PARTICLE DAMPER FOR WIND TURBINE BLADES

DESIGN CENTER COLORADO

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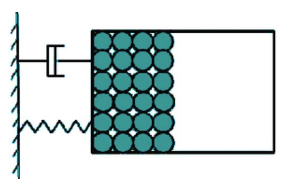
Background

- Wind turbines blades are slender, flexible structures subject to dynamic loading
- Effective damping will minimize unwanted blade vibrations
- Particle damping uses chaotic particle motion in a cavity to create energy losses



- Particle dampers are more resistant to wear and tear than other types of passive vibration suppression systems
- Majority of particle damping research occurs at high frequency with low amplitudes, turbine blades require the opposite

Objectives

Model Turbine Blade

- Beam characteristics represent a scaled turbine blade
- Exciter to generate amplitude deflection
- Data processing software to acquire data autonomously and output damping metrics

Particle Damper

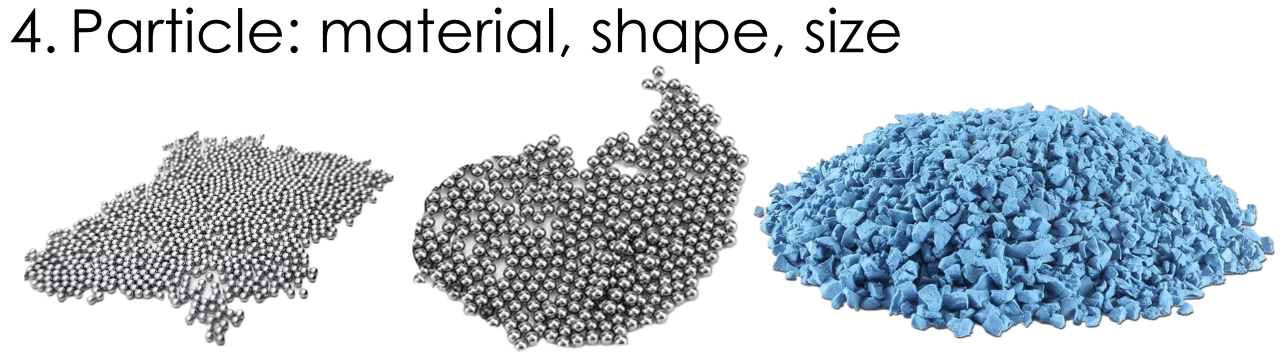
- Plurality of design parameters necessitates fast-paced prototyping to optimize design
- Damping performance independent of axial rotation
- Metric: improve log dec **damping by at least 5%**

