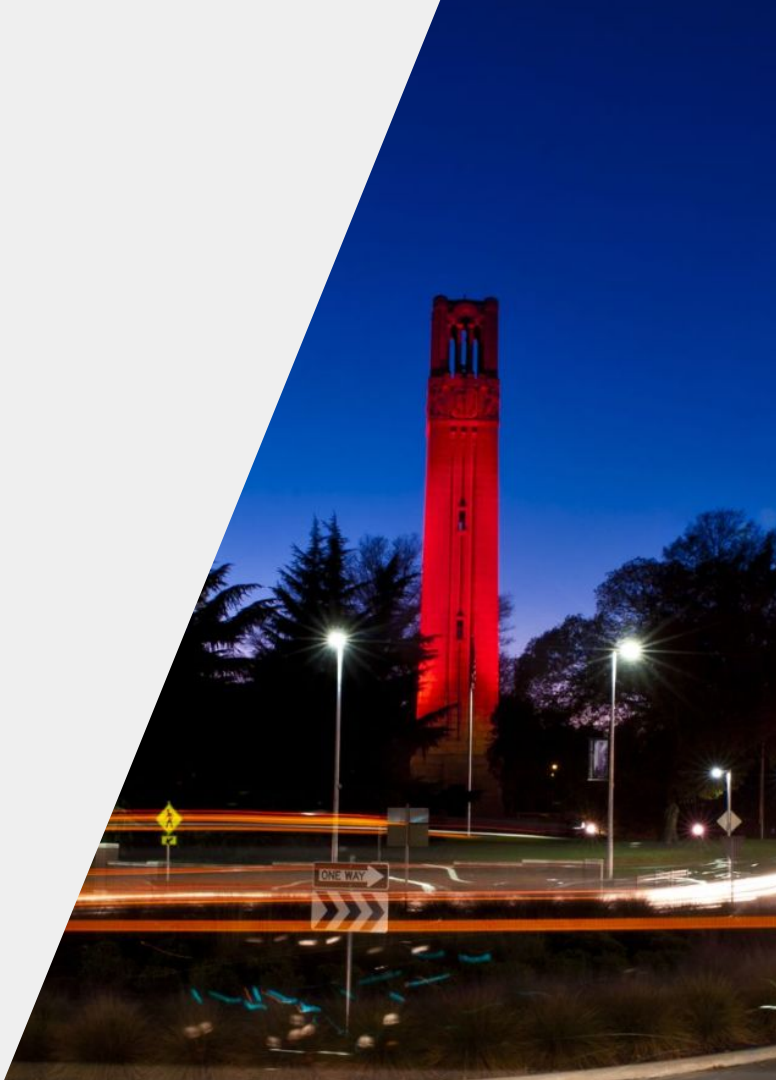
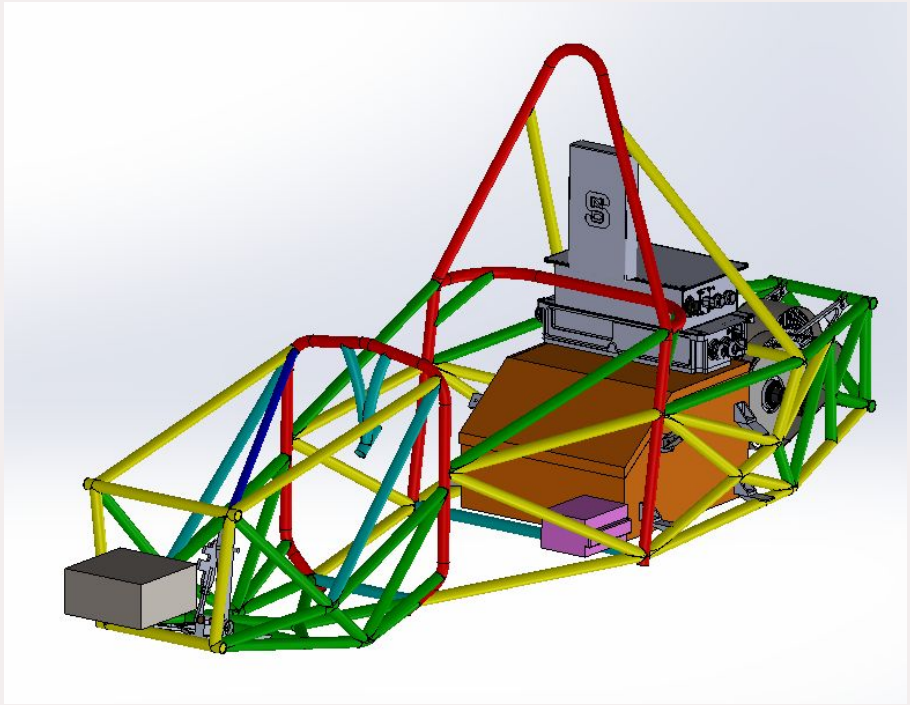
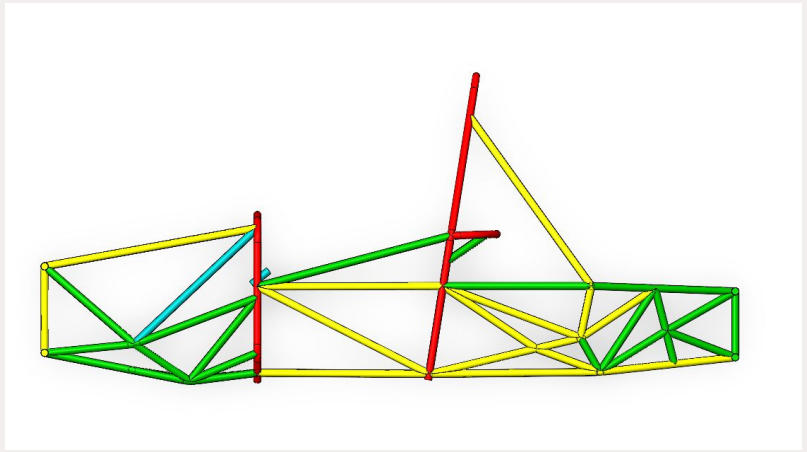
FEA Validation of FSAE Chassis Using Strain Gauge Data

