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The American University in Cairo

School of Humanities and Social Sciences

**The Development of Acoustics in the Religious Architecture of Cairo
from the Arab Conquest through the Ottoman Period 640-1914**

A Thesis Submitted to

The Department of Arab and Islamic Civilizations

In Partial Fulfillment of the Requirements

For the Degree of Master of Arts

By

Ahmad Awaad Mohamed Hussein

(Under the supervision of Dr. Bernard O'Kane)

May/2016

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In partial fulfillment of the requirements for
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DEDICATION

To whom I learnt from the passion of seeking science and knowledge:

Professor Dr. Awaad M. Hussein, University of California, Davis

Professor Dr. Magda Bahgat, Ain Shams University

Professor Dr. Adel A. Kader, University of California, Davis

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Abstract

It is strongly believed that the scholarship in the field of Islamic art and architecture still has many important under-researched areas, behind its visual aspects, that need to be explored and analyzed. Archaeoacoustics, which is scientifically known as "The archaeology of sound," is considered one of the significant disciplines in the field of acoustics due to its role in revealing priceless information about different archaeological sites and historic buildings around the world from the acoustic perspective.

Unfortunately, the archaeoacoustic studies of historic Islamic religious buildings, especially in Cairo, are relatively neglected. Accordingly, this study aims in the first place at analyzing the archaeoacoustic aspects and development of major Cairene religious buildings, from the time of the Arab conquest through the Ottoman period, in their relation to modern acoustics. Such analysis is believed to contribute effectively in partially reconstructing the soundscape of the examined historic buildings with regards to answering the following question: to what extent had the architect, throughout the different the different periods of the Islamic history of Cairo, been acquainted with the architectural acoustics principles? And how did that knowledge affect the architectural designs of his religious buildings?

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Introduction

"Recite in the name of thy Lord and Cherisher who created man from a clot of blood. Read and thy Lord is most generous, who taught by the pen, taught man what he knew not."¹ These divine commands and words represent the very first verses of the Holy Quran revealed during the month of Ramadan; namely in the Night of Power and Excellence in the year 610CE. They were sent by Allah, the most exalted, to the Prophet Muhammad at the age of 40 through a heavenly intermediary; later identified by tradition as the Archangel Gabriel.² That distinctive year marked the birth of Islam and has been traditionally known as the year of Revelation.³ The vocal nature of revelation alongside the term itself, which literarily translates as recitation, is a clear indication of the acoustic nature of Islam and its significance. The magnitude of acoustics in Islam can be assessed by analyzing the core rites and rituals which have been practiced by Muslims in their religious institutions since the birth of Islam. The aforementioned rituals are represented in: *salat* (prayers), the *khutba* (sermon), Quranic recitation, the *adhan* (the call to prayer), *du'a* (supplications), teaching *halqas* (sessions) and *dhikr* (remembrance). The numerous scholarships on each of those rites have clearly shown them to be acoustic-based rituals.

Certainly, since the very beginning of Islam most of these rituals have been practiced in the *jami'* (congregational mosque) as being the official home of religious practice in Islam. However, in the course of time, the development of Islamic religious architecture resulted in the introduction of new types of religious institutions

¹ Quran 96:1-4.

² Frishman, *The Mosque*, 18; Esposito, *Islam*, 6.

³ Frishman, *The Mosque*, 18.

and buildings; namely the *khanqah* (Sufi dwelling), the madrasa (theological school), and *turba* (domed mausoleum). All of these witnessed ritual performances as well.

Most Islamic religious architecture was designed to enable Islamic liturgical rites to function adequately.⁴ Consequently, I believe that creating an effective sound space, which is primarily based on sound intelligibility and diffusion, was among the architects' main priorities upon designing any type of religious buildings. In contrast, most research in the field of Islamic art history has focused on visual aspects of the buildings.⁵ However, in most cases, those historic Islamic religious buildings feature a splendid unseen aspect which is archaeoacoustics. It is scientifically known as "The archaeology of sound". Although archaeoacoustics aims at analyzing and studying the acoustics of ancient sites and buildings in terms of adding a valued sonic dimension to their architecture, archaeoacoustic scholarship in the field of historic Islamic religious buildings, especially mosques, is under-researched.⁶ Consequently, the main aim of the study is to analyze the archaeoacoustic development of the major Cairene religious buildings from the time of the Arab conquest through the Ottoman period. The end of the Ottoman period is chosen specifically for it witnessed the introduction of electrified sound systems to ancient and modern Cairene religious buildings. In accordance with the above, the first chapter aims at analyzing the value of acoustics in Islam through studying the main acoustic-related rituals which had been performed in Cairene religious institutions namely, prayer, the *khutba*, the *adhan*, Quranic recitation, *du'a* (supplications), *dhikr*, and *tabligh*, alongside the outlines and duties of the official religious personnel who were appointed to perform them.

⁴ 'Uthmān, *al-Wazīfiyyah*, 207, 219.

⁵ Blesser and Salter, *Spaces*, 1.

⁶ Cross and Watson, "Acoustics and the Human Experience," 107.

Since acoustics is believed to play a pivotal role in various Islamic liturgies, it is suggested that a mutual impact had taken place between acoustics and Islamic religious architecture. Chapter Two examines the archaeoacoustic dimension of Cairo's major religious buildings, in connection with the parameters of modern acoustics. It is believed that such analysis will help in reconstructing the historic soundscape of the selected buildings.

Finally, chapter three reviews the main conclusions of the study. Therefore, the study as a whole will answer the following question: to what extent could the architect – during the specified time span of the study – be regarded as an architect who attentively took into consideration the sonic dimensions of the Islamic religious buildings of Cairo?

Chapter One

Acoustics in Islam

1.1 The Value of Acoustics in the Quran

The Messenger of Allah, on whom be benediction and peace, delivered a sermon to mankind during the farewell Hajj in 10/632 and said: "O Mankind! I have left behind over you that which if you hold fast to it, you will never go astray: the book of Allah and the sunna of His Prophet."⁷ Accordingly, in order to understand the total value of acoustics in Islam, the study emphasizes the Quranic verses which are related to the following nomenclature:

A: sound

B: Hearing

C: Ears

1.1.1. Sound in the Quran

In this part, the selected Quranic verses are mentioned first in Arabic, then in English translation. Finally, a full commentary is provided. In accordance with the Prophetic traditions, God's revelation is twofold. First, it came through the voice of a heavenly intermediary, later identified by tradition as the archangel Gabriel. Second, it was received through God's direct divine speech, without an intermediary. However, God's voice had to be revealed from behind a partition.⁸

First, the abovementioned divine revelation criteria are demonstrable in the following Quranic verses:

⁷ [www.nairland.com/1470614/how-authentic hadith - leave amongst](http://www.nairland.com/1470614/how-authentic-hadith-leave-amongst).

⁸ www.islamtoday.net/toislam/art-105-2.htm.

إِنَّا أَوْحَيْنَا إِلَيْكَ كَمَا أَوْحَيْنَا إِلَى نُوحٍ وَالنَّبِيِّينَ مِنْ بَعْدِهِ وَأَوْحَيْنَا إِلَى إِبْرَاهِيمَ وَإِسْمَاعِيلَ وَإِسْحَاقَ وَيَعْقُوبَ
وَالْأَسْبَاطِ وَعِيسَى وَأَيُّوبَ وَيُونُسَ وَهَارُونَ وَسُلَيْمَانَ وَآتَيْنَا دَاوُودَ زَبُورًا (163)

"Verily, we have inspired you (O Muhammad) as we inspired Nuh and the Prophets after him We (also) sent the revelation to Ibrahim, Ismail, Ishaq, Yaqub, and al-Asbat, (the offspring of the twelve sons of Ya'qub) 'Isa, Ayyub, Yunus, Harun, and Sulayman; and to Dawud We gave the Zabur (163)."⁹

وَمَا كَانَ لِبَشَرٍ أَنْ يُكَلِّمَهُ اللَّهُ إِلَّا وَحْيًا أَوْ مِنْ وَرَاءِ حِجَابٍ أَوْ يُرْسِلَ رَسُولًا فَيُوحِيَ بِإِذْنِهِ مَا يَشَاءُ إِنَّهُ عَلِيُّ حَكِيمٌ (51)

"It is not given to any human being that Allah should speak unto him unless [it be] by Revelation [descended upon this heart], or from behind a veil, or [that] He sends a messenger [an angel] to reveal what He wills by His Leave. Verily, He is most High, Most Wise."¹⁰

وَأَذْكُرُ فِي الْكِتَابِ مَرْيَمَ إِذِ انْتَبَذَتْ مِنْ أَهْلِهَا مَكَانًا شَرْقِيًّا (16) فَاتَّخَذَتْ مِنْ دُونِهِمْ حِجَابًا فَأَرْسَلْنَا إِلَيْهَا
رُوحَنَا فَتَمَثَّلَ لَهَا بَشَرًا سَوِيًّا (17) قَالَتْ إِنِّي أَعُوذُ بِالرَّحْمَنِ مِنْكَ إِنْ كُنْتَ تَقِيًّا (18) قَالَ إِنَّمَا أَنَا رَسُولُ رَبِّكِ لِأَهَبَ
لَكَ غُلَامًا زَكِيًّا (19)

"And mention in the Book about Mary when she withdrew from her family to an eastern place so she took a veil (to screen herself) apart from them (16), then we sent unto her Our Spirit (Holy Spirit) that presented himself to her a perfect man (17), She said: I seek refuge from thee to (Allah) Most Gracious: (come not near) if thou dost fear Allah (18), He said: Nay, I am only a messenger from thy Lord, (to announce) to thee the gift of a holy son (19)."¹¹

When Allah created sound it was meant to be the dynamic energy by which the sense of hearing could functionalize. However, we have learnt from the Quran that those

⁹ Quran 4:163.

¹⁰ Quran 42:51.

¹¹ Quran 19:16-19.

peaceful and useful sonic waves could be converted, at God's will, to be a harsh punitive tool by which sinners and unbelievers were punished. This sort of marvelous acoustic retribution is twofold; first, a mundane punishment which had already existed in the past, second, another punishment of a different acoustic nature that is related to Hellfire. As for the mundane sonic punishment, the disobedient nation of Thamud is an example in respect of being annihilated by a severe blast that transcended the bearable threshold of human hearing due to their evil action of refusing Allah's messengers. Their blast took the form of a death dealing thunderbolt.¹² The following verses relate this:

وَلَقَدْ كَذَّبَ أَصْحَابُ الْحِجْرِ الْمُرْسَلِينَ (80) وَأَتَيْنَاهُمْ آيَاتِنَا فَكَانُوا عَنْهَا مُعْرِضِينَ (81) وَكَانُوا يَنْحِتُونَ
مِنَ الْجِبَالِ بَيْوتاً آمِنِينَ (82) فَأَخَذْتَهُمُ الصَّيْحَةُ مُصْبِحِينَ (83)

"And the dwellers of al-Hijr also belied the messengers (80), we brought them signs, but they turned away (81), they hewed their dwellings out of the mountains in safety (82), but the shout seized them in the morning (83)."¹³

Regarding acoustic punishment in the hereafter, Allah mentions that Hellfire will display such a high level of rage from the sinners and unbelievers that its fury and roaring sound will be heard by those people of hell.

إِذَا رَأَوْهُمْ مِّن مَّكَانٍ بَعِيدٍ سَمِعُوا لَهَا تَغِيْطًا وَزَفِيرًا (12)

"When the Hellfire sees them from a distant place, they will hear its fury and roaring (12)."¹⁴

In the same Quranic context of illustrating the acoustic dimensions of the Judgment Day, Allah – in many verses – mentions and describes the state of

¹² www.al-islam.org/enlightening-commentary-light-holy-quran-vol-8/section-6-people-rock=Sura-al-hijr-verses-80-81; Pulkki and Karjalainen, *Acoustics*, 402.

¹³ Quran 15:80-83.

¹⁴ Quran 25:12.

reverence that mankind will show while gathering before God for judgment. This state of anxiety will reflect on the people's voice capabilities. In other words, all the beings' sounds will be hushed before the Most Gracious and nothing will be heard but a faint sigh in the air,¹⁵ which is demonstrated in the following verse:

يَوْمَئِذٍ يَتَّبِعُونَ الدَّاعِيَ لَا عِوَجَ لَهُ وَخَشَعَتِ الْأَصْوَاتُ لِلرَّحْمَنِ فَلَا تَسْمَعُ إِلَّا هَمْسًا (108)

"On that Day will they follow the Caller (straight): no crookedness (can they show) him: all sounds shall humble themselves in the presence of (Allah) Most Gracious: nothing shalt thou hear but the tramp of their feet (as they march) (108)."¹⁶

Upon analyzing the Quranic verses in connection with the different miracles which were assigned by Allah to a specific group of Prophets and Messengers, we see that Christ's very first miracle when he was a baby was a sound miracle. The Holy Quran states that right before she gave birth to Jesus, Mary cried in pain and held tight onto a palm tree. At this moment, a voice came from "beneath her", understood by many Quran scholars to be the voice of Christ, who was yet in her womb.

Surprisingly, the baby said:

فَنَادَاهَا مِنْ تَحْتِهَا أَلَا تَحْزَنِي قَدْ جَعَلَ رَبُّكِ تَحْتَكِ سَرِيًّا (24) وَهْزِي إِلَيْكَ بِجِذْعِ النَّخْلَةِ تُسَاقِطُ عَلَيْكَ رَطْبًا

جَنِيًّا (25)

"Give not! Your Lord has provided a water stream under you (24), and shake the trunk of the palm tree, it will let fall fresh ripe dates upon you (25)."¹⁷

At this point, Christ's voice miracle had not yet ended, as there was a second phase through which Allah intended to use Christ's marvelous voice to rebut a false

¹⁵ www.alim.org/library/quran/ayah/compare/20/108/a-scene-from-the-day-of-judgement.

¹⁶ Quran 20:108.

¹⁷ Quran 19:24-25.

accusation from Mary and to prove his prophecy. The following verses recite this important miracle as follows:

فَأْتَتْ بِهِ قَوْمَهَا تَحْمِلُهُ قَالُوا يَا مَرْيَمُ لَقَدْ جِئْتِ شَيْئاً فَرِيحاً (27) يَا أُخْتَ هَارُونَ مَا كَانَ أَبُوكِ امراً سَوْءاً وَمَا
كَانَتْ أُمُّكِ بَغِيّاً (28) فَأَشَارَتْ إِلَيْهِ قَالُوا كَيْفَ نُكَلِّمُ مَنْ كَانَ فِي الْمَهْدِ صَبِيّاً (29) قَالَ إِنِّي عَبْدُ اللَّهِ آتَانِيَ الْكِتَابَ
وَجَعَلَنِي نَبِيّاً (30)

"At Length, she brought the (baby) to her people carrying him (in her arms). They said: "O Mary! Truly an amazing thing hast thou brought (27), O sister of Aaron! Thy father was neither a man of evil nor thy mother a woman unchaste (28), but she pointed to the babe. They said: "How can we talk to one who is a child in the cradle?" (29), He said: "I am indeed a servant of Allah: He hath given me revelation and made me a prophet (30)."¹⁸

1.1. 2 Audition in the Quran

Through examining the Holy Quran from a linguistic perspective, we could observe the repetition of many of its words, idioms, and expressions. Allah evidently wished to affirm the significance of the repeated words. However, it is noteworthy that each time the term is repeated, it stands for a specific linguistic meaning.

Hearing is one of those frequently repeated terms in the Holy Quran, for Allah has singled out this sense as the most important one through which people could realize the different mundane and religious matters of life. In the next part, the study addresses the multidimensional prominence of hearing in the Holy Quran. Obviously, audio and visual senses are among God's great gifts to mankind.¹⁹ In the Holy Quran

¹⁸ Quran 19:27-30.

¹⁹ Rajabnejad, "Value of Ear," 8, 10.

one notices that both words of "hearing" and "seeing" have been repeated together 19 times. In 17 times, the "hearing" has preceded "seeing".²⁰

Allah Almighty says:

قُلْ هُوَ الَّذِي أَنْشَأَكُمْ وَجَعَلَ لَكُمُ السَّمْعَ وَالْأَبْصَارَ وَالْأَفْئِدَةَ قَلِيلًا مَّا تَشْكُرُونَ (23)

"Say it He Who had created you and endowed you with hearing and seeing and hearts, though little thanks you give? (23)."²¹

Accordingly, it could be understood that God created human beings and provided them with means of observation and experience to optimize their use in following the straight path of God. However, the misuse of those physical and moral senses could result in deviation from that straight path. Thence, in a venerable Judgment Day scene, the disbelievers will deeply regret their misbehavior of neither listening nor responding to apostles and who had been sent to them by Allah in their worldly life. This is demonstrated in the following verse:

قَالُوا بَلَىٰ قَدْ جَاءَنَا نَذِيرٌ فَكَذَّبْنَا وَقُلْنَا مَا نَزَّلَ اللَّهُ مِن شَيْءٍ إِنْ أَنْتُمْ إِلَّا فِي ضَلَالٍ كَبِيرٍ (9) وَقَالُوا لَوْ كُنَّا نَسْمَعُ أَوْ نَعْقِلُ مَا كُنَّا فِي أَصْحَابِ السَّعِيرِ (10) فَاعْتَرَفُوا بِذُنُوبِهِمْ فَنَسْحَقُوا لِأَصْحَابِ السَّعِيرِ (11)

"They will say: "Yes, indeed a Warner came unto us, but we belied him and said: "Allah never sent down anything, you are only in great error (9), And they will say: Had we but listened or used our intellect, we would not have been amongst the dwellers of the blazing Fire! (10), Then they will confess to their sins. So, damned are the dwellers of the Fire (11)."²²

Allah used lack of hearing itself as a punishment for the sinners and disbelievers in the worldly life and hereafter. This is demonstrated in the following verse:

²⁰ Ibid, 9.

²¹ Quran 67:23.

²² Quran 67:9-11.

أُولَئِكَ الَّذِينَ لَعَنَهُمُ اللَّهُ فَأَصَمَّهُمْ وَأَعَمَّى أَبْصَارَهُمْ (23)

"Such are they whom Allah has cursed so that He has made them deaf and blinded their sight [to hinder them from perceiving the truth] (23)."²³

In the same context of demonstrating hearing-related miracles in the Holy Quran, it is important to mention the Prophet Solomon who was solely specified by God Almighty with virtue of hearing and speaking to the creatures of different species. These verses illustrate those Solomonic marvels.

