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Department of Mechanical Engineering

Mechanical Inerter for Vibration Mitigation

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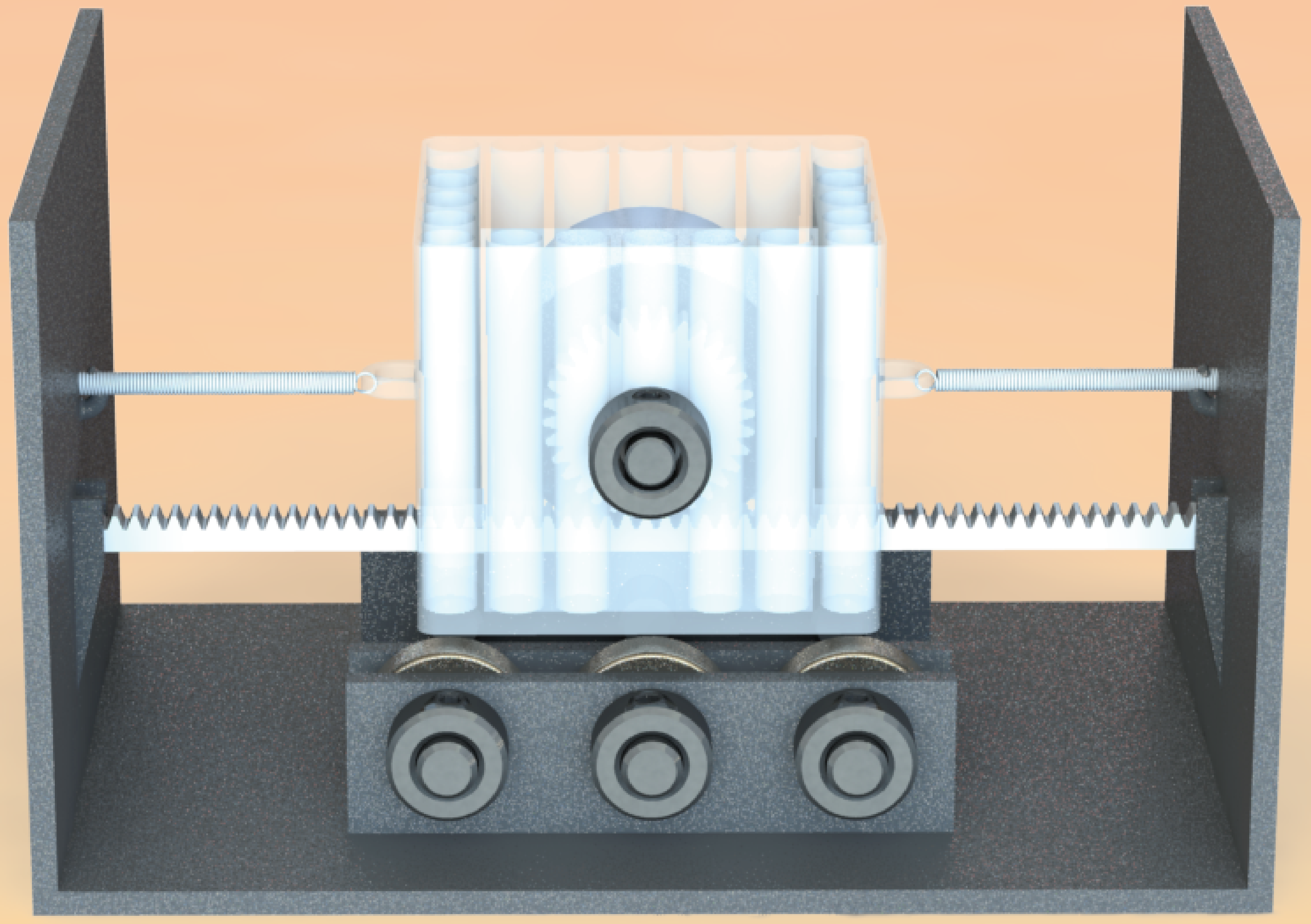
Introduction

An inerter is a device that converts translational energy into rotational energy. It is best described as the mechanical equivalent to a capacitor. Using a rack and pinion coupled with a weighted flywheel the interter will be used to raise the effective mass of the device along a single axis. With a higher effective mass, the inerter can be incorporated into building design to mitigate damage done from earthquakes.

The purpose of this project is to design a low cost inerter, that can be used to mitigate vibrations in structures during seismic events. The frequency response of this device will be specifically tuned to surface seismic waves.

