

ON THE STUDY OF THE ACOUSTIC PERFORMANCE OF
THE SEMINAR HALLS

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ON THE STUDY OF THE ACOUSTIC PERFORMANCE OF
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This report is submitted in fulfillment of the requirement for the award
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DECLARATION

“I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged.”

Signature:

Author: Nurul Hamizah Mohamed

Date:

SUPERVISOR DECLARATION

“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design & Innovation)”

Signature:

Supervisor: Assoc. Prof. Dr Azma Putra

Date:

For my left shoulders:

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Nor'ashikin Kasbi
Nurul Hasyimah Mohamed
Nurul Hazwani Mohamed
Muhammad Ammar Ashraf Mohamed
and
the right shoulder*

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ABSTRACT

A seminar is generally, a form of academic instruction, either at an academic institution or offered by a commercial or professional organization. While listening to a speech, a clear sound is a very important. Clear sound will directly affect the listener's attention. A person who develops skills in poor acoustic environment may develop long-term speech comprehension problems. Loud and noisy environment will tend to make the audience lose focus and the interest to learn. The noise and reverberation is also can inhibit the reading and spelling ability, behavior, attention, concentration and academic performance. In this research, the study of the acoustic performance of halls will be the main part of the projects. To narrowing the research, two Seminar Halls in UTeM have been chose to be the examples. The halls are Dewan UTeM 1 and Dewan Besar UTeM. This is because the reflection and refraction of sounds can be influenced by the materials used. Reinforcement system brings so much outputs of humming, buzzing, vibration and echoes. This study will helps on giving result of good acoustic performance in the way to give best decision for the architects to either choose the correct materials in building or else, allocate absorbers in the right position.

ABSTRAK

Seminar umumnya merupakan satu bentuk pengajaran akademik, sama ada di institusi akademik atau ditawarkan oleh organisasi komersial atau profesional. Semasa mendengar ucapan seminar, bunyi yang jelas adalah sangat penting. Bunyi yang jelas secara langsung boleh menjejaskan perhatian pendengar. Seseorang yang berada dalam persekitaran akustik yang lemah boleh meningkatkan masalah pertuturan kefahaman. Persekitaran yang kuat dan bising akan cenderung kepada pendengar untuk hilang tumpuan dan minat untuk belajar. Bunyi dan gema juga boleh menghalang bacaan dan kebolehan ejaan, tingkah laku, perhatian, tumpuan dan prestasi akademik. Dalam kajian ini, prestasi akustik dewan akan menjadi bahagian utama projek. Sebagai bahan penyelidikan, dua Dewan Seminar di UTeM telah dipilih iaitu Dewan UTeM 1 dan Dewan Besar UTeM. Bahan-bahan dinding, lantai dan siling dewan merupakan subjek utama yang akan dikaji dalam kajian ini. Ini kerana pantulan dan pembiasan bunyi boleh dipengaruhi oleh bahan-bahan yang digunakan. Sistem yang biasa digunakan membawa begitu banyak output bersenandung, bergetar dan bergema. Kajian ini akan membantu dalam kajian memberikan hasil prestasi akustik yang baik dengan cara yang memberi keputusan terbaik bagi arkitek untuk memilih bahan-bahan yang betul dalam pembinaan bangunan atau dalam pemasangan penyerap bunyi di kedudukan yang betul.

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LIST OF SYMBOLS

FIGURE	TITLE
RT	Reverberation Time
V	Volume of Rooms in m ³
S	Total surface area of room in m ²
A	Average of Coefficient of Material Absorption of the room surfaces
E(t)	Early Decay Time (EDT)
<i>p</i>	Impulse response
τ	Early Limit of Sound
C	Clarity
D	Early Energy Fraction

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

A speech is a method of delivering messages, knowledge or lectures. In delivering a speech, most all the activities involve speech between the source (deliver) and the receivers. While listening to a speech, a clear sound is a very important. Clear sound will directly affect the listener's attention. According to Smaldino & Crandell (1999), a person who develops skills in poor acoustic environment may develop long-term speech comprehension problems.

In a classroom, as example, loud and noisy environment will tend to make the students loss focus and the interest to learn. The noise and reverberation is also can inhibit the reading and spelling ability, behavior, attention, concentration and academic performance. Hence, classrooms and lecture halls are also important, often neglected, to have a perfect acoustic performance to make sure the speech can be delivered smoothly and correctly.

In this research, the study of the acoustic performance of lecture halls will be the main part of the projects. To narrowing the research, two Seminar Halls in UTeM have been chose to be the specimens. The halls are Dewan UTeM 1 and Dewan Besar UTeM. The materials of the walls, floors and tops of the halls are the main subject to be examined in this study. This is because the reflection and refraction of sounds can be influenced by the materials used.

