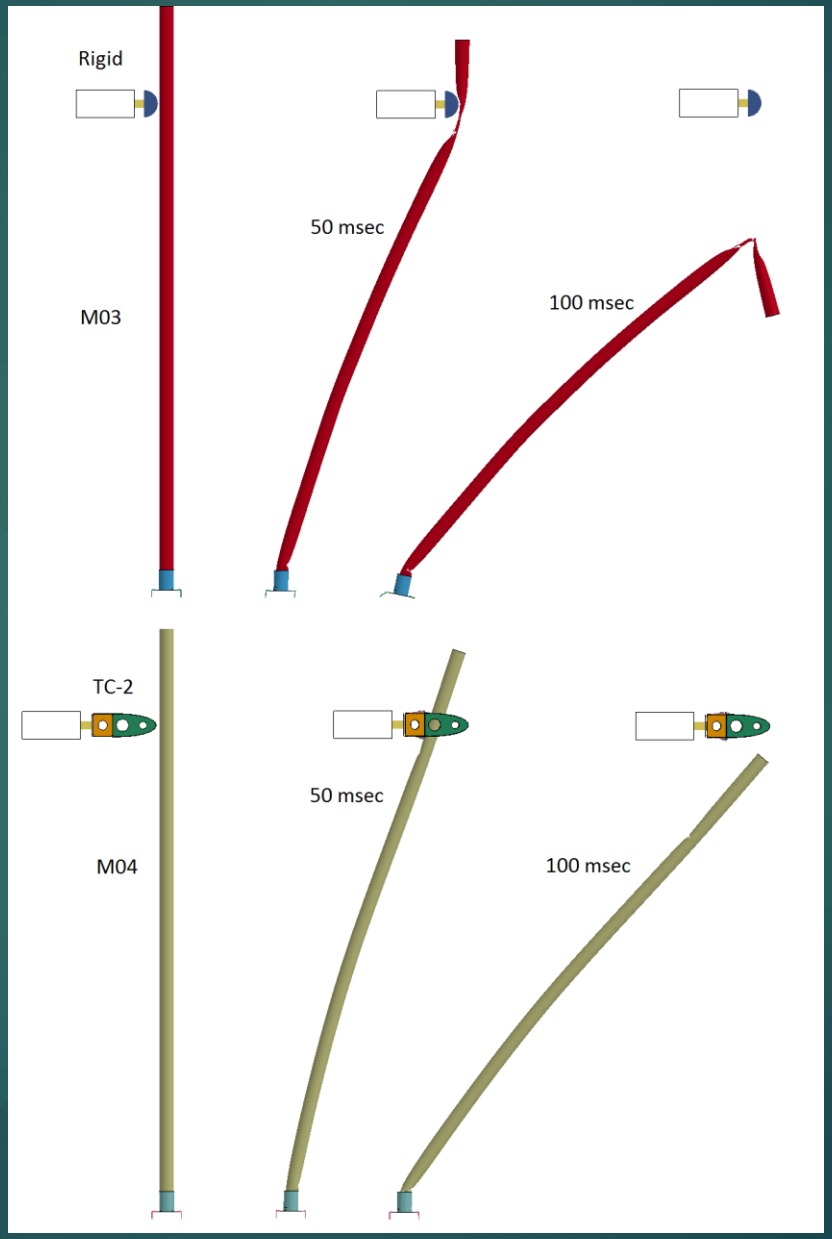
Rigid vs Soft Impactors

Tower Response



Rigid vs Soft Impactors

Tower Response



Rigid vs Soft Impactors

