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Predicting and Assessing the Acoustical Performance of Mosques Employing Computer Simulation: A Case Study

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Abstract: Since the construction of the first mosque, by the Prophet Mohammed (PBUH), the architectural form, space, construction system, and building materials of mosques have evolved and developed to a great extent. In mosques all devotional activities are dependent on speech audibility and intelligibility and thus, good acoustics are needed to achieve good listening conditions. However, the field of mosque acoustics, compared to that of other religious buildings where speech intelligibility is important has received very little attention.

This paper presents and discusses the potential of utilizing room-acoustics simulation in the early stages of mosque design where decisions establish the room geometry, surface materials, and the electro-acoustic sound system distribution. A typical mosque, in Saudi Arabia, is used as an example application. A state-of-the-art computer modeling and simulation software is used to assess the mosque's acoustical performance with and without the use of a sound reinforcement system. The overall objective is to draw attention to an efficient tool that facilitates interactive design and, when combined with an auralization system, it offers listening experience in the space under consideration. The study is expected to contribute to a better understanding of the acoustical requirements of mosques and provide acoustics design guidelines to improve the acoustical performance of existing mosques and those that are still in the design stage.

Introduction

Although mosques are important unique buildings in every Muslim community, in general their acoustic performance evaluation, problems and possible remedies to these problems have not received adequate attention in the literature. However, credit to the early attempt to evaluate the acoustic performance of mosques in Amman, Jordan, [1] must be given. The study concluded that, in general, the acoustic characteristics of mosques had been largely neglected. In 1991, the acoustic problems of a huge mosque built in Amman were investigated[2]. The authors recommended that acoustic properties of mosques should be considered at the early stages of design. Recently, a study [3] established the relative influence of active environmental control systems on the acoustic performance of a typical mosque.

Compared to the acoustics evaluation of other religious buildings [4-8] and halls used for other functions, the assessment of sound quality for speech intelligibility in mosques as well as its relation to their architectural features has been neglected. For example, the varying of the acoustics of a large cathedral for satisfactory speech intelligibility, by the use of carefully designed, installed, maintained and operated sound amplification system has been demonstrated and discussed [6]. In addition to assessing acoustic quality by using pressure-based room acoustics indicators, visualizing the directional characteristics of sound fields at the listener position is also possible by employing 3-D transient sound intensity impulse responses. This technique has been utilized to assess the effectiveness of a sound system in a

large reverberant church [7]. Subjective and objective acoustical field measurements have been conducted in a survey of 36 Roman Catholic churches in Portugal [8]. The idea was to evaluate and predict the acoustic quality of these churches. Correlation analyses and statistical modeling identified relationships between some room-acoustics indicators and speech intelligibility in this particular style of church.

On the other hand, the influence of architectural design on the acoustics of various halls has also been investigated [9]. The limited research work that has been reported on mosque acoustics in the literature underlines the need to develop a comprehensive knowledge, particularly of mosques in Saudi Arabia, where conditions are different from the few examples of mosques reported on earlier. Moreover, recent developments employing impulse response techniques [10,11] for acoustically evaluating different types of existing building have not yet been applied to mosques, bearing in mind their unique multi-function role. The applications of these techniques have been highlighted in reference [11].

Assessment of Acoustical Performance of Mosques

Nowadays, numerous subjective attributes of the listening experience in enclosures can be described by the many available contemporary room-acoustics indicators. The primary purpose of an objective room-acoustics indicator is to provide the acoustician, engineer, or architect with an explicit measure of subjective relevant quality. This purpose is well served by the many objective indicators available, which have been validated and systematically measured. A comprehensive listing of these contemporary indicators, their definitions, corresponding subjective attributes and suggested tolerance range values can be found in reference [12].

All activities in the mosque are dependent on speech audibility and intelligibility. These two factors are, thus, central to the evaluation of sound quality in a mosque. Knowledge pertinent to mosque acoustics in this regard compared, to that of other religious where speech intelligibility is important has received very little attention. This study surveys two relevant aspects of mosque acoustical design. These are speech intelligibility measures and computer-based modeling and simulation. Types and features of mosque design will also be presented, followed by an investigation of the case study.

The nature of speech intelligibility can be seen in terms of information loss in both the physical and the physiological domain [13]. The intelligibility of speech in rooms is related to both the speech signal-to-noise ratio and to the acoustic characteristics of the space. That is, it can be influenced by the ambient background noise and the Reverberation Time (*RT*) of the enclosure. In order to measure or predict speech intelligibility, two groups of measures can be used, subjective (direct) and objective (indirect). Examples of subjective-based indicators are Phonetically Balanced Words (PBW), and Modified Rhythm Tests (MRT) [14]. Examples of objective-based measures (indirect) are Definition (D_{50}), Clarity (C_{50}), Useful-to-Detrimental Sound Ratios (e.g. SNR_{95}, U_{50}, and U_{80}), Speech Transmission Index (STI)[15,16], Rapid Speech Transmission Index (*RASTI*) [17,18], and Articulation Loss of Consonants ($\%AL_{cons}$). A new measure, the Common Intelligibility Scale (*CIS*) is currently under consideration in the UK [14]. The most commonly used speech intelligibility measures have been examined to identify their use, and distinct limitations. The shortfalls of the *STI* method have been highlighted [19]. In a comprehensive comparison of three measures of speech intelligibility in rooms (i.e. U_{50} and U_{80}, $\%Al_{cons}$ and *STI*), a derivation of practical conversions among the different types of speech intelligibility measures was found to be possible [20].

Computer Modeling and Simulation of Acoustics

In general, room-acoustics evaluation can be performed in the early design stage by utilizing computer-based modeling and simulation. Room-acoustics programs have typically been used for the prediction and assessment of room acoustic indicators. For example, the prediction of echograms and impulse responses within enclosures utilizing "*Epidaure*" software has been described [21]. A combined beam tracing and radiant computer model of room acoustics has been developed [22]. Comparisons between results from a physical scale model and a computer image source model for architectural acoustics have also been conducted [23].

