Influences Reverberation Time to Human Activities: Method to Measure Reverberation Time for Different Mosque Structure

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Abstract

Nowadays, good acoustic quality becomes one of the main considerations in designing and constructing huge enclosed structure such as a mosque. It improves the speed effectiveness, hence provide a condusive environment and bring good psychology condition to the prayers. There are numbers of method and indicators that can be applied to define the acoustic quality for an enclosed room. One of them is using the Reverberation Time (RT60) as indicators. Optimum RT60 based on its volume should result in good speech intelligibility where it is the primary concern for a mosque to be build. In this study, RT60 is used to identify which mosque that fulfill the feature of the best acoustic quality. The three kinds of mosque involved are a mosque with 90% constructed of woods, mosque with 905 constructed with concrete and the last one is a mosque with combination of more than one material which is about 60% of concrete and 40% wood and glasses. After completing this task, it is defined that the mosque with combination of 60% concrete and 40% wood and glass has the best reverberation time which fulfill the best acoustic quality for multi-purpose room among the three types of mosques.

Keywords: Reverberation time, mosque, material, absorption, volume, human psychology.

1. Introduction

Actually, when a sound is triggered or generated in a room, many things will happen in the 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 (decibel) is called the “Reverberation Time” [1,2,3].

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 appropriate values of the reverberation time depends on the function of the room. Only then, we can specify the materials that to be used in the construction which will achieve the desired value of the Reverberation Time [1,2,3].

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

$$RT60 = KV/(\quad S \quad) \quad (1)$$

Where:

RT (60) = reverberation time (sec).
V = room volume (m^3).
S = surface area (m^2).
= absorption coefficient of material(s) at given frequency.
indicates the summation of S times for all room surface.

2. Methodology

Basically, there are two methods of measuring the reverberation time in a larger room. One method uses an impulsive noise source such a pistol, balloon or canon. The other one uses continuous noise source which is turned off at some specified time. The sound level in the room is measured as a function on a frequency analyzer or on a chart recorder. The slope of the sound level as a function of time may then be used to determine the reverberation time. In this project, we used the impulsive noise source method to find the reverberation time.

2.1 Mosque Selection

Before starting the experiment, the first step is to find the suitable mosque first. There are two criterias that must be fulfilled when selecting a mosque.

The first criteria is by identifying the type of the different type of mosque:

1. Mosque that constructed with 90% concrete.
2. Mosque that constructed with 90% wood.
3. Mosque with combination of more than one material.(60% of concrete and 40% of other which may be wood, glass, rubber and others.

The second criteria is the volume of the mosque must be the same but about 10% differences is allowed.

Each type of mosque should give different measurement of reverberation time because of the varying material used to constitute the ceiling, wall and the floor of the mosques. As the sound absorption for different material is different, we need to proof this theory by doing the experiment to measure the reverberation time for each mosque using proper acoustic equipment.

2.2 Equipment List

The list of equipment is as followed:

Figure 1 – Solo.

Solo is a multi functional device which is widely used in measuring acoustic indicators such insulation, impact noise, reverberation time and machinery noise. With this device, data can be measured, saved and transferred to personal computer or laptop using specific software called dBBATI32 which installed to the computer. More about this Solo device and dBBATI32 software is explained in the appendices.

Figure 2 - Firecrackers.

Using about five dozen of small firecrackers as the impulsive sound source, the reverberation time then being measured using sound level meter.

2.3 Equipment Setup

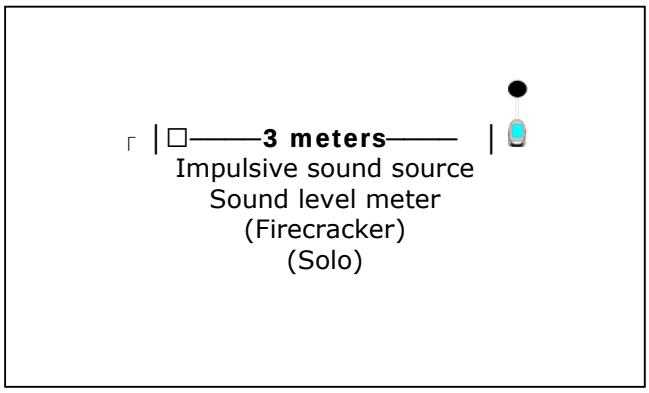


Figure 3 – Equipment Setup.

