Acoustic Quality Levels of Mosques in Batu Pahat

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Abstract. Every Friday, Muslims has been required to perform a special prayer known as the Friday prayers which involve the delivery of a brief lecture (Khutbah). Speech intelligibility in oral communications presented by the preacher affected all the congregation and determined the level of acoustic quality in the interior of the mosque. Therefore, this study intended to assess the level of acoustic quality of three public mosques in Batu Pahat. Good acoustic quality is essential in contributing towards appreciation in prayers and increasing *khusyu'* during the worship, which is closely related to the speech intelligibility corresponding to the actual function of the mosque according to Islam. Acoustic parameters measured includes noise criteria (NC), reverberation time (RT) and speech transmission index (STI), and was performed using the sound level meter and sound measurement instruments. This test is carried out through the physical observation with the consideration of space and volume design as a factor affecting acoustic parameters. Results from all 3 mosques as the showed that the acoustic quality level inside these buildings are slightly poor which is at below 0.45 coefficients based on the standard. Among the factors that influencing the low acoustical quality are location, building materials, installation of sound absorption material and the number of occupants inside the mosque. As conclusion, the acoustic quality level of a mosque is highly depends on physical factors of the mosque such as the architectural design and space volume besides other factors as been identified by this study.

1. Introduction

The Muslim community is the most heavily populated community in Malaysia. Referring to JAKIM statistics (2013), Johor owns the highest number of mosques in Peninsular Malaysia. Statistics from Jabatan Agama Islam Johor lists out 188 mosques in Batu Pahat district are qualified for Friday prayers. A mosque can be found in each village, residential compound, industrial area, and tourism area in this district. Due to its main function as a place of worship, mosque is subjugates a noble place in Islam [1]. Mosque is also been seen as a centres for Muslim communities around the world to perform worship, a process for the improvement of a Muslim's faith. Although the construction of a mosque in Malaysia strongly emphasized on the aesthetic value of architecture, it is often not accompanied by the presence

of a good acoustic quality level [2]. Undeniable, level of acoustic quality plays an important role which made the function of a mosque as a centres of worship and the spread of da'wa or knowledge can be achieved.

Some literatures only examine the quality level of the speech towards the listener in a room with the indicator on the contemporary room-acoustic. In a difficult acoustic condition such as in the church, assessments on loudspeakers or sound reinforcement systems are often used for evaluation [3-4]. However, there are no specific guidelines for mosques have been established [2]. One of the significance of good acoustical quality level in a mosque is to provides satisfaction to intelligibility in oral communication and enhance calmness during worship. Furthermore, mosque also needs for the same acoustic requirements as churches and other religious buildings for the purpose of delivering revelation of God. Nonetheless, other activities that held in the mosques such as prayer, public speaking, teaching, lectures, and Quran reading are needs for intelligibility in speech.

Speech intelligibility is an accuracy in which listeners can understand the clarity and conciseness of spoken words or phrases. The understanding of speech in that situation is measured by the presence of interference in the speech signal caused by the noise in the transmission route. It can be affected by background noise and reverberation in a room. Facilities operating in mosques such as fans, air-conditioners, closed doors, etc. contributes to low acoustic performance levels. Therefore, noise criteria and reverberation time should be taken into consideration for a wider application in determining the permissible value in a room or space.

By focusing on the specifically the public mosque in the district of Batu Pahat, this study was conducted to achieve two main objectives: (i) evaluating the acoustic quality level in the mosque using sound level meter and sound measurement instrument; and (ii) identify the factors that influencing the acoustical quality level inside the mosque.