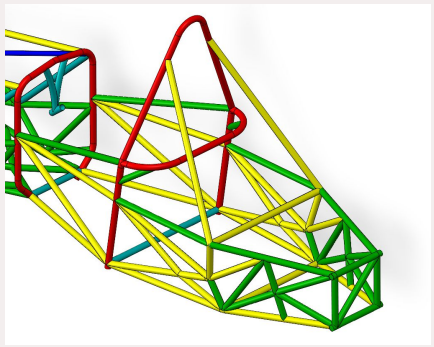
Asher Ostrowski
MAE 496

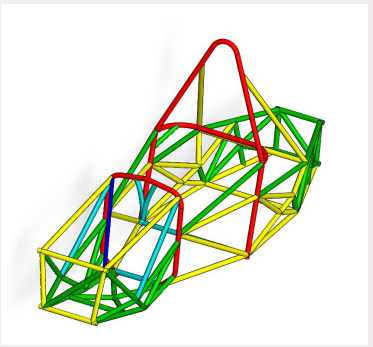


Cad Models









Goals

The goal is to create a more accurate FEA model of the Pack Motorsports FSAE chassis and compare it to physical strain gauge data.

Main objectives:

- Apply realistic chassis load cases with more accurate features and combined loading cases
- Identify high-stress strain gauge locations
- Validate simulation results with data
- Create a repeatable process for future chassis design iterations

Load cases:

- Torsional loading
- Acceleration loading
- Braking loading

Optimization

The chassis was modeled in SolidWorks as a 3D weldment and imported into ANSYS as a STEP file.

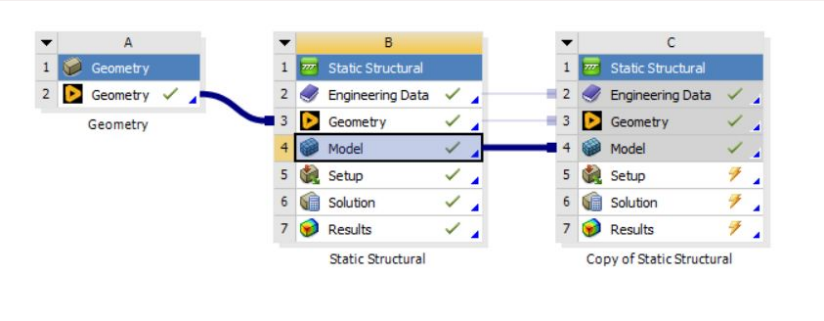
Model setup:

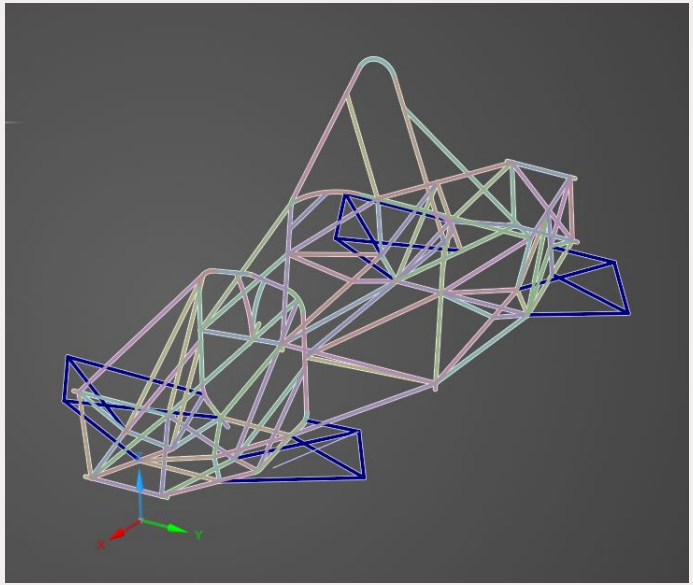
- Beam elements extracted to represent the tubular frame
- AISI 4130 chromoly steel properties assigned
- Boundary conditions refined to better match the real test setup

