

Team 9 - Design

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Initial Hand Sketch

Case Spec

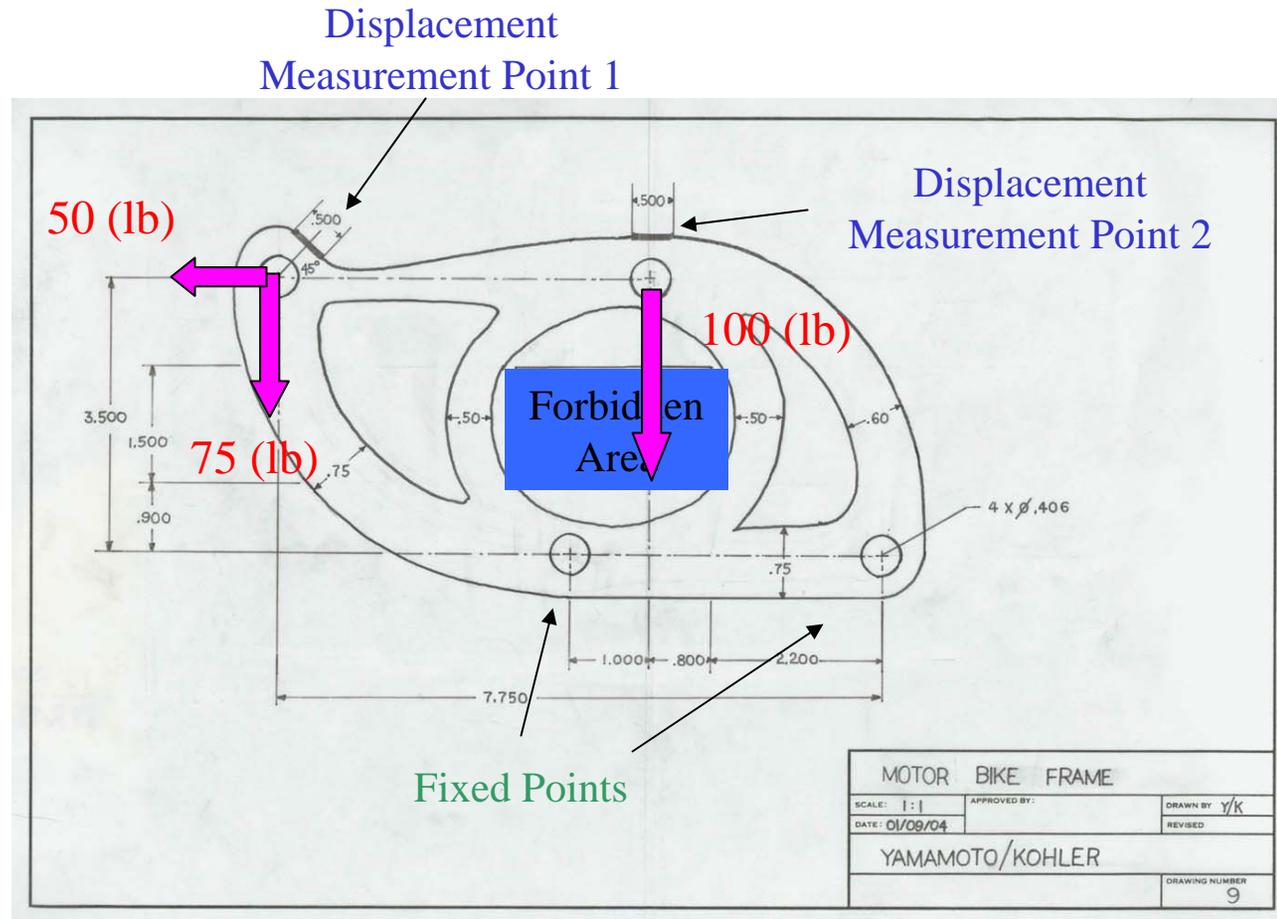
- Loading
- Fixed Points
- Forbidden Area