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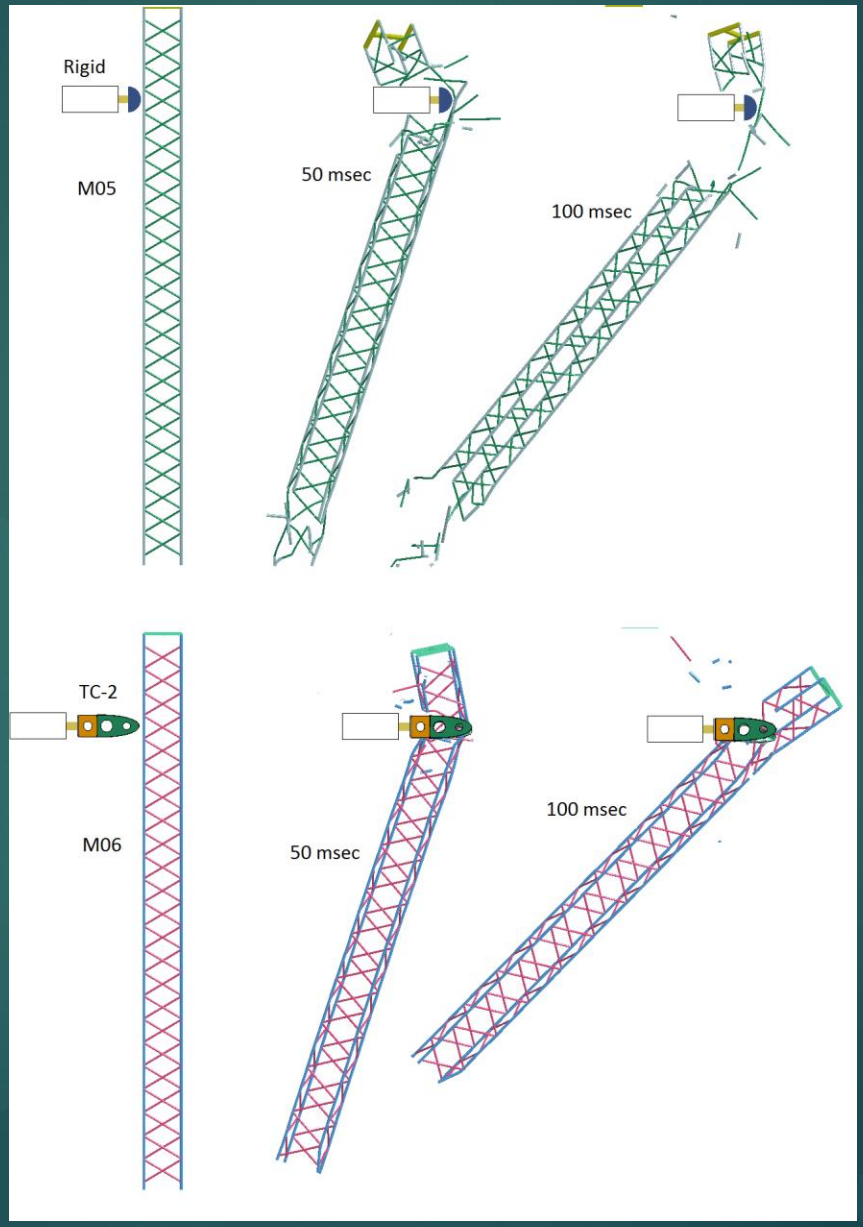
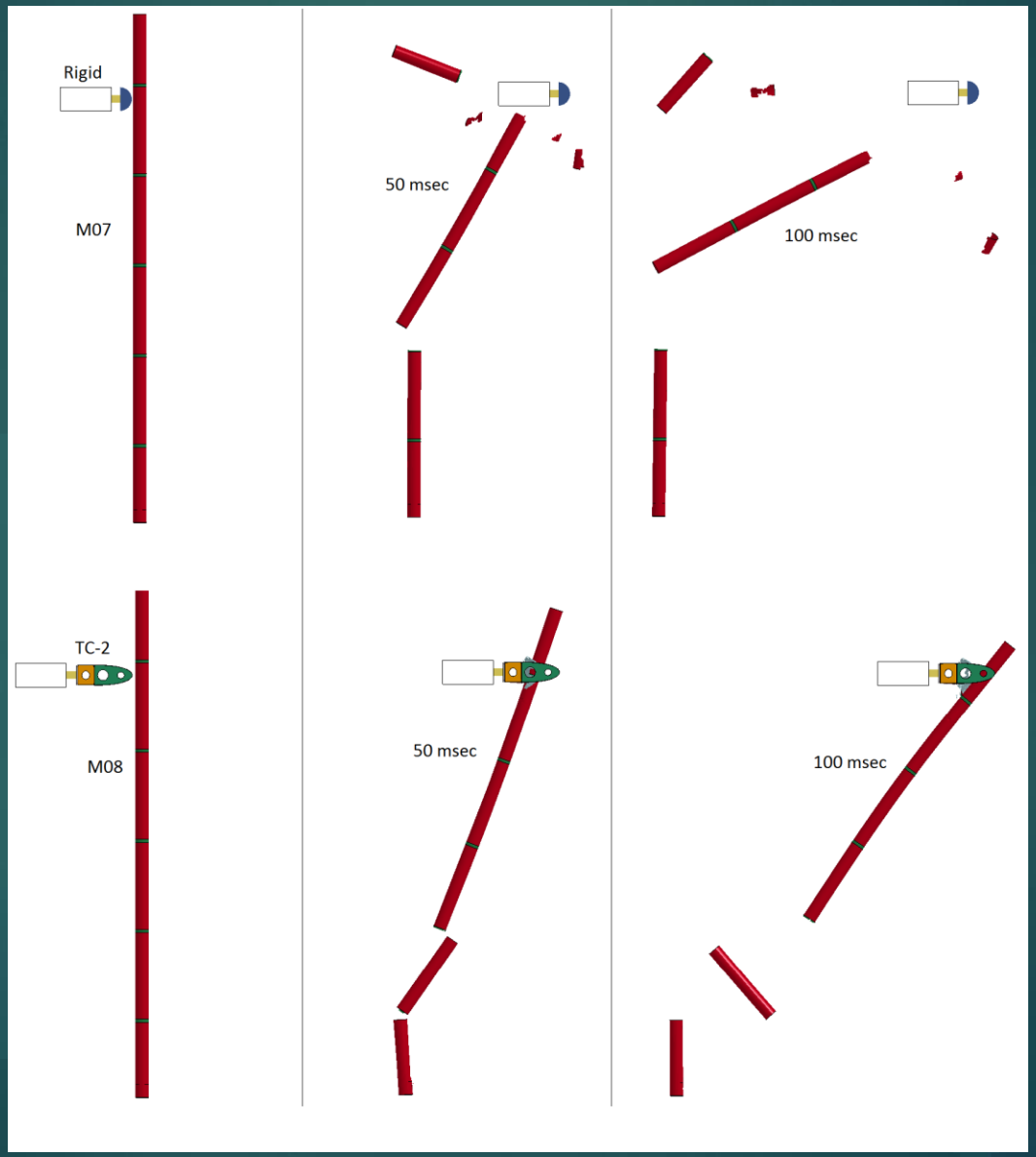