Requirements

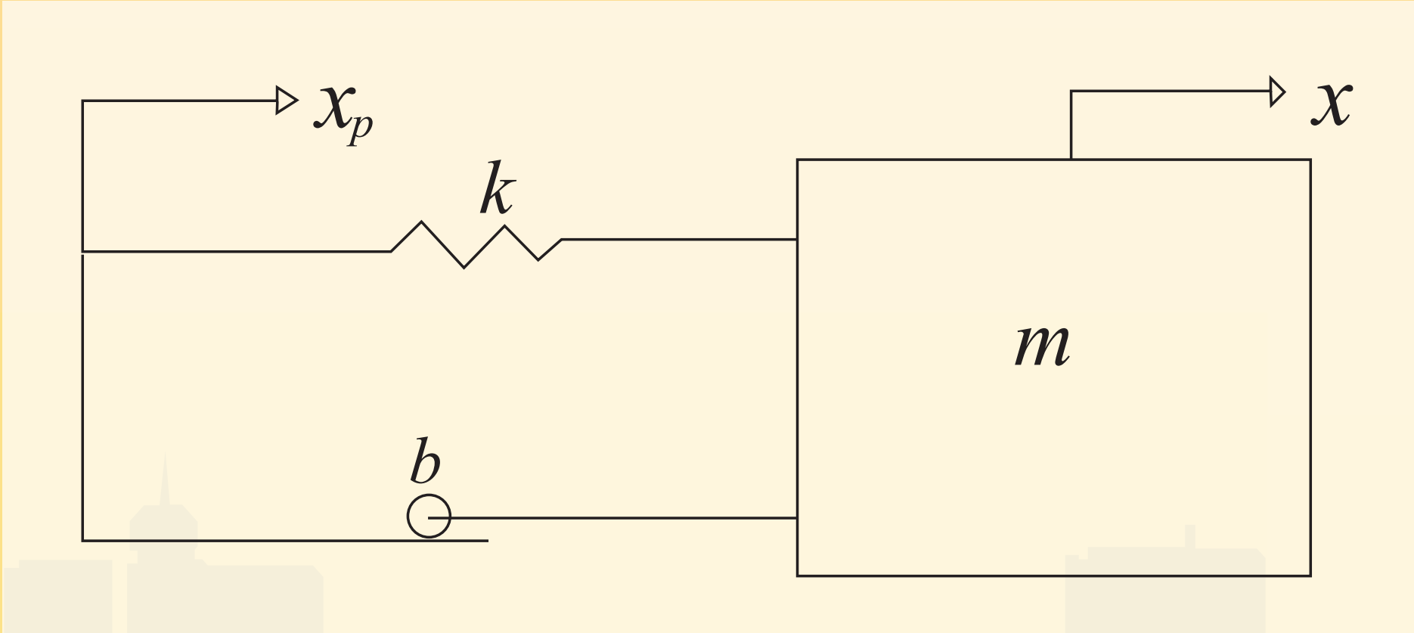
Design Requirement	Customer Specification	Explanation
Compact Size	< 1000 cm³	A compact size is needed to integrate the inerter into existing constructive methods
No Maintenance	Must function for the entire lifespan of the building	Inerters will be placed into buildings without access for maintenance
Tunability	Functions between 0.1-10 Hz	Target range is within the love frequency range (0.1-10 Hz) which is the most destructive component of an earthquake
Affordable	< $100 to manufacture	To compete in the existing market, price must remain low to allow the addition of hundreds to thousands of inerters in a single building



Final prototype of rack and pinion inerter

Calculations

The system was modeled as a simple spring-inerter system with a suspended mass as shown below. The inertance is represented by b and this value illustrates the "simulated mass" that the system provides and is calculated from equation (1). This equation was then placed into the ODE system (2) and solved with xp simulating a seismic wave. This was solved in Matlab with the following theoretical results.

