The Look of Sound: Acoustic Cancellation in Architecture

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Key Terms

- **Sound** - perception of compressional waves traveling through a medium

- **Architectural Acoustics** – study of controlling sound within buildings

- **Wave Cancellation** – occurs when the sum of waves is less than their added magnitudes

Cancellation of waves
When two waves of opposite phase and equal amplitude meet (A&B), the resultant is the cancellation of both (C)
Research Questions

- How are sound waves modeled on a computer?
- What characteristics of certain sounds lead to cancellation?
- What levels of sound intensity are needed for clear perception?
- In what ways can structures be built or modified to produce audible and useful sound?
Difficulties with Transmission

- Oddly sized structures
- Absorptive or reflective materials
- Background noise
- Other sound sources
- Lack of good hearing
- Repetitive structures

The diffusion of sound around a barrier:
The sound waves are partially blocked by the barrier, then diffuse on the other side.
Acoustic Cancellation

- Two or more waves meet, decrease intensity
- Usually occurs when structures are spaced at half wavelengths of the sound
- With periodically placed structures, creates a “stop-band” or “band-gap” filter

Cancellation
The source (dark circle) sends sound directly to the receiver (white circle) and by reflecting from the top. If the distance between the absorptive surfaces on the ceiling is a certain interval, the sound will cancel at the receiver.
Acoustic Cancellation

- Band-gap filter blocks only a certain range of frequencies and passes all others

![Diagram showing magnitude and bandwidth (BW) in a log scale graph with frequencies f₁, fₖ, f₀, f₂ and half-power level at 0.707.](image)
Acoustic Cancellation

- Areas of high amplitude (good transmission) and areas of near zero amplitude (cancellation) in a generic room

![Frequency v. Amplitude of Transferred Sound](chart)

- Two Divisions
- Three Divisions
Methodology

- Create a PVC pipe with variably spaced holes
  - Put white noise and a frequency sweep of the tube at each interval
  - Determine which frequencies pass and which are blocked
  - Establish a model for which frequencies pass in relation to the spacing of the holes
- Measure existing buildings with filtering effects

Evenly spaced holes block low frequency sound from trains

DC Metro Line
Other Concerns

- Large machinery
  - Physics Student Shop
- Repeatability of data
  - Will certain frequencies always be blocked?
Brief Bibliography


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Questions (and Answers)

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