Rigid vs Soft Impactors

Tower Response



Rigid vs Soft Impactors

Historical Test Results

- Contact Period and Energy
  - Significant Difference

Measurement	Rigid (avg of 3)	TC2 (avg of 2)	% Difference
Contact period (msec)	59.3	85	**43%**
Energy over contact period (kN-m)	13.0	15.9	**22%**

Rigid vs Soft Impactors

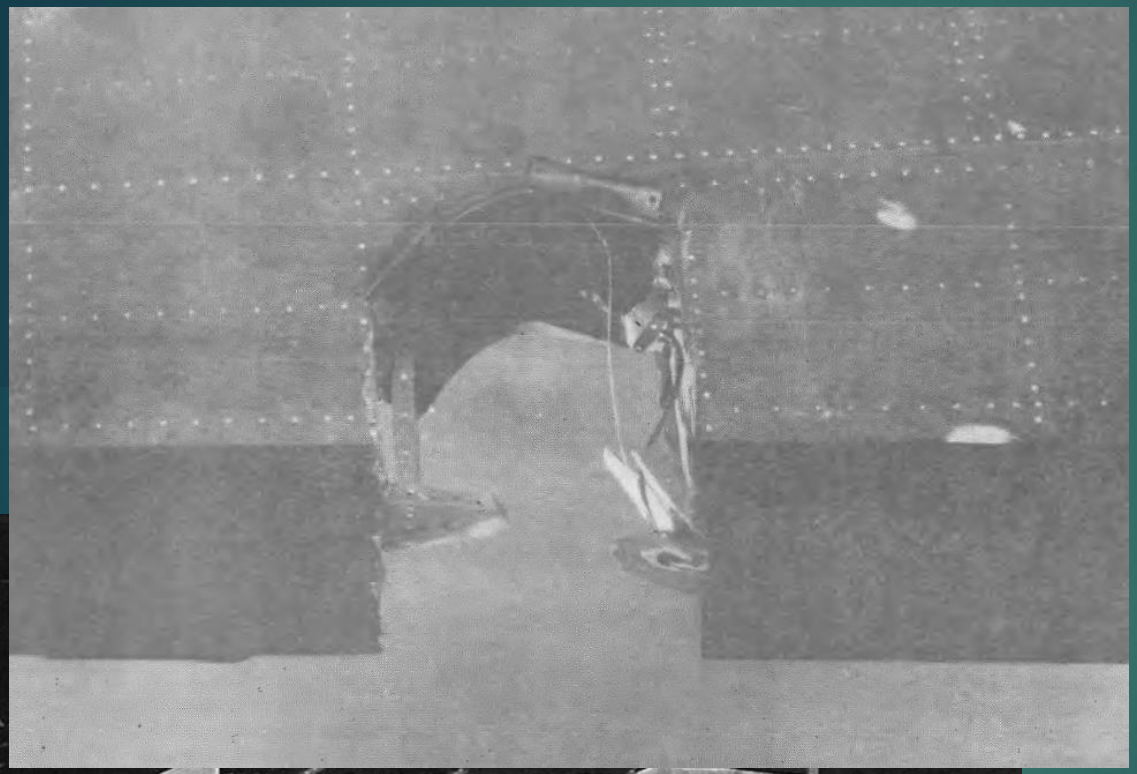
Historical Test Results

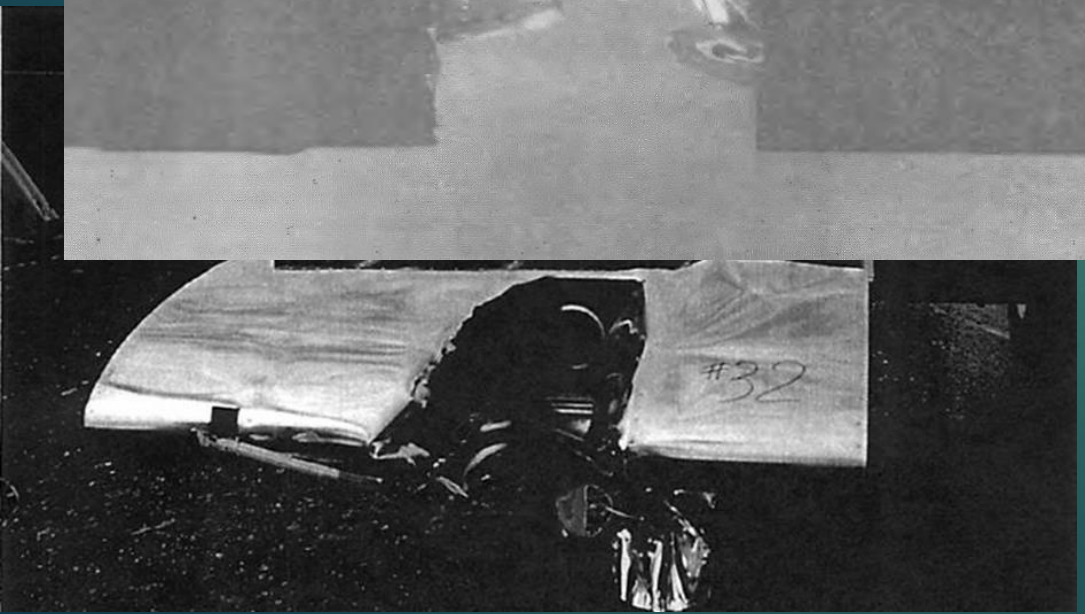
- Different Failure Mechanisms

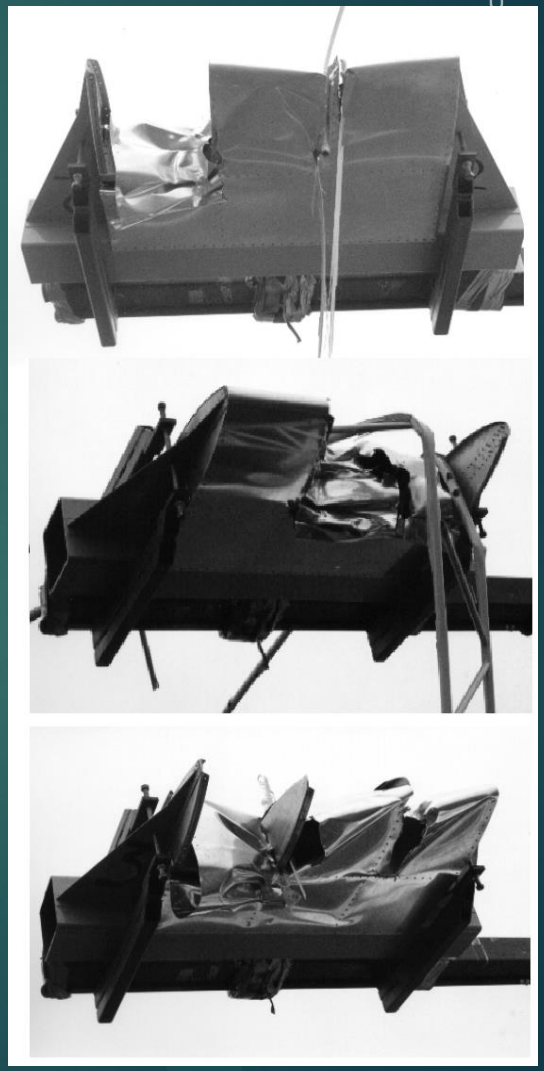
Measurement	Rigid (avg of 3)	TC2 (avg of 2)	% Difference
Time to failure: First (msec)	14.7	32.0	**118%**
Time to failure: Second (msec)	32.0	n/a	n/a
Energy to failure: First (kN-m)	5.01	10.7	**114%**
Energy to failure: Second (kN-m)	10.1	n/a	n/a

Rigid Impactors

Lost Value of Visual Inspection







Rigid vs Soft Impactors
Summary

- Rigid impactors do not yield higher energy values than soft wing surrogates.
- Tower responses and failure modes are very different for rigid versus soft impactors.
- Rigid impactors do not support visual inspection of wing damage.
- Impactors similar to the wings of a small aircraft are simply more realistic.