Damper Parameters

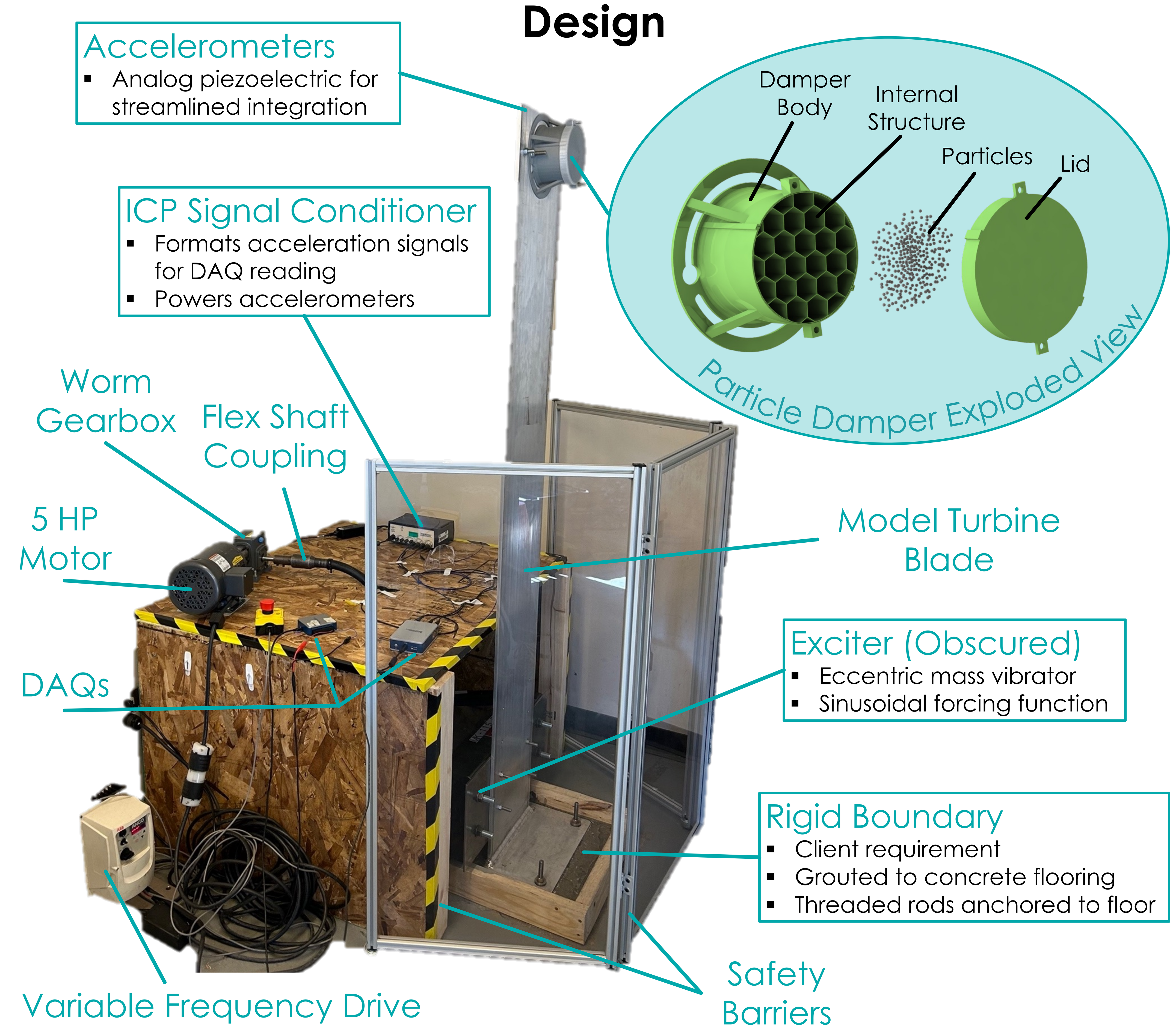
1. Mass 790g
2. Container height

3. Internal structure

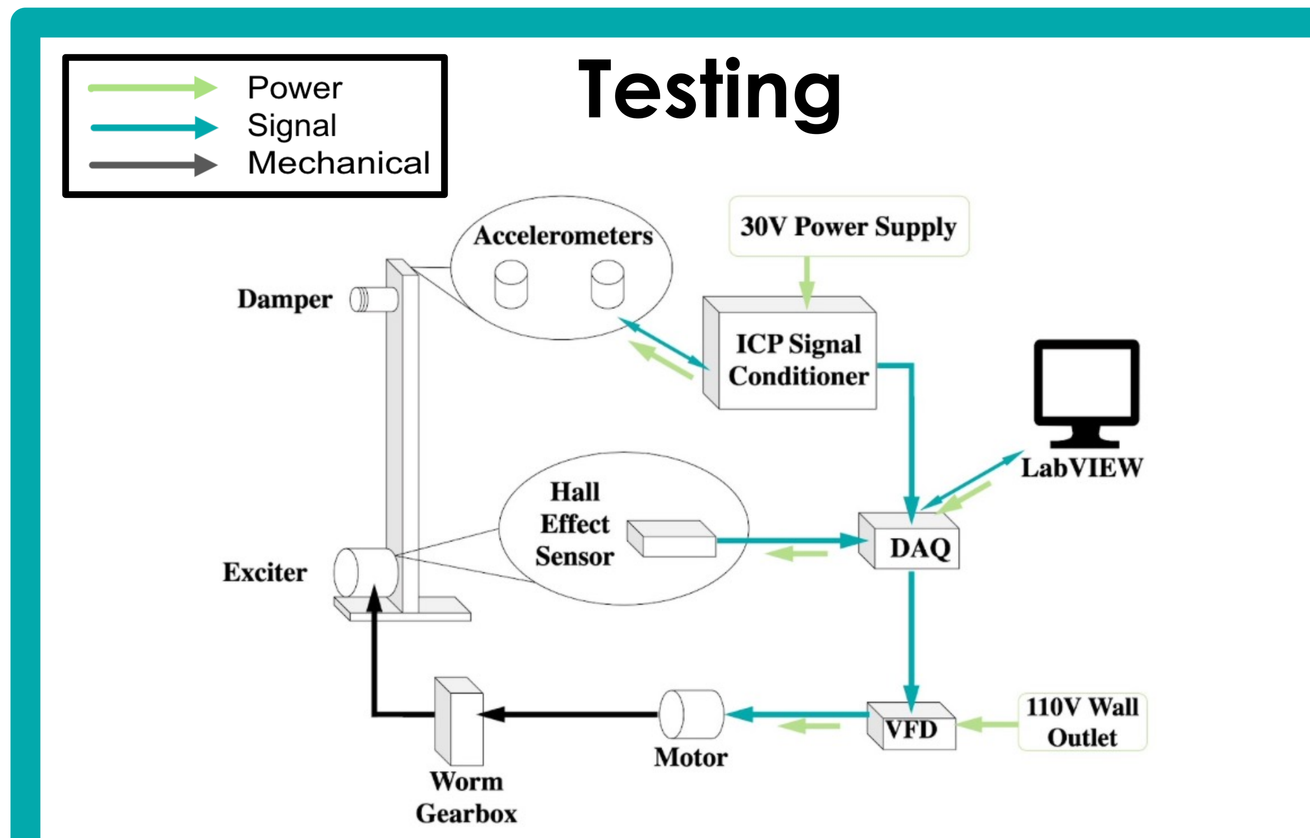
4. Particle: material, shape, size



Design



Testing



- Tested two different vibration amplitudes: 10cm and 20cm
- 13 discrete oscillation frequencies at 0.02 Hz spacing
- Error from sampling rate: ± 1.1% log dec damping
- Characterization of the beam's vibration through validation and modeling
- Built frequency response function and used half-power bandwidth to obtain system damping