وَوَرِثَ سُلَيْمَانُ دَاوُودَ وَقَالَ يَا أَيُّهَا النَّاسُ عَلَّمْنَا مَنْطِقَ الطَّيْرِ وَأَوْتَيْنَا مِنْ كُلِّ شَيْءٍ إِنَّ هَذَا لَهُوَ الْفَضْلُ
الْمُبِينُ (16)

"And Solomon inherited David and he said: "O people! We have been taught the language of the birds, and we have been granted of everything; verily this is manifest favor (16)."²⁴

حَتَّىٰ إِذَا أَتَوْا عَلَىٰ وَادِي النَّمْلِ قَالَتْ نَمْلَةٌ يَا أَيُّهَا النَّمْلُ ادْخُلُوا مَسَاكِنَكُمْ لَا يَحْطِمَنَّكُمْ سُلَيْمَانُ وَجُنُودُهُ وَهُمْ
لَا يَشْعُرُونَ (18)

"Until when they came to the Valley of Ants, an ant said: "O you ants! Get into your habitations, so that Solomon and his hosts may not crush you, being unaware (18)."²⁵

فَتَبَسَّمَ ضَاحِكًا مِّن قَوْلِهَا وَقَالَ رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ
صَالِحًا تَرْضَاهَا وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ (19)

"Then he smiled, laughing at its words, and said: "My Lord! Dispose me that I may be thankful for your bounty, which you have bestowed on me and my parents,

²³ Quran 47:23.

²⁴ Quran 27:16.

²⁵ Quran 27:18.

and that I may do righteousness such as you are pleased with, and admit me, by your mercy among your righteous (19)."²⁶

1. 1. 3 Ears in the Quran

Allah said:

لَقَدْ خَلَقْنَا الْإِنْسَانَ فِي أَحْسَنِ تَقْوِيمٍ (4)

"We have indeed created man in the best of moulds (4)."²⁷

This Quranic verse demonstrates the solicitude of Allah in creating humankind with all necessary senses, organs and systems all of which made him God's most honored creature. When the hypocrites aimed at underestimating Muhammad, they called him an ear as if he naively accepted whatever everybody says. Immediately, Allah revealed a counteracting verse enclosing an important meaning

وَمِنْهُمْ الَّذِينَ يُؤَدُّونَ النَّبِيَّ وَيَقُولُونَ هُوَ أُذُنٌ قُلْ أُذُنٌ خَيْرٌ لَّكُمْ يُؤْمِنُ بِاللَّهِ وَيُؤْمِنُ لِلْمُؤْمِنِينَ وَرَحْمَةٌ لِّلَّذِينَ
آمَنُوا مِنْكُمْ وَالَّذِينَ يُؤَدُّونَ رَسُولَ اللَّهِ لَهُمْ عَذَابٌ أَلِيمٌ (61)

"And there are among them those who hurt the Prophet and say: "He is an ear! Say: An ear that is good for you; he believes in Allah, and believes the Believers, and he is mercy to those of you who believe. And those who hurt the messenger of Allah, there is a painful punishment for them (61)."²⁸

The next part of the research will briefly comment on the Holy Quran's approach to the ear in compliance with the previously mentioned importance of both sound and audition.

Generally speaking, when the Holy Quran was revealed, it meant to address the ears over the eyes. Such distinction was primarily intended by Allah since the Arabs

²⁶ Quran 27:19.

²⁷ Quran 95:4.

²⁸ Quran 9:61.

broadly believed in magic and optical illusions. Accordingly, it was very easy for the infidels to deny any Islamic-related factual reality or observation under the pretext of being either magic or optical illusions.²⁹ However, their skepticism would have been reduced if the miracle addressed their audition. This is clarified through this verse:

وَلَوْ فَتَحْنَا عَلَيْهِمْ بَابًا مِّنَ السَّمَاءِ فَظَلُّوا فِيهِ يَعْرُجُونَ (14) لَقَالُوا إِنَّمَا سُكَّرَتْ أَبْصَارُنَا بَلْ نَحْنُ قَوْمٌ

مَسْحُورُونَ (15)

"And even if we opened to them a gate from the sky, so that they ascended into it all the while (14), They would definitely say: "Indeed our eyes have been blindfolded, rather we are a people bewitched (15)."³⁰

Throughout the Holy Quran we can observe many verses which demonstrate auditory miracles to provide evidence on the certainty of Islam. One is the story of the *ashab al-kahf* (The cave owners). The story relates that a group of young faithful resorted to a cave to seek refuge from their polytheist tribe. Upon entering the cave, they asked their Lord to provide a way to deliver them from straitened circumstances.³¹ Allah accepted their prayer and covered a veil of sleep over their ears in the Cave so that they slept 309 years before they woke up. In connection with saving them from their tribe, these verses explain this miracle:

²⁹ McClain, *Mediations through the Quran*, 31.

³⁰ Quran 15:14-15.

³¹ <http://www.al-islam.org/enlightening-commentary-light-holy-quran-vol-9/section-1-#Sura-al-kahf-verse4-5>.

فَضَرَبْنَا عَلَى آذَانِهِمْ فِي الْكَهْفِ سِنِينَ عَدَدًا (11) ثُمَّ بَعَثْنَاهُمْ لِنَعْلَمَ أَيُّ الْحِزْبَيْنِ أَحْصَى لِمَا لَبِثُوا أَمَدًا (12)

"Then we set over their ears (a curtain of sleep) in the Cave for a number of years (11), Afterwards we raised them up in order to test which of the two parties would better calculate the time they had tarried (12)."³²

وَأَلْبَثُوا فِي كَهْفِهِمْ ثَلَاثَ مِئَةٍ سِنِينَ وَازْدَادُوا تِسْعًا (25)

"And they remained in their Cave three hundred years, and (to that also) they added nine more (25)."³³

The Almighty used an eloquent metaphor to describe his punishment to those infidels who persisted in disbelieving.³⁴ The punishment takes the form of loading their ears with heaviness so as not to be aware of the right path. This meaning could be understood from the next verse:

مِنْهُمْ مَن يَسْتَمِعُ إِلَيْكَ وَجَعَلْنَا عَلَى قُلُوبِهِمْ أَكِنَّةً أَنْ يَفْقَهُوهُ وَفِي آذَانِهِمْ وَقْرًا وَإِنْ يَرَوْا كَلَّ آيَةٍ لَا يُؤْمِنُوا بِهَا حَتَّى إِذَا جَاءُوكَ يُجَادِلُونَكَ يَقُولُ الَّذِينَ كَفَرُوا إِنْ هَذَا إِلَّا أَسَاطِيرُ الْأَوَّلِينَ (25)

"And of them there some with hearken to you, and we have laid veils upon their hearts lest they understand it, and their ears a heaviness; and (even) if they see every sign they will not believe in it, so that when they come to you they dispute with you, those who disbelieve say: This is naught but the legends of the ancients (25)."³⁵

Certainly, there are multiple other verses throughout the Holy Quran which could be classified as acoustic-related Quranic verses. However, our study pinpoints the specific verses which could effectively contribute to the multidimensional acoustic

³² Quran 18:11-12.

³³ Quran 18:25.

³⁴ <http://www.al-islam.org/enlightening-commentary-light-holy-quran-vol-5/section-3-polytheists-shall-themselves-confess-their#Sura-al-anam-verse-25>.

³⁵ Quran 6:25.

value of the Holy Quran through independently examining the Holy Quran's approach to the sound, hearing and the ear.

1.2 Acoustic-Related Rituals in Islam

In addition to examining the Holy Quran's approach to acoustics we need to study the prime acoustic-related Islamic phenomena which were performed in historic Cairene religious buildings, namely the *salat* (prayers), *khutba* (sermon), Quranic recitation, *adhan* (call to prayer), *du'a* (supplications), *dhikr* (remembrance), and *tabligh* (ritualistic informing).

1.2.1. Prayers in Islam

Prayer in Islam, which translates in Arabic as *salat*,³⁶ is prescribed by the Almighty to be performed, five times a day;³⁷ at day break, around noon, in the mid afternoon, at sunset and at night.³⁸ In this context, God says in the Holy Quran: "Prayers have been set for the believers at set times (103)."³⁹ Furthermore, it is prescribed for every adult male to participate in the weekly congregational prayer at midday on Fridays.⁴⁰ The interest and logic behind the prayers' frequency in Islam and their distribution along day and night times is to enable the Muslim automatically to remember Allah at all times.⁴¹

³⁶ Frishman, *The Mosque*, 20.

³⁷ Chinchilla, *Islamic Architecture*, 13; Frishman, *The Mosque*, 20.

³⁸ Loc. cit.; Esposito, *Islam*, 89; Bloom, *Minaret*, 25.

³⁹ Quran 4:103.

⁴⁰ Chinchilla, *Islamic Architecture*, 13.

⁴¹ Gabr, *The Influence*, 117.

From the acoustic perspective, prayer has been regarded by many scholars as a physical repetitive commemoration of the first revelation and the birth of Islam.⁴² Thus, a hypothesis could be placed at this point i.e., that acoustics constitutes a substantial dimension in the Islamic prayer. It is believed that the acoustics of Islamic prayers could be effectively approached if the basic phases of the prayer are analyzed within the acoustic context of their recitals.

1.2.1.1 The Acoustics of Islamic Prayer from the Beginning to the End

Generally speaking, Islamic prayer, whether performed individually or in a congregation, encloses seven stages, five of which are essential to complete one *rak'a* (cycle or unit).⁴³ The seven stages are: *al-takbir*, Quran recitation, *al-ruku'* (genuflection), *al-i'tidal* (straightening up), *al-sujud* (prostration), sitting and reciting *al-tashahud* (testification), and finally, performing the *taslim* (salutation) to the right and to the left.⁴⁴

In this part of the study, communal prayer is highly emphasized because it is the prayer which features recitations aloud by the imam (prayer leader) in front of the congregation who respond to him. As soon as the worshippers line up properly in their rows behind the imam, he makes *al-takbir* that is, reciting aloud "الله أكبر" "Allah is Great." Due to its importance, this formula is repeated by the imam many times during the prayer. From the acoustic perspective, the *takbir* statement is recited aloud to keep the hearts and minds of worshippers away from any sort of distraction by means of clearly hearing the statement from the imam and then repeating it silently.

⁴² Esposito, *Islam*, 89.

⁴³ Gabr, *The Influence*, 120.

⁴⁴ Orfali, "Acoustics," 10; Gabr, *The Influence*, 120.

As soon as the imam commences the communal prayers; namely, the *fajr*, *maghrib* and *'isha'* prayers, he starts reciting aloud verses from the Holy Quran, i.e. Sura al-Fatiha followed by a recitation from any other Sura in the Holy Quran of his choice. Sura al-Fatiha is considered, according to the Holy Quran and traditions, the greatest Sura in the whole Quran. In it, the Muslims praise the Almighty, affirm His oneness, seek His Guidance and bestow His Grace. Therefore, the acoustics of the Fatiha recitation is believed to play the core role in delivering the different meanings enclosed within the Sura.

1.2.1.2 The Imam (Prayer Leader)

If prayer in Islam is the mainstay of the religion, then one could possibly presume the superiority of the imam over all other personnel within the religions premises. It is believed that such superiority sprang originally from the belief that the imam stands in the same position of the Prophet when leading the prayer in his mosque in Madina.

In accordance with the information provided by multiple *waqf* deeds, one could notice that the Imamate is considered the most important religious position. Many qualifications and expectations have to be covered by the candidate of the position. The *waqfiyya* of Sultan al-Ghawri is a good example of the Mamluk *waqfiyyas* related to the position of imam. The endower stipulated that the imam has to be a scholar and a memorizer of the Holy Quran. Furthermore, the imam should be popular for his religious practices, goodness, enjoy a good voice optimized for Quranic recitation and be familiar with the legal acts of worship.⁴⁵ Accordingly, from the acoustic point of view, most of the endowers were very strict about the vocal qualifications of the imams.

⁴⁵ Amīn, *al-Awqāf*, 184.

1.2.2 The Acoustic Dimension in Friday Prayer

Allah has honored Friday prayer to the extent that a whole Sura (chapter) in the Holy Quran is named after this honored day. Thereupon, Friday is regarded by Muslims all over the world as their weekly feast which they celebrate by performing al-Jum‘a congregation prayer – instead and in the same time of *zuhr* prayer – in compliance with Almighty's command which is mentioned in the Holy Quran as follows:

يَا أَيُّهَا الَّذِينَ آمَنُوا إِذَا نُودِيَ لِلصَّلَاةِ مِنْ يَوْمِ الْجُمُعَةِ فَاسْعَوْا إِلَىٰ ذِكْرِ اللَّهِ وَدَرُّوا الْبَيْعَ نَلِكُمْ خَيْرٌ لَكُمْ إِنْ كُنْتُمْ تَعْلَمُونَ (9)

"O you who believe! When the call is proclaimed for the Friday prayer, hasten toward the remembrance of Allah and leave off business. That is better for you if you did but know (9)."⁴⁶

Upon analyzing verse number 9 in Sura al-Jum‘a, which urges the faithful to perform the Jum‘a prayer, one could observe three acoustic aspects of this religious event. First, Allah intended to mention the Jum‘a prayer in the Holy Quran in terms of assuring its recitation until the Judgment Day in order to always remind the faithful of its merits and virtues. Second, in the first part of the verse, Allah says: إِذَا نُودِيَ لِلصَّلَاةِ مِنْ يَوْمِ الْجُمُعَةِ which translates as: when the call is proclaimed for the Friday prayer, most probably the call here refers to the *adhan*. Therefore, the actual Jum‘a prayer starts by performing the *adhan* to inform the faithful that it is the time for the prayer. Third, in the second part of the verse, Allah encourages the faithful to perform *dhikr* (the remembrance of God) on Fridays. *Dhikr* is considered a major acoustic aspect in Islam which will be discussed later in chapter one.

⁴⁶ Quran 62:9.

1.2.3. The Friday Khutba (Sermon)

This part of the study examines the acoustic context of the Friday *khutba* and the *khatib* (orator). Based on many prophetic hadiths, most Islamic scholars agreed that attending Friday *khutba* is mandatory for all Muslims.⁴⁷ This obligation springs from the importance of the *khutba* to the Muslims and the great rewards awaiting them if it is properly attended. The following hadith shows the rewards awaiting Muslims if they follow the Friday *khutba* and prayer ethics. It is narrated by Abu Hurayrah that the Prophet said: "Whoever does *ghusl* (ritual washing), then comes to Jum‘a, and prays what is decreed for him, then listens attentively until the *khutba* is over, then prays with him (the imam), will be forgiven (his sins) between this Jum‘a and the next one, and three days more."⁴⁸

The acoustic aspect of the *khutba* could be detected from tracking the outlines of the original Friday *khutba*'s performance by the Prophet and his behavior as an orator. When the Prophet mounted the *minbar* he faced the people, to be audible and visible. Then he saluted them before he sat and signaled to Bilal to make the call to prayer. Afterwards, the Prophet embarked on one or more subjects that mattered to Muslim society.⁴⁹ The Prophet's original *khutba* consisted of two parts interposed by a brief sitting. When he finished the second *khutba* he signaled to Bilal to perform the *iqama* (the second call to prayer). Finally, he led a two *rak‘as* of prayer.⁵⁰ In the same

⁴⁷ Ayyūb, *Fiqh al-‘Ibādāt*, 219.

⁴⁸ <http://qurancoaching.com/importance-of-listening-to-the-jummah-khutbah>.

⁴⁹ Ayyūb, *Fiqh al-‘Ibādāt*, 229; Frishman, *The Mosque*, 30.

⁵⁰ Ayyūb, *Fiqh al-‘Ibādāt*, 230.

context, many scholars, such as Ibn al-Qayim described the vocal qualities of the Prophet, especially in connection with raising his voice.⁵¹

1.2.3.1 The Khatib (Orator) in Islam

The *khatib* has always been highly regarded by Muslims due to his sacred role in succeeding the Prophet Muhammad on the *minbar* in terms of delivering the sermons. His role in religious buildings is well illustrated in many Mamluk *waqf* documents. They state, in detail, his basic and secondary duties and responsibilities, and the vocal qualifications which he has to have in order to be appointed. For example, the *waqfiyya* of Sultan al-Ashraf Barsbay states that the oration, in its general context, is applied to the person who delivers public speeches or preaches. However, in its distinct religious context, it stands for the person who delivers religious sermons. Consequently, the term *khatib*, upon being mentioned in *waqfiyyas*, refers to the religious personnel who deliver both *khutbas* of Friday, and the two ‘aids (feasts).⁵²

As for the personal behavior and characteristics, the *khatib* should be reputed for his godliness and piety along with being trustworthy, honest and knowledgeable. From the acoustic perspective, the *khatib* should be eloquent and have a clear loud voice.⁵³

Although the *khatib* was initially hired during the Mamluk period to deliver both Friday and feast sermons, sometimes he was responsible for delivering secondary *khutbas* as part of special prayers. The *waqfiyya* of Sultan al-Mu‘ayyad Shaykh’s mosque states that the orator should deliver sermons in the mosque on

⁵¹ Ibid, 228.

⁵² Abū-Bakr, *al-Manābir*, 533.

⁵³ Loc. cit.; Amīn, *al-Awqāf*, 186, 188.

Fridays, the two feasts in addition to *salah al-kusufayn* (two eclipses prayers) and *salah al-istisqa'* (prayer for rain) which were performed in congregation.⁵⁴

1.2.4. Quranic Recitation in Islam

The Acoustic nature of the Holy Quran could be determined from the Holy name itself "Quran" which translates as "the recited," as it was meant from the very beginning, by Allah, for the Holy Quran to be read or recited aloud, and memorized by the faithful.⁵⁵

The next part of the study addresses the different acoustic aspects of the Holy Quran and its recitation.

1.2.4.1 The Holy Quran's Revelation Stages from an Acoustic Perspective

As mentioned before, the first revealed verses from the Holy Quran to the Prophet Muhammad began with the verbal extortion "Read" or "Recite" aloud. It is a command which could be regarded metaphorically as an evidence of the acoustic nature of Islam, a nature which has transcended the boundaries of the Holy Quran to include most Islamic rituals.

1.2.4.2. The Acoustic Essence of Quranic Recitation

Allah said in the Holy Quran:

إِنَّا نَحْنُ نَزَّلْنَا الذِّكْرَ وَإِنَّا لَهُ لَحَافِظُونَ (9)

"Surely, we have sent down the reminder, and We will most surely be its guardian (9)."⁵⁶

⁵⁴ Ibid, 187.

⁵⁵ 'Abd Allāh, *Tilāwit al-Quran*, 17.

⁵⁶ Quran 15:9.