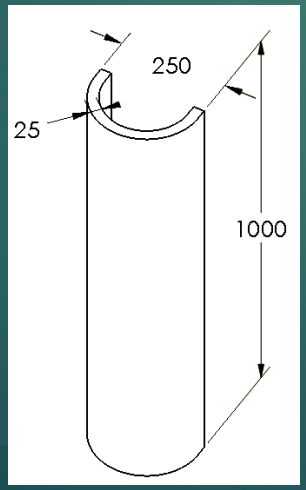
Shane Shurtliff, P.E.

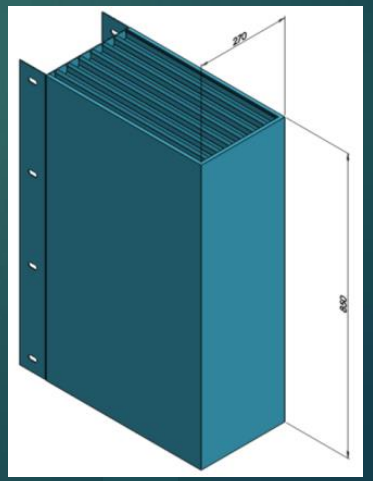
SELECT ENGINEERING SERVICES

Rigid vs Soft Impactors

Impactor Design

- Using a rigid impactor does not produce the same results as a deformable impactor such as an airplane wing.
- To use a deformable impactor, it must be repeatable in order to establish a standard.
- Crush Strength would be designed to represent an aircraft wing.
- Honeycomb impactor are repeatable, customizable, and inexpensive to produce.
- Recommend using honeycomb impactor

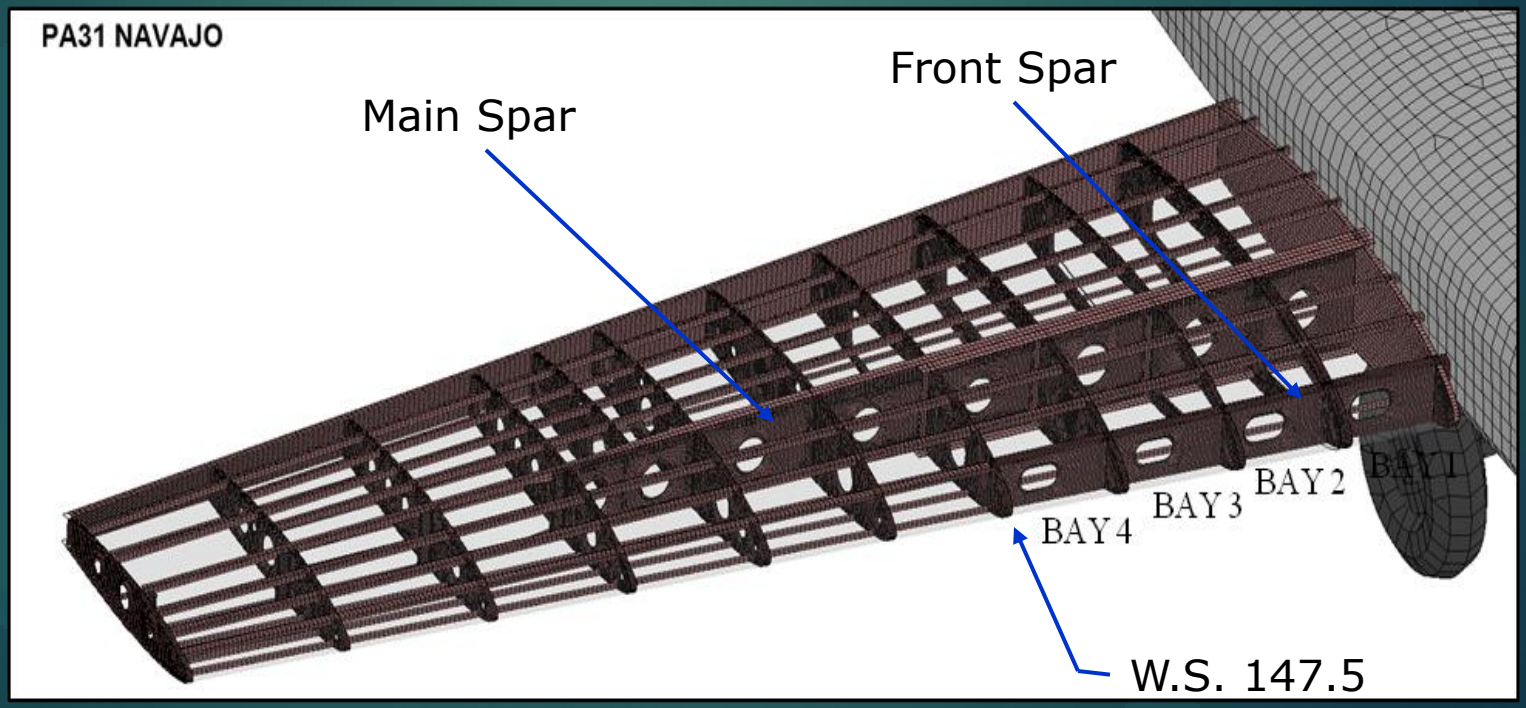




Rigid vs Soft Impactors

Impactor Design

- Used previously for FAA Tests
- Close to 3000kg weight
- Able to obtain full drawing package to generate computer model