As part of an ongoing research project [24], the "*Odeon*" acoustics simulation package offers utilities necessary for the basic acoustic evaluation of large rooms. The modeling approach combines both image source theory and ray-tracing algorithms taking diffusion into account using hybrid calculations. The aim is to maximize the accuracy of the prediction in short calculation times. The model runs on IBM PC's and compatibles. In an international "round robin" on room acoustical computer simulation [25] the "*Odeon*" model has proven to be reliable in the predication of room acoustic indicators. The program capabilities and features can be found in reference [26]. Using such computer modeling and simulation, problems such as echoes and localization can be identified and the overall acoustic performance can be assessed. In addition, computations of introducing sound reinforcement systems using multiple electro-acoustic sources can be investigated at the very early building design stages. Based on the modeling approach and the above features, "*Odeon*" was chosen for conducting the acoustic simulations.

Mosque Architectural Design

In Muslim societies the mosque is the most important building in the community, providing a sense of identity and place. The first mosque was built in *al-Madinah al-Monawarah* by the Prophet Mohammad, (PBUH). Historically, it formed the model for subsequent mosques throughout the Islamic world in its combination of basic elements. It was a simple rectangular, walled enclosure with a roofed prayer-hall on the *qibla* side, a *mihrab*, and an open *sahan*, with the *minbar* from which to deliver the *khutba* to the right of *mihrab* [27]. These elements are the essentials of mosque design in Saudi Arabia, as they are elsewhere in the Islamic world. Since the construction of the first mosque, the multi-functional nature of the mosque has remained unchanged. However, the mosque architectural form, space, construction system, and building materials have evolved and developed to a significant extent. Nevertheless they have retained the basic common design features as spaces for worship.

In general, traditional mosques all over the Muslim world can be classified based on their architectural configuration. Contemporary mosques may also be broadly classified, according to their size and location [28, 29], as **1.** *Large Mosques* located in large cities as public landmarks. These mosques are usually built by the government expressing the state's commitment to Islam. They are generally grand in size and of large congregational capacity **2.** *Community Mosques* (*"Jamma" Mosques)* distributed in urban and rural communities and may house multiple functions (e.g. library, school, meeting rooms, clinic, etc.) in addition to the prime function of a space for prayer. They are usually utilized for both "*daily*" as well as "*Friday*" prayers and occasionally are supplemented with a separate annex on the same floor level or in a mezzanine for female worshippers. **3.** *Small Local Mosques* located in small neighborhoods, which are of modest dimensions. The planning standards for the above three types of mosque are available [29].

Interior materials of contemporary mosques vary. Walls are mostly finished with reflecting materials such as painted plaster partially faced with marble tiles. The floor area is always carpeted. Hard, painted concrete ceilings with simple to elaborate decorations are commonly used. Due to the harsh climatic conditions in most of Saudi Arabia's regions, air-conditioners are virtually a necessity. Therefore, almost all types of mosque are equipped with either a central, or a split unit air-conditioning system or window type units, in concert with some ceiling fans. Electro-acoustic sound reinforcement systems have also been implemented in mosques of all sizes to improve the hearing conditions in the space, particularly after the introduction of the air-conditioning systems and the subsequent increase of ambient noise in the mosque.

A Typical Mosque: Case Study

In Saudi Arabia, many types of mosque design exist [30]. In the documents of the Ministry of Islamic Affairs, they are denoted with alphabetical letters for identification. Figure (1) shows the architectural design layouts and the main features of sample contemporary mosque types commonly constructed in the Kingdom. A typical mosque with the architectural design as shown in figure (2) (referred to as *Type C*) is used as the case study for this investigation to show the potential benefits of utilizing acoustic simulation in the early design stage. As can be seen from the parts of figure (2) (i.e. plan, sections and isometric), the mosque has a covered rectangular prayer-hall of 20.0 x 12.0 m and a height of around 4.8 m. It is a medium-size, community mosque with a volume of approximately 1130 m^3 and a distance of approximately 14.0 m from the *Imam's* (i.e. the speaker) usual location near the *qibla* to the most distant worshipper. A rectangular open court *sahan* leads to the covered main prayer hall and is usually used as an extension area for worshippers. The interior finishes used for the mosque have been selected to mimic typical finishes commonly applicable in such mosque types constructed in practice. The mosque roof is flat, supported by 8 slim square columns carrying intersecting beams of moderate depth which in turn support the roof slab. Since a comparison of alternative mosque forms is not the subject of this study, the architectural form and space design are assumed constant with the only allowable changes or modifications being to the interior surface materials. That is, the form of the mosque will not be altered.

Two different design scenarios were examined by the simulation program, through which other modifications were introduced to improve the mosque's acoustic performance and to study the impact of design decisions. These scenarios are:

The Mosque without an Electro-Acoustic Sound System

The following simulation conditions are assumed: The *Imam* is delivering a speech (*khutba)* from the *minbar* which is elevated one-meter from the mosque floor. The *khutba* is delivered in a raised voice without the aid of any sound reinforcement system. The sound power spectrum of the *Imam* raised talk is depicted in figure (3) compared to that of a normal voice. The worshippers are assumed to be seated on the floor listening the to the *khutba* as is usually the case during "*Friday*" prayer. Their ear height is taken to be 0.80 m from the floor.

As a starting point, knowing the volume of the prayer hall, it is possible to estimate the required optimum mid-frequency reverberation time (*RT*) for good speech intelligibility. Figure (4) depicts the relationship between the room volume and the optimum mid-frequency (500-1000 Hz) (*RT*) for speech purposes. From the graph it can be seen that in the

case at hand, the global *RT* optimal value should be in the range of 0.6 to 0.7 *sec*. This value is then considered the initial goal to achieve when considering the selection and the proper location assignment of the mosque interior finishes, particularly for large surfaces such as the ceiling, walls and floor areas.