In the same context the Almighty also said:

وَأْتِلْ مَا أُوحِيَ إِلَيْكَ مِنْ كِتَابِ رَبِّكَ لَا مُبَدَّلَ لِكَلِمَاتِهِ وَلَنْ تَجِدَ مِنْ دُونِهِ مُلْتَحَدًا (27)

"And recite that which has been revealed unto you of the Book of your Lord; none shall change His words, and you shall not find any refuge besides Him (27)."⁵⁷

In both verses, Allah ensures the existence and preservation of the Holy Quran over time. The Prophet Muhammad had always been keen on establishing a special Quranic transmission group from the qualified companions to learn from him the methods of Quranic recitation. Whenever any part of the Holy Quran was revealed to the Prophet, he taught to the transmitters the same exact way of recitation he learnt from Archangel Gabriel.⁵⁸

Among the prominent aspects through which the acoustic nature of Quran is emphasized is *tartil* (hymnody).⁵⁹ The term *tartil* is a recitation-related Arabic term which stands for the ultimate proper way of Quranic recitation i.e., reading the Quran aloud and slowly, with no haste, so as to make the pronunciation as clear and audible as possible. Such acoustic criteria play a pivotal role in achieving a better understanding of the Holy Quran and its meanings.⁶⁰ The acoustic action of *tartil* has been mentioned in Holy Quran for its significance, for example, when the Almighty said:

أَوْ زِدْ عَلَيْهِ وَرَتِّلِ الْقُرْآنَ تَرْتِيلاً (4)

"And recite the slowly Quran slowly and meditatively (4)."⁶¹

⁵⁷ Quran 18:27.

⁵⁸ ‘Abdullāh, *Tilāwīt al-Qurʿān*, 117.

⁵⁹ Al-Wakīl, *Athāth al-Muṣḥaf*, 256.

⁶⁰ Loc. cit.; ‘Ali, *Fiqh al-Tajwīd*, 13.

⁶¹ Quran 73:4.

In this verse Allah signaled the significance of *tartil* as an acoustic tool in transcending the verbal meanings of the recited words to contemplate their philosophical meaning.⁶²

The twin acoustic ritual of the *tartil*, in Quranic recitation, is *tajwid*, which translates as the art of chanting the Holy Quran.⁶³ The prominence of *tajwid* as an integral element in the art of Quranic recitation could be determined by two hadiths. In the first hadith the Prophet says "Embellish the Quran with your voices," while in the other hadith he declares: "He who does not recite the Quran melodiously is not one of us."⁶⁴

1.2.4.3. The Psychoacoustic Impact of Quranic Recitation

Auditory psychophysics, more often known as psychoacoustics, is the science which studies the perception of sound; in other words, it studies the psychological responses to sounds, and the physiological impact of sound and music on the human nervous system.⁶⁵ Since sound is the main component in Quranic recitation, a strong hypothesis suggests that Quranic recitation has a psychoacoustic impact on its listeners. It is believed that a good voice, *tartil*, and *tajwid* are the main components in creating a Quranic psychological impact on people. Accordingly, it is unsurprising to find that well-educated and professional Quran reciters have been using, since the very early ages of Islam, special acoustic effects, such as extension of phonemes, nasalization, repetition, and pauses in a way that will emphasize specific passages,

⁶² Al-Wakīl, *Athāth al-Muṣḥaf*, 256.

⁶³ Al- Said, *Recited Koran*, 56.

⁶⁴ Loc. cit.

⁶⁵ Pulkki and Karjalainen, *Acoustics*, 133; the power of sound.net/ psychoacocustics-defined.

suggest multiple meanings and increase dramatic tension.⁶⁶ Consequently, the reciters, through mastering their voices and other aspects of recitation technicalities and provisions, could enhance the listeners' emotions and engage them intellectually and spiritually with the recitation.⁶⁷ The followings verses express the discussed notion:

أُولَئِكَ الَّذِينَ أَنْعَمَ اللَّهُ عَلَيْهِمْ مِنَ النَّبِيِّينَ مِنْ ذُرِّيَةِ آدَمَ وَمِمَّنْ حَمَلْنَا مَعَ نُوحٍ وَمِنْ ذُرِّيَةِ إِبْرَاهِيمَ وَإِسْرَائِيلَ
وَمِمَّنْ هَدَيْنَا وَاجْتَبَيْنَا إِذَا تُتْلَىٰ عَلَيْهِمْ آيَاتُ الرَّحْمَنِ خَرُّوا سُجَّدًا وَبُكِيًّا (58)

"Those were some of the prophets on whom showed favour of the seed of Adam, and of those we carried (in the Ark) with Noah, and of the seed of Abraham and Israel, and of those We guided and chose. When the revelations of the Beneficent (Allah) were recited unto them, they fell down prostrating and weeping (58)."⁶⁸

قُلْ آمِنُوا بِهِ أَوْ لَا تُؤْمِنُوا إِنَّ الَّذِينَ أُوتُوا الْعِلْمَ مِنْ قَبْلِهِ إِذَا يُتْلَىٰ عَلَيْهِمْ يَخِرُّونَ لِلْأَذْقَانِ سُجَّدًا (107)
وَيَقُولُونَ سُبْحَانَ رَبِّنَا إِنْ كَانَ وَعْدُ رَبِّنَا لَمَفْعُولًا (108) وَيَخِرُّونَ لِلْأَذْقَانِ يَبْكُونَ وَيَزِيدُهُمْ خُشُوعًا (109)

"Say: Believe in it or believe not, (it makes no difference to Allah), verily, those who were given knowledge before it, when it is read to them, they fall down prostrate on their faces (107), adoring. And they say: "Glory be to our Lord! Verily, our Lord's promise is to be fulfilled (108), And they fall down (in prostration) weeping and it adds up to their humility (109)."⁶⁹

1.2.4.4. The Acoustic Role of the Qari' (The Quran Reciter)

This part of the study analyzes the multiple acoustic dimensions of the *qari'* for he was the one dedicated religious person in charge of Quranic recitation within

⁶⁶ Ergin, "The Soundscape," 212.

⁶⁷ Loc.cit.

⁶⁸ Quran 19:58.

⁶⁹ Quran 17:107-109.

Cairene religious buildings. His related duties include *hifz* (memorization) and its teaching.⁷⁰

Throughout the Mamluk period the title of the *qari'* had been suffixed with many terms in respect of demonstrating the nature of his job as a Quran reciter, such as *qari' al-Quran*, *qari' al-mushaf* (the Holy Quran scripture), and *qari' al-hizb* (Quranic group).⁷¹ Due to their importance within religious premises, Quran reciters were recruited for mosques and other religious buildings since the time of Ahmad b. Tulun (d. 884).⁷² However, their role was crystallized during the Mamluk and Ottoman periods; such crystallization is illustrated in the division of the *qari'* post into many distinctive types such as *qari' al-shubbak*. The reciter who belongs to that type was a *hafiz* and he performed his Quranic recitations by the *shubbak* (window pl. *shababik*), of *jami's*, madrasas, *khanqahs*, *sabils* and *qubbas*, which overlooked the main streets.⁷³

The *shubbak qari's* alternated Quranic recitation through day and night shifts. Each shift was terminated by reciting the chapters of al-Ikhlās, al-Falaq, al-Nas, and al-Fatiha. Then, they send the blessing upon the final Prophet along with making *du'a'* to the endower and all Muslims. This was performed, for example, within the mausoleum of Sultan al-Mansur Qalawun (1284-85).⁷⁴

⁷⁰ Al-Wakīl, *Athāth al-Muṣḥaf*, 251.

⁷¹ Loc. cit.

⁷² Swelim, *The Mosque*, 96.

⁷³ Al-Wakīl, *Athāth al-Muṣḥaf*, 258.

⁷⁴ Loc. cit.

The second type of *qari'* is known, according to many Mamluk *waqfiyyas*, as *qari' al-Sab' al-Sharif*. This title stands for those *hafiz* reciters who recited the Quran according to the basic seven known readings.⁷⁵

The last type is known as *qari' al-dikka* (the reciters of the lectern), those reciters sit on *dikka al-qari'* (the lectern) to read the Holy Quran which is placed on its special *kursi*.⁷⁶ Despite the fact the term "*qari' al-dikka*" has not been mentioned in the medieval texts, it is mentioned and inscribed on the three facades of the Shahidiya madrasa in Mardin 658/1260-1261.⁷⁷

These reciters had to enjoy a good voice, to be a *hafiz* (memorizer), and be capable of reciting aloud and performing *tartil* along with the group reading.⁷⁸ Due to their significance and the quality of their voices, many reciters were hired during the Mamluk period by the elite for special religious ceremonies. For example, in 889/1484 Sultan Qaytbay organized a *mawlid* for al-Sayda Nafisa in which he invited the Caliph, the four qadis and notables. Ibn Iyas mentions that the entire group of reciters of the city participated with their recitations in that event.⁷⁹

It is important to mention that during the Mamluk period the reciters' main performance localities were in *jami's*, *khanqahs*, madrasas, and *turbas*, whether they stood independently or were a part of a larger complex.⁸⁰ Those locations are discussed in details in chapter two.

⁷⁵ Ibid, 260.

⁷⁶ Ibid, 267.

⁷⁷ Loc. cit.

⁷⁸ Ibid, 253.

⁷⁹ Al-Ḥadād, *Qarāfit al-Qāhira*, 317.

⁸⁰ Al-Wakīl, *Athāth al-Muṣḥaf*, 285.

1.2.5 The Adhan (Call to Prayer) in Islam

Willard Carroll "Will" Smith, Jr., a famous American actor, producer, and song writer, once said: "I was in India recently and my hotel was near the Taj Mahal. Five times a day there would be a call for prayer, and it was the most beautiful thing. I was lying on my bed thinking, no matter what your religion is, it would be great to have that reminders five times a day to remember your lord and savior."⁸¹

This eloquent statement could briefly explain to the reader the spiritual core of the *adhan* and its acoustic role in relating the faithful, across the world, to the Islamic community at large, everywhere on earth and at every historical moment in connection with solidifying their divine connections with the Almighty.⁸²

What is exactly the acoustic dimension of the *adhan* in Islam? The Prophet favored an audible acoustic method of announcement to inform the increasing number of the faithful across the city.⁸³ All of a sudden, the companion Abdullah b. Zayd al-Ansari rushed to the Prophet and told him that he had a dream in which someone taught him the full formula of the *adhan* in Islam. Immediately, the Prophet Muhammad chose Bilal to intone, with his beautiful voice, the newly invented *adhan*. Thus, he was honored in Islam by both titles of "the first *mu'adhhdhin*," and "the lord of *mu'adhhdhinin*" and he became the role model of *adhan* intoning in Islam.⁸⁴

⁸¹ <http://www.awamipolitics.com/will-smith-good-remarks-about-islam-14226.html>.

⁸² Ergin, "The Soundscape," 213.

⁸³ 'Azzab, "Fiqh 'Imārit," 49.

⁸⁴ Ayyūb, *Fiqh al-'Ibādāt*, 116.

In relation to acoustic nature of the *adhan*, presumably, the word *adhan* – which literally means "announcement" – has been derived from the root word أذن which means ear.⁸⁵

Based on the acoustic nature of the *adhan*, the Prophet Muhammad had chosen distinct elevated spots for Bilal to perform the *adhan* from to assure the best quality of sound audibility and diffusion across the city. Consequently, in Madina, Bilal stood on the top of al-masjid al-Nabawi to perform the *adhan* while, in Makkah, he stood on the top of the Ka‘ba to recite it.⁸⁶ Bilal continued to perform the call to prayer during the lifetime of the Prophet Muhammad and kept the same post during the reign of Abu-Bakr.⁸⁷

1.2.5.1. The Acoustic Role of the Mu‘adhdhin

The *mu‘adhdhin* (muezzin), as a vocal-based religious post, has always enjoyed a distinctive stature over the long history of Islam. The acoustic significance of the *mu‘adhdhin* arises from using his voice to intone the Islamic *adhan* in terms of announcing the correct times for the five daily prayers.⁸⁸ Despite the fact that the word مؤذن is mentioned in the Holy Quran twice within different contexts than that of the *adhan*,⁸⁹ their mentioning affirms the acoustic nature of the post.

⁸⁵ Al-Sha‘rāwī, *al-Aḥādīth*, 2:316.

⁸⁶ Gottheil, "History of the Minaret," 134.

⁸⁷ Abouseif, *The Minarets*, 7.

⁸⁸ Bloom, *Minaret*, 21.

⁸⁹ *Ibid*, 23.

First,

وَنَادَى أَصْحَابُ الْجَنَّةِ أَصْحَابَ النَّارِ أَنْ قَدْ وَجَدْنَا مَا وَعَدَنَا رَبُّنَا حَقًّا فَهَلْ وَجَدْتُمْ مَا وَعَدَ رَبُّكُمْ حَقًّا قَالُوا
نَعَمْ فَأَذَّنَ مُؤَذِّنٌ بَيْنَهُمْ أَنْ لَعْنَةُ اللَّهِ عَلَى الظَّالِمِينَ (44)

"And the inhabitants of Paradise will call to the inhabitants of the (Hell) Fire:

'We have found what our Lord promised us true; have you, too, found what your Lord promised true? They will say: 'Yes. 'Then a crier will proclaim between them that:

'Allah's curse is on the unjust (44)."⁹⁰

Second,

فَلَمَّا جَهَّزَهُمْ بِجَهَّازِهِمْ جَعَلَ السَّقَايَةَ فِي رَحْلِ أَخِيهِ ثُمَّ أَذَّنَ مُؤَذِّنٌ أَيُّهَا الْعَيْرِ إِنَّكُمْ لَسَارِقُونَ

"Then, when he provided them with their provisions, he put the drinking cup into his brother's saddle-bag. Then a herald shouted: 'O you men of the caravan! You are certainly thieves"⁹¹ In the same acoustic context, the main job of the *mu'adhdhin*, i.e., performing the call to prayer, is mentioned in the Holy Quran twice;⁹² however, in a purely religious context; First,

وَإِذَا نَادَيْتُمْ إِلَى الصَّلَاةِ اتَّخَذُوا هُزُوعًا وَلَعِبًا ذَلِكَ بِأَنَّهُمْ قَوْمٌ لَا يَعْقِلُونَ (58)

"And when you call to prayer they take it in mockery and play. That is because they are people who do not apply reason (58)."⁹³

⁹⁰ Quran 7:44.

⁹¹ Quran12:70.

⁹² Bloom, *Minaret*, 23.

⁹³ Quran 5:58.

Secondly:

يَا أَيُّهَا الَّذِينَ آمَنُوا إِذَا نُودِيَ لِلصَّلَاةِ مِنْ يَوْمِ الْجُمُعَةِ فَاسْعَوْا إِلَىٰ ذِكْرِ اللَّهِ وَذَرُوا الْبَيْعَ ذَلِكُمْ خَيْرٌ لَكُمْ إِنْ كُنْتُمْ تَعْلَمُونَ (9)

"O you who believe! When the call is proclaimed for the Friday prayer, hasten toward the remembrance of Allah and leave off business. That is better for you if you did but know (9)."⁹⁴

Thanks to Mamluk *waqfiyyas*, one learns much about the vocal, physical and ethical characteristics which had to be present in the *mu'adhdhin*. As for the vocal qualities, it was a necessary for the *mu'adhdhin*, in accordance with Islamic jurisprudence, to enjoy a good and loud voice in order to assure the audibility and the diffusion of the *adhan* in a way that it could best be heard by the faithful.⁹⁵

Furthermore, he had to know the principles of the *adhan* and its different ways of performance.⁹⁶ From the physical and ethical perspectives, the *mu'adhdhin* had to be a presentable, honest, trustworthy and devout person.⁹⁷ In this context, al-Maqrizi tells us an interesting incident; that is, when Sultan al-Nasir Muhammad b. Qalawun established his mosque at the citadel, he gathered all the *mu'adhdhinin* of Egypt so as to choose the best of them in terms of their vocal qualities.⁹⁸

Despite the fact that reciting the *adhan* was the *mu'adhdhin*'s prime job, there were many other acoustic-based duties assigned to the *mu'adhdhin* as well. Similarly, the Mamluk *waqfiyyas* are useful in this point. For example, the *mu'adhdhin* was

⁹⁴ Quran 62:9.

⁹⁵ Amīn, *al-Awqāf*, 190; Al-Maṣrī, *al-'Ibādāt*, 420.

⁹⁶ Amīn, *al-Awqāf*, 190.

⁹⁷ Loc. cit.

⁹⁸ Al-Maqrīzī, *al-Khiṭaṭ*, 2:212.

responsible for making *tasbih* (praising the Almighty) during the last few hours of the night, sending blessings on the Prophet Muhammad, reciting the last three Suras of the Holy Quran i.e., al-Ikhlās, al-Falaq, and al-Nas, and he performed the role of the *muballigh* (responder) as well.⁹⁹

Amongst the most important side acoustic duties which were assigned to the *mu'adhdhin*, was to perform the job of *muraqqi*. The *muraqqi* was in charge of making the *adhan* as soon as the *khatib* left his room on his way to the minbar.¹⁰⁰ This *adhan* was followed by reciting the following verse:

إِنَّ اللَّهَ وَمَلَائِكَتَهُ يُصَلُّونَ عَلَى النَّبِيِّ يَا أَيُّهَا الَّذِينَ آمَنُوا صَلُّوا عَلَيْهِ وَسَلِّمُوا تَسْلِيمًا (56)

"Verily Allah and His angels send blessings on the Prophet, O, you who believe! O you who believe! Send you also blessings on him, and you salute him with submission (56)."¹⁰¹

The *muraqqi* was also responsible for reciting the second *adhan*, that is, the *adhan* which is performed right after the imam's ascension to the *minbar*.¹⁰² Last but not least, the *muraqqi* made the call to prayer at the steps the mosque, especially during the Ottoman period, after the *khutba* but before the Friday prayer.¹⁰³ Additionally, his employment may have extended further to the recitation of religious poetry and liturgical chanting.¹⁰⁴

⁹⁹ Amīn, *al-Awqāf*, 190.

¹⁰⁰ 'Uthmān, *Naẓariyyat al- Wazīfiyyah*, 140.

¹⁰¹ Quran 33:56.

¹⁰² 'Uthmān, *Naẓariyyat al- Wazīfiyyah*, 140.

¹⁰³ Williams, "Ottoman Cairo," 463.

¹⁰⁴ Abouseif, *The Minarets*, 12.