Rigid vs Soft Impactors

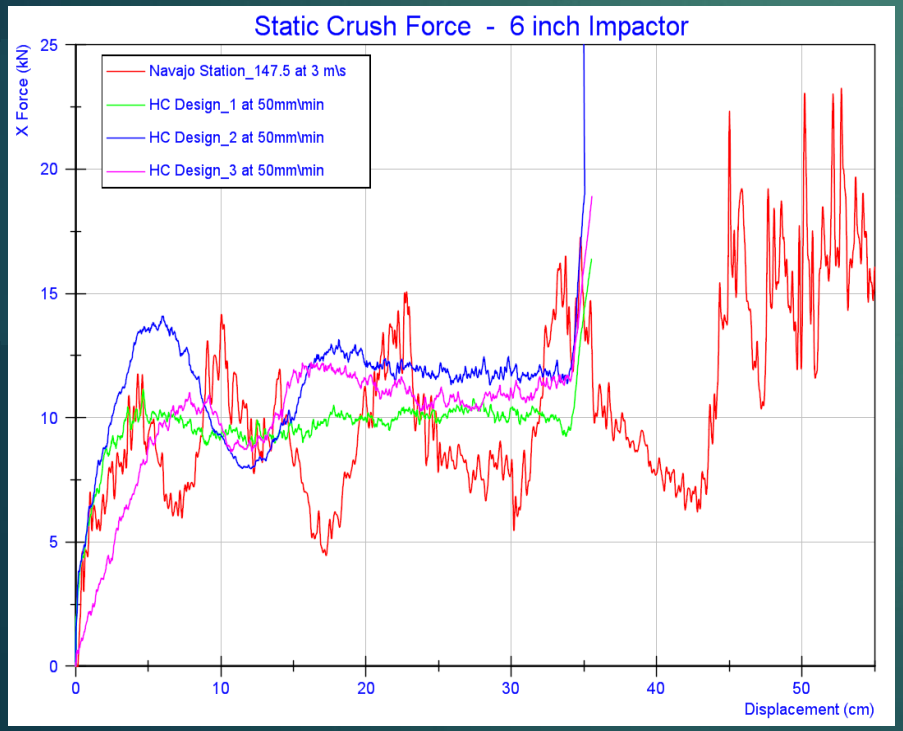
Impactor Design

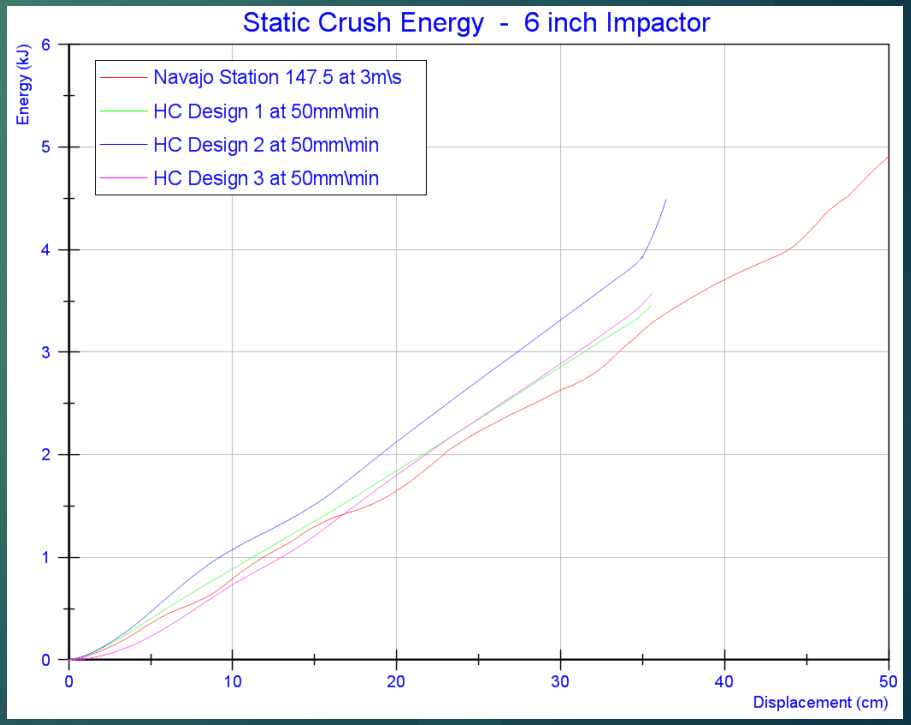
- Performed static crush tests on three different designs
- Determined which design to use based on crush forces as compared to wing data
- Performed dynamic impacts using drop tower system
- Standard design allows test data between different products to be compared

