Department of
MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

Open Air Noise Reduction

Team Members: Phillip Cullinane, Taylor Downs, Jason Grosklags, Zachary Hunzeker, Alex Rinn.
Advisor: Dr. Pai Wang

Problem Statement:

Transportation creates a lot of noise and reducing that noise is important in packed urban environments. We will design a helmholtz resonator or series of helmholtz resonators that can be built next to a form of transportation that will reduce noise without removing the view. An example is in Figure 1. The size, shape, and spacing of these caverns will be determined by the frequency of the sound waves which, for traffic noise is centered at 1000 Hz.

Figure 1: *Above is an example of where these Helmholtz resonators will be placed.*

What is a Helmholtz Resonator?

A helmholtz resonator is a caven consisting of a volume and a neck opening to the outside air. As sound waves pass over the top opening of the resonators, the inside air will begin to resonate at a specific frequency. This will essentially reduce the energy level of that frequency and reduce the decibel level heard on the other side. Helmholtz resonators are built to resonate at a specific frequency which is determined by their geometry. These parameters and how they affect the frequency of a resonator is shown in Figure 3.

Goals:

- Create an 2D abaqus model of resonators to determine size, number, spacing, and location of sound reduction.
- Build the resonators that were determined by the abaqus models.
- Test the prototype and determine if this idea will work in a real world environment.

Abaqus Modeling:

Abaqus is a modeling tool that can be used to simulate sound. We are using Abaqus to create a 2D model of the resonator with standard air conditions to determine if we can achieve any sound reduction. Some important aspects of our setup is that the top and left edges of our system is a non-reflecting surface meaning that those edges act like infinite space. Another is that we have a 1000 Hz of 10 unit amplitude sound wave that propagates from the right side. Below is an example of the set up with the resonators at the bottom. Along with the pressure of the sound wave in the blue and red. Red is the positive amplitude and Blue the negative amplitude.

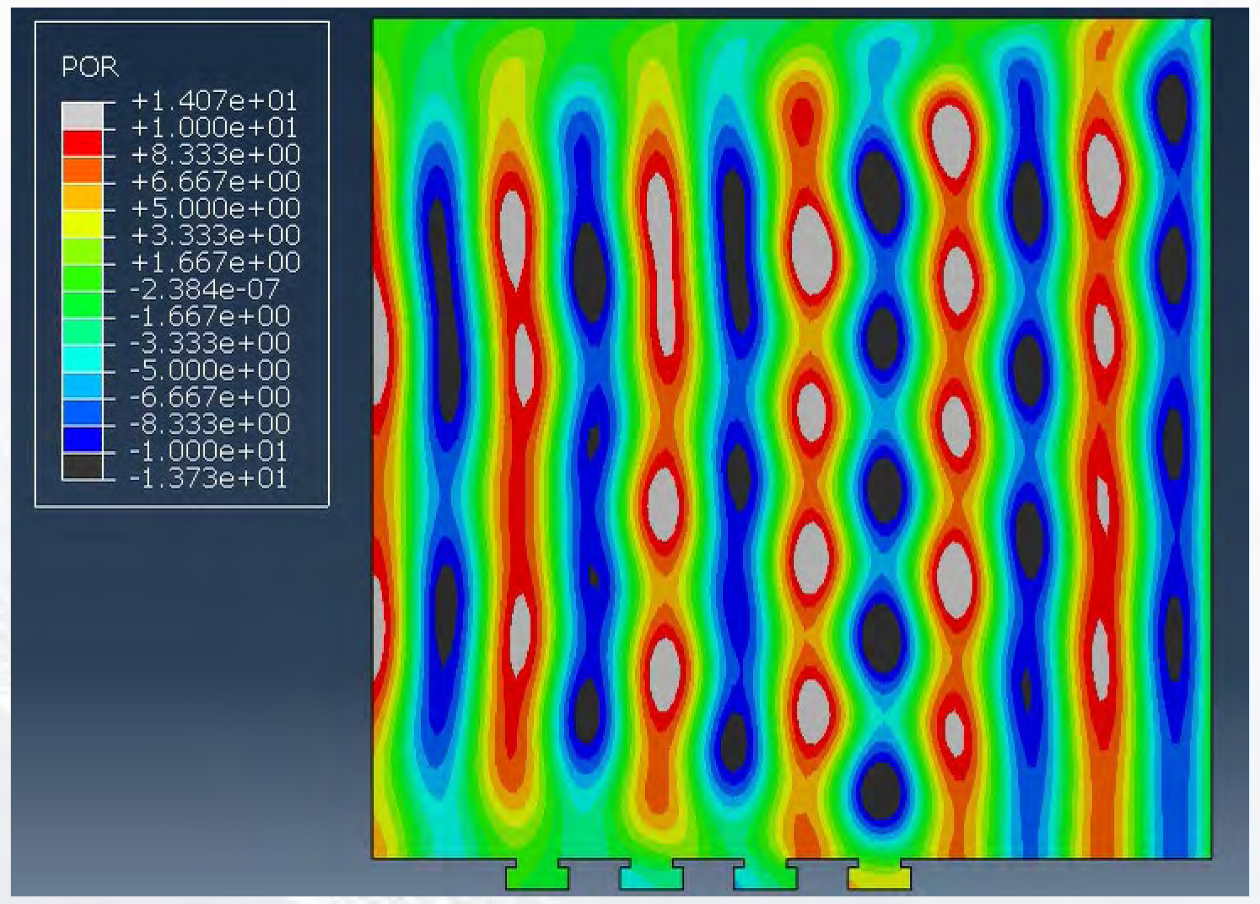

Figure 2: *Above is a Abaqus test that was done with 4 of the same resonators. We can see the sound as a wave in the blue and red. Red being a high sound pressure and blue being a low sound pressure.*

Abaqus Results:

From our abaqus testing we discover the following results. This will be used to create our prototype and will be used for real world testing.