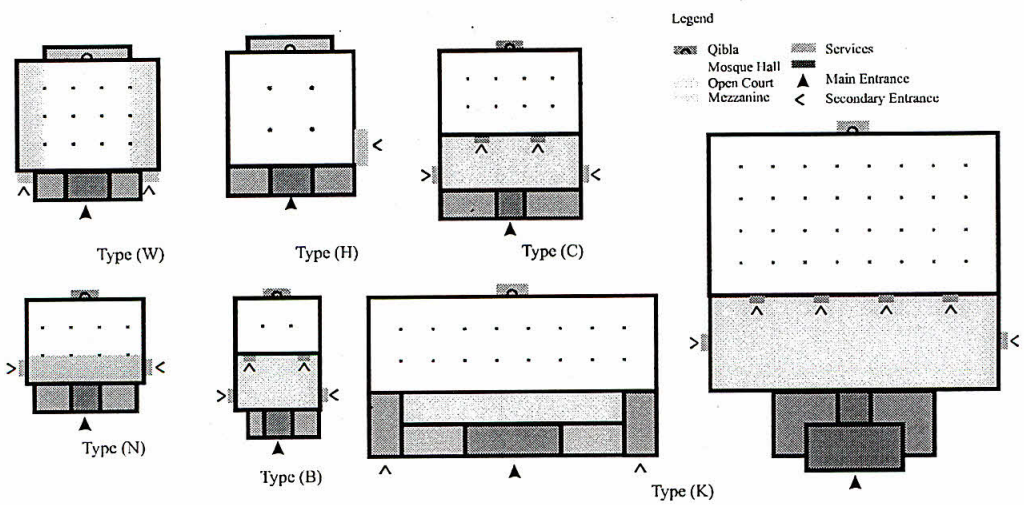


Fig. 1: The architectural design layouts and main design features of sample mosque types.

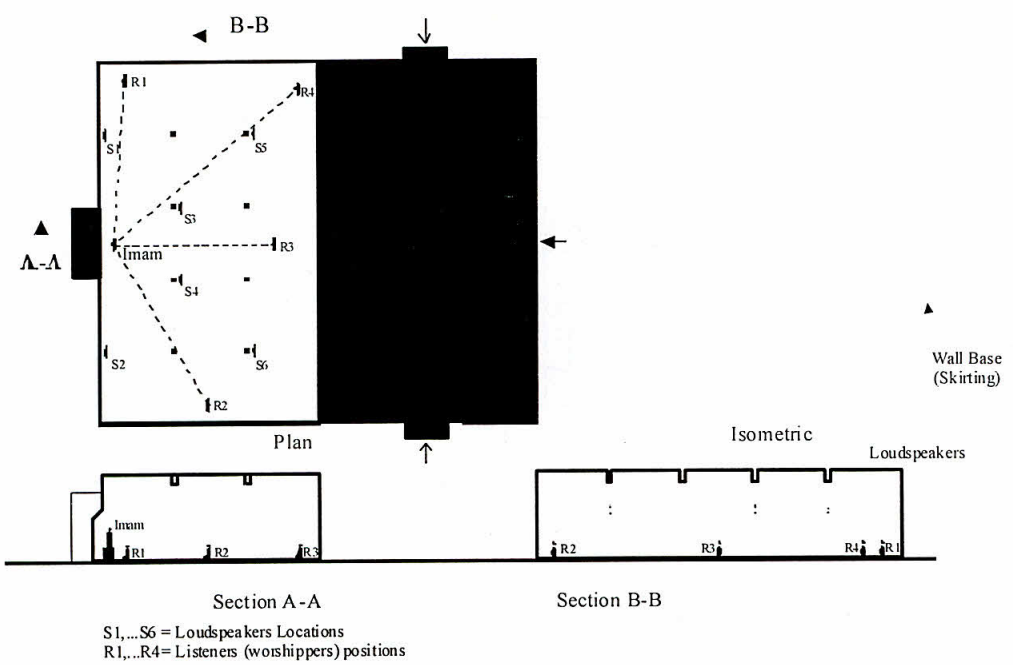


Fig. 2: The case study: A typical mosque design (i.e. Type C). The "Imam" position along with four listeners' locations are indicated and denoted R1, R2, R3 and R4.

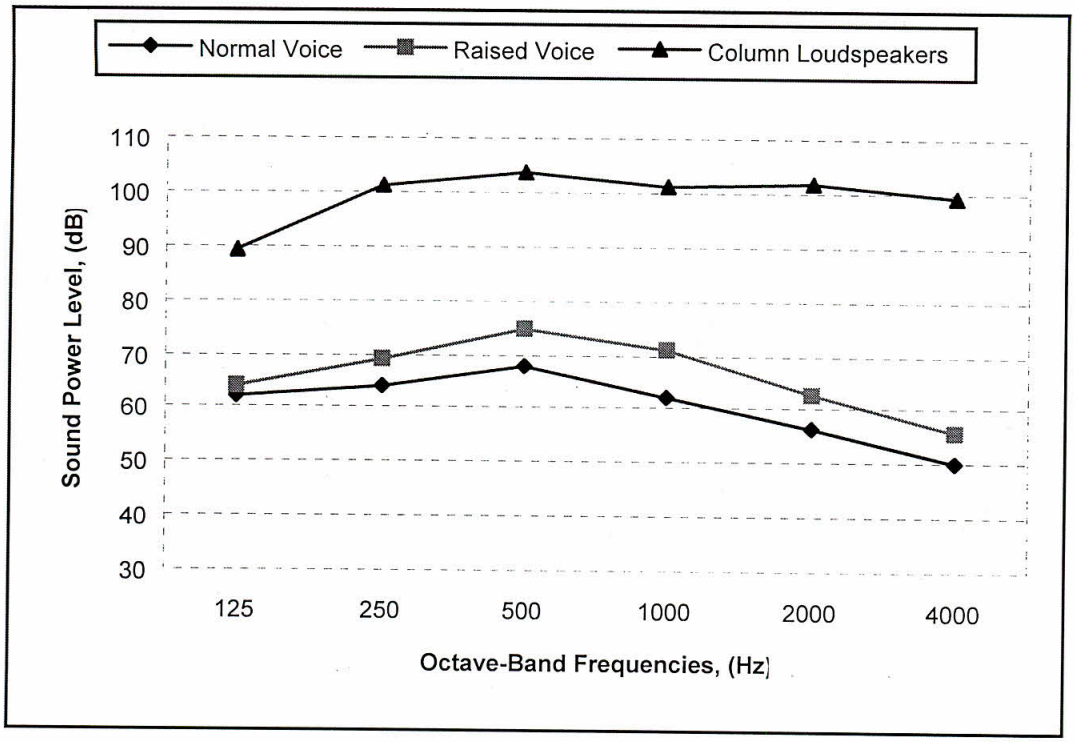


Fig. 3: The sound power spectrum (dB) of a person speaking in a raised voice compared to that of a normal voice