2. Acoustic Literatures

The level of acoustic quality within the mosque varies depending on numerous factors. However, the key factors that might affecting the acoustic quality inside the mosque include the physical factor such as type and design of the mosque, and acoustic factors such as the presence of background noise and reverberation sound [5]. The acoustic quality level in the mosque refers to the satisfaction of the congregation in it towards the clarity in delivering speeches or Khutbah, as well as khusyu' during the worship without any noise disturbance. A good acoustic design will provide a better and more comfortable environment within the mosque in terms of clarity and the intelligibility of speech [6]. Various linear measurement analyses were used to develop several empirical models to predict the sound levels toward the occupants with various parameters, for example, the volume of the room, the number of occupants, the background noise in the room without an occupant, or the reverberation time [7]. Acoustic parameter that denote the comfort and clarity of speech is the time of the echo and classroom background noise [8-9]. This statement proves that background noise and reverberation significantly contributes towards a good acoustic quality level of a space. In order to create a good acoustic level, consideration of the noise criteria (NC) based on the background noise, the reverberation time (RT) and the speech delivery index (STI) should be accounted.

3. Methodology

Initial study identified five "government mosques" (managed by state) out of 188 mosques in Batu Pahat. However, three mosques were chosen as the case studies for assessment on the acoustic quality level and the factors that might influencing their acoustical performance. This selection is based on the categories of mosques built by the Johor government in full with facilities and maintenance management as well as considering the design of the floor plan and roof of the mosque. Two mosques have rectangular floor plan design (1: 2, elongated) and a mosque has square floor plan design (2: 2, both sides). Floor plan design of Masjid Sultan Ismail (Figure 1) is square shaped like others government mosque built after independence which is with the spacious interior and big dome and the additional mezzanine

flooring. In contrary with mosque built before independence, Masjid Dato Bentara Luar (Figure 2) has an elongated spacious interior without pillar while Masjid Sultan Ibrahim (Figure 3) has elongated spacious interior with many pillars. In addition, both of these old mosques have flat ceiling and thick walls construction.

3.1 Case Studies

The volume of the mosque is an important parameter that can affect the acoustic characteristics. Table 1 summarized the main physical features of the three selected mosques. All the data includes information such as length, width, height, volume, and total expected capacity when the mosque is fully occupied. However, only the size of the main prayer space was recorded.

The volume of the main prayer hall of those three mosques are varies and ranging from volume of 2962.2m3 with the capacity of the congregation within 760 people as the smallest, up to the largest volume of 32157m3 with the capacity of the congregation within 2230 people. However, the actual capacity of each mosque was expected to increase if all the spaces within the mosque being occupied especially during the Friday prayers.

Table 1: Case Studies Measurement

No	Mosque Code	Floor Plan Measurement			Parameters for Main Prayer Activities Room	
		Prayer Room Dimension (m)			Volume (m^3)	Expected Capacity
		Length	Width	Height		
1	M1	39.7	37.5	21.6	32157.0	2230
2	M2	33.6	15.2	5.8	2962.2	760
3	M3	13.6	28.3	7.8	3002.1	1050

3.1.1 Case Studies 1: Masjid Sultan Ismail (M1)

Masjid Sultan Ismail which is located in the district of Batu Pahat was constructed at a strategic location alongside Jalan Bakau Condong, at the junction of Jalan Batu Pahat-Kluang opposite Wisma Anak Yatim. The mosque complex also houses Pejabat Agama Daerah, Mahkamah Syariah and Majlis Agama Islam Johor. Sultan Ismail Mosque was built to meet the population capacity and was completed and inaugurated by the Sultan of Johor, Sultan Iskandar Al-Haj on 3 October 1996. The mosque is capable of accommodating over 5,000 congregations led by Imam who hold a bachelor's degree and memorized the entire Al-Quran. Masjid Sultan Ismail has also actively helping new followers of Islam.

3.1.2 Case Studies 2: Masjid Dato Bentara Luar (M2)

Masjid Dato Bentara Luar was established in the early 1930s on the Sultan Ibrahim's order by taking the name of Dato' Mohammad Salleh Bin Perang which in charge of opening the towns of Muar, Endau and Batu Pahat. The design is similar to Masjid Jamek Bandar and is recognized as a district mosque after the Masjid Sultan Ibrahim in Air Hitam town, Batu Pahat. Masjid Dato Bentara Luar was completed around 1934 and was able to accommodate over 3000 congregations. Quarters for the mosque's staff were also built in the mousqe compound including the Kadi Daerah house.