Rigid vs Soft Impactors

Impactor Design

- Crush Strength of Honeycomb compared to crush strength of wing
- Good match to Piper Navajo

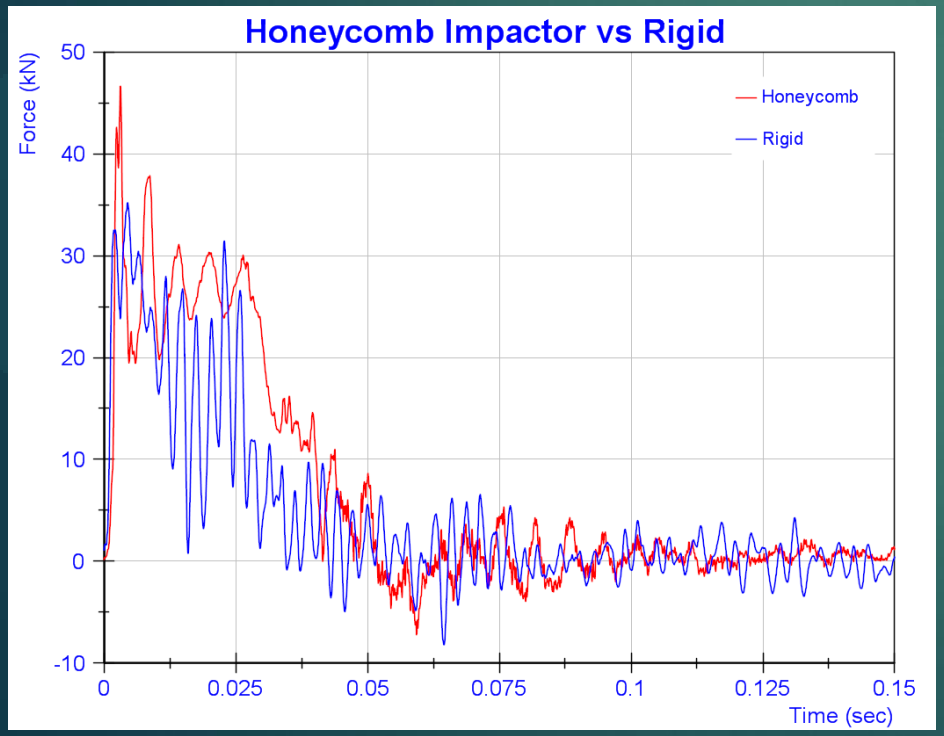


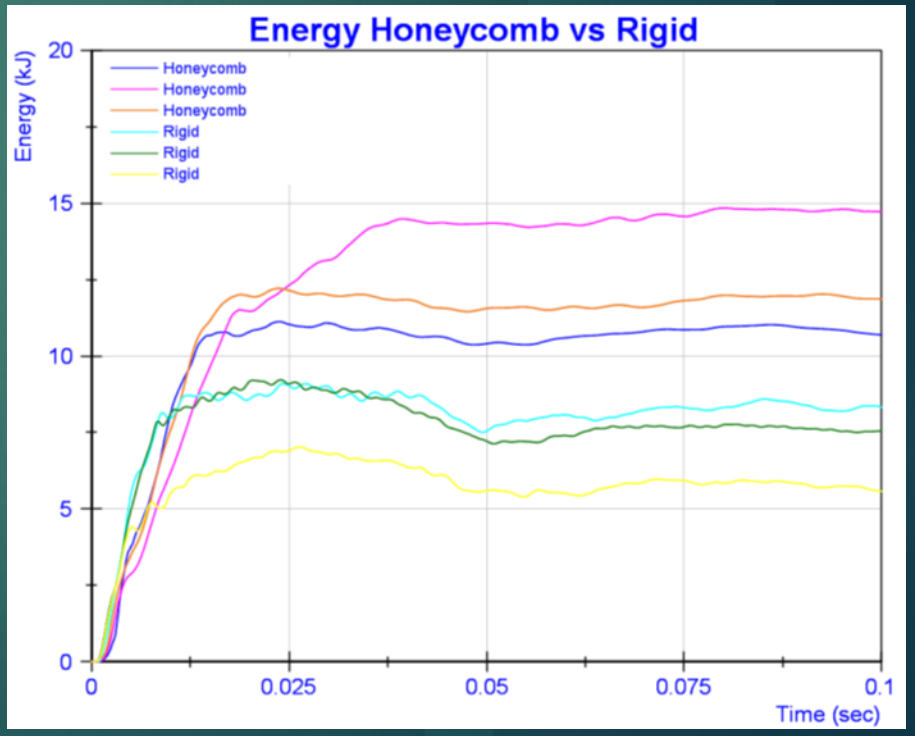


Rigid vs Soft Impactors

Impactor Design

- The rigid impactor generated more noise in the data
- Significantly reduced the energy required to break through the pole.
- Changes failure mode





Rigid vs Soft Impactors

Impactor Design

- Soft vs Rigid Impactor
  - The rigid impactor does not provide energy values representative of an airplane wing.