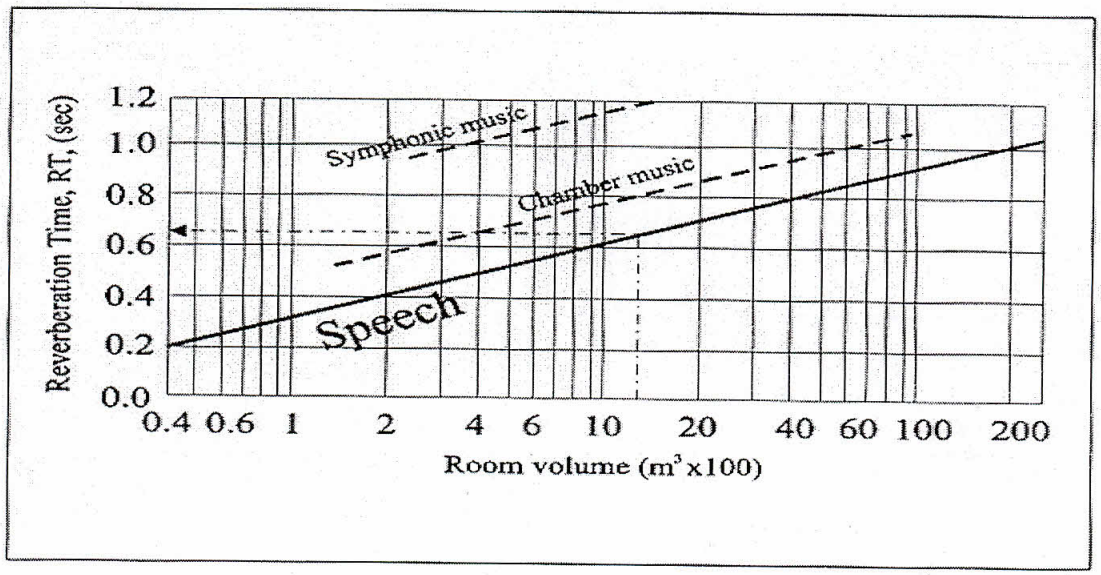


Fig. 4: Optimum mid-frequency (500-1000 Hz) reverberation time (*RT*) as a function of room volume and use. [31, p. 1325]

In all the attempts to reach a best overall *RT*, four listeners' locations, representing different zones of the mosque, were investigated to study the positive impact or otherwise of the changes on the sound quality with respect to speech intelligibility. These locations are indicated in (Fig. 1) and denoted *R1*, *R2*, *R3*, and *R4*. Sound quality indicators such as *RT*, an A-weighted sound pressure level *SPL*(A), C_{80} and *RASTI* were used for comparisons. *RT* values based on the classical "Sabine" RT_{Sabine}, "Eyring", RT_{Eyring} formulae, RT_{20} , *and* RT_{30} , (evaluated from the sound level decay curves between –5 and –25 or -35 dB) were considered in both the unoccupied and fully occupied state of the mosque.

(Table 1) indicates the assigned finish materials to the mosque surface and interior architectural features along with their diffusion coefficients. These were used as a "*first choice*" design decision for the simulation and will be referred to as Case 1. The range of absorption characteristics of all assigned finish materials used throughout the simulation process for approaching a satisfactory *RT* value are shown in (Fig. 5).

Table 1: Material assignments for the typical mosque interior surfaces: Case 1

Surface	Assigned Material	Diffusion Coeff.
Ceiling, Beams and Walls	Painted plaster, surface; smooth finish	0.15
Floors	9mm tufted pile carpet on felt underlay	0.4
Wall Base (1.0 m)	Cladding of marble tiles (see Fig. 1)	0.1
"Qibla" niche	Ceramic tiles with smooth surface	0.1
Columns	Cladding of marble tiles	0.1
Windows	Single pane of glass, 3 mm	0.1
Doors	Solid wooden door	0.1

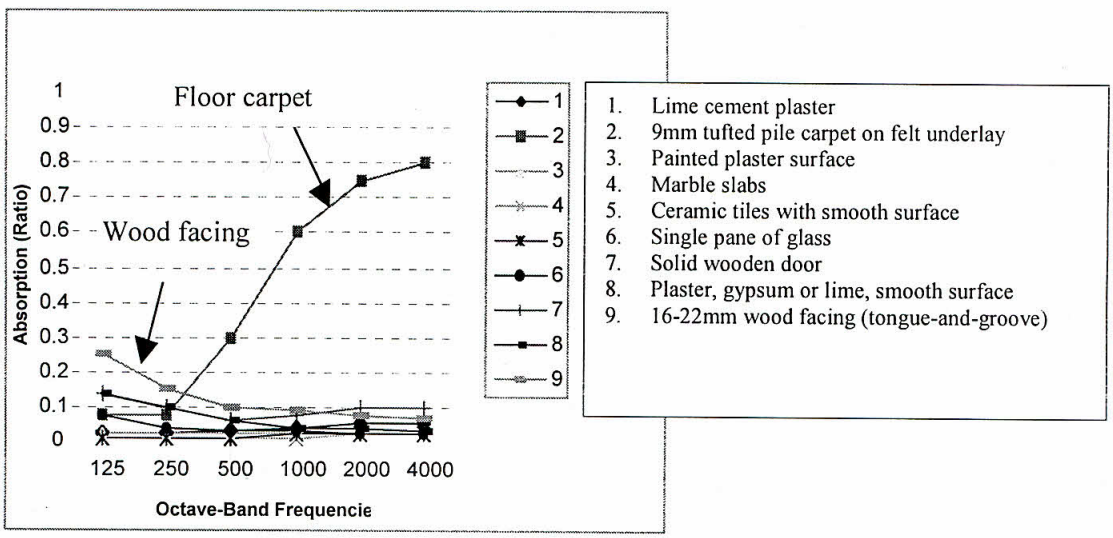


Fig. 5: The range of the absorption characteristics of all assigned finish materials used throughout the simulation process for approaching a satisfactory global *RT* value.

