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Validation of Balloon Burst Method in Measurement of Reverberation Time in a Classroom

Aris A. Rusiana, Joshua Marl C. Aves, and Kenje C. Hofileña

Basic Education Department,
Capitol University,
Cagayan de Oro City, Philippines

ABSTRACT: This paper aimed to validate the experimental result of reverberation time using balloon burst method with the model (sabine equation) using AcMus software. The experimental procedure utilized dynamic microphone as the receiver, balloon as the sound source and AUDACITY software to record and analyze the impulse created upon popping the balloon. Balloon Burst method has a reverberation time value of 1.28s while the AcMus software gave a reverberation time value of 1.33s. The percent error was calculated and showed a 3.76% error. Hence, the balloon burst method can be used to determine the reverberation time of a classroom also, it can be utilized as instructional materials in science classes.

KEYWORDS: Balloon burst method, reverberation time, Audacity, AcMus and dynamic microphone.

1 INTRODUCTION

Reverberation time measurement is very vital in improving the acoustics not only of classrooms but any other rooms. It can strongly affect the learning of the students since it can interfere to the student and teacher interaction [1]. For auditoria, it served as the basis whether it is for music playing or for speech. In theaters or opera houses, the rooms must be designed in such a manner that every sit receives the acoustic quality that includes reverberation time. And in cinemas, to obtain an outstanding quality of acoustics the reverberation time linear to the frequency must be aimed [2].

There are many methods that can be utilized to determine reverberation time this includes integrated impulse response method, interrupted noise methods, filtered burst method implemented by Bruel & Kjaer and method of recording the room response to an impulsive source. The first three methods mentioned in the latter statement utilized omni-directional speakers which makes it expensive. The method of recording the room response to an impulsive source was preferred since inexpensive sound source like balloon can be used. In addition, balloon is an omni-directional source and has a good spectral content than other inexpensive impulsive sound source [3],[4]. Room response to an impulsive source was applied in the study elsewhere using dynamic microphone, amplifier and speaker. Results showed good agreement with the conventional sound level meter [5].

In this work, the balloon burst method was the preferred method. This method is a specific kind of method of recording the room response to an impulsive source. Based on its name, the sound source used in this method is a balloon. Rusiana et al. (2012) utilizes balloon burst method to determine the reverberation time for 3 classrooms. Same materials were used with the current study applying sabine equation as the model. However, the reliability of the balloon burst method was not tested. In this work, the reverberation time values were determined using the balloon burst method and compared with the model sabine equation using AcMus software to avoid manual calculations.

2 Materials and Methods

2.1 Materials

This paper made use of SLR MC-502 Sharp dynamic microphone as the sound receiver and balloon with a circumference of 80cm as the sound source. The free software AcMus was utilized and set applying the sabine equation to theoretically calculate the reverberation time of a classroom. The experimental set up made use of Audacity software to record and analyze the sound impulses created upon popping the balloon. In addition, an HTC-1 temperature with humidity meter was used to monitor the temperature and relative humidity of the room. Furthermore, 4-Edison classroom having a volume of 148.78 m^3 located at the third floor of Capitol University Basic Education Department (CUBED) was utilized as the testing room.

2.1.1 Measurement Setup

The sound source which was the balloon was positioned in front of the black board (represented by star) where the teacher usually stays most of the time. The microphone was positioned in 5 different places inside the classroom (represented by cross marks). Figure 1 shows the various positions of the microphone and the sound source.

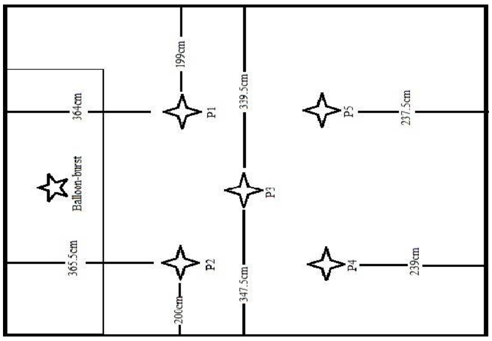

Figure 1 The Position of the Sound Source and the Microphone inside the Classroom.

During the testing process, the doors were closed as well as the windows. The things inside the room were removed like the lockers, tables and the chairs living the classroom almost totally empty. Figure 2 shows the interior of the classroom and the experimental set up.

Figure 2. The Interior of the Classroom and the Experimental Setup

2.2 METHODS

The balloon was popped using pin in front of the blackboard and the impulse was recorded using the dynamic microphone and Audacity. The latter procedure was repeated for the remaining 4 positions. The files were saved and analyzed using the same software.

The recorded data were opened using the Audacity software. An impulse that looks like a white noise with an exponential decay was seen. The unnecessary periods or junks (the blank portion) were deleted and the impulse was analyzed. The impulse was highlighted and normalized by going to the "effect" feature and clicking the "normalize". The highlighted impulse was normalized to zero. The feature "audio track" was selected and the impulse was transformed in waveform (dB). Figure 3 show the sample impulse loaded to the Audacity and the waveform (dB).

