Decreasing Effects of Prolonged Noise Exposure in Homeless Encampments

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Project Goal:

Decrease the ambient sound level of the homeless encampment to below 85 [dB] by developing and prototyping a solution.

Project Abstract

University of Pittsburgh Swanson School of Engineering's senior design class worked with Street Medicine at Pitt to create a project that aims to provide aid to the residents of a Pittsburgh encampment that is settled alongside and below an interstate. According to the PA Department of Transportation, in 2023 a daily average of 40,000 cars utilized the road. The encampment can be seen in Figures 1 and 2 (CBS News – Pittsburgh).

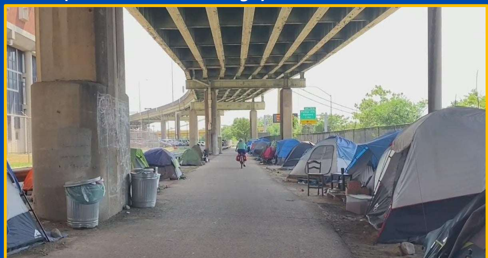


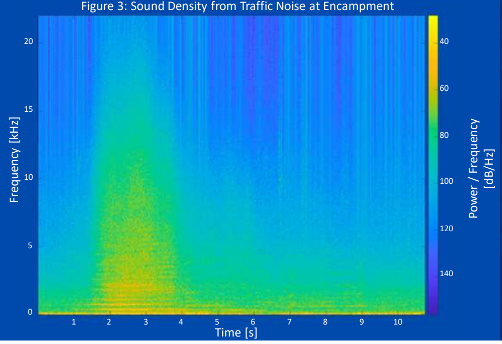
Figure 1

Figure 2

Sound levels along high traffic areas can reach as high as 95 [dB]. Hearing damage occurs at prolong exposure of 85 [dB] or above - prolonged noise not only harms hearing abilities, but also negatively impacts sleep, communication, and mental health. These then increase stress levels and even physical ailments. Our team of mechanical engineering students was tasked to create a solution that can help mitigate these negative effects by designing a sound barrier to attach to existing fences.

Traffic noise is dense in low frequency sound waves, shown in Figure 3. In our design, we created a sound barrier to be attached to existing fences and target low frequency sound by using Helmholtz resonators.

Figure 3: Sound Density from Traffic Noise at Encampment



Final Design

Figure 4

The final design is a 3 ft x 6 ft sound panel that is designed with Helmholtz Resonators built into the interior to absorb frequencies that are prevalent in traffic noise. Figure 4 shows the completed prototype. Figure 5 shows the 3D-model as well as a section view. The final prototype consists of 2 sheets of laser-cut corrugated plastic, 1 sheet of solid corrugated plastic, and 1 sheet of laser-cut foam board adhered between the plastic sheets, as well as other materials used to seal and adhere the final prototype.

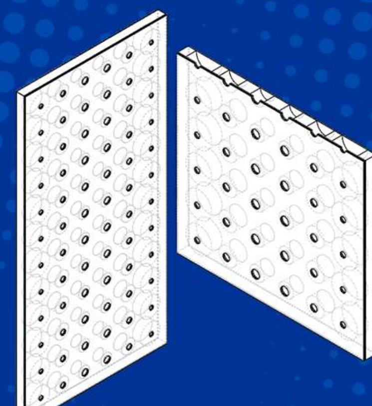


Figure 5

Design Iterations

Design 1

Figure 6

Design 1, seen in Figure 6 was built using eight sheets of corrugated plastic. The fabrication process included laser-cutting seven sheets, which led to a long and high effort fabrication process.

Design 2

Figure 7

In Design 2, seen in Figure 7, the corrugated plastic interior was replaced with insulating foam board to decrease weight, cost, and fabrication time. Design 2 was chosen as the final design.

Design Criteria

PRIMARY

- LIGHTWEIGHT – < 50 lbs
- SOUND DAMPENING – < 85 [dB]
- LOW COST – < $300
- SIZE – About 6 ft x 9 ft

SECONDARY

- USER FRIENDLY
- SUSTAINABLE
- DURABLE

Future Improvements

- *Run more tests to limit data anomalies*
- *Design full-length fence to target larger array of frequencies*
- *Design panels so they can be attached to any size fence or stand alone while still ensuring sound dampening*
- *Determine how product would be mass produced and assembled*

Design Choices

Helmholtz resonators are incorporated into the panel by laser-cutting cavities in the interior of the board and small openings on one side of the panel. Figure 8 shows the shape of the resonators. The resonators act as a spring-mass-damper system, converting sound energy into kinetic energy at specific frequencies, therefore, absorbing sound waves. Figure 9 demonstrates this process. The resonant frequency of the resonators depend on the dimensions of the neck and cavity.

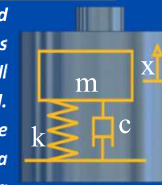


Figure 8

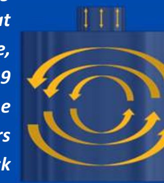


Figure 9

In this unique design, low frequencies are targeted, with resonators designed to absorb 550, 1000, and 1500 [Hz]. Traffic noise is dense with low frequency noise. This includes frequencies below 2500 [Hz]. Low frequency sound waves are also harder to absorb, as they are more likely to reflect and refract over a sound barrier.

Results

After a singular panel was tested outside using a noise source and a calibrated sound level meter, when the barrier was in place, all sound levels above 85 dB were lowered to below this threshold. Therefore, the goal of the project to lower the sound levels was met. Shown in Figures 10 and 11 are results from tests at which frequency tones were played with and without the barrier in place. As shown, there were drops of over 20 dB when the barrier was in place.

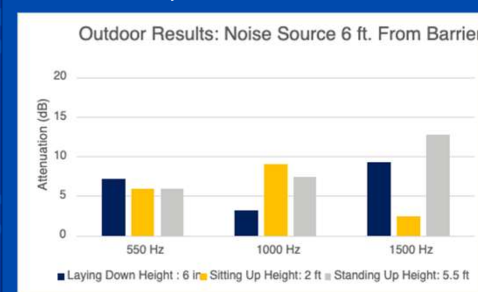


Figure 10

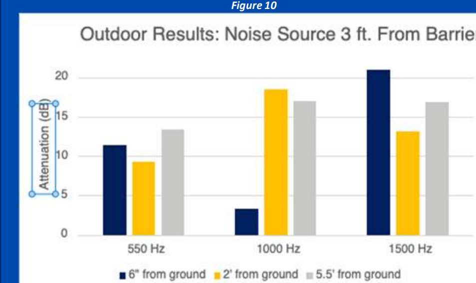


Figure 11