3.1.3 Case Studies 3: Masjid Sultan Ibrahim (M3)

Masjid Sultan Ibrahim mosque is a government-owned mosque which was initially built by Penghulu Yusuf Abdullah around the late 1920s. With the fund from the people and the help of the state government, the site of the 'wakaf' mosque was then handed over to government officials Capt. Ahmad

Mohammadon and Major Dato 'Muhammad Said Bin Sulaiman to be developed. With the touch of Johor painter Sulaiman Alias, this mosque was completed similarly to the design of the traditional Malay house but combines the features of Islamic and Western architecture. The mosque remains to this day without much renovation which is located on a hill near the main streets of Kluang, Batu Pahat, Yong Peng and Simpang Renggam. The mosque was first used on April 28, 1931, in conjunction with the arrival of Aidiladha. Upon the decree of Sultan Ibrahim through the Yang Dipertua of the Jabatan Agama Johor, Dato' Abdullah bin Abdul Rahman, the mosque which was named after the Sultan of Johor was perfectly inaugurated on the 1st May 1935.

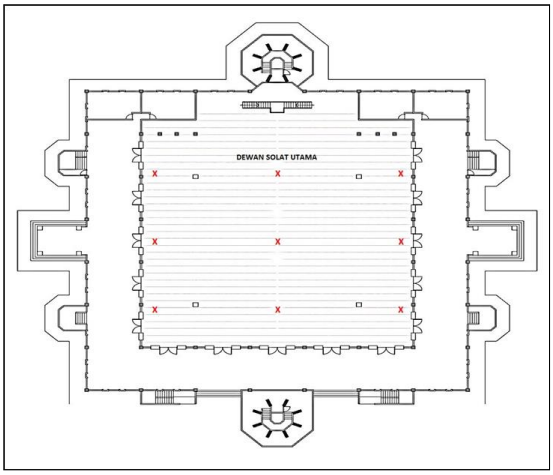

Figure 1: Point of measurement Masjid Sultan Ismail (M1)

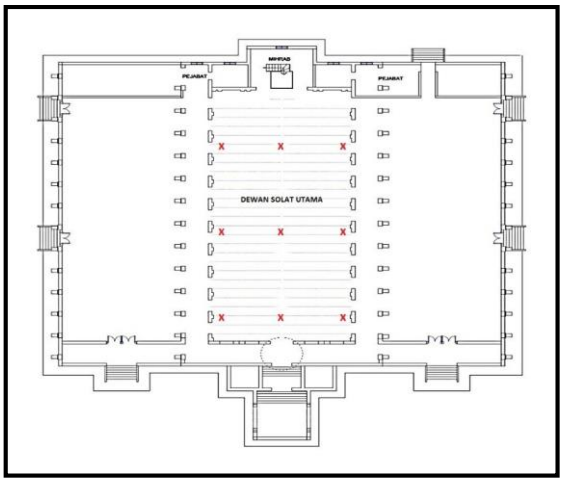

Figure 2: Point of measurement Masjid Dato Bentara Luar (M2)

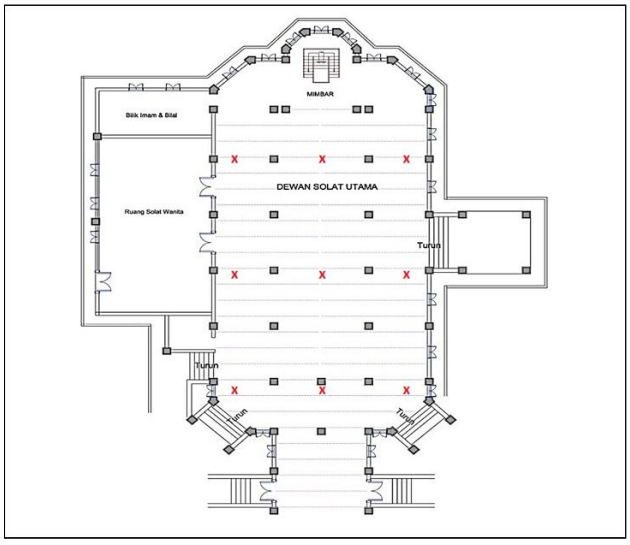

Figure 3: Point of measurement Masjid Sultan Ibrahim (M3)