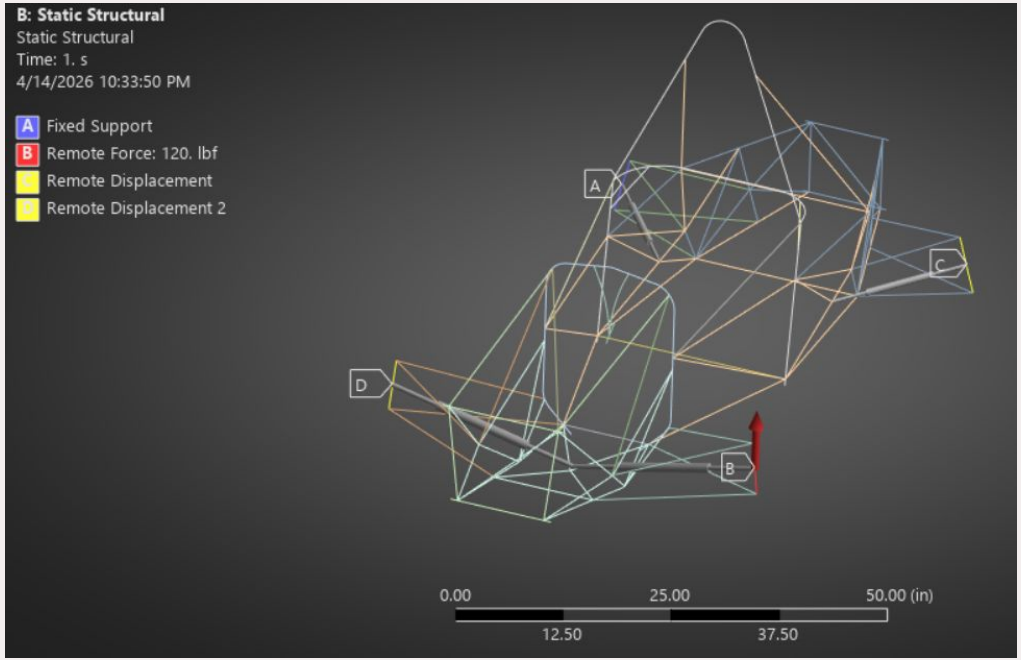
Model improvements:

- Add battery container
- Add differential/motor carriers
- Add driver seat
- Improve weld and joint stiffness behavior

Ansys Prep


A
1 Geometry
2 Geometry
Geometry
B
1 Static Structural
2 Engineering Data
3 Geometry
4 Model
5 Setup
6 Solution
7 Results
Static Structural
C
1 Static Structural
2 Engineering Data
3 Geometry
4 Model
5 Setup
6 Solution
7 Results
Copy of Static Structural



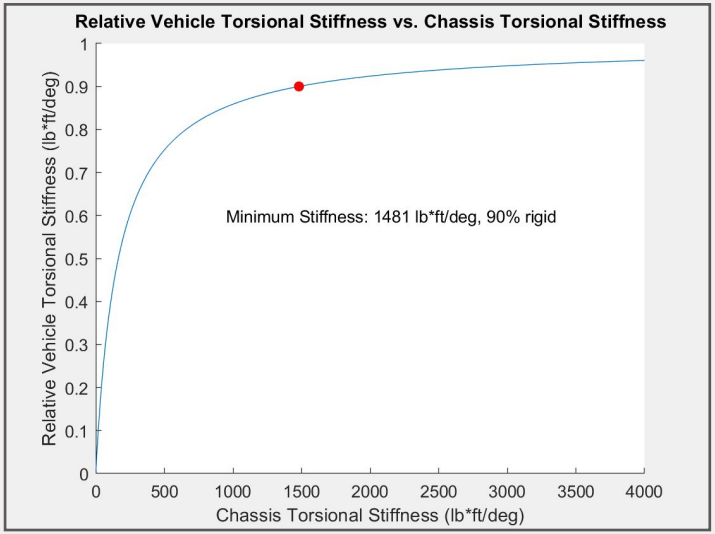

B: Static Structural
Static Structural
Time: 1. s
4/14/2026 10:33:50 PM
A Fixed Support
B Remote Force: 120. lbf
Remote Displacement
Remote Displacement 2
A
B
C
D
0.00
25.00
50.00 (in)
12.50
37.50