Goals

- Meet Constraints
- Optimize Cost
- Accept Mass

Difficulty

- Forbidden Area = *Introduction of Arches*



Design Version 1

Goal

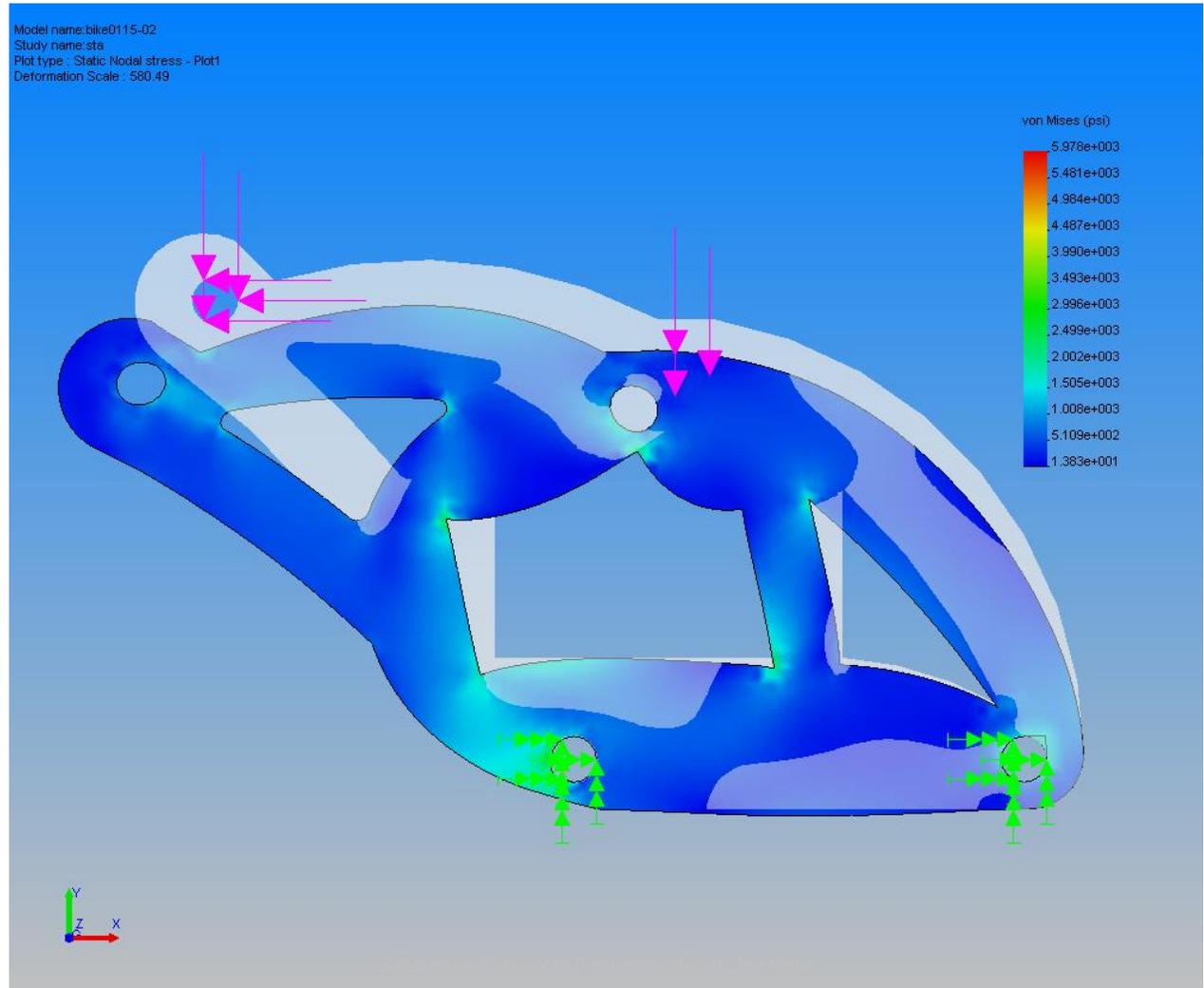
- Meet Displacement Requirements

Achievements

- Correct Usage of Arches
- Sharp Cleavage

Problems

- Heavy Mass
- Large Displacement 2



Design Version 2

Optimization

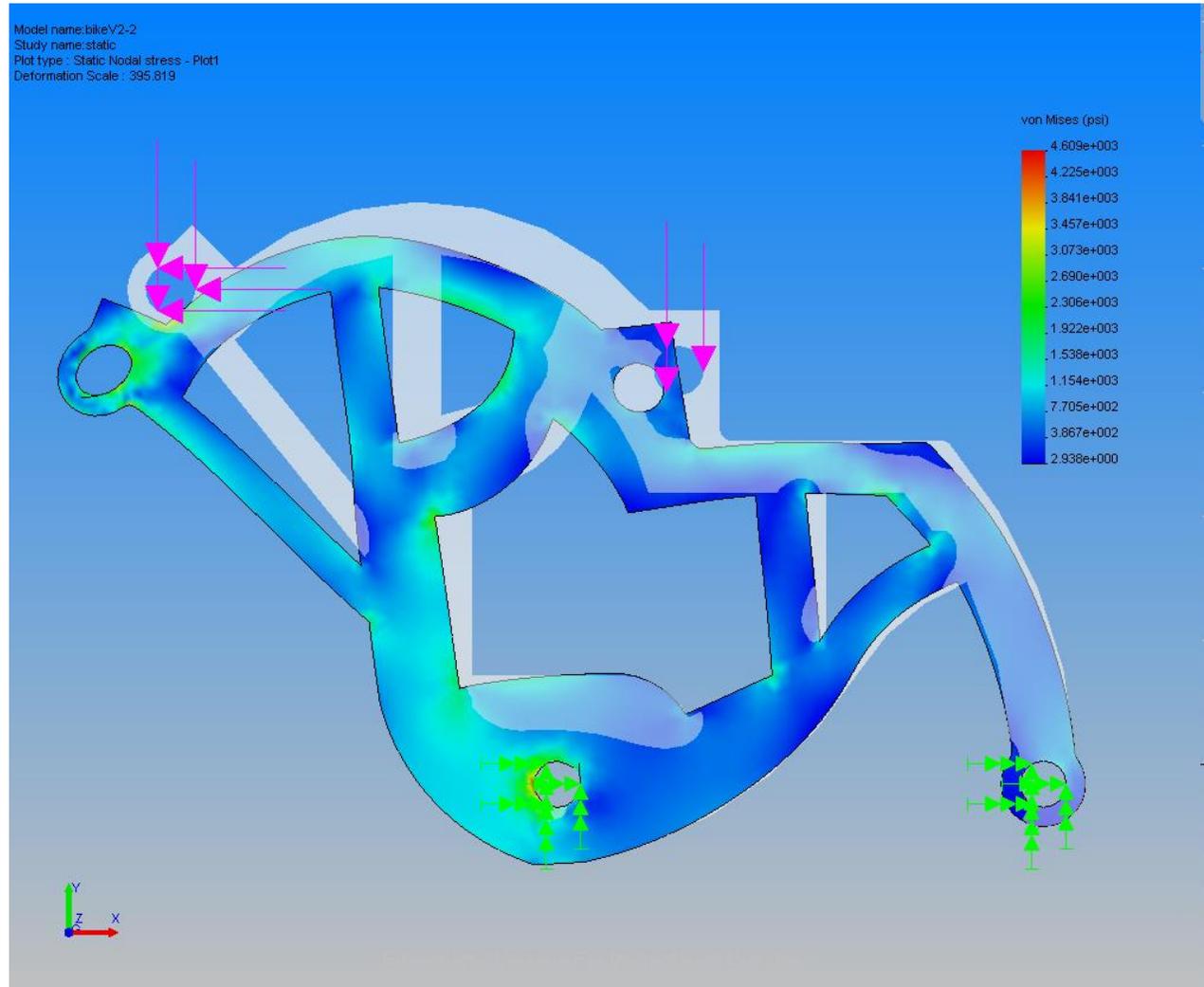
- Meet Requirements
- Optimize Cost

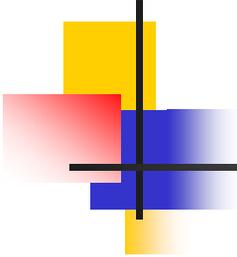
Improvement Factors

- Arches with Supporting Pillars
- Identification of Segment Function

Difficulty

- Mass/Cost Relationship

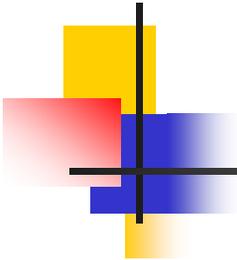




Feature Comparison

- All Requirements Met
- Less Mass and More Stiffness
- Testing Errors

		Version 1		Version 2	
	Requirement	FEA	Testing	FEA	Testing
Displacement 1 (mm)	< <i>0.056</i>	0.0428	0.0943	0.0546	0.1260
Displacement 2 (mm)	< <i>0.009</i>	0.0126	0.0630	0.0087	0.0441
Mass (lb)	< <i>0.340</i>	0.492	0.500	0.337	0.347