3.2 Testing Procedure

The test procedures performed for this study referred to the procedures as stated in BS ISO 3382: 1997 [10]. Based on the shape and area of the floor of each selected mosque, the number of points or locations selected and determined to create modes referring to the distance difference of the meter level meter from the sound source. These modes serve as a reference to the acoustic quality level of a congregation's location based on its distance from the sound source. The value for the measurement is also set to A-weighted decibel (dBA) and measurements are performed at any predetermined measurement point. To assess acoustic quality level, testing is carried out using a sound level meter and sound measurement

instrument. The sound level meter is used to obtain sound pressure level data, while the sound measuring instrument along with dBBati 32 software is used to obtain data for the noise criteria and the reverberation time value.

To obtain values for the noise criteria (NC), the background noise level in the mosque should be measured first using a sound level meter. The microphone used should be placed 1.5 m from the floor surface. This method of measurement is carried out in the absence of other occupants which is before the presence of the crowd to reduce the level of sound pressure in the mosque. These measurements are performed repeatedly at each predetermined location points. After the background noise level obtained, the calculations through the dBBati 32 software are performed to obtain noise criteria values and for further analysis.

To conduct the reverberation time (RT) test, RT60 is used as a standard for the testing. RT60 is the standard for the reverberation time measurement which refers to the amount of time taken for the sound pressure to decrease by 60 dB. The frequency value used in this measurement is set to a value between 125 Hz up to 8000 Hz using dBBati 32 software. The sound source is switched on and the measurements are performed with the time interval for every 10 seconds recorded up to one minute and a series of sound pressure level (SPL) are recorded into memory. The estimations were performed at the time the test signal created was quit utilizing a sound estimation instrument. Like the clamor criteria testing, the mouthpiece utilized ought to be put 1.5 m from the floor surface.This method of measurement is also carried out when during the absence of occupants in the mosque. These measurements are repeatedly carried out at each predetermined location point and the data obtained is stored in memory for further analysis purposes.

Measurement for speech transmission index (STI) is a continuation of the test of noise criteria and reverberation time where the basic calculation method using Microsoft Excel. The data obtained from the test of noise criteria and reverberation time are recorded and tabulated for calculation process for obtaining the speech transmission index value. The value of this speech transmission index will then be the determinant of acoustic quality level for a mosque.

4. Data Analysis & Result

4.1 Sound Pressure Level and Acoustic Parameters

Table 2 shows the overall data for the tests conducted in the case studies which is the data for sound pressure level (SPL), noise criteria (NC), reverberation time (RT) and speech transmission index (STI). To facilitate understanding towards the measured values, Figure 4 to Figure 7 compares the data from all tests conducted for those cases study.

Table 2: Sound Pressure Level and Acoustic Parameters

	Sound Pressure Level (SPL)						Noise Criteria (NC)	Reverberation Time (RT)	Speech Transmission Index (STI)
	Before Khutbah			During Khutbah					
	Min	Average	Max	Min	Average	Max	Average	Average	Average
M1	51.10	55.60	53.42	64.10	89.10	80.87	45.00	3.73	0.38
M2	41.90	47.10	44.59	68.80	83.10	77.15	40.00	1.77	0.38
M3	44.80	49.90	47.38	66.50	93.80	85.91	45.00	1.17	0.41

The sound pressure level (SPL) for the three mosques has practically comparative for least, greatest and average esteem which is extending from between 41dB to 56dB for before Khutbah conditions. Alluding to the gauges, the weight level esteems for structures for religious capacities are

inside 35dB to 45dB [6]. This shows that the sound pressure level in this mosque is high compared to the standards. One of the factor is the location of these three mosques is near a busy road and in a town area with various daily activities. For the sound pressure level during Khutbah, the sound pressure value is higher than the original value with ranging from 64dB to 94dB. This is due to the presence of the mosque speaker system during the speech in progress.