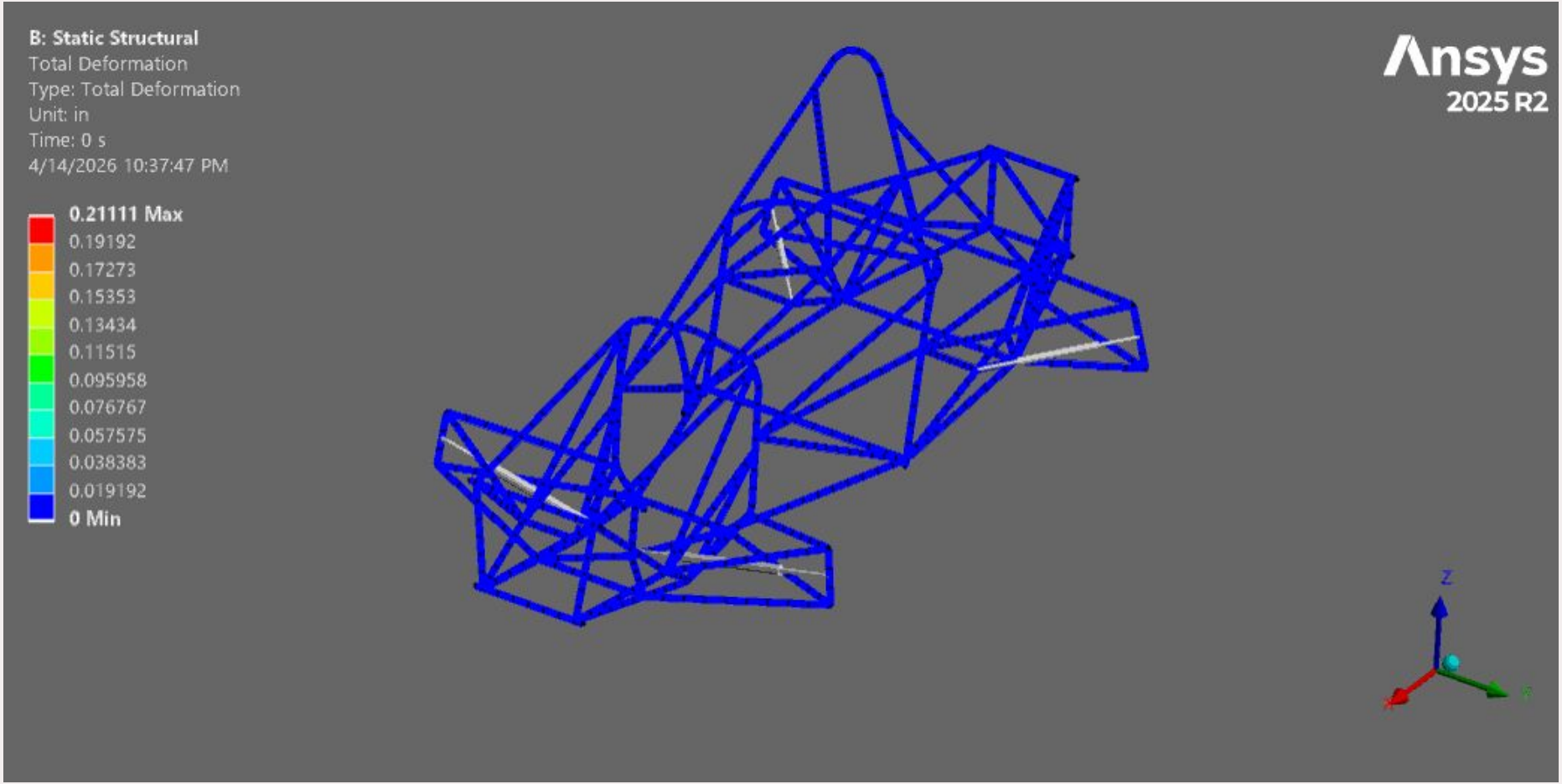
Simulation and Validation

The primary simulation so far is the torsional loading case. Vertical loads from **40–120 lb** are applied at the front left spindle, while the remaining spindle locations are constrained to match the torsional test rig.

Initial results showed:

- Expected chassis deformation patterns
- Higher strain near suspension mounting points
- Mostly linear deformation as load increases
- Elastic behavior within the tested range

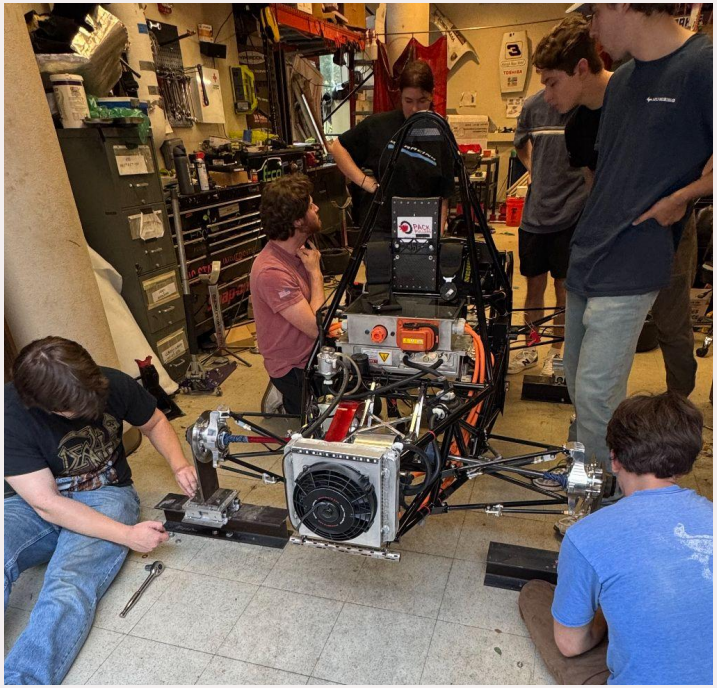



B: Static Structural
Total Deformation
Type: Total Deformation
Unit: in
Time: 0 s
4/14/2026 10:37:47 PM
0.21111 Max
0.19192
0.17273
0.15353
0.13434
0.11515
0.095958
0.076767
0.057575
0.038383
0.019192
0 Min
Ansys
2025 R2
Z

Calculated Torsional Stiffness from FEA

FLF (Left) [in]	RLF	LRA	RLA (Right) [in]		Front		Rear					
Load [lbs]	**FLF (Left) [in]**	**FLF (Right) [in]**	**RLA (Left) [in]**	**RLA (Right) [in]**	**Torque (relative to zero)**	**Radians**	**Degrees**	**Radians**	**Degrees**	**lb-ft/deg**		
120.000	0.290	0.203	0.006	-0.024	460.000	0.006	0.332	0.001	0.085	1866.497	Average	1866.364
110.000	0.266	0.186	0.006	-0.022	421.667	0.005	0.304	0.001	0.078	1866.420		
100.000	0.242	0.169	0.005	-0.020	383.333	0.005	0.277	0.001	0.071	1866.325		
90.000	0.218	0.152	0.005	-0.018	345.000	0.004	0.249	0.001	0.064	1866.185		
80.000	0.193	0.135	0.004	-0.016	306.667	0.004	0.221	0.001	0.057	1866.472		
70.000	0.169	0.118	0.004	-0.014	268.333	0.003	0.194	0.001	0.050	1866.349		
40.000	0.097	0.068	0.002	-0.008	153.333	0.002	0.111	0.000	0.028	1866.300		
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#DIV/0!		