2.4 Measuring the reverberation time.

To measure the reverberation time of the mosque, the firecracker is set up at the center of the mosque with the sound level meter switched on about at least 3 meters from the firecracker. In the mode to measure the reverberation time, the sound level meter will show the ambient noise of the environment which will be the reference as the measurement is going to start. This ambient noise need to be set by the user as it so the result will be dynamic to the environment. After has been set up, the firecrackers is being light up using ordinary lighter. When the firecrackers explode, an impulsive sound is triggered and the reverberation time is measured and recorded by the sound level meter as the sound level decay by the time.

Those methods to measure the reverberation time apply to all the mosques that I choised. But to make sure the measurement do not have any unwanted error, the unwanted noise or ambient noise should be low. Make sure the fan or other equipment in the mosque is turned off. Try to prevent other noises to such as the vehicle's noise or people's voice.

Below is the Figure 4 which shows the picture of the mosque with wood construction. The mosque is known in the name Surau Kampung Chemumar located in Kampung Chemumar, Serdang, Perlis.

Figure 4 - Surau Kampung Chemumar.

Figure 5 - Equipment setup in the wooden mosque.

Figure 6 is the picture of the mosque constructed with combination of the mix material such as concrete, wood and glass. The mosque is located at Kampung Abi Tok Hasyim, Abi, Perlis and known as Surau Kampung Abi Tok Hasyim.

Figure 6 - Surau Kampung Abi Tok Hasyim.

The setup of equipment in the mosque is shown in Figure 7.

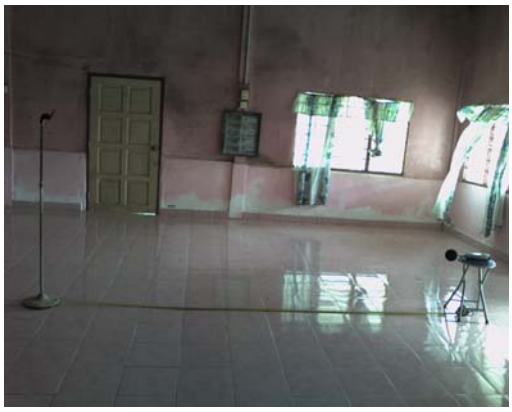


Figure 7 - Equipment setup in mix material mosque.

Figure 8 is the picture of the mosque construct with concrete which located at a recreational park in Kangar.

Figure 8 - Concrete Mosque.

Figure 9 and Figure 10 show the fire cracker which used as the impulsive noise source in the setup. The firecracker is hanged up by the microphone stand.

Figure 9 - Microphone with firecracker.

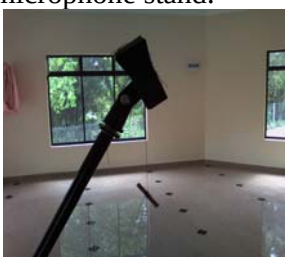


Figure 10 - Firecracker stand closed-up.

Figure 11 shows the full equipment setup in the concrete mosque.

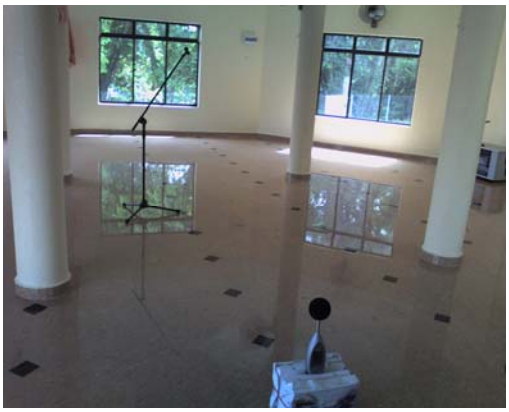


Figure 11 - Equipment setup in concrete mosque.