Based on the value obtained from the noise criteria (NC) testing, the three mosques obtained almost similar average value of 40 to 45 based on the calculation of the presence of background noise inside the mosque. Referring to the standards, the noise criteria level for the three mosques is at an elevated level and is less suitable for its function where the sound criteria level corresponding to religious buildings is between 25 and 30 [11]. This is because of the influence of the background noise for the prayer room in all mosques.

As for the reverberation time (RT) obtained for each octave band frequency between 63 Hz and 8000Hz, the value between 500Hz and 1000Hz is chosen as the optimum value. The average optimum reverberation time value for M1 is 2.82 seconds, M2 is 1.77 seconds and M3 is 1.17 seconds. The optimum reverberation time for M2 and M3 was inconsistent as set out in the standard which is the value most suitable for religious buildings is between 2.00 and 3.00 seconds [12The optimum echo time for M1 is high because of its high and high roofs in the prayer room, while the optimum echo time for M2 and M3 is low because the roof is flat and low in the prayer room. Therefore, the factor to be seen is that the material on the roof is high and also the low roof itself causes the echo of the sound reflection, should take into account the amount of space, space design, absorption factor also greatly influences the echo time.

Speech transmission index (STI) value obtained by all three mosques reffering to IEC 60268-16 standard shows poor performances [13]. M1 and M2 obtained 0.38 coefficients while M3 obtained 0.41 coefficient. The index value acquired for every mosque relies upon the esteem gotten for the sound pressure level, noise criteria and resonation time as expressed in the writing survey. Be that as it may, the value gotten for this discourse transmission record is additionally affected by different factors, for example, the proximity of an denizen in the room.