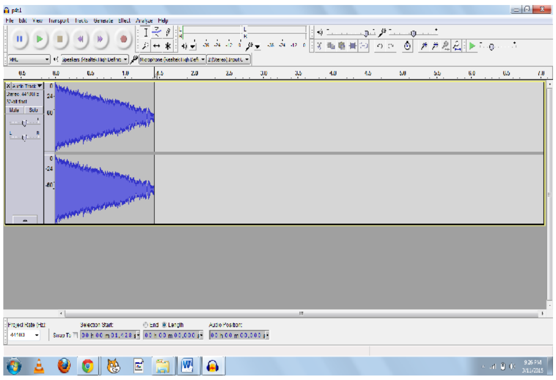

Figure 3. The Sample Recorded Sound Impulse of the Classroom in CUBED.

In figure above, the impulse has a linear pattern staring from 0 dB down to -60 dB. The period that the impulse decayed from 0dB up to -60dB was determined through observation and by clicking the part where the impulse decayed to -60dB. The period served as the reverberation time of the room at a certain position. Same process had been done to other positions in that room and the average result was computed and reported as the reverberation time (Rusiana et al., 2012).

2.3 REVERBERATION TIME MEASUREMENT USING ACMUS SOFTWARE

Every aspect of the interior of the classroom was sketched like the ceiling, walls and the floor. In addition, the area of the materials that composed the classroom was noted and measured. Figure 4 shows an example of our sketch and measurements.

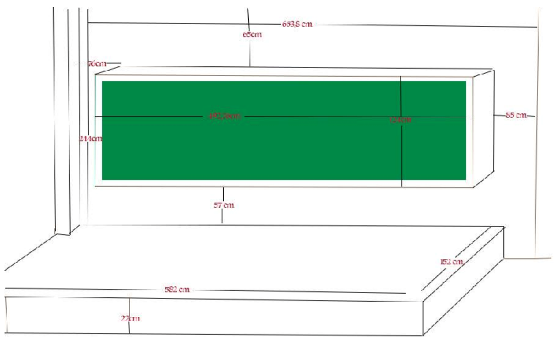

Figure 4. A sample from our sketches.

On the process of running AcMus, the software asks for the location of the saved file of your workspace. After finding a location, the interface will show lots of buttons and windows. The reverberation option was clicked from the drop-down box. Text boxes will be available from there.

The condition of the room was plugged in the AcMus like the temperature, humidity, room volume and pressure. The sabine equation was chosen as the model based on the research problem of this paper. The AcMus has a Portuguese default language hence the researchers translated this with the help of the internet. Figure 5 shows the sample AcMus page in computing the reverberation time.

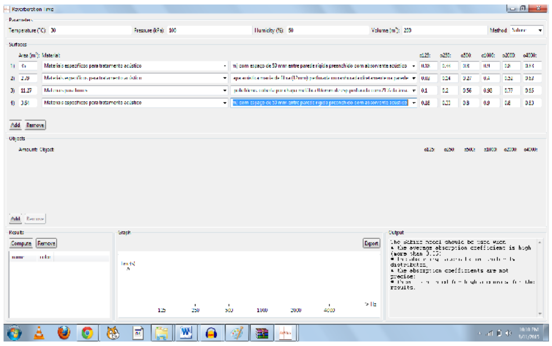

Figure 5. Sample AcMus page

3 RESULTS AND DISCUSSION

Table 1 shows the average reverberation time values every position using the balloon burst method and the AcMus software. The classroom's temperature and humidity were 30.2 +/- 1˚C and 67 +/- 5% respectively during the duration of the experiment. The same conditions were plugged-in the AcMus software while assuming a standard pressure since the location is sea level. Experimental result has an average value of 1.28s while AcMus gives a value of 1.33s.

The calculated percent error was low having a value of 3.76%. This error might be due to the assumption made that the pressure is at standard having a value of 101.33kPa. Despite of having such error, it did not go beyond the limit which is 5%. In addition, these results have a good agreement with the work of Gollmer that a dynamic microphone can be utilized as a sound receiver even if it is inexpensive.

Table 1. Reverberation Time Values from balloon burst method and AcMus Software and the Percent Error

<table>
<tr><th rowspan="2">Position</th><th colspan="2">Reverberation Time</th><th rowspan="2">Percent error (%)</th></tr>
<tr><th>Experimental Results (s)</th><th>AcMus Result (s)</th></tr>
<tr><td>1</td><td>1.33</td><td rowspan="6">1.33</td><td rowspan="6">3.76</td></tr>
<tr><td>2</td><td>1.32</td></tr>
<tr><td>3</td><td>1.27</td></tr>
<tr><td>4</td><td>1.26</td></tr>
<tr><td>5</td><td>1.24</td></tr>
<tr><td>average</td><td>1.28</td></tr>
</table>

4 CONCLUSION

The primary goal of this research was to determine the reliability of using balloon burst method in determining reverberation time. The experimental result was compared with the model sabine equation using the AcMus software. Results revealed that balloon burst method can be a reliable method to determine the reverberation of a room due to an acceptable percent error which is 3.76% despite of being inexpensive.

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