Torsional Test Rig





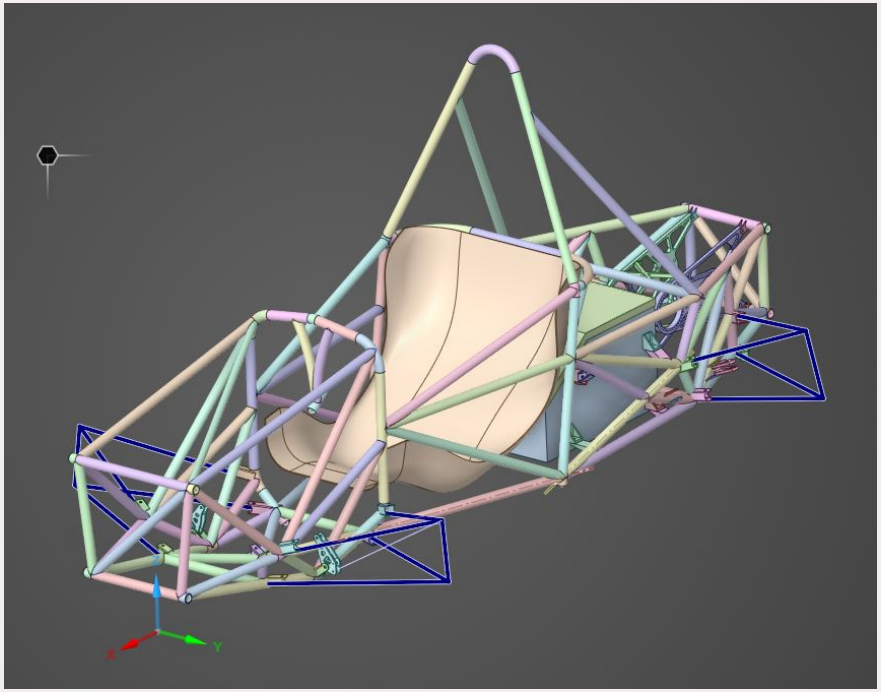


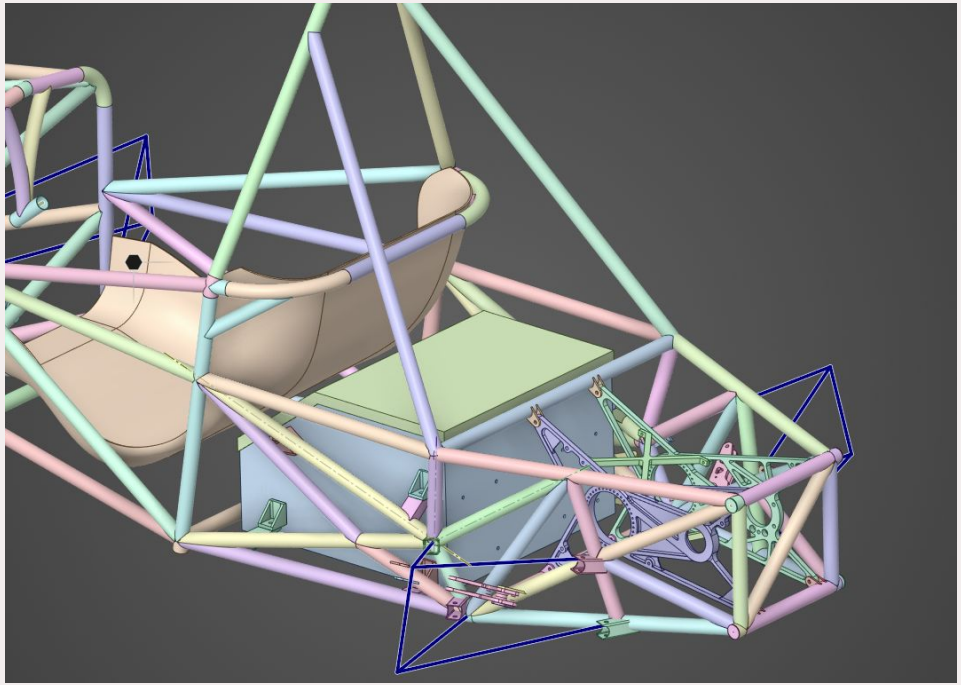


Torsional Test Rig Stiffness Calulated Numbers

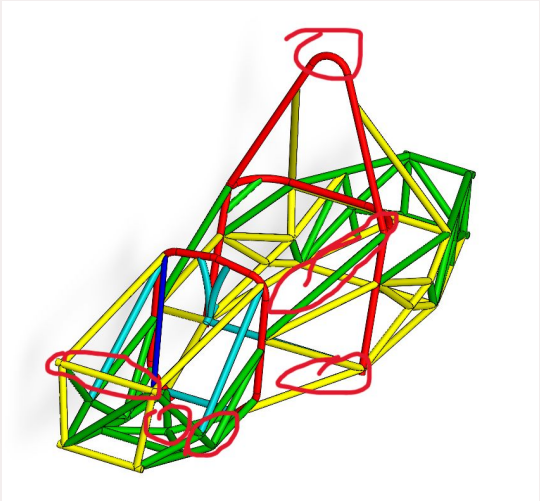
FLF (Left) [in]	RLF	LRA	RLA (Right) [in]		Front		Rear					
Load [lbs]	**FLF (Left) [in]**	**FLF (Right) [in]**	**RLA (Left) [in]**	**RLA (Right) [in]**	**Torque (relative to zero)**	**Radians**	**Degrees**	**Radians**	**Degrees**	**lb-ft/deg**		
120.000	0.463	0.361	0.017	-0.004	460.000	0.007	0.388	0.001	0.060	1404.772	Average	1404.737
110.000	0.425	0.331	0.016	-0.004	421.667	0.006	0.355	0.001	0.055	1404.651		
100.000	0.386	0.301	0.014	-0.004	383.333	0.006	0.323	0.001	0.050	1404.897		
90.000	0.348	0.271	0.013	-0.003	345.000	0.005	0.291	0.001	0.045	1404.765		