Simulating Case 1 resulted in a mid-frequency *RT* value of 1.4 *sec*. The interior surfaces finishes were then modified. Lime cement plaster with a smooth finish was assigned to the ceiling, beams and columns. The material of the wall bases (skirting) was changed to 16-22 mm thick wood facing (i.e. Case 2). In Case 3, the ceiling, beams and wall surfaces were assumed to have a smooth finish of plaster, gypsum or lime. The wall base and the columns were faced with marble tiles. (***Table 2)*** shows the final material selection for the mosque interior surfaces. The finish materials of the *qibla* niche, windows and doors were kept constant in the four cases.

Table 2: Material assignments for the typical mosque interior surfaces: Case 4.

Surface	Assigned Material	Diffusion Coeff.
Ceiling, Beams and Walls	Plaster , gypsum or lime, smooth finish	0.15
Floors	9mm tufted pile carpet on felt underlay	0.4
Walls' Base (1.0 m)	16-22 mm wood facing (tongue-and groove)	0.2
"Qibla" Niche	Ceramic tiles with smooth surface	0.1
Columns	Lime cement plaster	0.1
Windows	Single pane of glass, 3 mm	0.1
Doors	Solid wooden door	0.1

(Fig. 6) shows comparisons of the global *RT* values versus octave-band frequencies (Hz) resulting from the simulation of Cases 1, 2, 3 and 4 when the mosque is empty or with only a few worshippers. The impact of the finish material changes, or modifications to ceiling, walls and columns, is evident. As can be seen from (Figs. 6a & 6b) long *RT* values at low frequencies compared to the mid- and high frequency range are evident. This may be due to the low absorption at low frequencies and the size of the painted plaster surfaces. Although mid-frequency *RT* values may be acceptable, the high values at low frequencies might cause masking of frequencies relevant to speech. Consequently Case 4 was considered the best overall. The case was then re-simulated with a full occupancy of worshippers. (Fig. 7) shows the resulting *RT* values. As expected, further reduction of *RT* values can be seen to result in an average of RT_{Sabine} of 0.7, RT_{Eyring} of 0.6, and RT_{20} of 1.1 sec at 500-1000 Hz. While the wise and objective selection of proper surface materials helped to reduce the global RT of the mosque, one may notice from Figure (8) that sound pressure levels (SPL) at the worshippers' four locations R1, R2, R3 and R4 are not adequate for proper speech audibility. Since RT is only one contributor to intelligibility of speech, it was necessary to study and satisfy other parameters such as SPL(A) and C_{80}. At this point of the investigation, a full assessment that included a grid mapping of the other relevant indicators for the entire prayer-hall was found necessary. Consequently, a grid of 1.0 x 1.0 m was established at a height of 0.80 m from the floor to represent the worshippers' ear level. The purpose was to study the distribution patterns of speech indicators and to be able to judge acoustical deficiencies in terms of locations and parameters of widely acceptable value ranges. (Fig. 9) depicts the distribution patterns of early decay time (*EDT*), *RT*, and $C_{80\ at}$ the 500 Hz octave-band. As can be noticed from part (a), sound decays in a short time i.e. < 0.8 *Sec* in the zone near the *Imam*. This occurs where direct sound dominates, with a radius of 4-5 m beyond which the reverberant sound field dominates and both *EDT* and *RT* increase

to higher values greater than 1.3 *Sec* in the furthest locations of the prayer hall. This is due to the effect of configuration, and the existence of columns and large wall surfaces. Sound clarity, C_{80} as shown in part (c) of the same figure is quite poor behind the columns in a diagonal direction towards the back corners of the floor area.

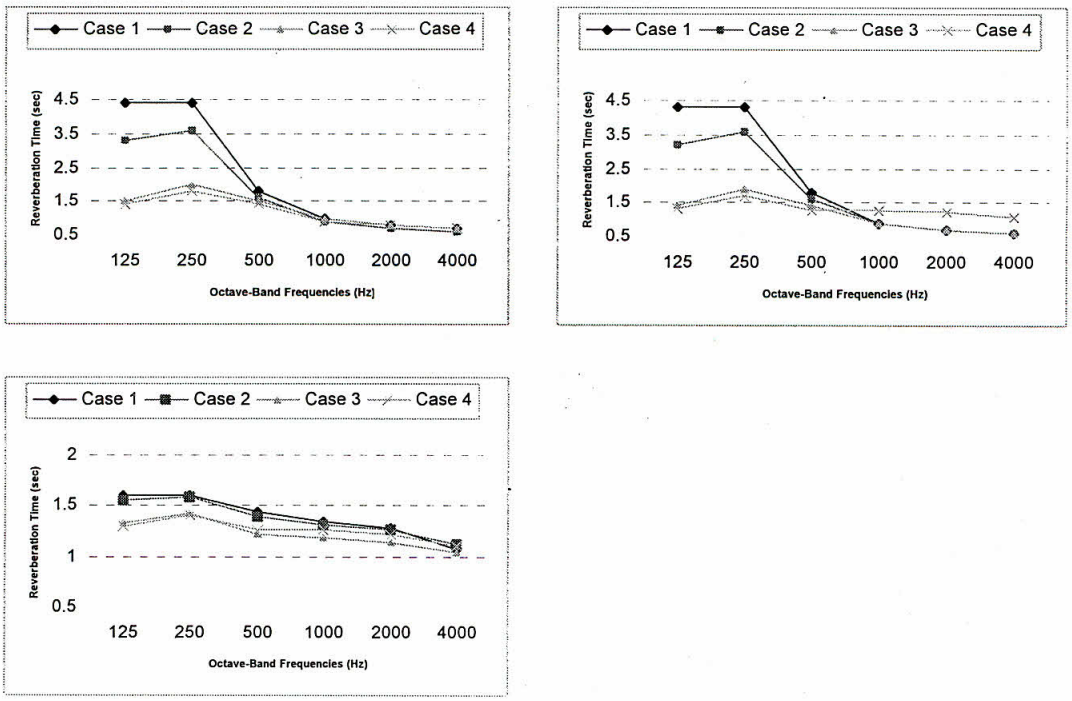


Fig. 6: Global RT values versus octave-band frequencies resulting from the simulations of Case 1, 2, 3 and 4, when the mosque is empty or with very few worshippers, (a) based on the classical Sabine formula, RT_{Sabine} (b) based on the Eyring formula, RT_{Eyring} and (c) RT_{20} values evaluated between –5 and –25 dB