Resonator Size:

- Radius of neck = 0.0508 m
- Neck length = 0.02 m
- Base = 0.15 m x 0.15 m
- Height = 0.053 m

Number of Resonators:

- 4

Spacing:

- 17 cm

Main Location of Data Collection:

- 16 cm up and 34 cm from the last resonator.

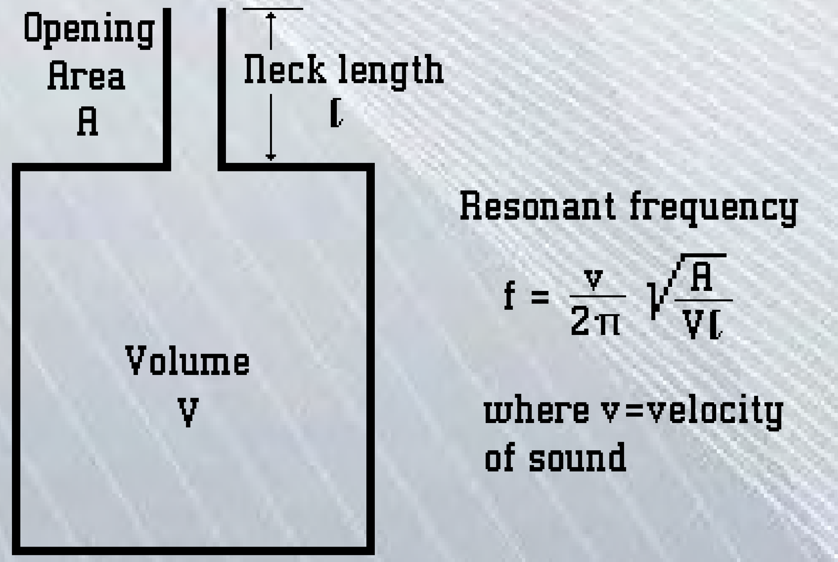

Figure 3: *Diagram of a Helmholtz Resonator and the equation of the resonant frequency*

Real-World Testing and Results:

Four 3D printed resonators are glued onto the back of a ½ inch plywood board. This can be seen in the picture below.

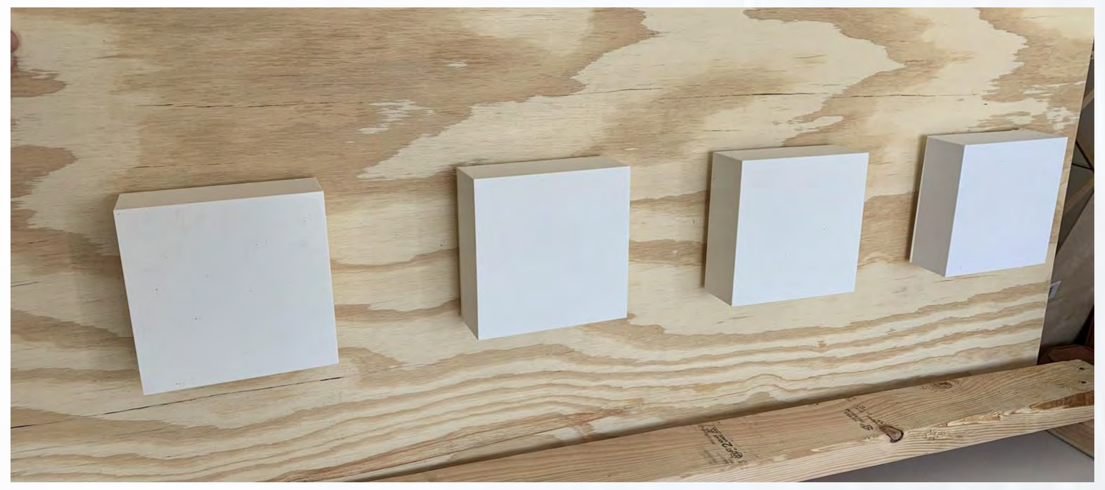

Figure 4: *Photo of the bottom side of 3D-printed Helmholtz resonators attached to ½ inch plywood top plate.*

For testing a speaker that generates a 1000 hz frequency is used as the source. On the other side a sound app in three Iphones determines the decibel level of the sound at a specific location. The setup can be seen in the figure below.

Figure 5: *Photo of our real-world testing setup.*

From the testing the following results are presented in a table below.

Table 1: *Below is a table showing the decibel reduction at different testing locations with respect to the last resonator.*

Location of data collection	0 cm 0 cm up	34 cm 0 cm up	34 cm 16 cm up
Abaqus Reduction	18.27 dB	7.07 dB	6.77 dB
Testing Reduction 1	7.7 dB	-1 dB	0 dB
Testing Reduction 2	8.3 dB	-1.9 dB	-2.4 dB

Conclusion:

From our results we have concluded that this open air noise reduction is possible. There is no doubt that helmholtz resonators reduce the frequency in our testing environment. But a lack of proper sound equipment does not allow a proper conclusion to be formed. More experiments should be performed in better testing environments to further legitimize this theory.