Technical Note: Measurement of Background Noise Level and Prediction of Reverberation Time in University Classrooms

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A study was conducted to measure background noise levels and to predict reverberation times in university classrooms. Twenty-five classrooms were selected due to the dimensions and location. Background noise level in all classrooms exceeds the recommendations in ANSI S12.60-2002. Calculated reverberation times based on the Sabine equation indicate that none of the classrooms have reverberation times below the recommendations in ANSI S12.60-2002, as well as the Building Bulletin 93. It is concluded that interior noise sources, such as classrooms' HVACs, students from other classrooms or corridors, and corridors' HVACs, must be taken into consideration rather than exterior noise sources because all eight buildings were located far from any environmental noise sources. The classrooms' doors (due to the openings) are more responsible for sound transmission than are the walls.

NOMENCLATURE

ANSI	—	American National Standards Institute
ASHRAE	—	American Society of Heating, Refrigerating and Air-Conditioning Engineers
HVAC	—	Heating, Ventilating and Air Conditioning
RT	—	Reverberation Time

1. INTRODUCTION

Background noise levels in educational spaces are a critical problem. This problem is commonly a result of HVAC systems and creates difficulties for teachers and students. Teachers must raise their voices to achieve the +10 dB signal-to-noise ratio,[1] which is essential for acceptable speech intelligibility. By straining their voices, many teachers must take several sick days, students struggle to hear their teachers and can become more easily distracted and stop paying attention.[1] Unfortunately, reducing HVAC noise is complicated.

Moreover, too long a reverberation time reduces speech intelligibility and produces a higher background noise level. A short reverberation time reduces background noise levels but muffles speech.[2]

Therefore, the goal of this study is to measure background noise levels and to predict reverberation times in Islamic Azad University, Science and Research Branch, Tehran, Iran, to learn more about the acoustical conditions of the classrooms.

2. MATERIALS AND METHODS

To measure background noise level, 25 classrooms from 8 buildings were selected due to the dimensions and location.

Reverberation time was calculated by the Sabine equation as follows:[2]

$$RT = 0.161\frac{V}{A}, \tag{1}$$

where V is the volume of the room (m^3), A is the total absorption of the room (m^2) and RT is the reverberation time (in seconds). RT was calculated in each octave band frequency from 250 Hz to 4 kHz; then an arithmetic average was computed over the frequency range 250 Hz to 4 kHz.

The measurement of background noise level was carried out according to recommendations in ASHRAE;[3] therefore, three different positions greater than 1 m from the HVAC, the door and the window, as well as one position approximately in the middle of the classroom, were selected. Finally, the mean equivalent sound level from four positions was taken into consideration.

A Brüel & Kjær sound level meter model 2236C was used. In some classrooms HVAC systems were manually turned off during the experiment to judge their effects on the background noise level. Background noise levels were also measured in unoccupied classrooms during the summer and winter.

3. RESULTS

Calculated RTs range from 0.88 seconds to 2.94 seconds. None of the occupied classrooms have RT below 0.6 seconds.

As shown in Fig. 1, background noise levels in 25 classrooms range from 41.7 dB to 61.2 dB during the summer and range from 43.3 dB to 59.0 dB in the winter. None of the classrooms have a background noise level below 35 dB.

Overall, both background noise level and reverberation time in all samples exceed the recommendations in ANSI S12.60-2002.[4]

[1]This study was a part of P. Jafari Shalkouhi's MSc thesis