Adaptable Acoustics For The Built Environment

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MOTIVATION

Many venues suffer from poor sound quality due to inadequate acoustics, causing echoes and poor speech clarity that degrade the experience for audiences and performers. Fixing this often requires costly renovations and is especially difficult for venues that hold diverse performances with varying acoustic properties.

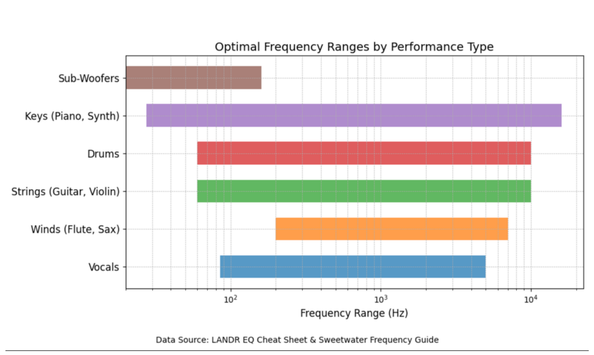

Figure 1: Frequency Ranges of Different Programs

BACKGROUND

- **Reverberation time (RT60)** measures how long it takes for sound to decay.
- Absorptive sound treatment uses porous materials to dissipate and reduce sound energy.
- Absorption can be increased by putting an air gap between the panel and wall.
- Diffusive sound treatment uses specific reflective geometries to evenly distribute sound in a room.
- The **diffusion coefficient** (0 to 1) measures how much a panel diffuses sound.

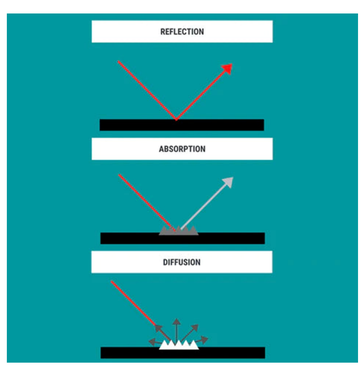

Figure 2: Different Types of Sound Behavior
https://www.soundassured.com/blogs/blog/how-do-acoustic-diffusers-work

DESIGN

- Our **binary amplitude diffuser** has a fiberglass absorber backing with wooden diffuser slats in the front. This reduces RT60 with absorption and prevents “dead sound” with diffusion.
- Total prototype cost was **$364** and features:
  - Wooden frame (2 ft x 4 ft) with 2" fiberglass insulation and 2" air gap.
  - Plywood diffuser slats mounted to acoustically transparent fabric.
  - Driven roller with chain drive rotates between diffuser configurations.
  - Free-spinning roller adjusts horizontally to tension the fabric.

Figure 3: Prototype of panel where **red slats diffuse 125-2000 Hz** and **yellow diffuse 250-4000 Hz**

ABSORPTION TESTING

- RT60 was measured in a conference room using the interrupted noise method
- Pink noise is played and paused from an omnidirectional speaker and a calibrated **sound level meter (SLM)** records and calculates the RT60
- Experimental data was compared to Eyring's model for reverberation
- Tested room RT60 with and without the panel.

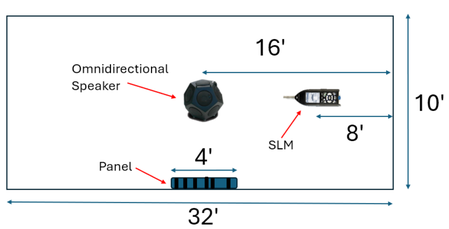

Figure 4: Diagram of Absorption Test Setup

DIFFUSION TESTING

- Conducted in an **anechoic chamber** using a directional speaker and rotating SLM.
- The speaker plays an impulse sound and the SLM records the reflected sound in decibels.
- The autocorrelation function calculates the diffusion coefficient from the reflected sounds.
- Tested with bare wood, absorber, and both absorber and diffuser.

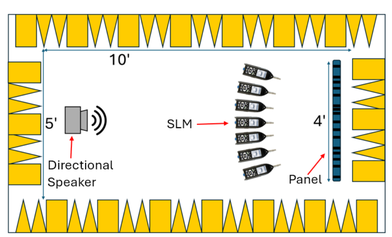

Figure 5: Diagram of Diffusion Test Setup

RESULTS

- RT60 reduced by up to 60% in mid-range frequencies.
- Eyring model matched experimental data within 8.4%.

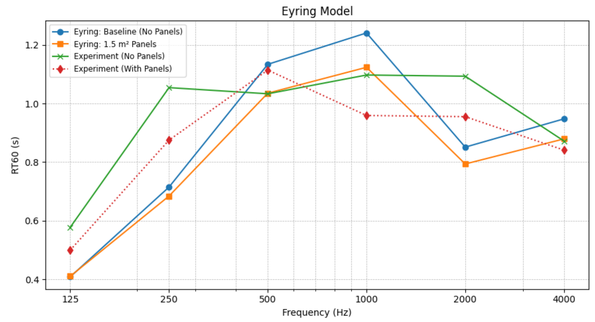

Figure 6: RT60 of Experimental Data and Eyring Model with and without Panel

- Diffuser fronts significantly improve diffusion in their design range compared to reflective wood

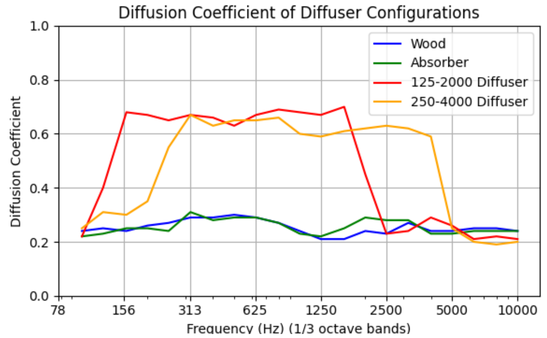

Figure 7: Diffusion Coefficient of Diffusers, Wood, and Absorber

CONCLUSION

We developed a mechanically adaptable acoustic panel that improves room acoustics by adjusting to use-case needs. Our testing confirms both absorption and diffusion functions work effectively. The design is affordable, scalable, and suitable for auditoriums, performance halls, and multipurpose spaces.

ACKNOWLEDGEMENT

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