On the same time, most of the lecture halls, in huge or small size, are using reinforcement system. Reinforcement system is where combination of tools used to make the sound can be heard in every side of the hall. Addition of tools like microphones, signal processors, amplifiers and loudspeakers will help to make the voice louder. Sometimes, connection of too many reinforcement tools will bring the outputs of humming, buzzing, vibration and echoes. Hence, the factor of getting the clear sound is neglected.

This study will helps on giving result of good acoustic performance in the way to give best decision for the architects to either choose the correct materials in building or else, allocate absorbers in the right position.

1.2 PROBLEM STATEMENTS

Audience of a speech cannot give full commitment when listening to the presenter as the sound is having echoes and humming. This problem is actually plays a big role on distracting them to start ignoring and neglecting the speaker. In Dewan UTeM 1 and Dewan Besar UTeM, the reinforcement system brings the echoes and humming during speaker is giving the speech. In Dewan Besar moreover, audiences that sit on the stage are having problem to listen to the speech. Thus, the audience feels uncomfortable with the noisy situations.

1.3 OBJECTIVES

1. To model and simulate the acoustic performance of Dewan UTeM 1 and Dewan Besar UTeM using CATT software.
2. To suggest the solutions on improving the acoustic quality of the halls.

1.4 SCOPE

This research will only focus on the experimental of acoustic performance of the Seminar Hall by using CATT software. Modelling the shape of the hall will be done as the first step before any analyzing works take place. Measurement of the perimeter of the hall and the material used is noted on modelling the hall inside the software. The project also intends to find the result of the clarity of speech and the reverberation time of the sound waves.

The audience area will be set on the floor, and will be labelled in 5 different coordinates. This is to make sure that the performance of the sound will be tested in different points of the hall. Source will be located at where the microphone is always set.

The results will then being interpreted and finding solution on how to improve the acoustic quality will be doing. These solutions will be suggested to make sure the sound can be heard clearly and the performance can increase the audience interest.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Every day we are exposed to sound either is not required, necessary or beneficial for almost twenty-four hours a day, seven day a week. Sound is a vibration that propagates as a typical audible mechanical wave of pressure and displacement, through a medium such as air or water. Sound wave that travels through air is the resulting of the physical disturbance of air molecules such when tapping a tuning fork and the waves will combine to reach the listener direct or indirectly (Crandall, 1926).

In a general way, the sound wave is any disturbance that transmitted in an elastic medium consisting of gas, liquid or solid (Tong & Wong, 2001). In physical way, there was no different between sound and noise. Actually, sound is sensory perception by human (Mechel et al, 2002) which it is can be detected by the human ears (Everest & Pohlman, 2009).

Although sound travels and can be heard but not all sound is audible. Limits of audibility for humans are only between 20Hz to 20 kHz (Charles, 1998). Sound below 20Hz is infrasonic and sound greater than 20 kHz is called an ultrasonic sound.

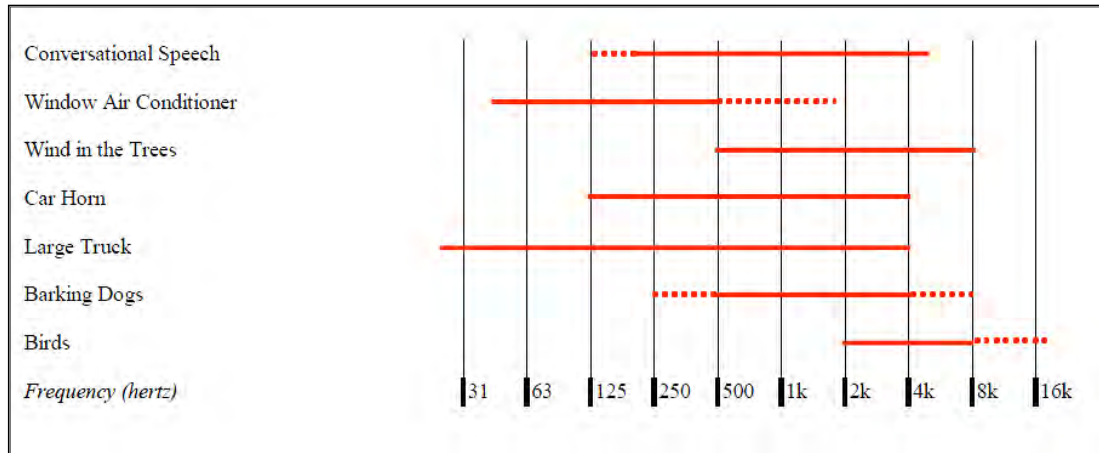


Figure 2.1: Frequency Range of Typical Sound Source (Everest & Pohlman, 2009).