80.000	0.309	0.241	0.011	-0.003	306.667	0.005	0.258	0.001	0.040	1404.828		
70.000	0.270	0.211	0.010	-0.002	268.333	0.004	0.226	0.001	0.035	1404.659		
40.000	0.154	0.120	0.006	-0.001	153.333	0.002	0.129	0.000	0.020	1404.583		
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#DIV/0!		

New Model Prep





Locating Strain Gauges

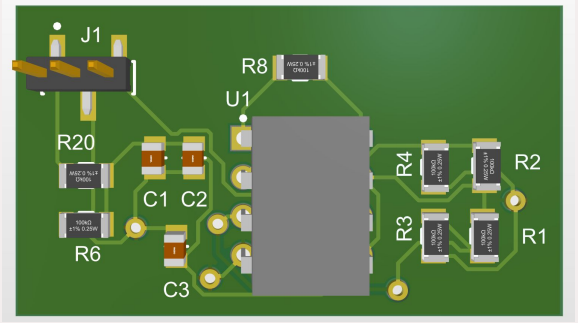


Considered gauge areas:

- Suspension pickup points
- Front lower X-brace
- Lower side impact structure tubes
- Rear suspension regions

Instrumentation setup:

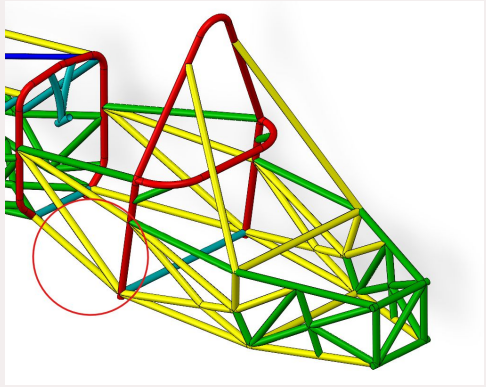
- Full-bridge strain gauge configuration
- Raw signal output is only about **0–30 mV**
- Custom PCB amplifier increases signal to **0–5 V**
- MoTeC L180 records the amplified strain data