Calculated Energy Values for FAA Impact Tests			
	Rigid Impactor	Soft Impactor	% Difference
Product X	8.43	12.60	33.07
Product Y	25.67	36.43	29.55
Product Z	25.50	42.67	40.23
	Average % Difference		**34.28**

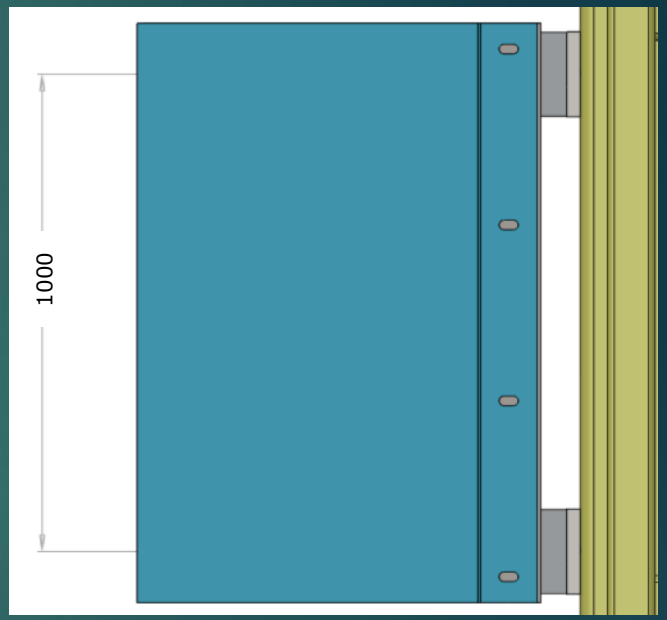
Rigid vs Soft Impactors
Impactor Design

- Rigid impactor causes more localized failure in the LIR structure

Summary and Recommendations

Impactor Design and Instrumentation

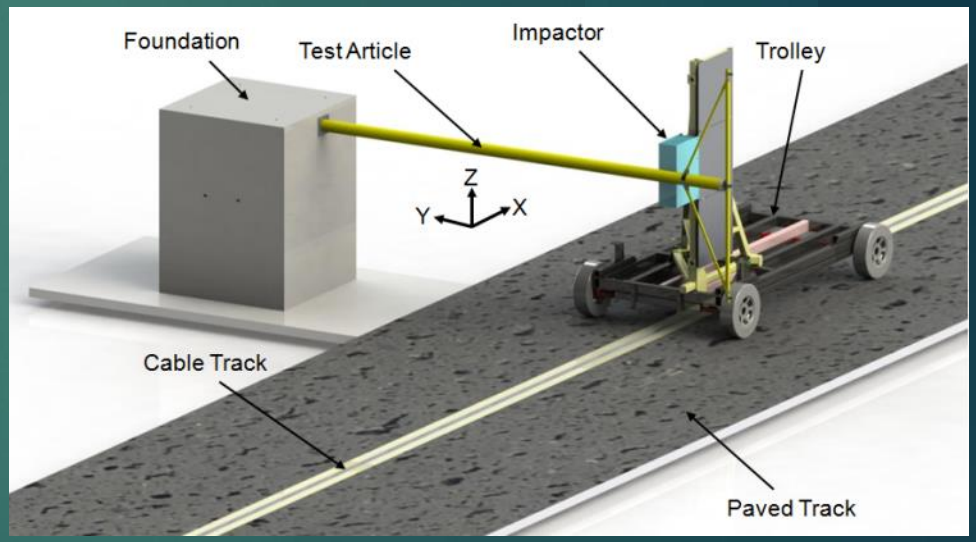
- Standard Honeycomb Impactor
- Tri-axial load cells
- Max two load cells per impactor
- Load cell spacing should be no larger than 1 meter
- Minimize weight in front of load cells (no greater than 55 pounds (25 kg)
- Record data at a min of 10 kHz
- Use High Speed video at a minimum of 1000 fps
- Video must capture failure mode and duration of impact



Summary and Recommendations

Test System and Setup

- Define stiffness requirement for structure behind impactor.
- Test article may be mounted horizontal or vertical.
- The X-axis is defined as the direction of impact.
- Impact location 1 meter from top (research needed for other impact locations)
- Standardize Pole Length



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