Finally, the *mu'adhdhinin* were sometimes employed, especially during the Mamluk period, at funerals to perform eulogies for the deceased and to walk in the cortege while reciting *takbirs*.¹⁰⁵

On account of the significance of the *mu'adhdhin*'s role in Mamluk society, it was always overseen by the *muhtasib* (market watcher), i.e., the *muthasib* examined the *mu'adhdhin*'s knowledge of prayer times. In addition, he assured that the *mu'adhdhin* intoned the *adhan* in an audible manner without any sort of unneeded protraction.¹⁰⁶

1.2.6 The Du'a' (Supplication) in Islam

Due to its significance as a divine acoustic-related act of worship, Allah encompassed the *du'a'* (supplication) with a distinctive stature. Such singularity is well conveyed in the Holy Quran via many verses in which the Almighty shows the faithful the different useful dimensions of the *du'a'* as a behavior as well as an act of worship. For Example, Allah says:

وَإِذَا سَأَلَكَ عِبَادِي عَنِّي فَإِنِّي قَرِيبٌ أُجِيبُ دَعْوَةَ الدَّاعِ إِذَا دَعَانِ فَلْيَسْتَجِيبُوا لِي وَلْيُؤْمِنُوا بِي لَعَلَّهُمْ
يَرْشُدُونَ (86)

"When My servants ask thee concerning Me, I am indeed close (to them): I listen to the prayer of every suppliant when he calls on Me: Let them also, with a will, Listen to My call, and believe in Me: That they may walk in the right way (86)."¹⁰⁷

Besides its great meaning of showing the faithful how the Almighty is so close to them, although they may feel far and removed from Him, the previous verse conveys

¹⁰⁵ Ibid, 10; Al-Ḥadād, *Qarāfīt al-Qāhira*, 340.

¹⁰⁶ Al-Shayzarī, *al-Rutba*, 111.

¹⁰⁷ Quran 2:186.

the sonic nature of this great ritual whether from the recited action of the supplication or the audition and the quick response of the Almighty.

The significance of the supplication in the Holy Quran is affirmed by the next verses in which Allah says:

وَقَالَ رَبُّكُمْ ادْعُونِي أَسْتَجِبْ لَكُمْ إِنَّ الَّذِينَ يَسْتَكْبِرُونَ عَنْ عِبَادَتِي سَيَدْخُلُونَ جَهَنَّمَ دَاخِرِينَ (60)

"And your Lord said: "Invoke Me, I will respond to your [invocation]. Indeed those who scorn My worship, they will surely enter Hell in humiliation (60)."¹⁰⁸ In this verse, Allah emphasizes the significance of supplication that acts as a borderline line between belief and unbelief. Furthermore, the acoustic nature of supplication is also metaphorically expressed in this verse when the Almighty promises the faithful that their sound and request will be heard and answered.¹⁰⁹

Despite the fact that making a *du'a* is one of the simplest Islamic rituals, there is a special etiquette which should be followed by the faithful while performing *du'a* whether individually or in a congregation. Allah says in the Holy Quran:

إِنَّ هَذِهِ أُمَّتُكُمْ أُمَّةً وَاحِدَةً وَأَنَا رَبُّكُمْ فَاعْبُدُونِ (92)

"Verily, this umma of yours is a single umma, and I am your Lord: so worship Me (92)."¹¹⁰

Hence, it could be understood from the previous verse that Islam has always called for the unity of umma (nation) in different aspects of life, especially the religious side. That is why performing prayer in congregation has 27 times more reward than individual prayer. The concept of favoring congregation rituals over individual ones is also applicable to the supplication due to its reward by Allah to

¹⁰⁸ Quran 40:60.

¹⁰⁹ Sirāj Al-Dīn, *al-Du‘ā*, 9-11; ‘Aṭīyah, *al-Du‘ā*, 180.

¹¹⁰ Quran 21:92.

those who perform it in a group. This concept is well illustrated in many Quranic verses which relate to making *du'a* in terms of using the pronoun "we" to support the congregational idea.¹¹¹ For instance, Allah says:

رَبَّنَا إِنَّا سَمِعْنَا مُنَادِيًا يُنَادِي لِلْإِيمَانِ أَنْ آمِنُوا بِرَبِّكُمْ فَآمَنَّا رَبَّنَا فَاغْفِرْ لَنَا ذُنُوبَنَا وَكَفِّرْ عَنَّا سَيِّئَاتِنَا وَتَوَفَّنَا

مَعَ الْأَبْرَارِ (193)

"Our Lord! Verily we have heard (the invitation of) a Crier calling to the faith, saying: 'Believe in your Lord!' So we did believe. 'Our Lord! Forgive us therefore our sins, and cover of us our evil deeds, and make us die with the righteous (193)."¹¹²

1.2.7 The Dhikr (Remembrance) in Islam

The Prophet Muhammad said in the traditions, as narrated by al-Bukahri:

"Allah the Most High says, 'I am with my slave when he thinks of Me and I am with him when he mentions Me. For if he mentions Me to himself, I mention him to Myself; and if he mentions Me in a gathering, I mention him in a superior gathering. If he approaches Me by a hand's width, I approach him by an arm's length. If he approaches Me by an arm's length, I approach him by two arms length. And if he comes to Me walking, I hasten to him swiftly."¹¹³

Based on the general theme of the study, the importance of this hadith is twofold. First, it illustrates how weighty is *dhikr*, this simple Islamic ritual which is felt by the hearts of the true believers then expressed silently or aloud. Second, Allah Almighty conveys, probably in an indirect way, the acoustic nature of this ritual through maximizing the rewards of the faithful who make *dhikr* aloud in a superior

¹¹¹ Ahmad and al-Khaṭīb, *al-Du'a*, 59.

¹¹² Quran 3:193.

¹¹³ www.islamawareness.net/dua/fortress/000_1.html.

gathering, for making *dhikr* aloud plays an axial role in reminding other faithful by the importance of striving to remember the Almighty in all situations and conditions.

From the religious perspective, Islam encompasses many different acts of worship, all of which include specific types of *dhikr* formulae which are recited by the faithful such as performing prayers, giving alms, fasting in the month of Ramadan, or making pilgrimage.¹¹⁴ In terms of mentioning the significant benefits and other dimensions of *dhikr*, nothing could be more useful and illustrative than the Holy Quran. In many verses Allah mentions *dhikr* within a specific context, for instance, the Almighty promises the faithful, who remember Him through making *dhikr*, that He will remember them as well, the verse is:

فَاذْكُرُونِي أَذْكَرُكُمْ وَاشْكُرُوا لِي وَلَا تَكْفُرُونِ (152)

"Therefore, remember Me, and I will remember you; and be thankful to Me, and be you not ungrateful (152)."¹¹⁵

The acoustic stature of the *dhikr* in this verse could be emphasized if related to this hadith; observed I am with My Slave when he remembers Me and move his lips (with remembrance)".¹¹⁶

From a different perspective, the Holy Quran shows many positive psychoacoustic impacts of the *dhikr* on the faithful upon reciting or hearing it. Among the most important psychoacoustic effects of making *dhikr* is that it brings tranquility and peace to the heart of the believers. Such meanings are conveyed in the following verse:

¹¹⁴ Hasan, *al-Tasbīh*, 3.

¹¹⁵ Quran 2:152.

¹¹⁶ Al-Sha‘rāwī, *al-Aḥādīth*, 2:159.

الَّذِينَ آمَنُوا وَتَطْمَئِنُّ قُلُوبُهُمْ بِذِكْرِ اللَّهِ أَلَا بِذِكْرِ اللَّهِ تَطْمَئِنُّ الْقُلُوبُ (28)

"(The guided are) those who believe and their hearts are set at rest by the remembrance of Allah. Behold! By Allah's remembrance (only) the hearts are set at rest (28)."¹¹⁷

Among the most popular methods of making *dhikr* is sending peace and blessing upon the Prophet Muhammad.¹¹⁸ Such *dhikr* evolved over time to be crystallized in the form of *al-madih al-Nabawi* which in turn became one of the most popular acoustic related rituals in religious buildings, especially during the Mamluk period. Consequently, many Mamluk patrons, especially the Sultans, were keen on endowing special personnel known as "the *madih*" or "the *munshid*" (eulogist) within their endowed religious buildings.¹¹⁹ His exact acoustic role could be illustrated in the *waqf* deed of Sultan Hasan which states that the *madih*'s job was to chant different Prophetic eulogies.

Moreover; he should recite Sura al-Kahf on Friday, after the congregation, followed by chanting ten or more phrases from the Prophetic eulogy.¹²⁰ Due to the significance of his acoustic role, many *waqfiyyas* stipulated that the eulogist should enjoy a good voice sound besides being of good character.¹²¹

1.2.8 Al-Tabligh (Ritualistic Informing) in Islam

The-increasing numbers of the faithful in the Muslim societies resulted in expanding the areas of the religious buildings to accommodate large congregations.

¹¹⁷ Quran 13:28.

¹¹⁸ Aḥmad, *al-Du'ā'*, 149.

¹¹⁹ Amīn, *al-Awqāf*, 192.

¹²⁰ Ibid, 213; 'Uthmān, *Nazriyat al-Waḥfiyyah*, 175-176.

¹²¹ Loc. cit.

Thus, there was an acoustic problem with regards to transferring the prayers actions of the imam to the congregation at the back rows. As a result, the *tabligh* became one of the significant acoustic duties performed by the *mu'adhdhinin* within the different types of religious buildings, especially during the Mamluk period. Accordingly, when the *mu'adhdhin* performed the role of the *muballigh* his prime duty was to repeat the ritual postures of the imam, from the *dikka*, which was popularly known in the Mamluk *waqfiyyas* as *dikkat al-mu'adhdhin*, as in the case of the of Sultan Faraj b. Barquq's *waqfiyya*,¹²² and speak the responses so that the different stages of the prayer could be projected out to a large congregation in a clear audible fashion.¹²³ The *tabligh* mission which was performed by the *mu'adhdhin* after the imam is clearly stated in the *waqfiyya* of Sultan al-Ghawri.¹²⁴

However, the *waqfiyya* of Amir al-Jamali Yusuf specified the *dikka* as the station from which the *mu'adhdhinin* recited the *iqama adhan* along with performing the *tabligh* after the imam i.e. repeating his actions during the prayers.¹²⁵

Due to its essential nature in the newly designed spacious religious premises, most of the Islamic jurists approved the acoustic notion of the *tabligh*.¹²⁶

¹²² 'Uthmān, *Nazriyyat al-Wazifiyyiah*, 301.

¹²³ Gabr, *The Influence*, 190; El-Khateeb and Ismail, "The Acoustics," 115; Frishman, *The Mosque*, 37.

¹²⁴ Amīn, *al-Awqāf*, 190.

¹²⁵ 'Uthmān, *Nazriyyat al-Wazifiyyiah*, 302.

¹²⁶ Ibn Taymīyah, *al-Fatāwā al-kubrā*, 1:82-83; Ayyūb, *Fiqh al-'Ibādāt*, 242.

Chapter Two

The Archaeoacoustics of Cairo's Major Islamic Historic Religious Buildings

In chapter one, the multi-dimensional value of acoustics in Islam has been illustrated; especially from the ritualistic view. Religious buildings in Islam were the spaces where the primary Islamic rites were performed. Therefore, it is strongly believed that there was some sort of mutual impact between the acoustic essence of those rites and the general architectural outlines of the religious buildings.

This chapter aims chiefly at analyzing the different architectural elements along with the special pieces of furniture which have contributed to the creation of the soundscape of Cairo's religious buildings. The analysis should be able to determine which elements were introduced to serve solely for an acoustic purpose. Other elements were originally introduced to serve another purpose but partially contributed to one or more acoustic dimension in the premises. Those elements could be classified into two categories;

First: sound transmission elements; namely, the minaret, the *minbar*, the *dikka*, the *kursi*, and the fenestration; second: sound diffusion and amplification elements; namely, the mihrab, the dome, and the muqarnas.

Surprisingly, when architects aimed at creating a quality soundscape within religious buildings, they also resorted to noise reduction techniques.

Another important aspect to analyze here is the factual acoustic aspects, that is to say determining the rate of sound diffusion and intelligibility in major Cairene religious buildings from the time of the Arab conquest through the reign of Muhammad 'Ali Pasha. The selection is based on the fact that each building has featured a specific architectural development, whether in its architectural design or through introducing an acoustic-related architectural novelty. According to the

archaeological theme of this chapter, it will be analytically approached from an archaeoacoustic perspective in relation with modern acoustic parameters.

2.1 The Essence of Archaeoacoustics

Archaeoacoustics, which is also known as the archaeology of sound,¹²⁷ is classified as an interdisciplinary science that merges the sciences of acoustics, architecture, archaeology and history in order to analyze a feature of intangible cultural heritage.¹²⁸

All ancient spaces, both natural and cultural, have somehow displayed acoustic properties that would have been readily perceived by different historic societies.¹²⁹ Many of those spaces; especially the religious, have been intentionally designed and explicitly chosen, for rituals, ceremonies or other performances in which sound intelligibility and quality is a crucial ingredient,¹³⁰ for instance, temples, churches and mosques. Accordingly, archaeoacoustics is considered the most effective scientific discipline through which the acoustics of Cairo's religious architecture could be analyzed and studied.

¹²⁷ Zubrow, "Sound," 12.

¹²⁸ Brezina, "Historic Spaces," 579.

¹²⁹ Scarre, "Archaeology of Acoustics," 1.

¹³⁰ Zubrow, "Sound," 7, 12.

2.2 Sound Theory and Acoustics Fundamentals

Based on the acoustic nature of the study, this part has been allocated to briefly demonstrate the basics of sound theory and fundamentals of acoustics in connection with achieving a better understanding of the essence of aural architecture.

2.2.1 Fundamentals of Acoustics

Acoustics, like any other science, is outlined and controlled by a set of fundamentals which, if properly studied, could effectively contribute to identifying the soundscapes of a given historic building. Accordingly, the next part of the study briefly demonstrates the significant acoustic fundamentals and parameters which are used throughout the research, especially when dealing with the archaeoacoustics of the selected historic buildings.

2.2.1.1 Frequency

A steady sound is produced by the repeated back and forth movement of an object at regular intervals. The time interval over which the motion recurs is known as the period.¹³¹ In the common equation, the time period is inverted to obtain the number of complete cycles of motion in one time interval. This number is called frequency i.e. $F = \frac{1}{T}$.¹³² The frequency is expressed in units of cycles per second, or Hertz (Hz).¹³³

2.2.1.2 Sound Waves

The sound wave is a longitudinal pressure fluctuation that moves through an elastic medium, mainly the air. The wavelength of a sound wave is a particularly

¹³¹ Long, *Architectural Acoustics*, 37.

¹³² Loc. cit.; Borham, *Environmental Aspects*, 66.

¹³³ Long, *Architectural Acoustics*, 37.

important measure for it represents the traveled distance of sound during a cycle of vibration. Much of the behavior of a sound wave relates to the wavelength. Therefore, it becomes the scale by which the physical size of objects can be judged.¹³⁴

2.2.1.4 Sound Directions

When a sound wave is generated, it tends to travel in multiple directions. However, it changes its travel direction when it strikes a boundary or any sizable surface.¹³⁵ Consequently, a part of the sound energy is absorbed, a part is reflected, and a part is transmitted into and possibly through the construction. The sum of the three components is equal to the total sound energy.¹³⁶ The proportion of each part depends on the physical properties of the material and the impinging sound. For instance, hard surfaces, such as the stone walls, reflect nearly all of the sound energy. On the other hand, soft porous materials, such as wood, fabrics, and even people absorb a great part of the energy striking them. In porous materials, a large portion of energy is usually transmitted through the material.¹³⁷

2.2.1.5 The Magnitude of Sound

When sound is generated from a still source, such as that of the imam in the mihrab, it radiates sound energy in all directions. The pattern of this sound energy resembles a sphere centered around the source.

2.2.2 Room Acoustics

Room acoustics is the science that is concerned with the behavior of sound in enclosed spaces. Inside any building, sound is affected by the boundaries and

¹³⁴ Ibid, 51.

¹³⁵ Borham, *Environmental Aspects*, 67.

¹³⁶ Loc. cit.

¹³⁷ Ibid, 68.

obstructions within the structure. The size and shape of the building also determines the sound distribution within its space.¹³⁸

In a given room, where listening to some sound is an important function, it is said to have good acoustics if the following conditions could be met:

1. Any background noise is low enough and the wanted sound is loud enough to be audible and free of disturbance.
2. The sound field is well-diffused.
3. There are no echoes or other acoustic distortions.¹³⁹

In consequence, there are particular acoustic fundamentals in connection with achieving the desired quality of room acoustics, especially from the intelligibility perspective.

2.2.2.1 Sound Intelligibility Components

The speech intelligibility level is determined by two factors which are speech sound level and the ambient noise. It could be expressed by the speech signal to noise ratio which states that: the less the room reverberation and the higher level of the speech sound relative to the ambient noise, the greater the intelligibility of speech.¹⁴⁰

2.2.2.2 Sound Diffusion Pattern

Based on multiple acoustic scholarship, it has been shown that in a room with simple geometry, sound propagation from source to a receiver (listener) takes the pattern shown in (fig. 1).

¹³⁸ Ibid, 70.

¹³⁹ Loc. cit.

¹⁴⁰ Abdou, "Acoustical performance," 41.

The first wave front arrives along the direct path (if the source is visible).
Soon after this, the first reflections from walls, ceiling and floor arrive.¹⁴¹

2.2.2.3 Reverberation

Reverberation is the prolongation of sound after being produced and interjected within a given space. Such persistence occurs when the original sound is reflected causing multiple other reflections which decay over a given period of time after being absorbed by the surface of the present different objects in the room or space.¹⁴² In the same context, the reverberation time (RT) refers to the required time for a signal to drop by 60 dB from its initial level.¹⁴³

2.2.2.4 Sound Echoes

Echoes are sounds that encounter and rebound from reflecting surfaces while they travel through the medium.¹⁴⁴ In other words, echo is the reflection and repetition of the original sound that is distinctively perceptible.¹⁴⁵

2.3 Sound Transmission Elements

Thanks to modern acoustic scholarship, it has been easier to understand the different components and parameters of acoustics which could be used nowadays by scholars in the field of Islamic art and architecture to uncover the archaeoacoustic aspects of Islamic religious monuments.

¹⁴¹ Pulkki and Karjalainen, *Acoustics*, 34.

¹⁴² Long, *Architectural Acoustics*, 585; Borham, *Environmental Aspects*, 70.

¹⁴³ Al-Khafaji and ‘Abd Al-Ḥasan, "Acoustic Performance," 68.

¹⁴⁴ O'Callaghan, "Echoes," 403.

¹⁴⁵ Long, *Architectural Acoustics*, 585.