Decibel or dB is the most common unit of sound measurement (Charles, 1998). The threshold of hearing is considered to be 0dB and the range sound for normal human experience is 0dB to 140dB.

2.2 SOUND ABSORPTION

Sound absorption refers to a material, structure or object absorbing sound energy when sound waves collide with it, as opposed to reflecting the energy. Every material has its own ability to absorb sound energy. Materials that have low absorption ability tend to reflect most of the acoustical energy.

Sound absorption is a capability of a material to convert sound energy into other energy. Sound energy usually converted to heat energy. Part of the absorbed energy is

transformed into heat and part is transmitted. The energy transformed into heat is said to be lost.

The property of material absorbing ability is called Sound Absorption Coefficient. To find the coefficient, architect usually used the Noise Reduction Coefficient (NRC). If the scale of NRC is 1.0, that mean that the material is perfectly absorptive and if it is 0.0, it is a reflective materials (Crandall, 1926). This coefficient helps the work on choosing the right material for each building walls.

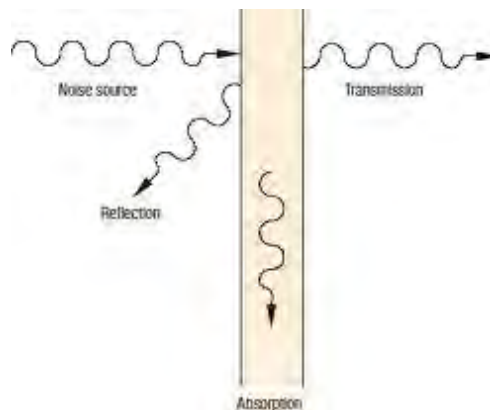


Figure 2.2: The Ray Path of the Reflection and Absorption of Sound (Crandall, 1926)

2.3 REVERBERATION TIME

When a sound is triggered or generated in a room, many things will happen in a blink of eye. The reflecting boundaries of the room will result repeated reflections which determine the rapid establishment of more or less uniform sound field. And this field then decays as the sound energy is absorbed by the bounding materials. The reflecting surface with its absorptive ability will determine the rate of the sound energy decays. And time taken for the sound intensity to decays for 60 dB is called the “Reverberation Time” (Grade et al, 2001).

The Reverberation Time is an important part as a quantity for characterizing the acoustic properties of a room. When building a room, the first step in architectural

acoustic design is to identify the good values of the reverberation time depends on the function of the room. Furthermore, we can specify the materials that to be used in the construction which will achieve the desired value of the Reverberation Time.

For an example, a classroom should have the reverberation time in the range of 0.4 to 0.6 seconds. But in reality, many did not manage to achieve the suitable reverberation time and having reverberation time of 1 second and more. In such reality cases, teachers have to compete against the lingering reflection of his or her own voice to get the student's attention. The result is a chaotic jumble of sound (Goelzer & Hansen).

In 1922, a pioneer in the study of room acoustics, Wallace Sabine came up with the formula which is defined as Eq. (1) below,

$$RT = 0.16m^{-1} \frac{V}{S\alpha} \quad (1)$$

The equation above show that the RT is the reverberation time, where V is for the room volume in m³, S will be the total surface area in m², and α is the average of the absorption coefficient of room surfaces.

The formula is based on the volume of space and the total amount of absorption within a space. The total amount of absorption within a space is referred as "Sabins" where the product of $S\alpha$ is the total absorption in Sabins.

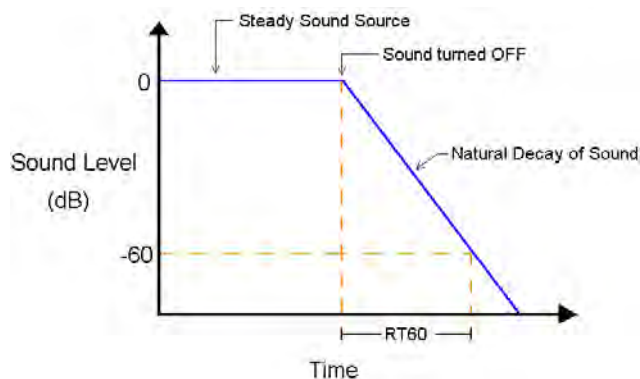


Figure 2.3: Graph of Reverberation Time by Taking Sound Level versus Time
(Grade et al, 2001)

The graph above show of RT60 where T is defined as the duration required for the space-averaged sound energy density in an enclosure to decrease by 60 dB after the source emission has stopped (Grade et al, 2001). Things that will be effect reverberation are size of space and the amount of reflective or absorptive surface within space (Goelzer & Hansen). A space with high absorptive surface will absorb the sound and stop it from reflecting back into the space (Grade et al, 2001). Reflective surfaces will reflect sound and increase the reverberation time within space. Therefore, a large space will need more absorption instead of reflection in the way to achieve the same reverberation time as a smaller space.