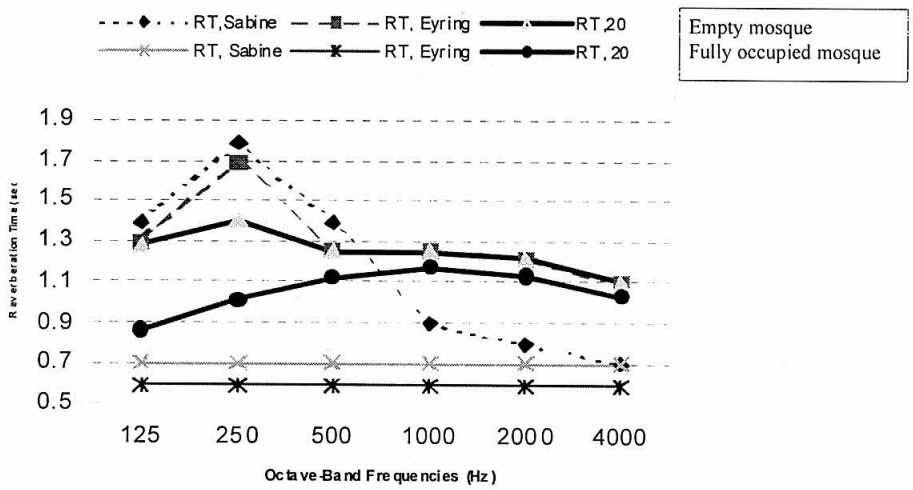


Fig. 7: Global RT_{20} values versus octave-band frequencies resulting from the simulations of Case 4 when the mosque is empty and fully occupied

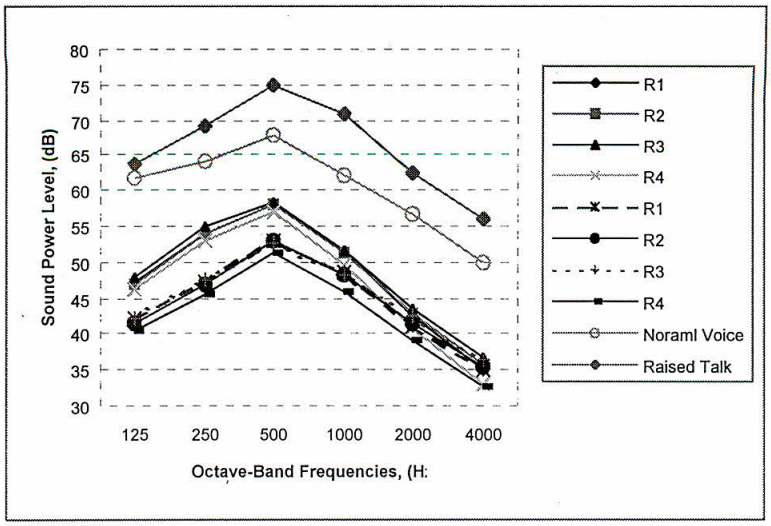


Fig 8: Sound pressure levels (*SPL*) values at *R1, R2, R3 and R4*, versus octave-band frequencies resulting from the simulation of Case 4 when the mosque is empty and fully occupied.

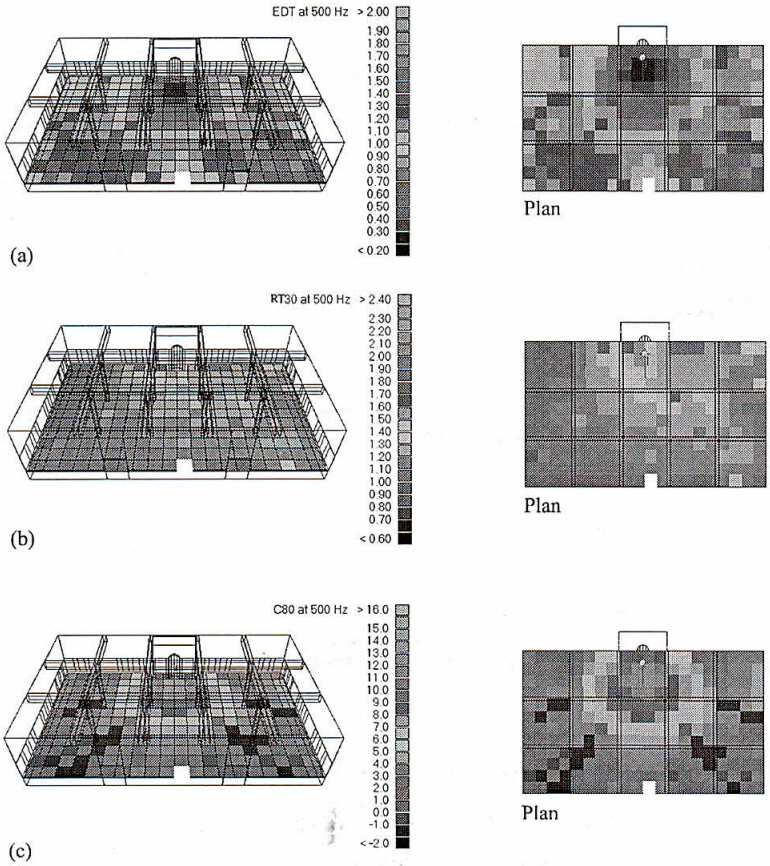


Fig 9: Distribution pattern of sound quality indicators within the mosque hall (occupied) at a grid of 1.0X1.0 m, 0.80 m above the floor, at 500 Hz octave-band frequencies, (a) distribution pattern of early decay time, *EDT*, and (b) reverberation time, RT_{30}, and (b) sound clarity, C_{80}.

