Acoustic Characterization of 41 Cooper Square Academic Spaces

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Problem Statement

Building acoustics play an important role in design of an academic space. Inappropriate acoustics can have a negative impact on student performance; therefore, it is important to be able to quantify the acoustic properties of the various labs, classrooms, and study spaces. This project has three primary goals:

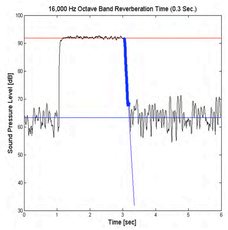
1. **Calculate the reverberation times of various rooms in the new academic building.**
2. **Quantify background noise levels.**
3. **Determine frequency response of rooms.**

Additionally, the new Cooper Union Anechoic Chamber was recently completed. A preliminary analysis of the acoustic properties of the chamber was performed.

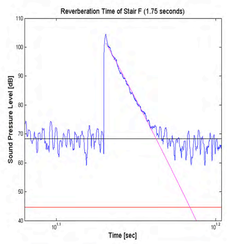
Reverberation Time Measurement Techniques

Two measurement techniques can be used to determine reverberation time of a room:

1. Interrupted Noise Method: Steady state white or pink noise is played, and the sound pressure level is measured. The sound is interrupted, and the time to decay by 60dB is measured (or extrapolated). Allows greater control over frequency content of signal, and is the preferred method if equipment exists.

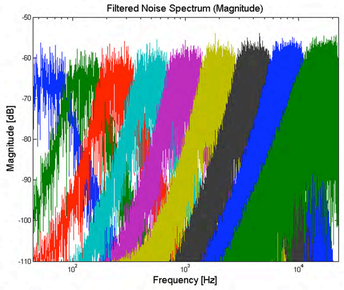


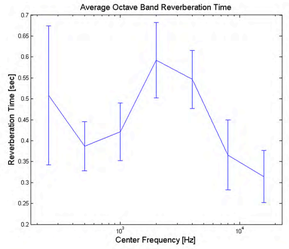
2. Impulse Response Method: A loud, nearly instantaneous sound source is used as an "impulse" source, and the decay time is measured. Common sources include gun shots, discharge of large capacitors, and balloon pops. Less control over frequency content of impulse, which generally lacks low frequencies, but is quicker and easier.

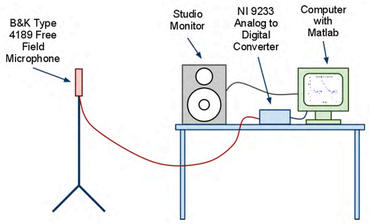


Octave Band Reverberation Time

White noise was filtered into octave bands (seen at right), and played over loudspeakers into a room. A measurement microphone recorded the instantaneous sound pressure level. Custom Matlab scripts were used to automatically calculate the reverberation time at each band level. Ten trials were recorded for each band level, and the mean and standard deviation were calculated (shown below). Reverberation time measurements were consistent with recommended levels for laboratory and classroom spaces [1,4]. A schematic of the setup is shown on the bottom right.







Results

ANSI standard S12.60-2002 recommends that classroom spaces should not have reverberation times exceeding 0.6 - 0.7 seconds. The following table shows the results of reverberation testing in various spaces in the building [5].

Table 1: Reverberation Time (seconds)

Room	Narrow Band (≈250 – 2000 Hz)	Broad Band (≈125 – 4000 Hz)
Anechoic Chamber	< 0.01	< 0.01
Grand Staircase	–	1.20
Stairwell D (Orange)	–	1.54
Stairwell F (Yellow)	–	1.75
4th Floor Study Lounge	0.53	0.54
Rose Auditorium	0.65	0.65
LL210 (classroom)	0.75	0.88
101 (classroom)	0.53	0.53

Reverberation times were generally acceptable, with the exception of LL210, which falls beyond the acceptable time of 0.7 seconds. The reverberation time of the anechoic chamber was less than the precision of the measurement system, which was expected, since the purpose of the chamber is to eliminate all reverberation.

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The following resources were used for preliminary research into the design and testing of anechoic chambers, and background acoustic testing information:

[1] "Acoustical Performance Criteria, Design Requirements and Guidelines for Schools." ANSI S12.60-2002

[2] Ressl, Marc S; Wundes, Pablo E. "Design of an Acoustic Anechoic Chamber for Application in Hearing Aid Research." *Recent Advances in Acoustics and Music.*

[3] Everest, F. Alton; Pohlmann, Ken C. *Master Handbook of Acoustics.* 5th ed. McGraw-Hill, 2009.

[4] Lord, Gatley, and Evensen. *Noise Control for Engineers.* McGraw-Hill, 1980

[5] Patynen, Katz, and Lokki. "Investigations on the Balloon as an Impulse Source." *J. Acoust. Soc. Am.* **129**(1), January 2011.