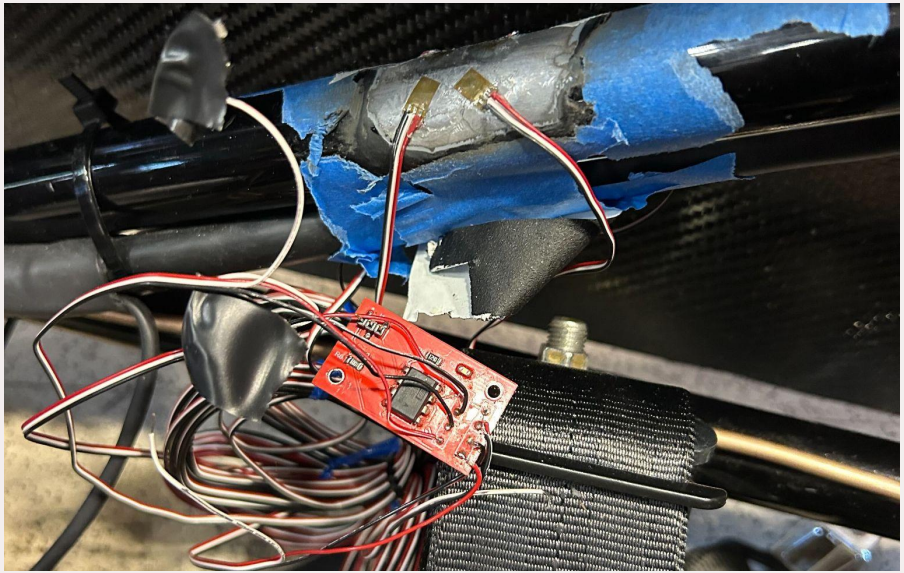


Final Gauge Location

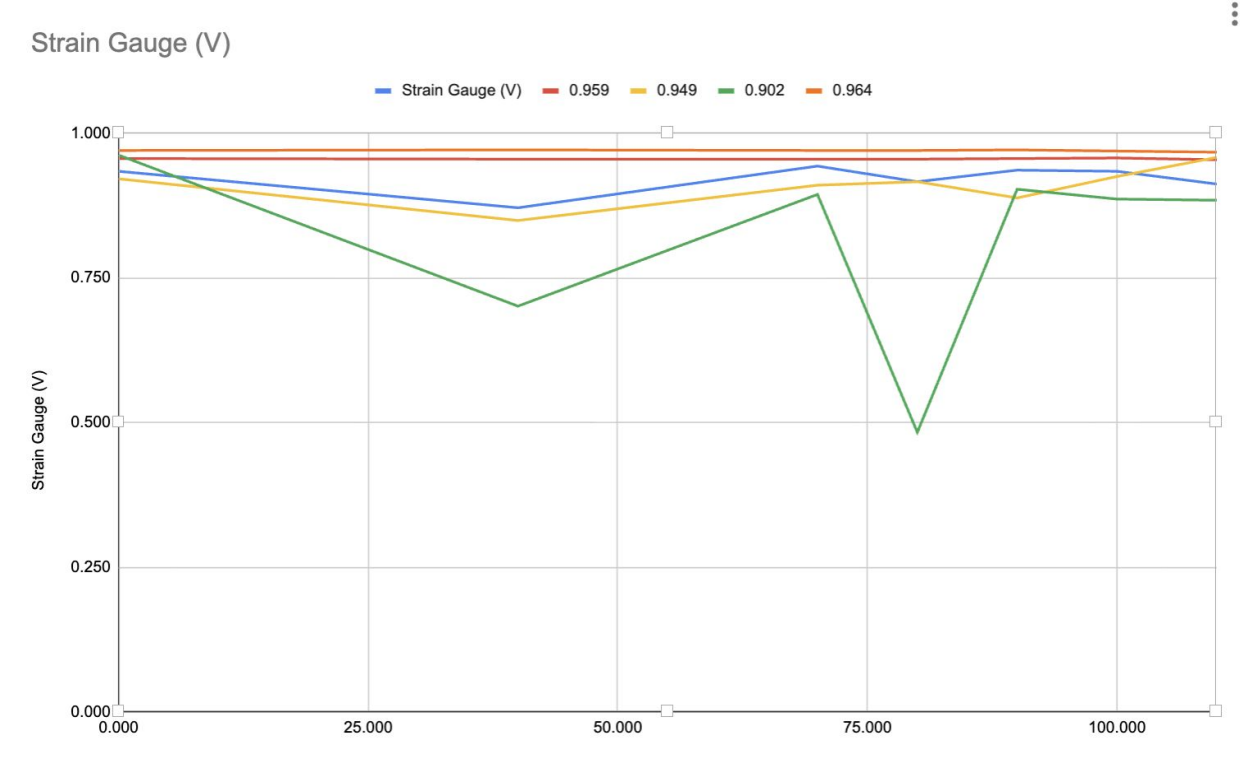
The final location selected for the full bridge strain gauges to be bonded was the lower, left, diagonal side impact structure tube (pictured below).

This location was chosen for its proximity to the load applied during the torsional test and high stress seen in the FEA model.





Strain Gauge Results

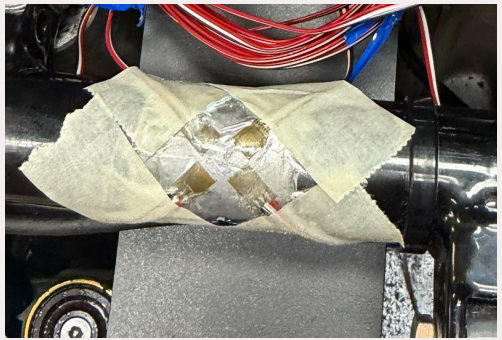


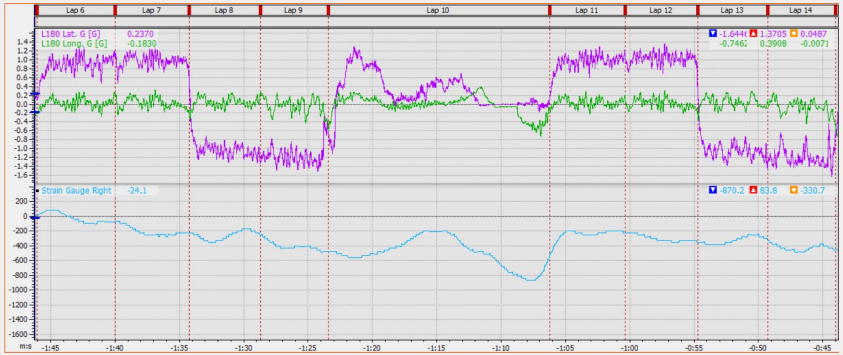
PM25-IC Testing

The strain gauge system is being tested on the IC car before being used on the EV chassis. This gives the team time to solve data collection issues early and gather comparison data.