2.3.1 The Minarets

"Give us rest with it, O Bilal." This metaphorical command had always been given by the Prophet Muhammad to his favorite *mu'adhdhin* Bilal as a sign to ascend the roof of his house in Madina in order to perform the *adhan*.¹⁴⁶ This simple austere roof was the architectural nucleus of those later high-rise acoustic elements that punctuated the skyline of the Islamic world, i.e. the minarets. Since minarets have been associated with announcing the times of the prescribed prayers in Islam, they became in most cases an acoustic mainstay in various types of Islamic religious buildings, especially in Islamic Cairo which has been entitled "the city of a thousand minarets."

This section addresses the different aspects of the minaret from an acoustic perspective. When the first Muslim generation migrated from Makkah to Madinah, they used to pray, at least for a while, without any preceding *adhan*. However, when it was established, the Prophet Muhammad commanded Bilal, who was his herald and first *mu'adhdhin* in Islam, to rise and give the call to prayer.¹⁴⁷ Al-Nawawi, Muslim author of *fiqh* and hadith d. 676/1277, placed a permissible interpretation to this command by stating that the Prophet meant, "O Bilal, go to some prominent place and summon to prayer."¹⁴⁸ Accordingly, Bilal understood that he should aim for a place from where he could be seen and heard by the community,¹⁴⁹ i.e. an elevated spot in accordance with the acoustic nature of the *adhan*. It could be understood that during the time of the Prophet, al-masjid al-nabawi did not originally feature a minaret, for its architecture was so simple to the extent that there was no place for building a tower

¹⁴⁶ Frishman, *The Mosque*, 40.

¹⁴⁷ Gottheil, "History of the Minaret," 134.

¹⁴⁸ Loc. cit.

¹⁴⁹ Loc. cit.

to be used for making the call to prayer.¹⁵⁰ However, both elements, i.e. the high place and the elevated structure contributed to the crystallization of the minaret notion afterwards.¹⁵¹ From the physical acoustic perspective, the Prophet Muhammad aimed for a special spot with a reasonable height for the *adhan* performance in order to make Bilal's voice, during his recitation, as audible as possible for the Muslim community.¹⁵²

When the *adhan*, as a sound, is generated by a *mu'adhdhin*, it takes the form of sound waves which tend instantly to travel, diffuse and spread in all directions. The strength of the sound source, along with its given height over the surrounding structures, helps the sound waves to travel farther.¹⁵³ In conclusion, in most cases, height is an essential component in the development of historic minarets in terms of boosting the *mu'adhdhin*'s voice intelligibility and projection over the surrounding neighborhood.¹⁵⁴

2.3.1.1 The Acoustic Role of the Minaret

Right after the Islamic conquest of Egypt, 'Amr b. al-'As, commander in chief of the conquering Arab troops, built the first congregational mosque in al-Fustat in 21/641-20.¹⁵⁵ A few years later the Muslim community of al-Fustat witnessed a rapid growth. The Caliph Mu'awiya then ordered his *wali* (governor) in Egypt, Maslama b. Mukhallad to pull down the mosque and rebuild it in a more spacious fashion along

¹⁵⁰ Ibid, 133.

¹⁵¹ Abouseif, *The Minarets*, 10.

¹⁵² Abouseif, *The Minarets*, 1; 'Azzab, "Fiqh 'Imārit," 49.

¹⁵³ Long, *Architectural Acoustics*, 167-168.

¹⁵⁴ Abouseif, *The Minarets*, 2-3; Kleiner et al., *Worship Space*, 269.

¹⁵⁵ Abouseif, *Islamic Architecture*, 47.

with building four minarets, one on each corner of the renovated building.¹⁵⁶ Most probably, in his addition to the four minarets – صومعة – *sauma'a*, Mu'awiya aimed at copying the same arrangement of the great Umayyad mosque of Damascus that made use of the preexisting Roman corner towers as minarets.¹⁵⁷

Notably, the newly introduced structures did not take the complete shape of a tower, but they were like Christian monastic cells that projected only slightly from the mosque's roof.¹⁵⁸ For this reason, they were prominently called *sawami'*.¹⁵⁹ However, a few other terms were used as well to identify the tall towers attached to the mosques, such as *manara* or *manar* from which the current and most popular English term "minaret" derives.¹⁶⁰ Both Arabic terms i.e. *manara* and *manar* translate as a "light-tower" or a "light-house" for most probably the *mu'adhdhin* used to hold a light while reciting the call of prayer at night. Thus, the minaret looked like a light-tower for the onlooker below.¹⁶¹

Moreover, the earlier and more important designation of the minaret is *mi'dhanah* which stands for an instrument for giving the call to prayer,¹⁶² or the place of the *adhan*.¹⁶³ Consequently, it is quite obvious that the most popular names given to the minaret were based on its acoustic function. From the sound propagation

¹⁵⁶ Ibid, 47-48; Bloom, *The Minaret*, 30.

¹⁵⁷ Abouseif, *The Minarets*, 21.

¹⁵⁸ Ibid, 21, 23.

¹⁵⁹ Al-Maqrīzī, *al-Khiṭaṭ*, 2:248; Mussa, *al-Ma'ādhin*, 2:9.

¹⁶⁰ Bloom, *The Minaret*, 46.

¹⁶¹ Gottheil, "History of the Minaret," 133.

¹⁶² Abouseif, *The Minarets*, 15.

¹⁶³ Bloom, *The Minarets*, 33.

perspective, the arrangement of the previously mentioned elevated minarets, in the four corners of the mosque, was adequate for each *mu'adhdhin* addressing the *adhan* to a specific side of the city.¹⁶⁴

In terms of improving the *adhan* acoustics, the *mu'adhdhinin* of al-Fustat mosque resorted to an effective sound amplification technique, namely performing the *adhan* collectively.¹⁶⁵ The trend of appointing more than one *mu'adhdhin* in the same mosque most probably occurred in the time of the Prophet. Ibn Hajar said, in this context, that the Prophet ordered almost twenty of the companions to summon the *adhan* and they did.¹⁶⁶ According to al-Maqrizi, Maslama b. Mukhalad commanded the *mu'adhdhinin* to perform the *adhan* in a single loud voice, after they finished all other *mu'adhdhinin* across al-Fustat recited the *adhan* in a collective fashion as well.¹⁶⁷ Unfortunately, any information about the any minaret of al-'Askar's mosque (169/785) is completely lacking.

The minaret of Ahmad ibn Tulun's mosque (263-265/ 876-879) has always been a problematic issue between art historians in its original architectural form. However, it was the most exotic high-rise construction in medieval Cairene architecture.¹⁶⁸ The original Tulunid minaret, following the *malwiya* of Samarra, consisted of a square base which supports an external ramp that spirals upwards around a central solid cylinder.¹⁶⁹ This fashion was – most probably – imported from

¹⁶⁴ Abouseif, *Islamic Architecture*, 47-48.

¹⁶⁵ Mussa, *al-Ma'ādhin*, 1:14.

¹⁶⁶ Mussa, *al-Ma'ādhin*, 2:38.

¹⁶⁷ Al-Maqrīzī, *al-Khiṭaṭ*, 2:248.

¹⁶⁸ Abouseif, *The Minarets*, 101.

¹⁶⁹ Hillenbrand, *Islamic Architecture*, 144.

the ancient Mesopotamian ziggurats.¹⁷⁰ Since it followed the same organization of the Great Mosque of al-Mutawakkil and the mosque of Abu Dulaf, both in Samarra, the location of the minaret would be axial with its main mihrab.¹⁷¹ Certainly, the primary role of the minaret was acoustic, that is to say, sounding the *adhan* to the inhabitants of the Qata'ī city.

On the other hand, al-Maqrizi specified another unexpected platform from which the *iqama adhan* was recited i.e., from the dome of the fountain which was found in the center of the courtyard.¹⁷² This domed structure appeared to have been an octagon with two marble columns at each angle and another sixteen marble columns at the sides. It was paved with marble and contained a basin, made of marble as well, from the middle of which a fountain jetted water into the air.¹⁷³ The location of the *adhan* platform in the middle of the courtyard could have contributed, to a certain extent, to achieving a better diffusion of the *mu'adhdhin's* voice while reciting the *iqama adhan*.

Being one of the most distinctive dynasties in the history of Islam, the Fatimid Caliphate had succeeded, within a short time span, in shaping the major outlines of Islamic art and architecture across central Islamic lands, especially in Egypt.

Since the Fatimids were affiliated to the Isma'ili order, their main objective, in Egypt, was to exploit every possible facility, including art and architecture, to propagandize the newly introduced Shi'i creed throughout Egyptian society. Minarets were thus a pivotal acoustic tool in achieving their political and ideological targets in Egypt.

¹⁷⁰ Hillenbrand, "The Mosque," 42.

¹⁷¹ Swelim, *Ibn Tulun*, 102; Hillenbrand, *Islamic Architecture*, 144.

¹⁷² Al-Maqrīzī, *Al-Khiṭaṭ*, 2:268; Gabr, *The Influence*, 377; Bloom, *Minaret*, 129.

¹⁷³ Creswell, *Muhammadan Monuments*, 50; Swelim, *Ibn Ṭūlūn*, 232.

It is broadly agreed that the Fatimids had successfully found their way to this Tulunid high-rise landmark to be their first acoustic station from where they summoned their distinctive Shi‘i *adhan* for the first time in Egypt.¹⁷⁴

The recited Shi‘i *adhan* was slightly different from that of the Sunni, in respect of merely including the phrase *hayy ‘ala khayr al-‘amal* or "come to the best of works" between the fifth and sixth phrases of the regular *adhan*. However, this short ideological phrase became emblematic of the Shi‘i rule and dominance over Egypt.¹⁷⁵

Among the greatest archaeoacoustic inventions which are attributed to the Fatimid period is the introduction of the *mu’adhdhin*'s balcony which, in turn, became the official acoustic station within the minaret entity. The *mu’adhdhin*'s balcony has been used from the 11th century through the very beginning of the 20th century when electrified loudspeakers substituted the *mu’adhdhin*'s role, for instance, the loudspeakers which are mounted on the minarets of Faraj ibn Barquq *khanqah* in the Northern Cemetery (fig. 2).

Generally speaking, the balconies of minarets, which took the form of rings around the shaft at the top of the first and second stories, were for the exclusive use of the appointed *mu’adhdhinin* to broadcast their call to prayer on all sides.¹⁷⁶ The earliest and simplest rectangular *mu’adhdhin*'s balcony in Cairene religious architecture is that of al-Juyushi minaret (1085). According to Creswell, it became the prototype of the classic Cairene minaret that consists of three storeys; successively square, octagonal and circular in section.¹⁷⁷ Meanwhile, the *mu’adhdhin*'s balcony of

¹⁷⁴ Abouseif, *The Minarets*, Surūr; *al-Faṭimiyah*, 80.

¹⁷⁵ Loc. cit.; ‘Uthman, *Nazariyyat al-Wazifiyyah*, 201.

¹⁷⁶ Abouseif, *The Minarets*, 68.

¹⁷⁷ Mūsā, *al-Ma’ādhin*, 2:171.

the shrine of Abu'l-Ghadanfar (1157) has reserved its rank as the first well-structured wooden *mu'adhdhin's* balcony in historic Cairo.¹⁷⁸

The concept of applying double minarets to the main facade of the religious building, as in the case of the al-Hakim mosque, effectively contributed, in later periods, to the improvement of the minaret acoustics, especially during the Mamluk period in which the concept of applying double symmetrical minarets was frequent, for instance the minarets of Faraj ibn Barquq *khanqah* in the Northern Cemetery (fig.3).

It could be permissible to say that the *adhan* in those religious buildings which featured double or multiple minarets was given simultaneously. This hypothesis is supported by the *waqfiyya* of Sultan Hasan madrasa which states that a group or a choir of 4 *mu'adhdhinin* was gathered on each minaret of the premises to recite the *adhan* and perform *dhikr*.¹⁷⁹ In the same context, the term "جوقة", which translates as choir, is mentioned in many *waqfiyyas* such as that of Sultan Barquq mosque in terms of describing the *mu'adhdhinin* groups who delivered the *adhan* simultaneously.¹⁸⁰ The term choir itself could be a supportive linguistic evidence of group performance of the *adhan* as it always stands for artistic or religious collective chanting.

Throughout the Mamluk period (648-923/ 1250-1517), most Sultans and amirs had always tended to emphasize their political domination along with their strict ideological affiliation to Islam through executing distinctive religious building programs.¹⁸¹ Accordingly, in most cases, Mamluk patrons of religious buildings had

¹⁷⁸ Loc. cit.; Mūsā, *al-Ma'ādhdhin*, 1:47.

¹⁷⁹ 'Uthman, *Nazariyyat al-Wazifiyyiah*, 283.

¹⁸⁰ Loc.cit.; Amin, *al-Awqāf*, 189.

¹⁸¹ 'Ashūr, *al-Mujtama 'al-Miṣrī*, 90.

given considerable architectural and decorative attention to the minaret for its prominent audio-visual role in Cairene society.

Among the most distinctive acoustic innovations in the Mamluk minaret is the introduction of more than one *mu'adhdhin* balcony in the same minaret. For instance, the minarets of the Qalawun complex (fig. 4), the al-Nasir Muhammad mosque at the citadel, and the Tatar al-Hijaziya madrasa featured two balconies;¹⁸² while the minarets of al-Nasir Faraj b. Barquq *khanqah* and the mosque of al-Mu'ayyad Shaykh featured three balconies.¹⁸³ Mamluk *mu'adhdhin* balconies could be rectangular, octagonal, circular, or sometimes hexagonal.¹⁸⁴

The upper and lower *mu'adhdhin* galleries were sometimes used separately. In other words, the *mu'adhdhin*'s choir was ordered, in most cases, to use the upper galleries during the daytime. It is believed that this trend was applied to keep their sightlines away from the interior of the surrounding domestic buildings, or at least to make it difficult for the *mu'adhdhin* to identify the features of the women in the surrounding houses and roofs;¹⁸⁵ however, this issue is controversial as the presence of the *mu'adhdhinin* in those upper galleries could increase the chances of their views into the very adjacent houses, especially their courtyards. Yet, from the acoustic perspective their voices were well propagated due to the reasonably increased height of the balcony.¹⁸⁶

¹⁸² Mūsā, *al-Ma'ādhin*, 2:172-173, 175.

¹⁸³ *Ibid*, 177.

¹⁸⁴ *Ibid*, 184-186.

¹⁸⁵ 'Azzab, *Fiqh al-'Umran*, 107; 'Uthmān, *Aḥkām al-Bunyān*, 61-62.

¹⁸⁶ 'Uthman, *al-Waziffiyah*, 294; 'Azzab, *Fiqh al-'Umran*, 107.

Conversely, at night, they were directed to make the collective call to prayer from the lower balcony. In this case, their sound did not travel for a long distance.¹⁸⁷ However, it is difficult to calculate the precise sound transmission distance for there were many other variables that affected the sound transmission factor such as the temperature and the fluctuating levels of the noise background.

Upon analyzing the heights of many Cairene historic minarets¹⁸⁸ it has been found that the average height of the first *mu'adhdhin's* balcony is 24m high, while the average height of the second is 30.5m and the average height of the third is 31.3m. According to acoustician Hany A. Shawky, professor and researcher in the acoustics department at the Egyptian National Institute of Standards, the average height of a human sound source from where the generated sound could still be audible and distinguishable by listeners, in the area adjacent to the religious building, ranges between 35 and 45m considering that the average loudness of an adult singing voice ranges from 70 and 80 dB.

On the other hand, if the sound source height exceeds 45m up to 60m the generated sound could possibly be audible within earshot of the area immediately

¹⁸⁷ Loc. cit.; 'Uthmān, *al-Waziffiyah*, 294.

¹⁸⁸ The minarets of: al-Juyushi mosque, the shrine of Abu'l –Ghadanfar, the madrasa of al-Salih Najm al-Din Ayyub, the complex of Sanjar al-Jawli, the khanqah of Baybars al-Jashankir, the southern minaret of the Suyuti cemetery, the mosque of amir Aqusunqur, the mosque of Manjaq al-Yusufi, the mosque of amir Shaykhu, the madrasa of amir Sarghitmish, the Sultaniyya mausoleum, the madrasa of the Mother of Sultan Sha'ban, the mosque al-Mu'ayyad Shaykh, the mosque Sultan al-Ghawri, the mosque of Sulayman Pasha, the mosque of 'Abidin Bey, and the mosque of Sulayman Agha al-Silahdar.

adjacent to the sound source, but it would be substantially undistinguishable by the listeners.¹⁸⁹ Certainly, besides height there were many other variable factors that contributed to determining the rates of sound audibility, such as temperature, wind direction, humidity and surrounding background noise. However, since it is impossible to reconstruct the exact past soundscape of the open space that surrounded the minarets; the study only focuses on the height of the *mu'adhdhin's* balcony.

In conclusion, the architect, in most cases, showed conceivable skills in the field of architectural acoustics by choosing the aforementioned average heights for the *mu'adhdhin's* balcony in most of Cairo's historic minarets in respect of assuring the *mu'adhdhin's* audibility and diffusion.

However, sometimes the architect has exceeded the normal height ranges of the minarets as in the case of the southern minaret of Sultan Hasan madrasa which stands almost eighty meters high including its buttress, making it the tallest minaret in medieval Cairo.¹⁹⁰ All the more, the soaring minarets of Muhammad 'Ali mosque are also astoundingly high (84m)¹⁹¹. In both cases, it is believed that the architect was much more concerned with visual rather than acoustic effect.

Indeed, it is difficult to overlook the sonic behavior of the *mu'adhdhin* while reciting the *adhan* from his balcony because the way he acted, both physically and vocally, is believed to have contributed to achieving better acoustics. With regards to the *mu'adhdhin* vocal qualifications, many Mamluk *waqf* deeds of mosques stipulated that the *mu'adhdhin's* voice should be far-reaching and yet sound without strain.¹⁹²

¹⁸⁹ Interview with the Acoustician Dr. Hany A. Shawky, March 7, 2016.

¹⁹⁰ Abouseif, *The Minarets*, 189.

¹⁹¹ *Ibid*, 302.

¹⁹² *Ibid*, 13.