In general, the best reverberation times are less than 1 second for speech and longer than 1 second for music. Short reverberation times are necessary for clarity of speech; otherwise, the continuing presence of reverberant sound will mask the following sound and cause the speech to be blurred. Longer reverberation times are considered to enhance the quality of music, which will give “dead” environment if the reverberation time is too short. Larger rooms are judged to require longer reverberation times, as is also the case with lower frequencies of sound.

According to Berg and Stork on their research in 1995, the best RT for a speech should be less than 1 second at frequency band of 500Hz and below (Bies & Hansen,

1996). The reverberation time of a room must be suitable to the function and volume of the room, should apply for sound frequency from 125Hz to 4,000Hz.

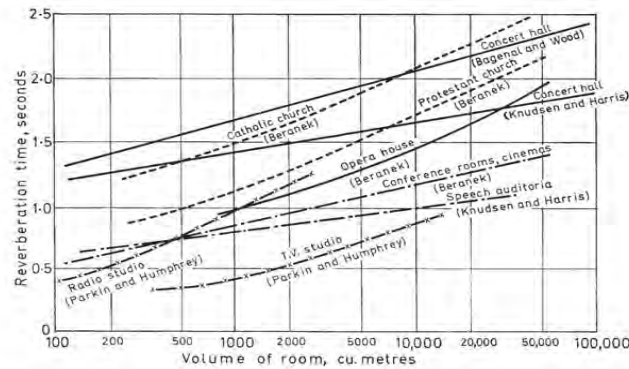


Figure 2.4: The Variation of Optimum Reverberation Time with Volume (Noise Pollution and Its Control, 1989)

2.4 SPEECH INTELLIGIBILITY

Speech intelligibility is defined as a percentage of speech or words heard correctly by the listeners. It is a vital element of human communication. Without outstanding speech intelligibility, communication is hampered. Good intelligibility is influenced by reverberation time (RT), background noise and distance of the listener from the speaker. From the three elements, RT and background noise are influenced by the architecture of the room; therefore, they should be given greater attention at the design stage. However, the quality of speech is also dependent on vocal strength or power, dialect and clarity of the spoken words.

From Noxon in his research in 2002 highlighted that in the draft version of the new ISO 9921 standard on the “Assessment of Speech Communication” defined speech intelligibility as “a measure of effectiveness of understanding speech”. The measurement is usually expressed as a percentage of a message that is understood correctly. Speech intelligibility does not imply speech quality. Speech intelligibility is related to the amount of speech items that are recognized correctly, while speech quality is related to

the quality of a reproduce speech signal with respect to the amount of audible distortions. Thus, a message that lacks quality may still be intelligible.

Speech intelligibility in the hall is a crucial aspect when talk or lecture is given. The non-uniform distribution of the intelligible speech was due to the impaired direct path of the sound from the speaker (Amasuomo, 2013). Echoes experienced in the lecture halls were as a result of the time delay between the arrivals of the initial sound from the speaker and then reflected sound from the parallel walls. The presence of echoes in the halls during speech or seminar is a nuisance. Thus, echoes should be avoided.

2.5 RAPID SPEECH TRANSMISSION INDEX (RASTI)

RASTI method is an objective method for rating the transmission quality of speech with respect to intelligibility (Sound System Equipment Part 16). The method is intended for rating speech transmission in auditorium, halls and room with or without the sound reinforcement system. It is economical, and time saving for each station can be evaluated either in eight, sixteen or thirty two seconds.

Rapid speech transmission index (RASTI) is a simplified version of speech transmission index (STI). A modulated test signal is fed to a loudspeaker at the talker's location. The receiver's microphone is positioned at the receiver location. The system gives an accurate read out of the measured RASTI value at the receiver position. RASTI can also take account of the effects of reverberation, as well as background noise (Sound System Equipment Part 16).

It tests in only two frequency band with the assumption that the response of the sound system is more than 100Hz to 8 kHz or higher with a flat frequency response. Poor designed systems often tend to show a too optimistic measurement. The measured values were represented by the properly flat systems with the frequency spectrum.