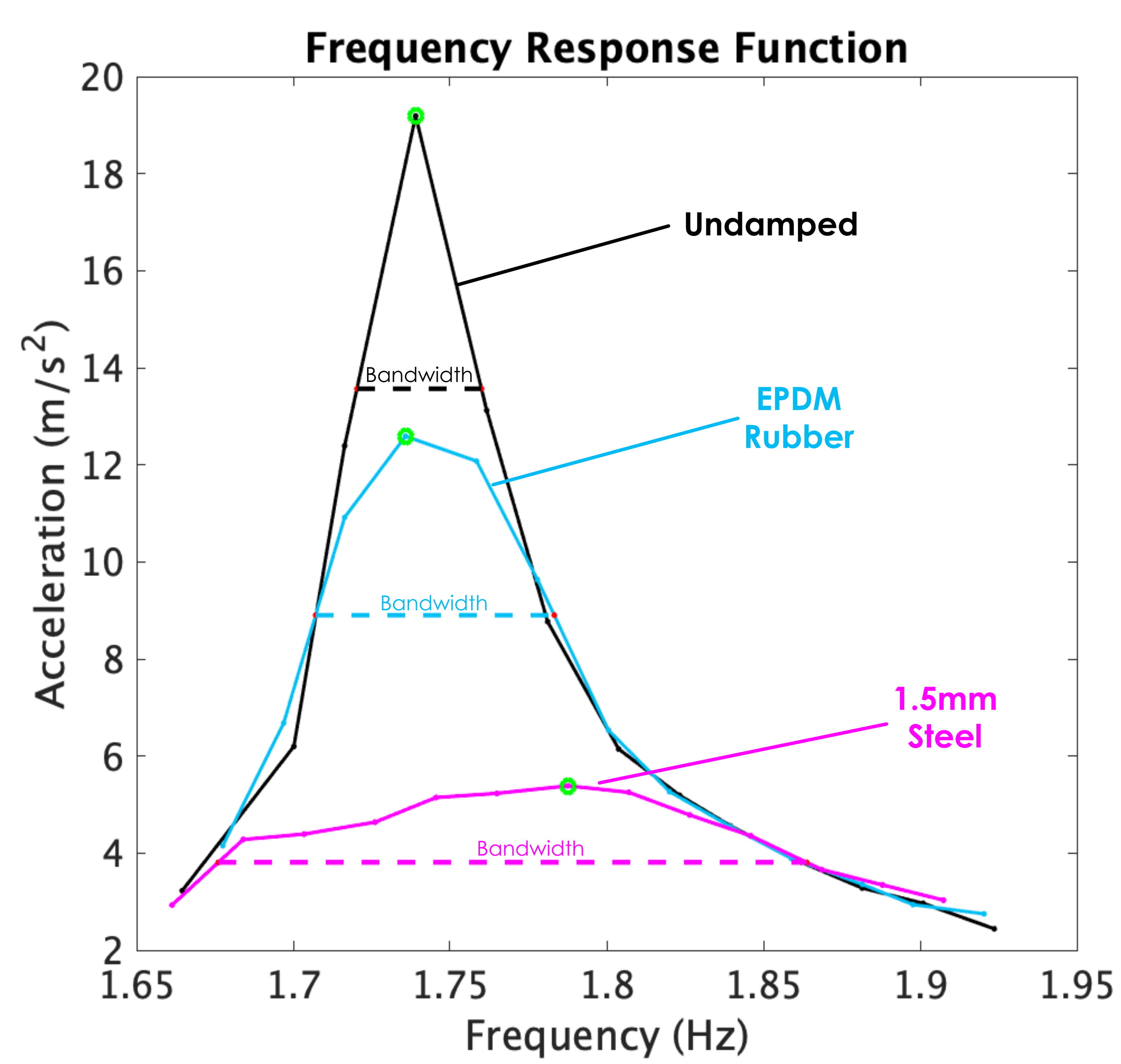
Test Statistics

- 5,280 minutes spent testing
- 44 tests conducted
- 18 configurations
- 6 parameters
- 2 final dampers