Examining the distribution pattern of SPL(A), shown in Figure (10), which is more relevant to human hearing, shows the deficiencies in the indicated locations. Further improvements can be implemented with respect to changes in the surface materials but this would not alleviate the low *SPL* decrease with distance. The next logical decision to overcome this acoustical deficiency would be to introduce a sound reinforcement system. The purpose of an electronic sound-reinforcement system is to provide all listeners with reasonably loud speech (satisfactory speech-to-noise ratio) so that it can be heard above the ambient noise and the reverberant sound where un-amplified sound would not be sufficient. In this case many decisions with respect to the type of the sound system and its distribution must be addressed and this is dealt with in the following section.

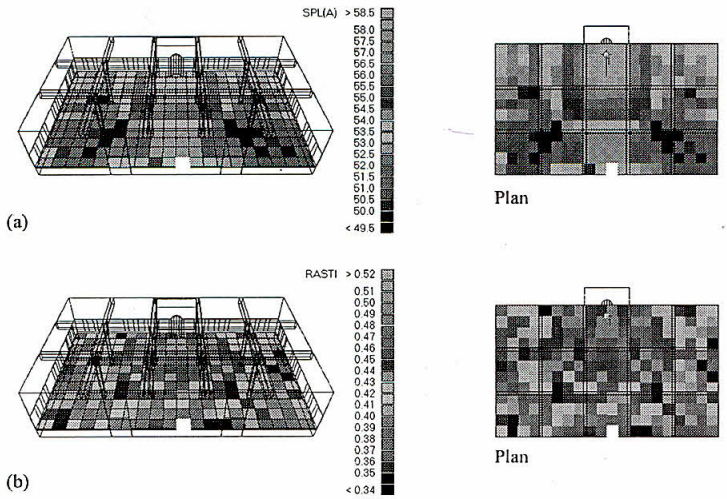


Fig 10: Distribution pattern of sound quality indicators within the mosque hall at a grid of 1.0X1.0 m, 0.80 m above the floor, (a) distribution pattern of *SPL(A)*, and (b) *RASTI.*

The Mosque with an Electro-Acoustic Sound System

The earlier simulation conditions were considered unchanged but a sound system composed of 6 column-type loudspeakers was then distributed to enhance the audibility of the speech at poor areas or locations. Figure (11) shows the configuration of the loudspeaker in question and its typical directivity pattern in the vertical and horizontal planes. Each column loudspeaker is composed of 4 small cone loudspeakers arranged in a vertical array to compose a line source. Initially, they were placed at a height of 3.6 m above the floor, and directed towards the congregation with a tilted angle of -20° around its vertical axis.

When speech is of interest, there is a desirable need for the sound to appear to be coming from the Imam i.e. realism. The sound levels of the loudspeakers on the qibla wall were set to a higher level (i.e. set with higher gain) relative to the sound level of speech and the rest of the loudspeakers, in order to achieve localization to the Imam position that would result in a sound corresponding to a raised voice. Time delays to the source signal. (i.e. delays in the electronics) were not introduced. The impact of the sound system was examined with different tilt angles ranging from 0° to –25°. The height of the loudspeakers was then modified to 2.2 m above the floor. Figure (12) depicts, RT_{30}, SPL and $C_{80\ sound}$ quality indicators at the most distant worshipper location R4, 0.8 above the floor, when the mosque is empty and fully occupied with and without the aid of the sound system.

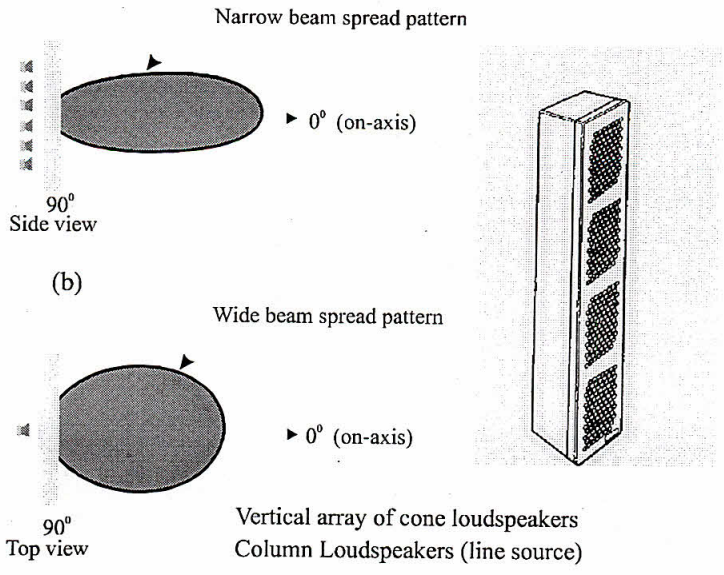


Fig. 11: Column loudspeakers, (a) configuration, and (b) typical directivity patterns in the vertical and horizontal plane ((b) adapted from reference [32, p. 370])