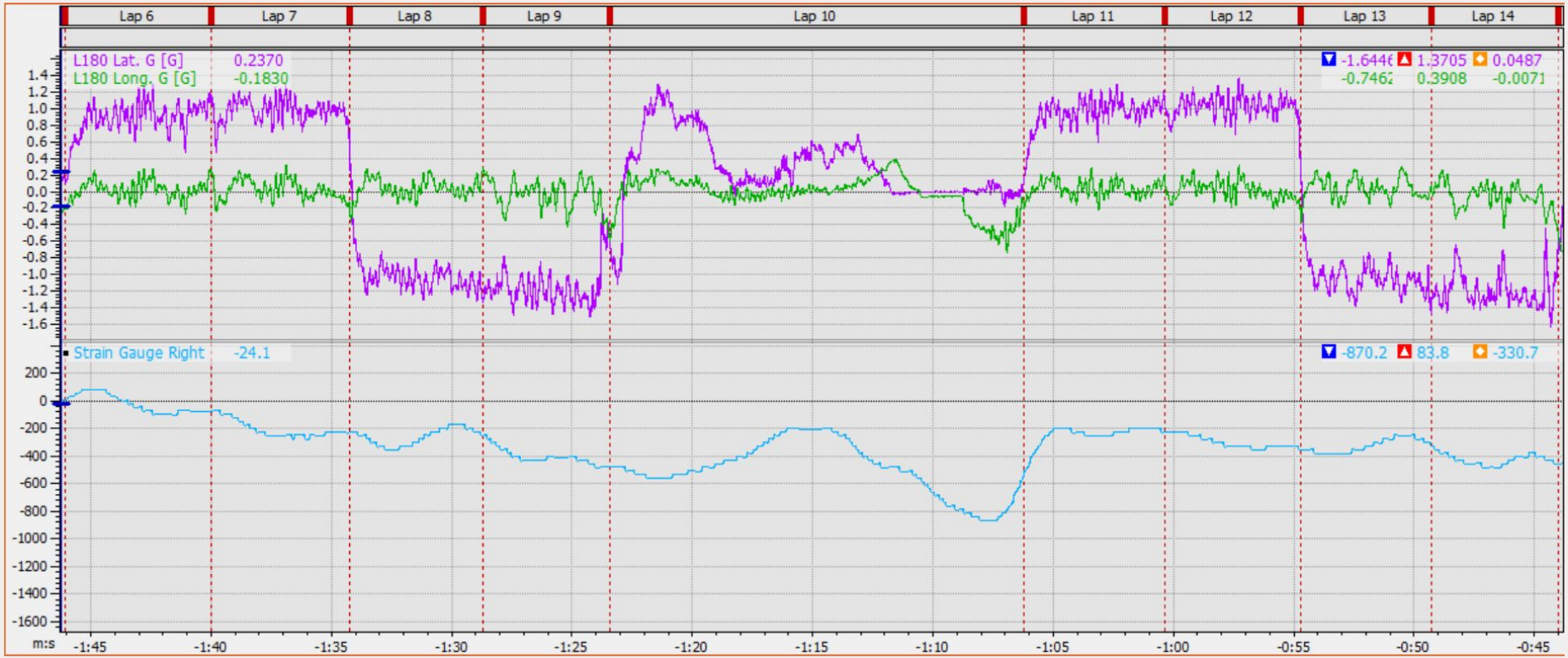
Early IC testing:

- Focused on the rear upper “rainbow” tube
- Area showed high stress and deflection from differential carrier loads and engine-chain tension
- Deflection caused suspension setup issues and some permanent chassis yielding

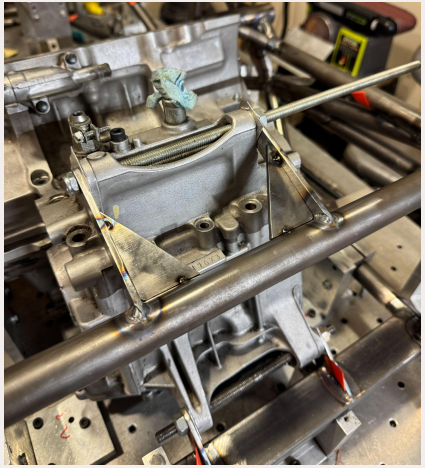




PM25-IC Strain gauge data vs. Long and Lat G force



IC Testing Continued

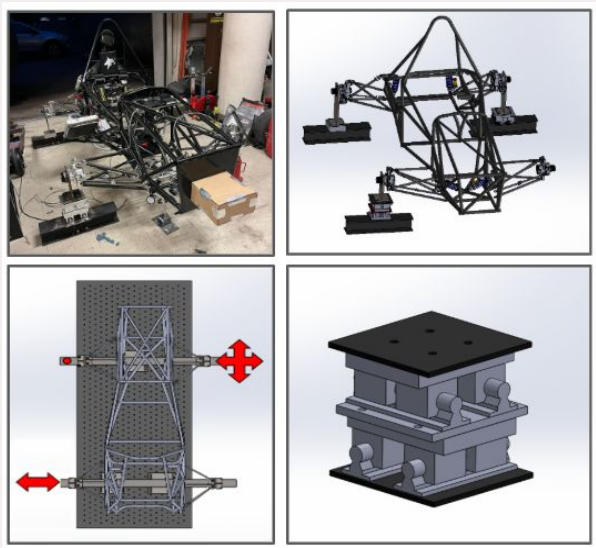


Design improvements:

- Increased tube thickness
- Added upper rear engine mounts
- Reduced bending moment on the rear rainbow tube

Torsional Test Rig:

- Bottle jack and force probe apply load at the spindle
- Dial indicators measure deflection at each corner
- Excel calculator determines chassis torsional stiffness



K_vehicle = K_chassis + K_suspension

Conclusion

Milestones Completed for this Project

- ANSYS model developed and refined
- Realistic torsional loading implemented
- Critical gauge locations identified and implemented on 2026 Chassis
- Data collection system developed and tested on IC car, implemented on EV chassis

Future Work:

- Continue improving stiffness modeling and adding components
- Complete acceleration and braking load cases
- Create documentation for future Pack Motorsports teams