As for the *mu'adhdhin's* physical behavior, it could be permissible to state that, in most cases, whenever the *mu'adhdhin* mounted the minaret, he was keen on rotating around the balcony while performing the *adhan*.¹⁹³ Possibly, he resorted to such acoustic fashion in terms of assuring that his recitation would be heard on all sides of the neighborhood. This phenomenon is known acoustically as the Doppler Effect. It occurs when the original sound source moves or rotates; such movement causes the sound frequency, which is heard by a stationary observer, to change. In other words, the received sound frequency gets higher during the approach, identical at the instant of passing by, and lower during the recession.¹⁹⁴

In the same context, most *mu'adhdhinin* were keen on thrusting one finger in each ear while summoning the *adhan*. This action was initially done by Bilal because it causes the *mu'adhdhin* to raise his voice.¹⁹⁵

Although being prominently dedicated to *adhan* recitation, the minaret had been engaged in other acoustic activities, i.e. additional religious recitations. Al-Maqrizi reports that Ibn Tulun introduced the *takbir* and *tasbih* and other invocations and recitations to be recited by the *mu'adhdhinin* from the minarets during the night.¹⁹⁶ Al-Maqrizi adds that those customs prevailed in his own days (the early fifteenth century).¹⁹⁷

¹⁹³ 'Azzab, *Fiqh al-'Umrān*, 108.

¹⁹⁴ Long, *Architectural Acoustics*, 182; Pulkki and Karjalainen, *Acoustics*, 33.

¹⁹⁵ Al-Maṣri, *al-'Ibādāt*, 426.

¹⁹⁶ Abouseif, *The Minarets*, 10.

¹⁹⁷ Loc. cit.

Cairene minarets during the Ottoman dynasty witnessed a sharp alteration in their architectural and aesthetic qualities.¹⁹⁸ Most Cairene minarets which had been built during that time were composed of a square pedestal surmounted by a tall polygonal shaft which ended with a single balcony crowned with a conical top.¹⁹⁹ However, a few Ottoman minarets featured two *mu'adhdhin*'s balconies, such as those of Muhammad 'Ali Pasha mosque (1830-48) and the minaret of Khedive Isma'il at the Shrine of al-Husayn.²⁰⁰

From the acoustic perspective, the number of *mu'adhdhinin* in most Ottoman as opposed to Mamluk religious buildings considerably decreased, for economic reasons. The decrease in *mu'adhdhin* balconies may also have contributed to lessening the number of *mu'adhdhinin*. For instance, the *waqfiyya* of the Sultan al-Ghawri madrasa (1502-4) states that sixteen *mu'adhdhinin* were appointed to the premises,²⁰¹ but that of the mosque of Muhammad Bey Abu'l-Dhahab (1774) states that only five blind men were appointed as *mu'adhdhinin* and *muballighin* to the premises.²⁰²

Apparently, the reduction in the number of *mu'adhdhinin* had not affected the volume of the *adhan*, for most Ottoman mosques were established within crowded neighborhoods near to other pre-Ottoman religious premises. However, the overlapping *adhans* would have made them less distinct.

¹⁹⁸ Ibid, 28, 34.

¹⁹⁹ Abouseif, *Islamic Architecture*, 29; Organization of Islamic Capitals, *Principles*, 450.

²⁰⁰ Abouseif, *The Minarets*, 300, 304.

²⁰¹ Amin, *al-Awqaf*, 189.

²⁰² Crecelius, "The Waqf," 66.

During the Ottoman period, the minaret was sometimes replaced by a small balcony which projected from the main face of the religious building, if established amidst other minarets. An example is the balcony which projects from the face of the Amir ‘Abd al-Rahman Katkhuda mosque (*zawiya*) (1729) (fig. 5) at Mugharbilin Street near the minarets of the Sultans al-Salih Najm al-Din and al-Zahir Baybars.²⁰³

But the beginning of the 20th century marked the arrival of loudspeakers. They were also normally mounted in the most favorable locations for sound, on the balconies of the *mu’adhdhinin*.

2.3.2 The Acoustic Role of the Minbar (Pulpit)

Many Arabic lexicons mention that the term "*minbar*" is derived from the root word "نبر" which stands for the elevated platform of the *khatib*. For this reason, this platform is called in Arabic منبر mainly for its elevation from the ground level.²⁰⁴

From a different linguistic perspective, it is suggested that the word منبر was originally derived from the root word نبرت which means elevated sound,²⁰⁵ both suggestions could therefore be regarded as evidence for the acoustic essence of the *minbar*.²⁰⁶

The Prophet Muhammad originally delivered his *khutba*, by just standing, easily visible and audible by the seated worshippers.²⁰⁷ Later on, when the Prophet grew older, he agreed to place a *minbar* in his mosque to improve audibility. ‘Amr b. al-‘As was the first one to use a *minbar* in his mosque for the Friday sermon.²⁰⁸ However,

²⁰³ Abouseif, *The Minarets*, 16.

²⁰⁴ ‘Azzab, "Fiqh ‘Imārit," 44; Organization of Islamic Capitals, *Principles*, 435.

²⁰⁵ Loc. cit.

²⁰⁶ Loc. cit.

²⁰⁷ Hillenbrand, "The Mosque," 37.

²⁰⁸ Abouseif, *Islamic Architecture*, 49.

the Caliph ‘Umar b. al-Khattab did not support the idea of the leader standing above the worshippers during the oration.²⁰⁹ However, al-Tabari states that when Sa‘d ibn Abi Waqqas conquered al-Mada’in (Ctesiphon) in 16/ 637, he placed a *minbar* in the mosque of the city which was originally within the Iwan Kisra.²¹⁰ The mosque of Ahmad b. Tulun is said, according to Ibn Duqmaq, to have featured a *minbar*. This *minbar* was replaced by Sultan Lajin in 696/ 1296.²¹¹ However, its location behind a pier means that its acoustic performance must have been somewhat diminished.

A related question can be raised here. How audible was the *khutba* from a *minbar* in a large mosque? According to acoustician Hany A. Shawky, it was not possible for the orator's sound to be intelligibly heard beyond the end of the qibla *riwaq*. The earliest *minbar* example that illustrates adding a *jawasq* to the *minbar* is that of the Jami‘ Nuri at Hama (559/1163-4).²¹² This *minbar* dome, which is basically a curved structure, could have contributed, if properly designed, to creating a sound resonance and amplification.²¹³ This dome was copied in later *minbars*. Unfortunately, no Ayyubid *minbars* survive from Egypt.

In the Mamluk period, the size of the *minbar* was sometimes related to the size of the prayer area surrounding it.²¹⁴ Examples are the marble *minbar* of Aqsunqur mosque (1347) (fig. 6) which measures 6.25 m in height and 5.14 m in length. This *minbar* is placed in the qibla *riwaq* which measures approximately 100 m². Also, the

²⁰⁹ Loc. cit.

²¹⁰ Al-Šmādi, "al-Minbar," 332-333.

²¹¹ Swelim, *Ibn Ṭūlūn*, 221; Ibn Duqmāq, *Kitāb al-Intiṣār*, 123.

²¹² O'Kane, "Two Minbars," 316.

²¹³ Reznikoff, "Sound Resonance," 82.

²¹⁴ Abūbakr, *al-Manābir fi Miṣr*, 33, 107.

stone *minbar* of Shaykhu mosque (1349) (fig. 7), which measures 5.74 m in height and 5.01m in length,²¹⁵ is placed in the qibla riwaq which measures approximately 53m². Consequently, it could be permissible to assume that, in many cases, there was a relative proportional relation between the area of the prayer hall from one side, and the height and the length of the *minbar* from the other side. However, from the acoustic perspective, the height of the *minbar* is considered the most important component which affects the quality of the transmitted sound. When the height of the *minbar* increases, it brings the orator, i.e. the sound source, closer to the ceiling which, whether of wood or stone, was in most cases a reflective surface.

Generally speaking, the *minbar* in Ottoman Cairo was executed in two distinctive fashions. First, the wooden *minbars* most of which followed the Burji Mamluk pattern except for the dome which was replaced by an elongated conical cap,²¹⁶ second, the marble *minbars* which followed the Ottoman *minbar* type in Istanbul.²¹⁷ Based on the consensus of most jurists, the *minbar* had always been placed, in all periods prior to the Ottoman dynasty against the qibla wall, to the right of the mihrab.²¹⁸ However, in some Ottoman examples the *minbar* was shifted forward, in other words, it was brought closer to the center of the prayer hall, for instance, at the mosques of Sulayman Pasha and Muhammad ‘Ali Pasha at the citadel (fig. 8). This should have improved the *khutba* acoustics within the prayer hall as the *minbar* was surmounted by a part of a central dome and another half dome. Both

²¹⁵ Ibid, 33-34.

²¹⁶ Ibid, 189.

²¹⁷ Loc. cit.

²¹⁸ Chikhaoui, "The Minbar," 96.

structures, as will be shown later in this chapter, accelerated both sound amplification and diffusion.

Furthermore, the new location of the *minbar* shortened the distance between the orator, in his *khutba*, and the courtyard of the mosque, accordingly, it could be possible that the orator's voice was transmitted to the courtyard through the windows and doorway that separated the two sections of the mosque.

When the electrified sound system was introduced to Cairo's mosques, at the beginning of the 20th century, the orator continued to deliver the sermon from the *minbar* through a microphone, either held by hand or mounted to the *minbar* itself in one of its upper parts. Loudspeakers were also mounted on the interior and exterior walls to enable the congregants to hear the *khutba*.

2.3.3 The Acoustic Role of the Dikka

By virtue of many Mamluk *waqfiyyas*, it has become easier to determine, with precision, the acoustic-related duties which were fulfilled by the *mu'adhdhin* besides responding to the imam during the prayers. The *waqfiyya* of Amir Qaraquja al-Hasani (845/1441) demonstrates many of those duties. It states that *mu'adhdhin* was required to recite the *adhan* in all Fridays and the two 'aids at the *dikka al-mu'adhdhinin*. He was also obliged to perform *tasbih* and *takbir* after Friday prayer, and *tahlil* and *tasbih* before and after 'aid prayer.²¹⁹ Moreover, the *waqfiyya* of al-Jamali Yusuf (850/1446) lists an extra role to be fulfilled from the *dikka* by the *mu'adhdhin*; namely, intoning the second *adhan*, i.e. the *iqama*. In the same context, the *waqf* deed of Sultan Barsbay states that the *dikka* should be used by the *mu'adhdhinin* to recite the *adhan* on Fridays along with making *takbir* and *tahlil*.²²⁰

²¹⁹ 'Uthmān, *al-Wazifiyyah*, 301.

²²⁰ *Ibid*, 303-304.

The *dikka* was usually placed for maximum audibility. In larger areas, the *dikka* was often placed in the middle of the west side of the qibla iwan towards the courtyard on the same axis as the mihrab²²¹ as in the madrasa of Sultan Hasan (1356-61) (fig. 9), and the madrasa of Sultan al-Zahir Barquq (1384-86).²²² Additionally, this *dikka* location was also favored in those religious buildings which followed the four riwaqs and courtyard plan, whether the riwaqs are connected, as in the mosque of Altinbugha al-Maridani (1340) (fig. 10), and the mosque of Amir Aqsunqur (1347), or separated from each other as in the *khanqah* of Sultan Faraj b. Barquq (1400-11) (fig. 11) and the mosque of Sultan al-Mu'ayyad (1416-21).²²³

In some cases, the narrowness of the qibla iwan drove the architect to relocate the *dikka* away from the qibla iwan to be placed in the opposite iwan, i.e. the western one in order to save its original space for extra rows of worshippers.²²⁴ In this case, the architect has aimed at establishing an extended *dikka*, with a height of 2.5m in average. Thus, it was high enough for the *mu'adhdhinin* to see and hear the imam at the front to speak aloud the responses.²²⁵ The best examples of these are those of the madrasa of Sultan al-Ghawri (1503-4) (fig.12),²²⁶ al-Nasir Muhammad mosque in the citadel, and the Mahmudiyya mosque (1567).

²²¹ 'Uthman, *al-Wazifiyyah*, 300; 'Azzab, *Fiqh al-'Umrān*, 155; Wazīrī, 'Anāšir al-
'Imārah, 2:39.

²²² 'Uthman, *al-Wazifiyyah*, 300.

²²³ 'Uthman, *al-Wazifiyyah*, 300.

²²⁴ Loc. cit.; 'Azzab, *Fiqh al-'Umrān*, 155.

²²⁵ Loc. cit.

²²⁶ *Ibid*, 301.

Most Mamluk and Ottoman *dikkas* were designed to accommodate more than one *mu'adhdhin*.²²⁷ This trend is affirmed by the *waqfiyya* of the Qadi Yahia Zayn al-Din madrasa (848/1444) which states that Zayn al-Din appointed nine *mu'adhdhinin* to gather on the *dikka* every Friday to awaken the people for the prayer and also to make *du'a* and *takbir* collectively.²²⁸ From the acoustic perspective, increasing the height of the *dikka* is considered one of its main development aspects over time. Such increase was relatively useful achieving better sound propagation; there are many examples of Mamluk and Ottoman *dikkas* that display unusual elevations. The mosque of al-Nasir Muhammad at the citadel (1318-35) features a small loggia above the northwestern entrance. It is the earliest elevated platform for the use of the *mu'adhdhinin*, instead of a more common version of column-mounted benches (fig. 13).²²⁹ In the same context, the T-shaped western iwan of the Mosque of Sultan al-Ghawri (1502-4), which is extended by a central recess, includes an eye-catching elevated *dikka*. It is entirely made of wood and it is set between a large lower rectangular window and an upper triple window.²³⁰

From a different perspective, the *dikka* of the Qadi Yahia Zayn al-Din madrasa (848/1444) was extraordinary. Although it is no longer extant, the *waqfiyya* of the madrasa gives full details of it. It states that it was within a small room on the roof of the madrasa, most probably on the roof of the western iwan. The room's façade was preceded by an arch supported by two wooden columns. The whole room was

²²⁷ Loc. cit.

²²⁸ Al-Shāfi'ī, *al-Qādī Yahīā*, 102.

²²⁹ Abouseif, *Cairo*, 178.

²³⁰ *Ibid*, 300.

surmounted by a gilded wooden dome.²³¹ This unusual location also must have been selected for increased audibility, especially within the courtyard and the side iwans.²³²

²³¹ Al-Shāfi'ī, *al-Qādī Yahīā*, 57, 101.

²³² The Arabic text states the following:

"القبّة ودكة المؤذنين ليس لهما وجود الآن حيث اندثرا، وأختفى كل أثر يشير الى وجودهما الا أن الوقفية أوضحت لنا أن يحيى زين الدين قد أنشأ غرفة صغيرة مربعة الشكل أعلى سطح المدرسة يتقدم واجهتها عقد يرتكز على عمودين من الخشب، و يعلو واجهتها مظلة خشبية تقى من الشمس والمطر. وقد سقفت هذه الحجرة بقبة خشبية وطلبت هي والأعمدة بالألوان الزيتية مع التذهيب، وكان بهذه القبّة دكة أطلق عليها دكة المؤذنين. وقد عين زين الدين في وقفته تسعة مؤذنين، واشترط ان يجتمعوا جميعا يوم الجمعة لتنهيض الناس للصلاة والدعاء والتكبير قبل أذان الجمعة على دكة المؤذنين هذه. وتعتبر هذه القبّة ودكة المؤذنين الموضوعه بهامثلا فريدا في العمارة الاسلامية إلى الآن وحتى تكشف لنا الوثائق عما نجهله في هذا الموضوع، وذلك من حيث التصميم المعماري، والموقع الذي انشئت به لأنه لم يصادفنا في العمائر الاسلامية مثل هذا الشكل المعماري الذي أنشئ للمؤذنين بجوار المئذنة بأعلى سطح المبنى"

The previous Arabic text translates as follows:" The qubba and *dikka al-mu'adhdhinin* are no longer extant without a trace of their presence. However, the *waqfiyya* showed that the Qadi Yahia Zayn al-Din has established a small square-shaped chamber on the roof of the madrasa. The chamber's façade was preceded by an arch supported with two wooden columns. The façade was also surmounted by a wooden sunshade that protected it against sun and rain. The chamber was roofed by a wooden dome which was gilded and painted, along with the wooden columns, in oil colors. The above-mentioned dome accommodated a *dikka* which is called *dikka al-mu'adhdhinin*. In his *waqfiyya*, Yahia Zayn al-Din appointed nine *mu'adhdhinin* whom were ordered to gather on Fridays to call the people to prayer along with performing *du'a* and *takbir* before the Jum'a *adhan* from the aforementioned *dikka*. The *dikka* and the qubba are considered unique examples in Islamic architecture,

The overhanging wooden *dikka* of the Sinan Pasha mosque (1571) (fig. 13) is a good example of an Ottoman period *dikka*. This may have been used as well for continuous Quranic readings.²³³ The *dikka* of the Muhammad ‘Ali mosque (1830-1848) displays a unique architectural style. It takes the form of a broad gallery that extends along the northwestern side of the prayer hall. Most probably, it was executed that way in terms of achieving an architectural harmonization with the monumental imperial style of the mosque. Acoustically, it is believed that this *mu’adhdhin* gallery was designed to accommodate tens of *mu’adhdhinin* to serve the voluminous prayer hall of the mosque (2, 393 m²) which could accommodate up to 6.500 worshippers.²³⁴

Despite the fact that the *dikka* is usually an interior feature, that of Sulayman Agha al-Silahdar mosque (1837-39) (fig. 14) has transcended this traditional boundary. It is a gallery with a wooden balustrade above the mosque entrance. However, it also communicates with a charming small round balcony that is very Western in style.²³⁵ This balcony overlooks the mosque's courtyard, accordingly, it could be suggested that the patron aimed at broadcasting some of the rituals, such as Quranic recitation, intonation of the *iqama adhan*, or the rituals of the prayer itself, which were performed within the mosque, to the worshippers in the courtyard through this small gallery.

especially the *dikka* with regards to its architectural design and its extraordinary location on the building's roof besides the minaret." Ibid, 101-102.

²³³ Swelim, "Mosque of Sinan," 104.

²³⁴ Al-Asad, "Muhammad ‘Ali," 41, 50.

²³⁵ Abouseif, *Islamic Architecture*, 168.

2.3.4. The Dikkat al-Qari'

Allah says in His Glorious Book

وَإِذَا قُرِئَ الْقُرْآنُ فَاسْتَمِعُوا لَهُ وَأَنْصِتُوا لَعَلَّكُمْ تُرْحَمُونَ (204)

"And when the Quran is recited, then listen to it and be silent, so that mercy may be shown to you (204)."²³⁶

It has always been believed that the Quranic recitation's etiquette is twofold. First, the reciter has to be qualified; especially from the vocal perspective for a better recitation. Additionally, he should always resort to using helpful furniture to improve the recitation acoustics. Second, the listener has to remain alert and silent, during the recitation, to understand and contemplate the meaning of the recited Quranic verses. The *dikkat al-qari'* has been regarded among the most important tools that were introduced to the Islamic religious architecture generally, and that of Cairo specifically. Its significance is demonstrated by the prominent role it plays in improving the transmission and dissemination of Quranic recitation within the religious building, especially in the qibla iwan, riwaq or the prayer hall in general.