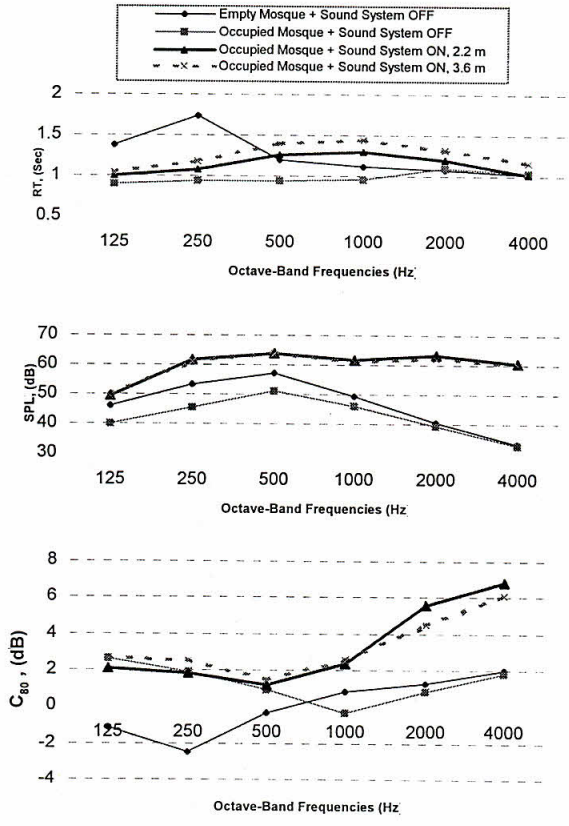


Fig. 12: Comparisons of sound quality measures at worshipper location R4, 0.8 m above the floor, RT_{30}, (b) *SPL*, and (c) clarity, C_{80} in the empty and fully occupied mosque without and with the aid of the sound reinforcement system.

Loudspeakers are compared in the two examined heights. The positive effect of the sound system in improving the *SPL* to a level comparable with a raised voice that is balanced at most octave bands, and sound clarity C_{80}, particularly in the mid-frequency range can be seen in part (b). Installing the loudspeakers at a 3.6 m height may excite the mosque volume above the congregation overhead before it reaches the ears of the worshippers, especially when they are seated on the floor.

Discussion and Guidelines

Numerous attempts were made to simulate a variety of design decisions in the process of designing a typical mosque, some of which were described in the earlier sections. It is very important to bear in mind that designing a space for good speech intelligibility must be achieved before considering any sound-aid systems. The case study showed that selecting proper surface materials is a first step towards satisfying this objective. Computer-based simulations facilitate this process. Designing with a sound reinforcement system comes second to eliminating inherent acoustical deficiencies. The selected electro-acoustic sound system should therefore increase the direct sound field more than it excites the reverberant sound field. This implies that the loudspeakers should be installed above the congregation when they are standing for performing of prayer and not too far away from them. Pointing the loudspeakers toward the closest worshippers by tilting them vertically at an angle between -15° and -25° also avoids exciting the volume of the mosque above the worshippers. The higher the loudspeakers, the greater the tilt angle should be. In addition, sound is absorbed by the worshippers' bodies before it can become reverberant. This also helps to avoid echoes as a result of axial sound propagation between parallel walls. There is also a desirable need for the sound to appear be coming from the *Imam*. This sound realism can be achieved by setting the sound level near the *Imam's* location to a level equal or higher, relative to that of the direct sound of the *Imam* and other suspended loudspeakers located further away at the back of the mosque. Uniform coverage of the sound pressure level of direct amplified speech evenly distributed throughout the prayer hall is also required. This will certainly be affected by the loudspeakers' characteristics and layout (placement), which when poorly positioned result in an ineffective sound reinforcement system.

Conclusions

It has been shown in this study that acoustics simulation is beneficial in the early design phase of mosques. By using computer simulation to evaluate the acoustic performance of mosques, it is possible to conduct an overall assessment of the sound quality by comparisons of different solutions and design decisions. The impact of material selection and location and introducing a particular sound-reinforcement system can be visualized and its effectiveness evaluated. The design process is explored via a case study of a typical mosque to show the potential of practical and objective selection of interior finish materials to achieve a satisfactory reverberation time for good speech intelligibility as a prerequisite, before introducing any type of sound system. The location, characteristics and guidelines for the installation of a distributed column sound system for the case being described are given. The impact of the loudspeaker set-gain, height, and tilt angle has been investigated. Comparisons between different sound systems can be made for the best overall acoustic performance.

It is the author's view that utilization of computer-based simulation tools will certainly help to bridge the gap between the "*deaf*" architect the and "*blind*" acoustician. The "*deaf*" architect usually places more emphasis on impressive forms and spaces that are aesthetically pleasing

without regard to its acoustical impact, while the "blind" acoustician who, most of the time, only cares about selecting a sound system with satisfactory quality, specifications and technical performance without regard to the enclosure in which the sound system will be used and subsequently how its different components will interact with the space. Further research is currently ongoing to investigate larger mosques (landmarks) with contemporary design and configuration. Field measurements in existing mosques are also integral in characterising their acoustic performance and allow post-construction evaluation. State-of-the-art impulse response techniques will be used to evaluate the typical mosque presented in this study via field measurements.

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تقييم الأداء الصوتي للمساجد باستخدام المحاكاة بواسطة الحاسب الآلي

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ملخص البحث: منذ بناء أول مسجد في الإسلام شهد بناء المساجد تطورا كبيرا ليتناسب مع التغير في الاحتياجات الإنشائية والوظيفية ومواد البناء الحديثة، ويعتبر سماع الحديث وإدراكه من أهم الخصائص التي يجب توفرها في المسجد ومن المعلوم أن جودة الصوت داخل الفراغ تعتمد بشكل كبير على خصائص الفراغ و مواد البناء الداخلية وكذلك أنظمة تقوية الصوت المستخدمة، إلا أن دراسة الصوتيات في المساجد لم تلق الاهتمام الكافي . يناقش هذا البحث إمكانية استخدام نمذجة ومحاكاة الصوتيات في الفراغات المعمارية في المراحل الأولى من تصميم المسجد حيث تتخذ العديد من القرارات التي تنعكس على الشكل الهندسي، ومواد التشطيبات الداخلية، وتوزيع نظام تقوية الصوت. وتستعرض الدراسة مثال تطبيقي على إحدى النماذج الحديثة التي تبنى في المملكة العربية السعودية لاستخدام أحدث برامج النمذجة والمحاكاة لتقييم الأداء الصوتي للمسجد، وتهدف الدراسة إلى توجيه الاهتمام بوسيلة فعالة للتصميم المتفاعل بهدف فهم أفضل للمتطلبات الصوتية في المساجد ووضع الأسس التصميمية لتحسين الأداء الصوتي في المساجد سواء القائم منها أو التي في طور التصميم الأولى.