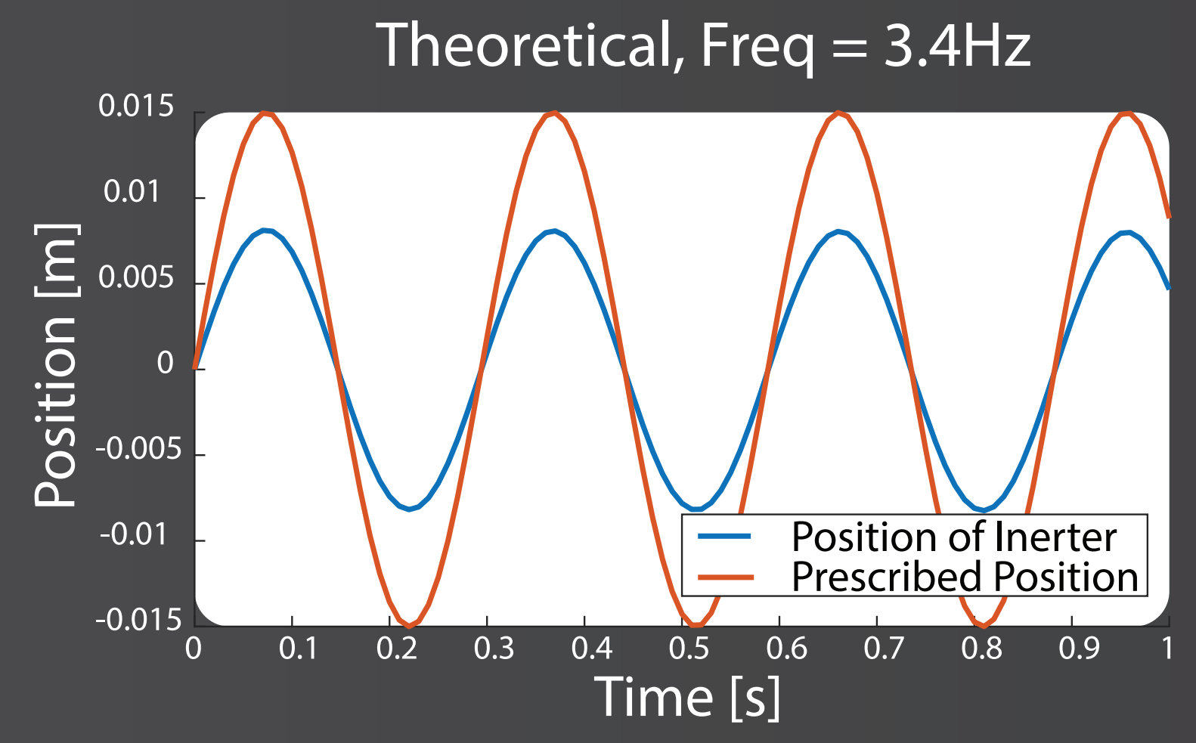


$$b=\frac{1}{2}m_{fw}\frac{r_{fw}^2}{r_p^2} \qquad (1)$$

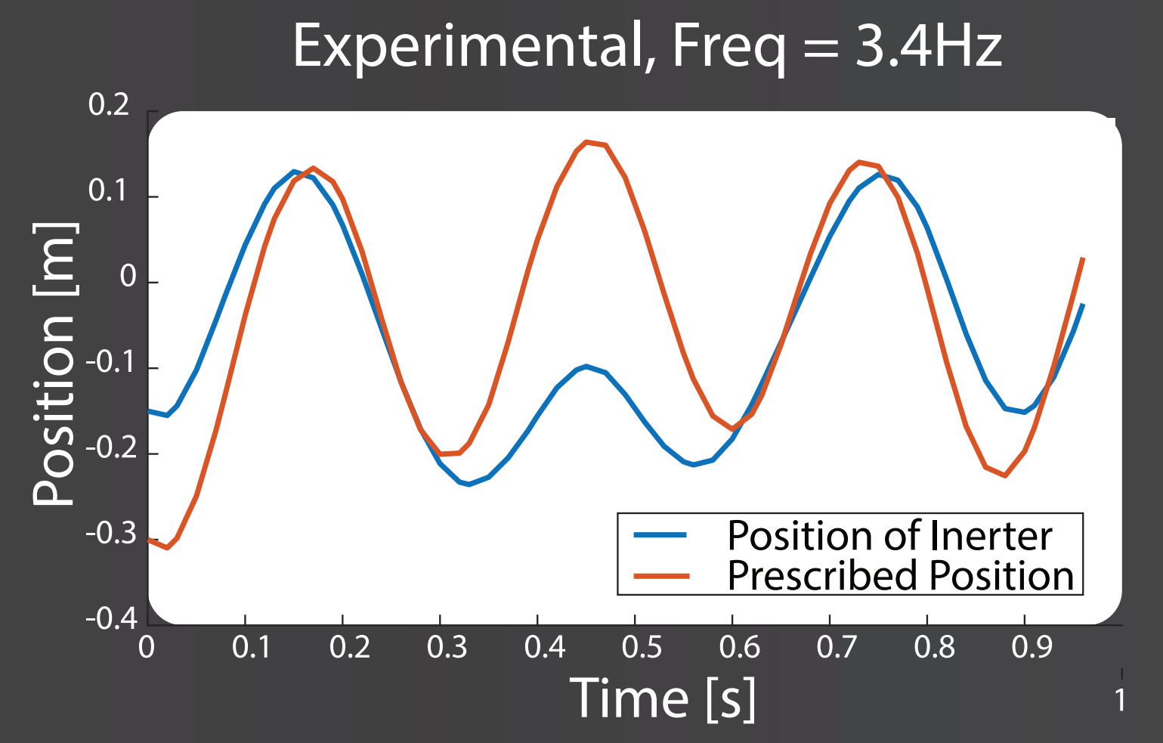
$$\ddot{x}=\frac{k(x_p-x)+b\ddot{x}_p}{b+m} \qquad (2)$$

Results

After multiple phases of optimization and prototyping, an inerter was successfully created that meets the customer's requirements in experimental testing. The results taken from the accelerometers as well as the theoretical results are shown to the right. Ultimately these results were found to be less reliable than a positional analysis of slow motion video in which the inerter's displacement showed a 51.4% decrease compared to the prescribed motion of the shake table on which it was tested.



Theoretical, Freq = 3.4Hz



Experimental, Freq = 3.4Hz

Conclusion

The inerter is ready for future teams to explore the possibility of implementing them into large infrastructure. The theoretical model has been matched to the experimental setup. There is a team that will be continuing the project in future semesters that will be testing to see if it will prevent damage to infrastructure during seismic events. It has been developed in a way that it meets the customers requirements to the size, cost and maintanence.