2.3.4.1 The Acoustic Role of the Dikkat al-Qari'

Albeit the *kursi* has been considered a prominent acoustic piece of furniture in Cairo's historic religious buildings, the notion of using an elevated stool for important readings, whether secular or religious, has taken a root in ancient Egypt onwards.²³⁷

The Mamluk period witnessed a significant innovation with regards to the evolution of the *kursi* (Quran stand), that is, the introduction of the *dikkat al-qari'* or *dikkat al-Mushaf* (Quran stool) to the religious premises.²³⁸ It was simply an elevated

²³⁶ Quran 7:204.

²³⁷ Al-Wakil, *Athāth al-Muṣḥaf*, 20.

²³⁸ Ibid, 49.

bench attached to the *kursi*. The new structure of *dikka al-qari'* was referred to in the Mamluk *waqfiyyas* by different terms such as *al-kursi*, *kursi al-Sura*, *dikka al-Shaykh* and *al-Mushaf* in respect of the Quran which the *dikka* holds.²³⁹ The *dikkas* of Sultan Hasan madrasa, Sultan Qaytbay madrasa, and Sultan al-Ghawri madrasa are among the best examples of the Mamluk *kursis* (fig. 15).

From the acoustic perspective, the simple elevation of the *dikka* has usually contributed to achieving a better sound transmission and propagation.

Due to the distinctive acoustic role of the *dikka*, it had been used for other purposes besides Quranic recitation such as performing *dhikr*, sending peace and blessings on the final Prophet along with making supplication for the endower and the Muslims. Such extra acoustic activities are listed in the *waqfiyyas* of Sultan Hasan and Kafur al-Shibli.²⁴⁰

2.3.5 The Acoustic Role of Fenestration

Cairo's religious architecture resorted to different fenestration techniques for providing the building's interior with the needed lighting and aeration. However, fenestration was also a way of providing the passersby with a window into the interior of the religious building and from the acoustic perspective, an effective means of sound transmission between the interior and exterior of the building, especially with regards to Quranic recitation.

The funerary complex of Sultan al-Mansur Qalawun (1284-85) is a good example of this. The long passage which runs between the madrasa and mausoleum is flanked on either side by windows, almost facing each other (fig. 16). Besides their primary role in lighting the dark corridor, the presence of windows in such precise

²³⁹ Loc. cit.

²⁴⁰ 'Azzab, *Fiqh al-'Umrān*, 159.

fashion allowed some sort of sound transmission from the mausoleum to the madrasa, for the mausoleum had been regarded as the official home, within the complex, for multiple acoustic-related rituals and religious activities. Besides the unceasing Quran recitation, al-Maqrizi states that the mausoleum had sessions of hadith and *tafsir* teachings by venerable jurists besides a *mi'ad* (ritualistic appointment) for the Sufis.²⁴¹

The qibla wall of the madrasa of Qaytbay in the Northern Cemetery has four rectangular windows in its lower part that look like a strip of light interrupted only by the mihrab and the thin masonry between the windows (fig. 17).²⁴² These windows allowed the acoustics of the different religious activities, which were performed in the qibla iwan, to reach the ears of the passersby in order to acquire their blessings and supplications to the endower, i.e. Sultan Qaytbay. In most Mamluk religious buildings, especially the mausoleums, windows were used by Quran readers i.e. *qari'* *shubbak* (window reciter) for reciting the Holy Quran.²⁴³

Al-Maqrizi states that the domed mausoleum of al-Mansur Qalawun featured multiple Quran readers who relayed Quranic recitation all day and night at the mausoleum windows.²⁴⁴ Also, al-Maqrizi says that Baybars al-Jashankir endowed multiple Quran reciters to read the Quran at the famous Abbasid window of his mausoleum all day and night.²⁴⁵

²⁴¹ Al-Maqrīzī, *al-Khiṭaṭ*, 2:380.

²⁴² Abouseif, *Cairo*, 276.

²⁴³ ‘Abdallah, *Madārfīn Ḥokām Miṣr*, 48.

²⁴⁴ Al-Maqrīzī, *al-Khiṭaṭ*, 2:380.

²⁴⁵ ‘Abdallah, *Madārfīn Ḥokām Miṣr*, 48; Al-Maqrīzī, *al-Khiṭaṭ*, 2:417; Fernandes, "Baybars al-Jashankir," 22-23, 34.

In the same context, the *waqfiyya* of Sultan al-Ghawri states that a choir of readers was endowed to recite the Quran at the windows of the eastern iwan of his madrasa which overlooks the street.²⁴⁶ During the Ottoman period the fenestration continued, in most cases, to fulfill its acoustic role of sound transmission between the different parts of the mosque according to the plan of the mosque itself. For example, the plan of the mosque of Sulayman Pasha (1528) is entirely Ottoman in its architectural fashion. It takes the form of a rectangular building, approximately half of which is occupied by the prayer hall, while the other half by a courtyard whose main function was to accommodate the extra numbers of worshippers if the prayer hall was full.²⁴⁷ Accordingly, besides fulfilling the basic lighting purposes, it was essential for the architect to create an acoustic connection between the two parts of the mosque through exploiting the northwestern side of the prayer hall in placing windows. Possibly, this fenestration (fig. 18) trend contributed to improving the interior acoustics, as well as transmitting the sound of the different acoustic-related rituals, such as the prayer, Quranic recitation, and the *khutba*, from the prayer hall to the congregation in the courtyard.

Finally, the fenestration has probably fulfilled an important acoustical role in those Ottoman mosques with external porticoes (*ziyadas*) such as the mosques of Sinan Pasha (1571) and that of Muhammad Bey Abu'l-Dhahab (1774). Based on the fact that those *ziyadas* were the designated prayer areas for late comers, it was necessary to acoustically connect them with the interior of the mosque where the main acoustic stations are found; such as the *minbar*, *mihrab* and *dikka al-qari'*.

²⁴⁶ Amīn, *al-Awqāf*, 201.

²⁴⁷ Abouseif, *Islamic Architecture*, 158.

2.4 Sound Diffusion and Amplification Elements

The next part of chapter two explores the most significant sound diffusion and amplifying elements which had been prominently introduced to Cairo historic religious architecture, i.e. the mihrab, the dome and the muqarnas.

2.4.1 The Mihrab

The mihrab has always enjoyed a distinctive rank in the repertoire of Islamic art and architecture across the Islamic world. According to medieval historians, the first niche mihrab appeared in 707-9, during the reconstruction of the Prophet's mosque at Madina by the Umayyad Caliph al-Walid (705-15).²⁴⁸

In common usage it is a niche, usually concave and generally heavily decorated found in the qibla wall of a mosque.²⁴⁹ In terms of functionality, the most common explanation for the mihrab states that it indicates the qibla direction toward which worshippers must turn to pray,²⁵⁰ additionally, it is exclusively dedicated for the imam's use while leading group prayers.²⁵¹

2.4.1.1 The Acoustic Role of the Mihrab

From the sonic perspective, the niche mihrab is considered a pivotal element in improving the religious building's acoustics. Acoustically, the niche mihrab is considered as a sound resonator due to its concavity.²⁵² When the imam stands in front of the mihrab, the generated sound waves, by his recitation, tend to be magnified

²⁴⁸ Khoury, "The Mihrab," 1.

²⁴⁹ Grabar, *Islamic Art*, 114.

²⁵⁰ Ibid, 115; Ḥasan, *al-Mahārīb fi Miṣr*, 15.

²⁵¹ Khoury, "The Mihrab," 1.

²⁵² Reznikoff, "Sound Resonance," 80.

and bounced back towards the worshippers.²⁵³ Additionally, the reflected sound waves from the mihrab's concave surface could easily interact, depending on the strength of regenerated sound waves, with other reflecting surfaces. Such reflections contribute to making the original generated sound and voice louder in the more distant parts of the prayer hall.²⁵⁴

From the acoustic perspective, the development criteria of the mihrab are twofold. First, the profile and size of the mihrab both determine the magnitude of concavity which is responsible for the mihrab's acoustic quality. The two main mihrabs of al-Mansur Qalawun's complex (1284-9), i.e. those of the madrasa and the mausoleum, are good examples of this trend. Both feature a deep recess with deep concavity,²⁵⁵ which in turn contributed to achieving a high level of sound amplification and diffusion within the qibla iwan and the mausoleum (figs. 19, 20). Second, the magnitude of sound reverberation considerably depends on the physical properties of those materials used in cladding the interior of the mihrab recess.

Due to its unique physical properties, marble has been employed in cladding many of the Cairene mihrabs since the Ayyubid dynasty. Marble, in most cases, is considered one of the highest acoustically reflective materials.²⁵⁶ Examples of such work are found in the mihrabs of the mosque of Sulayman Pasha (1528) (fig. 21), and the mosque of Muhammad 'Ali Pasha in the citadel (1830-1848) (fig. 22). In this context, it is worthy to mention that, to a great extent, the usage of the marble in cladding the mihrab interior has reflected the prestigious rank of the patron, however,

²⁵³ Schoalr.lib.vt.edu/theses/available/etd050599-103655/unrestricted/ch/6/.pdf.

²⁵⁴ Pulkki and Karjalainen, *Acoustics*, 34.

²⁵⁵ Gabr, *The Influence*, 394.

²⁵⁶ Hossam Eldien and Al-Qahtani, "Acoustical Performance," 951.

this choice contributed, in an indirect way, to improving the imam's voice due to its sound reflection tendency. Although marble had always been regarded by patrons and craftsmen in medieval Egypt as an illustrious building and decorative material, it was not broadly used in cladding the Cairene mihrabs probably due to its scarcity in Egypt alongside its high cost.

Possibly, the cognition of the acoustic effect of marble by many Cairene architects could be affirmed by its favoring over other materials, such as stone, in making the *shadurwan*. Despite the fact that it is rarely found in religious architecture, many of its outstanding examples are still found in situ in many Mamluk and Ottoman *sabils*. From the acoustic perspective, when the water ran over the *shadurwan*'s carved and inclined marble surface it would have tickled the senses by the trickling of water over it.²⁵⁷ It is believed that this soft murmuring phenomenon occurred due to the high sound reflection tendency of marble. During the Ottoman period the architect sometimes resorted to coating the interior of the niche mihrab with ceramic tiles. This technique started off in a partial fashion before it was applied to the entire mihrab,²⁵⁸ for instance, the outstanding mihrab of Alti Barmaq mosque (1123/1711) which is fully covered in ceramic tiles (fig. 23).²⁵⁹ From the acoustic perspective, tiled surfaces feature a high tendency of sound reflection.²⁶⁰ Finally, when electrified sound system was introduced to Cairo's religious architecture, by the beginning of the 20th century, a microphone stand was placed within the niche mihrab in front of the imam.

²⁵⁷ O'Kane, *Museum of Islamic Art*, 111.

²⁵⁸ Ḥasan, *al-Mahārīb fī Miṣr*, 67.

²⁵⁹ Loc. cit.; http://archnet.org/sites/1505/media_contents/6760.

²⁶⁰ Ergin, "The Soundscape," 214.

2.4.2 The Acoustic Role of the Dome

The concavity of the dome's interior is considered the main component of its acoustic impact but its acoustic impact is also affected by its volume and elevation.²⁶¹

First, the acoustic influence of the dome is accelerated by the increase of its volume. The dome's sound energy interacts with its concave surface to be focused afterwards at certain point(s).²⁶² Such interaction results in a sound amplification the level of which is determined by the intensity of the generated sound reflections that bounce off the dome's acoustic focal point. Second, the elevation of the dome from the ground level; when the height of the dome increases it allows more sound energy to enter the cupola where it is focused in a certain acoustic focal point(s) in which the sound is amplified reflected and then finally diffused in different directions within the premises.²⁶³

The variation in the ratio between the height of the dome and its diameter affects the distribution of the generated sound reflection when the original sound of the imam in his mihrab interacts with the curved surface of the cupola.²⁶⁴ In other words, at a constant diameter, when the height of the cupola decreases the sound reflections of the imam's original sound tend to be diffused towards the back areas of the adjacent prayer domed area. The behavior of the sound reflections changes when the height of the cupola increases, as they tend to be diffused towards the middle and the front of the domed area.²⁶⁵ Accordingly, it is believed that domes with low height are acoustically more effective than those with high cupolas, especially if placed in

²⁶¹ Al-Khafāji and 'Abd al-Ḥasan, "Acoustic Performance," 70.

²⁶² Ibid, 71.

²⁶³ Al-Khafāji and 'Abd al-Ḥasan, "Acoustic Performance," 72.

²⁶⁴ Loc. cit.

²⁶⁵ Loc. cit.

the front of the prayer area, in terms of enabling the congregants at the back areas of the premises to hear the imam in a better way.

Additionally, the building materials of the domes also played a significant role in determining the acoustic effectiveness of the dome. Stone was broadly used in building the domes for its solidity and capability of accommodating various decorative arts, such the stone mausoleum domes of Barsbay (1425) (fig. 24) and Qaytbay (1472 - 74) (fig. 25) in the Northern Cemetery.²⁶⁶ Sometimes, the architect resorted to using red bricks in building the dome for its light weight or even to cut the building expenses, especially if the dome was built to cover large areas, such as al-Fadawiyya dome (1479-82) (fig. 26).²⁶⁷ Light wooden domes were also used in roofing many Cairene religious buildings, for example, the mausoleum of Imam Shafi'i (1211) and the mosque of al-Zahir Baybars (1266-69).²⁶⁸

In some cases, the architect used plaster in dressing the inner surface of the domes; especially those domes which were built in bricks.²⁶⁹ Notably, all the previously mentioned building or dressing materials do feature distinctive physical properties which make them architecture-friendly materials. However, most of those materials enjoyed specific acoustic characteristics which had, most probably, played a role in improving the acoustic qualities of domed premises. For instance, stones are very helpful in reflecting most of the sound energy.²⁷⁰ Moreover, when the inner surface of the dome is glazed with a layer of plaster, which is basically composed of hydrous

²⁶⁶ 'Uthmān, *al-Wazifiyyah*, 453.

²⁶⁷ *Ibid*, 454.

²⁶⁸ Organization of Islamic Cities, *Principles*, 455.

²⁶⁹ *Ibid*, 453.

²⁷⁰ Borham, *Environmental Aspects*, 74.

calcium sulphate,²⁷¹ it tends to act like a sound resonator.²⁷² In the same context, wood is considered, in most cases, an advantageous material through its active role in absorbing part of the sound energy and reflecting the rest, thus, according to modern acoustics, it contributes to achieving a good level of sound intelligibility.²⁷³

In conclusion, it is believed that stone was primarily used and favored over other building materials in the dome construction for its distinctive architectural properties; however, it was also helpful and useful, in most cases, from the acoustic perspective for its sound reflection tendency. In the same context, it is noteworthy to assure that many other factors contribute as well to determining the sound amplification tendency of the dome such as its height, diameter and the interior surface area of the building.

It is now clear that the Islamic dome featured an audio-visual dimension in religious architecture. In other words, it was employed in various types of buildings in Cairo's religious architecture as an impressive visual sign to underscore the significance of what is present underneath its shell; especially the mihrab, the tomb, or even the royal *maqsura*, which includes the mihrab and the *minbar* as in al-Zahir Baybars's mosque (1266-69).

Finally, it is believed that the Ottoman period; namely, the reign of Muhammad 'Ali Pasha, had witnessed the most remarkable innovation with regards to improving the acoustic behavior of the Islamic dome, that is, the insertion of sounding vessels, which are also known scientifically as Helmholtz resonators, within the outer rim of the central dome and the walls of his mosque at the citadel. Those resonating

²⁷¹ Wazīrī, *al-‘Imārah*, 109.

²⁷² Ergin, "The Soundscape", 214.

²⁷³ Borham, *Environmental Aspects*, 68.

vessels were discovered by the committee when the central dome and many other parts of the mosque were dismantled and rebuilt.²⁷⁴ Acoustically, the resonator can be freestanding, inserted into a wall, or even embedded within a dome-with its opening facing the hall.²⁷⁵ Helmholtz resonators reradiate the sound that they do not absorb in a hemispheric distribution. Accordingly, they used jugs to contribute to sound diffusion phenomenon along with absorbing unfavorable excessive frequencies which do negatively affect the desired sound intelligibility within the premises.²⁷⁶

2.4.3 The Muqarnas

As a rule of thumb, it is accepted by architectural acousticians that almost every single element in the buildings – regardless its size or shape – counts in shaping the acoustic characteristics of a given space; especially, in terms of determining the sound diffusion patterns and their intelligibility level within that space.²⁷⁷ Muqarnas could be a good example in demonstrating this acoustic principle. Muqarnas, a uniquely Islamic invention, are three-dimensional wedge forms that are combined into intricate designs in order to create honeycomb patterns on walls, portals, vaults, and domes.²⁷⁸ It was basically used as an aiding architectural element in terms of transforming the square base of the dome into a spherical shape.²⁷⁹ The muqarnas was

²⁷⁴ ‘Abd al-Wahāb, *al-Masājid*, 383; Rizq, ‘*Aṣr Muḥammad ‘Alī*, 219.

²⁷⁵ Kleiner et al., *Worship Space*, 51.

²⁷⁶ Ergin, "The Soundscape," 215.

²⁷⁷ Borham, *Environmental Aspects*, 65.

²⁷⁸ Hillenbrand, "The Mosque," 50; Ḥasan, *al-Mahārīb fī Miṣr*, 40; Chinchilla, *Islamic Architecture*, 21.

²⁷⁹ Ḥasan, *Turāth al-Islām*, 146; Gabr, *The Influence*, 380; Naẓīf, *al-‘Imārah al-Islāmiya*, 70.

firstly introduced to the Egyptian architecture in the cornices on the minaret of Badr al-Jamali's *mashhad* overlooking Cairo (1085).²⁸⁰ However, most art historians believe that the first use of the muqarnas as a transitional element, in Egypt, occurred in the Ayyubid dynasty.²⁸¹

Modern acoustic scholarship, especially the CHARISMA (Conservation of the Acoustical Heritage by the Revival of Sinan's Mosque's Acoustics) project proved that the architectural elements that were used as transitional zones, especially stalactites, in historic buildings, transcended the boundaries of their structural role and aesthetic appeal to fulfill useful acoustical purposes within the premises.²⁸² When the generated sound waves interact with the muqarnas units, they tend to diffuse most of those sound waves.²⁸³ In addition, they act as acoustic baffles that decrease excessive echoey sound reflection.²⁸⁴ Thus, they help in improving the sound intelligibility factor within the premises.