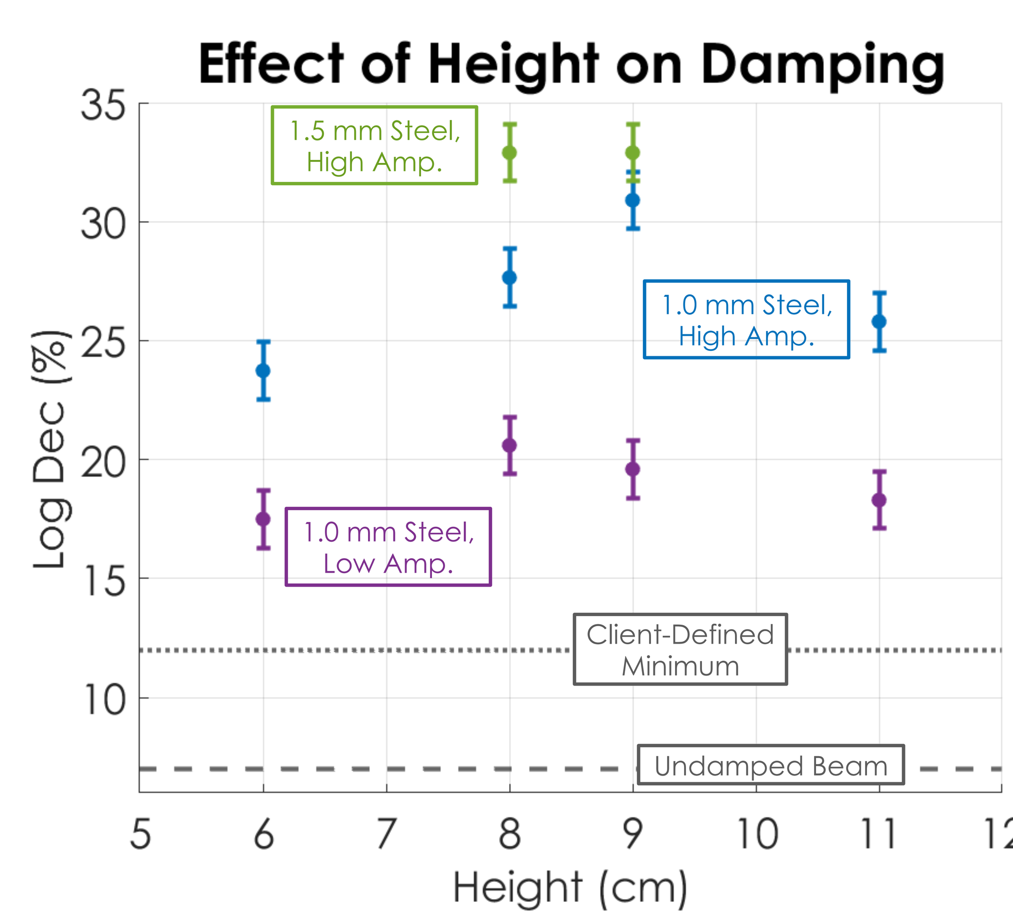
Model Blade Specs

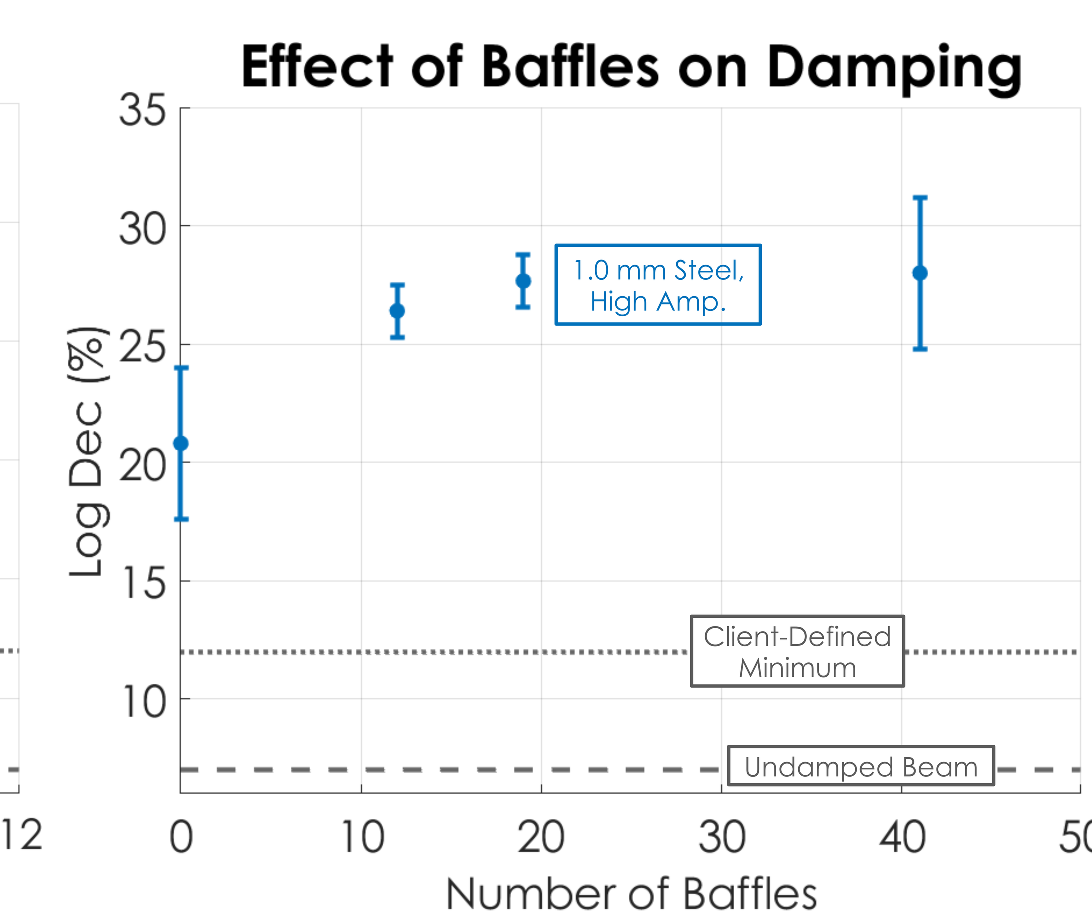
- Length: 2 m
- Frequency: ~ 2 Hz
- Deflection: 10% length
- Rigid boundary condition
- Particles: 5% of beam mass

Results



- 1mm & 1.5mm steel performs superior to rubber
- 9 cm container height found optimal
- 19 baffle internal structure (10,000 particles/segment) found optimal
- 1.5mm steel particles superior to 1mm
- Trends are independent of excitation amplitude
- Added **damping of over 25%** logarithmic decrement achieved





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