3 Results and Discussion

3.1 Measured results

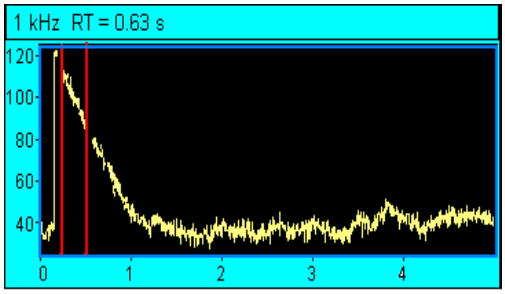
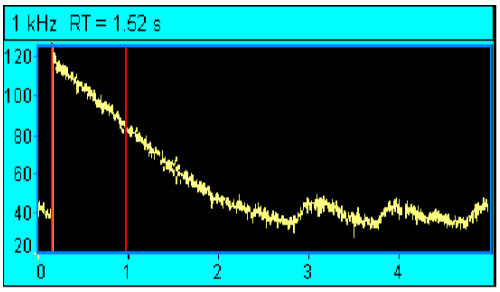


Figure 12 - Wooden mosque reverberation time at 1 kHz.



Figue 13 - Mix material mosque reverberation time at 1 kHz.

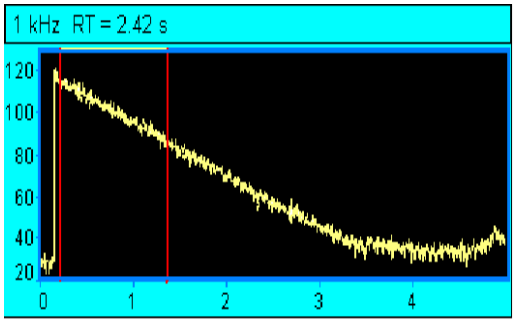


Figure 14 - Concrete mosque reverberation time at 1 kHz.

3.2 Theory Calculation

Using the Sabine's formula in equation (1), Reverberation time for the three mosques are as in table 1.

Table 1 - Reverberation times at 1000 Hz.

Mosque	Reverberation Time(s)
Wooden	0.53
Mix Material	3.27
Concrete	3.81

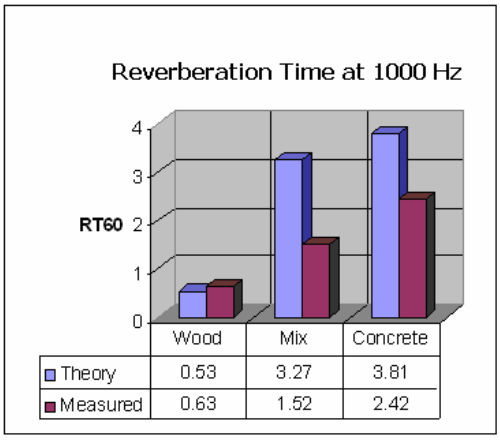


Figure 15 - Reverberation time data for all mosque at 1 kHz.

4. Conclusion

One of the method to identify the acoustic quality of a room is by defining it's reverberation time. My study need me to use this method to measure the acoustic quality in the selected mosque with different type of construction material where I need to define which is the best among the wood mosque, concrete mosque or the mosque with the combination of mix materials. In the end, I have concluded that the best mosque is the mosque with the mix materials in its construction. Referring to the best recommended reverberation time which suit the best acoustic quality for mosque, wood mosque give too short reverberation time while concrete mosque give too long reverberation time. The wood mosque represents how a room with too much absorbing materials can give poor acoustic quality by making the reverberation time short. For the vise versa, concrete mosque shows how a room with too much reflecting material can give poor acoustic quality by making the reverberation time too long out of recommended range. Since the mix material mosque give the best reverberation time in moderate value which suit the best acoustical quality of a room in its category which is a multipurpose or multifunctional room, this gives us example on how to control the reverberation time by using various type of material to get the desired value of reverberation time and in the end fulfill the best acoustic quality of a room proportional to its desired function.

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References

[1] M. Moser. Engineering Acoustic: An Introduction to Noise Control, Springer 1st Publication 2003.

[2] Adel A. Abdou (2003) .Comparison of the acoustical performance of mosque geometry, King Fahd University of Petroleum and Minerals, Architectural Engineering Department, Dahran Saudi Arabia, pp 45-46.

[3] Mohamad Ngasri Dimon, Sasni Ismail, Siti Zaleha Abdul Hamid, Fareha Abdul Rahman, Munirul Ula (2005) .The study of Reverberation Time for a mosque with a concrete ventilated block,pp 211-220.