Natural Frequency (Hz)	> <i>423.1</i>	618.5	600.0	647.4	648.7
Cost (\$/part)	< <i>5.7</i>	4.83		5.30	



Testing Errors

Relative Errors	Source of Errors	
Fork displacement		
-54.7%	1	Mounting/ shift in position (bending of support structure)
-55.6%	2	Loading order (leading to shift)
	3	Measurement equipment (bias / random error, metal interference, induction)
Saddle displacement		
-80.2%		see above
-76.8%		
Natural frequency		
-1.5%	1	Cable suspension acting as restraint >> freq. Change
-1.2%	2	Sensor-cable attached to frame acting as damper
	3	Measurement equipment (bias / random error)
Mass		
-2.0%	1	Inaccurate cut (serrated edge)
-2.9%	2	Density of Al 6061 (exclude, $\rho = 2.7 \text{ g/cm}^3 \gg 1\text{mg}$)
	3	Cutting temperature (exclude, $\text{CTE} = 23.6 \mu\text{m/m}^\circ\text{C} \gg .01\text{mg}$)
	4	Oxide layer (exclude, $\text{Al}_2\text{O}_3 = 2.97 \text{ g/cm}^3, \text{th} = 3\text{nm} \gg .001\text{mg}$)
	5	Scale (systematic error)