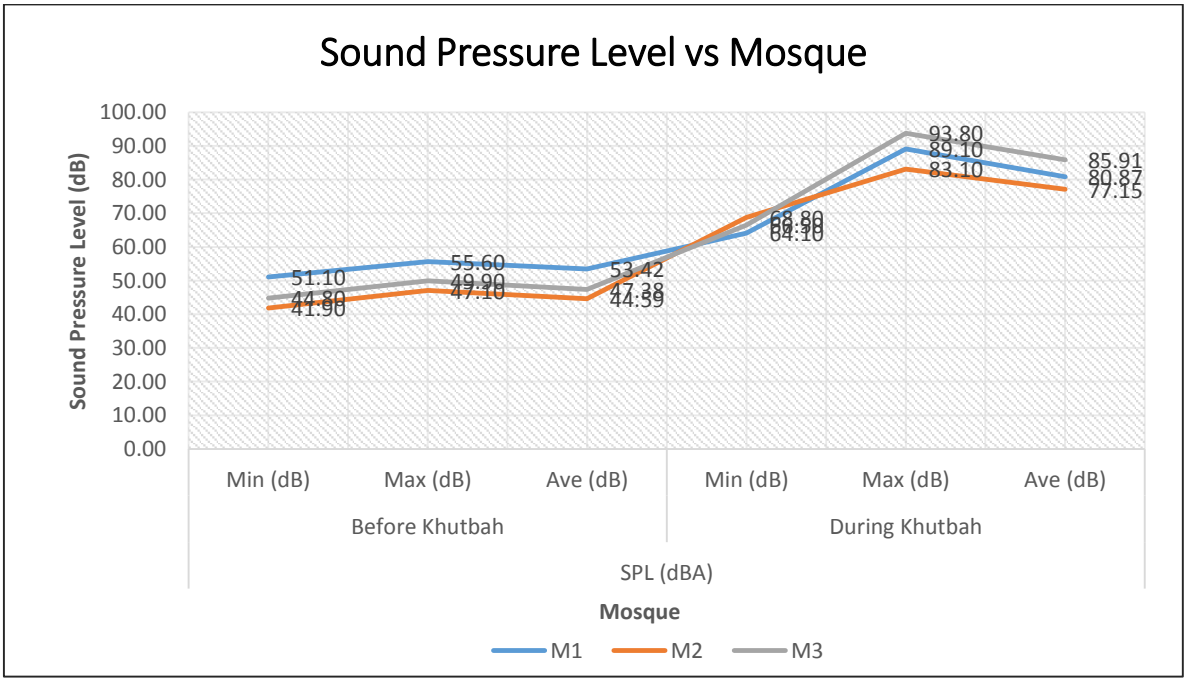

Figure 4: Sound Pressure Level (SPL) versus Mosque Graph

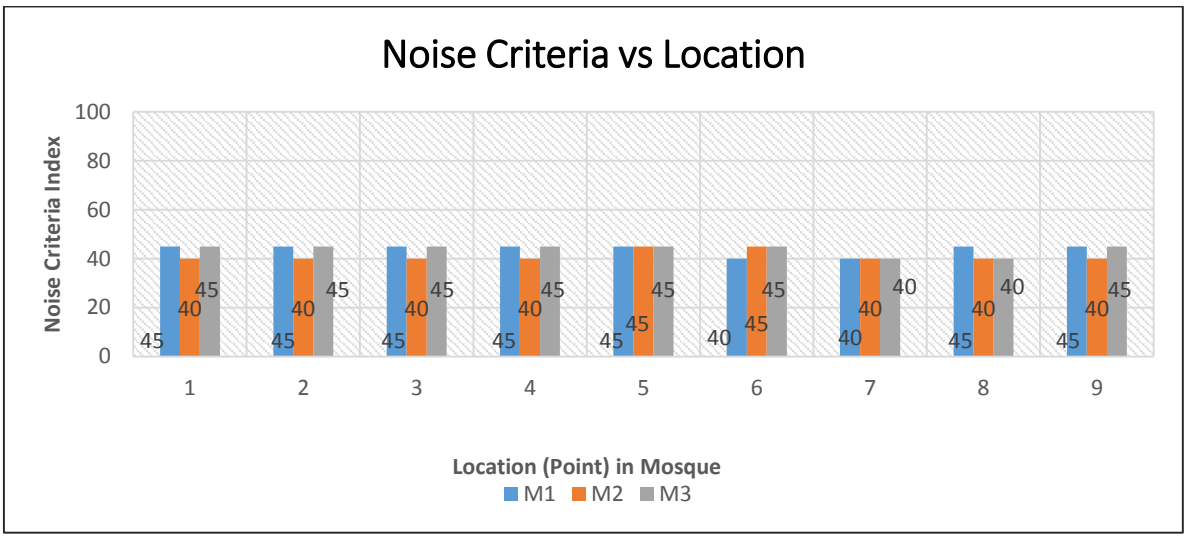

Figure 5: Noise Criteria (NC) versus Location Graph

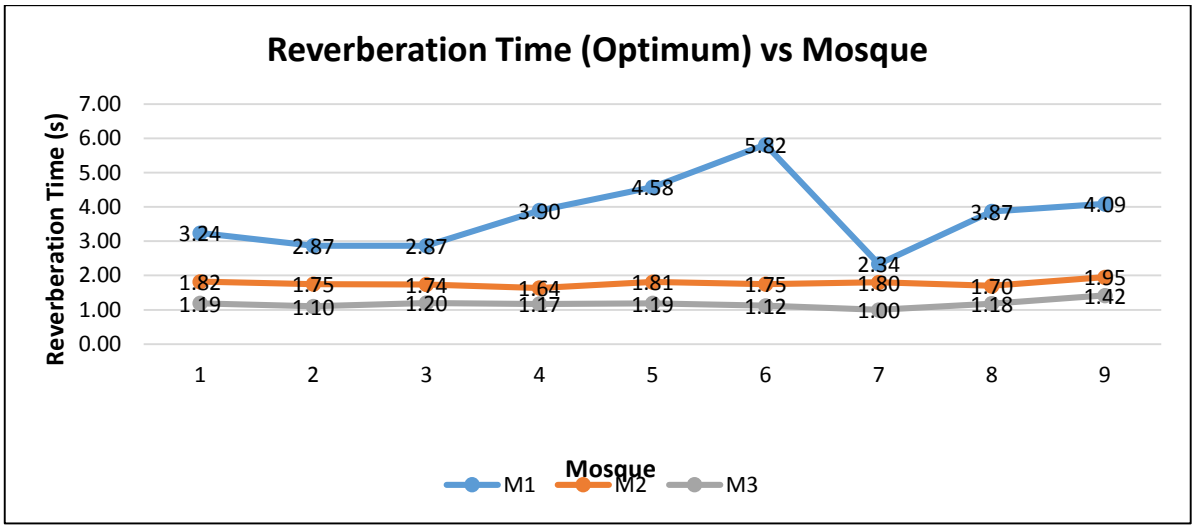

Figure 6: Reverberation Time -Optimum (RT) versus Location Graph

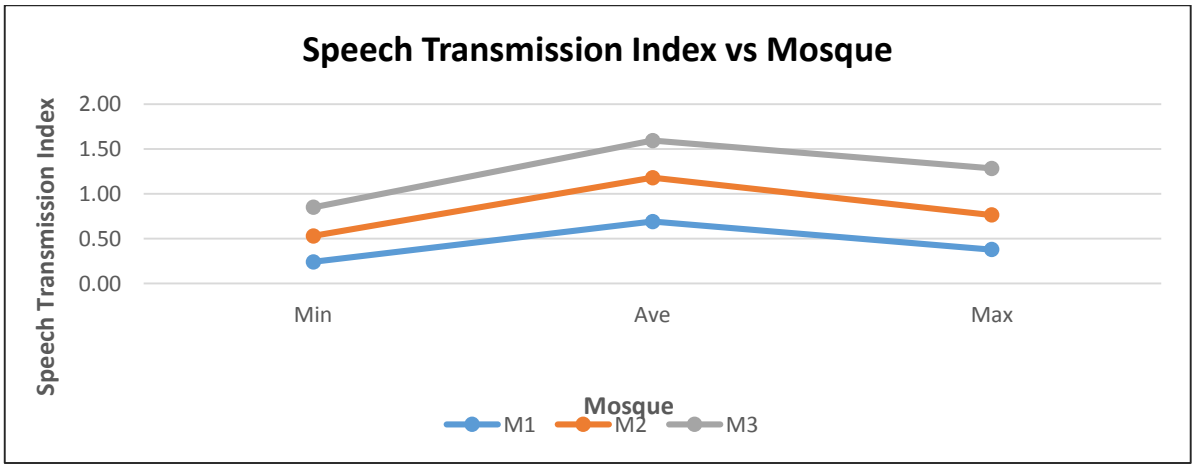

Figure 7: Speech Transmission Index (STI) versus Mosque Graph

5. Conclusion

This research has successfully achieved the two fundamental goals as been stated earliear. The primary aim is to assess the acoustic quality level in the mosque in term of noise criteria (NC) resonation time (RT) and speech transmission index (STI).. Meanwhile, the second objective is to identify factors affecting the acoustic quality level within the mosque based on the data obtained and observation during the testing. The significance of this study is to evaluate the variables that affect the acoustic quality level experienced by the gatherings in the mosque and can be utilized as a part of considering the best possible acoustics necessities to deliver great acoustic conditions in the mosque. An excellent quality of acoustics can help in increasing the satisfaction of hearing by the congregation towards speech while enhancing the khusyu' feeling during worship. In view of the outcomes from this research, other than the physical components of the mosque, which is the floor design plan and its volume, different factors, for example, area, building material, establishment of sound assimilation material and the quantity of tenants additionally impact the nature of the acoustics of a mosque.

6. References

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