Now, it could be understood that the hollow structure of the muqarnas, especially if executed in wood, is the main component in establishing their acoustic role within the transitional zone. Consequently, an acoustic hypothesis could be possibly placed regarding the number of the muqarnas tiers in each transition zone. In other words, in most cases, there is a proportional relation between the number of the muqarnas tiers, which could somehow range between three tiers as in the mausoleum of ‘Abdullah al-Manufi, in the Northern Cemetery (879/ 1474) and thirteen tiers as in

²⁸⁰ Bloom, "Muqarnas," 21.

²⁸¹ Al-Bāsha et al., *al-Qāhira*, 232.

²⁸² Moustafa, *Mosque Architecture*, 56.

²⁸³ Ergin, "The Soundscape," 214.

²⁸⁴ Ounodesign.com/2009/07/19/stalactite-ceillings-the608-the-12th-century/

the mausoleum of al-Ghawri (908-911/ 1503-1505) (fig. 27),²⁸⁵ and improving the interior sound quality of the premises, especially in the presence of many other reflecting surfaces that could generate unfavorable excessive sound reflections.

2.5 Noise Abatement Techniques within Cairo's Religious Architecture

Throughout the different periods of the Islamic civilization in Egypt, many architects have proved their skills and abilities in the field of aural architecture with respect to their success in establishing an exquisite soundscape within their religious premises, especially those of historic Cairo. However, it is important to mention that those architects' acoustic skills had not been merely demonstrated in employing sound transmission, diffusion and amplification elements, but also in resorting to skillful noise reduction/ elimination techniques which had, to a good extent, contributed to reducing the exterior noise leakage to the premises interior. The next part of the study analyzes the most important architectural techniques which had been used in terms of abating different kinds of noise pollution within Cairene religious buildings.

Noise is usually defined as harmful, unwanted or disturbing sound.²⁸⁶ This definition embodies two aspects which are harmfulness and disturbance. On the one hand, harmfulness is more objective as noise can be harmful even if it is perceived as a comfortable and non-disturbing fashion.²⁸⁷ On the other hand, the disturbance caused by sound is a more subjective concept. In other words, disturbance could be defined by how much a sound disturbs some action.²⁸⁸ It has been discussed earlier that most architectural elements within Islamic historic religious buildings are

²⁸⁵ Al-Ḥadād, *al-Qubba*, 117, 119.

²⁸⁶ Borham, *Environmental Aspects*, 72; Pulki and Karjalainen, *Acoustics*, 401.

²⁸⁷ Loc. cit.

²⁸⁸ Loc. cit.

classified as functional elements that reflect a jurisprudential aspect. This concept is applied to noise abatement elements as well, i.e., most architects were keen on keeping different types of noise away from their religious premises in accordance with the serenity and tranquility which are required by Islam to prevail in the worshipping spaces.

As a result, if the noise is loud enough, it could distract the worshippers. Accordingly, many architects focused on employing suitable noise abatement techniques, of different types, to their buildings in historic Cairo; especially in those buildings which are found in excessively congested areas or overlooking busy commercial or processional routes. The grand mosque of Ahmad b. Tulun (876-79) is considered among the very first examples in Cairo to exploit an architectural novelty, namely the *ziyada*, in reducing the effect of incoming noise from the surrounding markets (fig. 28). The *ziyada* successfully isolated the mosque proper from the undesired noise and bustle of the surrounding streets and bazaars.²⁸⁹ In terms of achieving the highest possible level of serenity within his mosque, Ibn Tulun allocated the middle *fawwara* of the courtyard as a praying area for the children to keep their expected noisy behaviors away from disturbing the serenity of the main prayer areas within the mosque, especially the qibla riwaq.²⁹⁰

Among the most effective noise reduction methods is placing the religious building few meters above the surrounding streets level in terms of increasing the vertical distance between the noise sources and the prayer hall. Al-Salih Tala'i

²⁸⁹ Briggs, *Muhammadan Architecture*, 50; Abouseif, *Islamic Architecture*, 52; O'Kane, "The Ziyāda," 157; Swelim, *Ibn Tulun*, 97.

²⁹⁰ Al-Maqrīzī, *al-Khiṭaṭ*, 2:266; Swelim, *Ibn Ṭūlūn*, 236.

mosque (555/ 1160) is considered the earliest remaining architectural model of such elevated mosques whose ground level is occupied by commercial shops (fig. 29).²⁹¹ This feature was repeated many times after the Fatimid period in the Mamluk and Ottoman periods. In this context, a special acoustic study has been carried out to evaluate the noise rate within Sultan Hasan Madrasa. Based on analyzing the interior noise rate of the madrasa alongside determining its frequency spectrum, the study has shown that the exterior noise level which was estimated at 82.9 dB dropped to 72.0 dB within the interior of the building.²⁹² The mosque's elevation above the street level was a pivotal factor in achieving such good acoustic results in respect of reducing the noise rate.²⁹³ The same noise reduction technique applied to the mosque of Malika Safiyya (1610), a good example of an Ottoman elevated mosque. The mosque is established on a level much higher than the street level and is reached by a long semi-circular flight of steps (fig. 30).²⁹⁴

Bent entrances had always been used by the architects of historic Cairo, in both religious and domestic architectures, in respect of providing privacy to the premises.²⁹⁵ However, bent entrances also reduced sound pollution from the external world.²⁹⁶ The length of the *majaz* (the corridor which connects the entrance of the premises to its interior parts) along with the number of bends that it features contribute proportionally to noise reduction. According to the results of the

²⁹¹ Organization of Islamic Cities, *Principles*, 46.

²⁹² Al-Flāflī, *al-Dirāsah al-Ṣawtiya*, 196.

²⁹³ Loc. cit.

²⁹⁴ Abouseif, *Islamic Architecture*, 162.

²⁹⁵ Organization of Islamic Cities, *Principles*, 472.

²⁹⁶ El-Hamamsy, *Mosque of Qijmas*, 49.

aforementioned acoustic study of Sultan Hasan madrasa, the *majaz*, which is formed of four bends leading from the entrance to the courtyard, also contributed to reducing the noise rate from 82.9 dB in the exterior to 70.0 dB within the interior of the premises.²⁹⁷ Sometimes the *majaz* was left roofless in order to admit light and fresh air to the different parts of the passageway, as at the Qijmas al-Ishaqi complex (1479-81) (fig. 31).²⁹⁸ This enabled no side window openings along the *majaz* which are the main breeders of noise leakages from the external world.

In some cases, the architect opened a secondary low-height door in the main huge wooden door of the religious premises i.e. *bab al-khukha*. The presence of such a door enabled the worshippers to enter and exit the building without having the main door opened. However, from the acoustic perspective, when the main door was left in a closed position it helped in reducing the rate of the exterior noise leakage to the interior of the building. The wooden door of Faraj ibn Barquq *khanqah* in the Northern Cemetery is a good example in terms of illustrating this trend (fig. 32).

Besides its axial role in accommodating the extra number of worshippers and providing the interior parts of the religious building with the needed lighting and ventilation, the *sahn* (courtyard) had also contributed to reducing the noise rate within the premises, for its presence enabled the architect to relatively isolate the riwaqs and the iwans from the external noise through decreasing the number of the windows that overlook the surrounding streets.²⁹⁹ The courtyard of al-Hakim mosque is a good example in respect of demonstrating the multiple advantages of the *sahn* presence within the mosques (fig. 33).

²⁹⁷ Gabr, *The Influence*, 469; Al-Flāflī, *al-Dirāsah al-Ṣawtiya*, 196.

²⁹⁸ El-Hamamsy, *Mosque of Qijmas*, 49.

²⁹⁹ Wazirī, *al-‘Imārah*, 111.

All the more, besides its act in providing the building with the required architectural stability, increasing the thickness of walls would also reduce interior noise, for example, the wall thickness in Sultan Hasan madrasa reanges from 40cm to almost 2m in the iwan walls. Such considerable wall thickness was proved by the previously mentioned acoustic study of Sultan Hasan madrasa to be the among the primary factors which played a crucial role in reducing the external noise rate from 82.9 dB to be 70 dB within the interior of the building.³⁰⁰

Based on their physical properties, the building materials of the historic religious buildings also contributed, besides their dominant architectural role, to determining the sound isolation characteristics of the walls. For example, limestone blocks were broadly used in Cairene religious buildings, especially during the Mamluk period, for their stability and ease of decoration alongside their remarkable thermal and acoustic isolation properties.³⁰¹

Sometimes the architect resorted to executing a partial noise reduction system with regard to serving specific areas within the religious premises. The three sliding wooden windows (*bab jarrar*) of the iwan in the mosque of Abu Bakr Muzhir (1479-80) near the Qasaba are good examples with regards to demonstrating this trend (fig. 34).³⁰² Those easy-closing sliding wooden windows were sometimes closed to moderately isolate the iwan form the ablution court and its undesired noises. In the same context, many Mamluk religious buildings featured windows with wooden shutters. Assuredly, although when those shutters were closed they did not entirely prevent noise leakage to

³⁰⁰ Al-Flāfī, *al-Dirāsah al-Şawtiya*, 196.

³⁰¹ ‘Uthmān, *al-Wazifiyyah*, 422, 439.

³⁰² Abouseif, *Cairo*, 289; El-Hamamsy, *Mosque of Qijmas*, 395; Shediao, *Qibla Orientation*, 97.

the interior of the premises, they slightly helped in lessening the noise rate; for instance, the windows in the facade of Sultan al-Zahir Barquq Madrasa (1384-88) (fig. 35), and those in the facade the *khanqah* of Amir Shaykhu (1355).³⁰³

"A landscape to serve the soundscape"; this statement could be applied to some distinctive Cairene Ottoman mosques which were found amidst charming gardens. The presence of such gardens around the mosques helped in creating a beautiful space of greenery which separated and preserved the mosque proper from the outside world and its undesired noises.³⁰⁴ From the scientific perspective, this noise reduction phenomenon occurs due to the effectiveness of the plant parts, i.e. stems, leaves branches, wood, etc. in absorbing sounds with their dynamic surface areas.³⁰⁵ Consequently, besides its natural aesthetic role, the vegetation around the Ottoman mosques acted as a noise-barrier from the sound pollution effects of the surrounding streets, markets and other facilities. The mosque of Sinan Pasha in Bulaq is a good example of this trend. It is freestanding in a garden (now of palms and fruit trees) (fig. 36).³⁰⁶ Historically, the very first mosque in Islamic Egypt to feature a garden around its proper was 'Amr b. al-'As mosque at al-Fustat.³⁰⁷

Finally, in some cases, the topography helped the architect in achieving the required level of calmness and tranquility within his religious building, that is to say, the architect sometimes indirectly exploited the long vertical distance between the noise sources and the chosen locality of his future religious building to achieve the

³⁰³ Dāwūd, *al-Nawāfīdh*, 77.

³⁰⁴ 'Azzab, "Fiqh 'Imārit," 47.

³⁰⁵ www.ambius.com/blog/how-plants-reduce-noise/.

³⁰⁶ Williams, *Islamic Monuments*, 255.

³⁰⁷ Al-Maqrīzī, *al-Khiṭaṭ*, 2:246.

desired serenity within the building. The Nizamiya *khanqah* (757/ 1356) (fig. 37) could be among the best architectural examples to illustrate this point. It is located on top of one of the Muqattam hills, to the north of the Cairo citadel, at an elevation of almost 50m above the ground level. From the incorporeal perspective, this unique locality symbolizes the sublimity of Sufi life. However, from the sonic perspective, this carefully chosen elevated site detached the Sufi residents of the *khanqah* from the city clamors underneath. Thus, the only sounds which prevailed across the building were the voices of the Sufis themselves when practicing their special divine rituals.

2.6 Assessing Sound Dissemination and Intelligibility Factors within the Qibla Areas of Major Cairene Religious Buildings

This part of the research aims at partially reconstructing the original soundscape within the qibla riwaqs, iwans, and prayer halls of major Cairene historic religious buildings, from the time of the Arab conquest through the reign of Muhammad ‘Ali Pasha, in connection with appraising the sound propagation within those areas. According to modern acoustics, it is believed that calculating the reverberation time (RT) rates of the imam's recitation sound in the mihrab in respect of its liaison with the spectrum of octave band frequencies (Hz) is one of the efficient acoustic mechanisms in achieving the aforementioned target. Consequently, Odeon room acoustics software, version 10, was chosen to execute the required calculations and analysis for its outstanding efficiency and accuracy in analyzing the basic given information of the historic building, such as its shape, area, and the used building materials, from an acoustic perspective. The acoustic results of each building are expressed in a graph form followed by a short analytic comment alongside stating special acoustic remarks if necessary.

According to Odeon software standards, it is noteworthy to mention that in most cases there is an inverse correlation between the given sound frequency and the value of its reverberation time. All the more, there is a proportional relationship between the reverberation time value and the level of sound intelligibility, however, such acoustic relation turns to be an inverse correlation if the reverberation time exceeds 25 sec with a steady upturn.³⁰⁸ In the same context of sound intelligibility, if the reverberation time drops below 2.8 sec and continues to decline with steadiness, the generated sound will become substantially unintelligible. Accordingly, it is possible to postulate that the standard reverberation time, with respect to the desired sound intelligibility, ranges between 2.8 and 25 sec mostly at low frequencies.

The first graph demonstrates the pre-discussed standard acoustic relationship between the sound frequencies and their reverberation time (fig. 38).

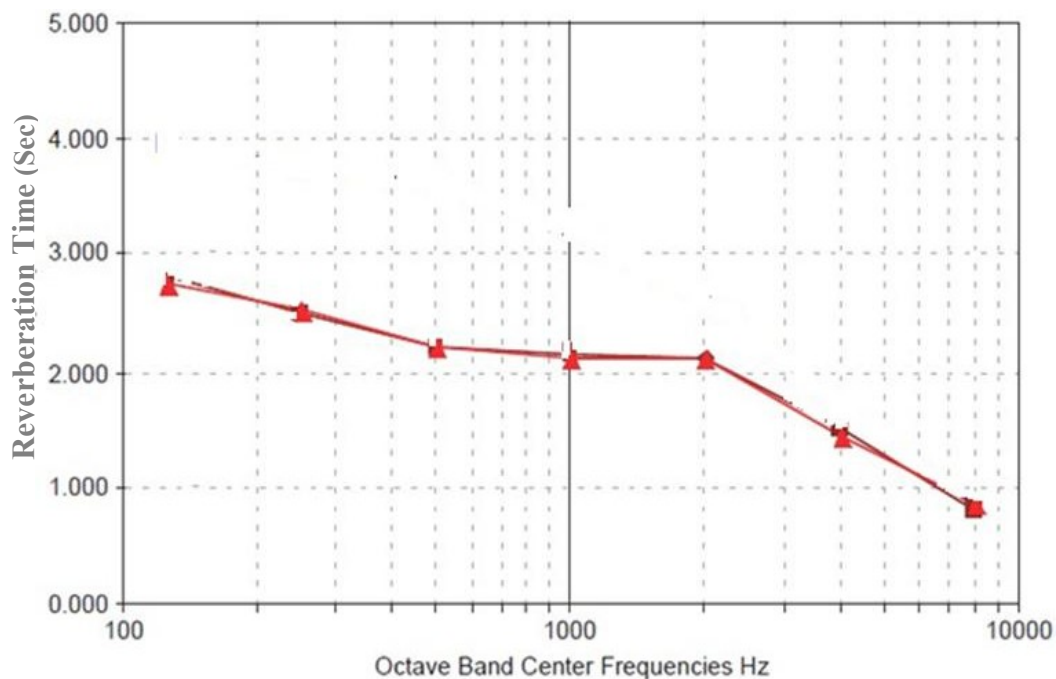


Fig. 38. The standard acoustic relationship between the sound frequencies and their reverberation time.

³⁰⁸ Interview with acoustician Dr. Hani A. Shawky, March 25, 2016.

Analysis:

The graph shows an inverse correlation between the sound frequencies and their estimated reverberation time. With regards to sound intelligibility parameter, the graph indicates that the standard reverberation time is 2.8 sec at low frequency of 120 Hz.

2.6.1 The Mosque of ‘Amr b. Al-‘As at Al-Fustat (641-2) (fig. 39)

- The original mosque was rectangular in shape, it measured 25 × 15 meters
- This plan could accommodate up to 500 worshippers.
- The walls were made of mud bricks and the columns from palm tree trunks. The roof was made of palm leaves covered by a mud layer, and it included palm trunks (wood).
- The ceiling height was too low, almost 3 meters.
- The floor was paved with gravel.

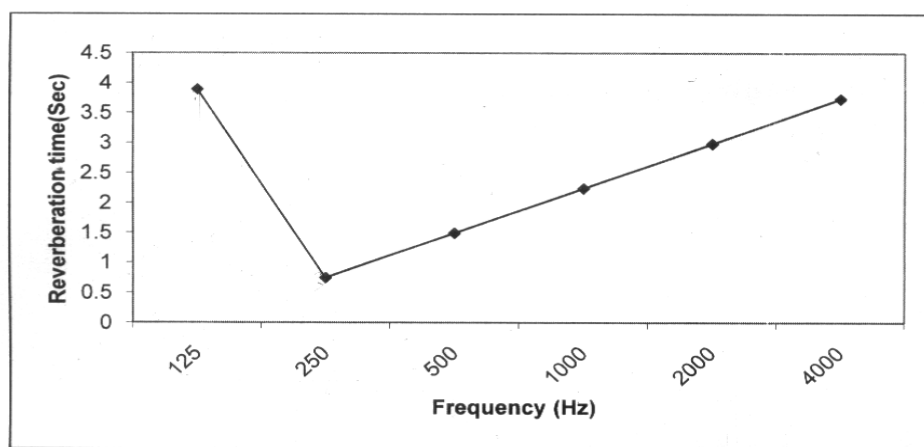


Fig. 39. The relation of RT and octave band frequency in ‘Amr b. Al-‘As mosque

Analysis:

The graph shows that the RT within the entire mosque was at its highest level of 4 sec when the sound frequency was 125 Hz. Thus, the mosque enjoyed a good level of sound intelligibility at low frequencies. On the other hand, the RT fell considerably at 250 Hz to be only 0.5 sec; such a sharp drop did not affect the sound intelligibility for the RT rate featured an immediate increase afterwards.

2.6.2 The Qibla Riwaq of Ahmad b. Tulun Mosque (876-79) (fig. 40)

- The length of riwaq was 37.52 m.
- The width of the riwaq was 26.63 m.
- The main building materials were red bricks for pillars and walls.
- The ceiling was covered in wood.
- The walls were covered in plaster or stucco.

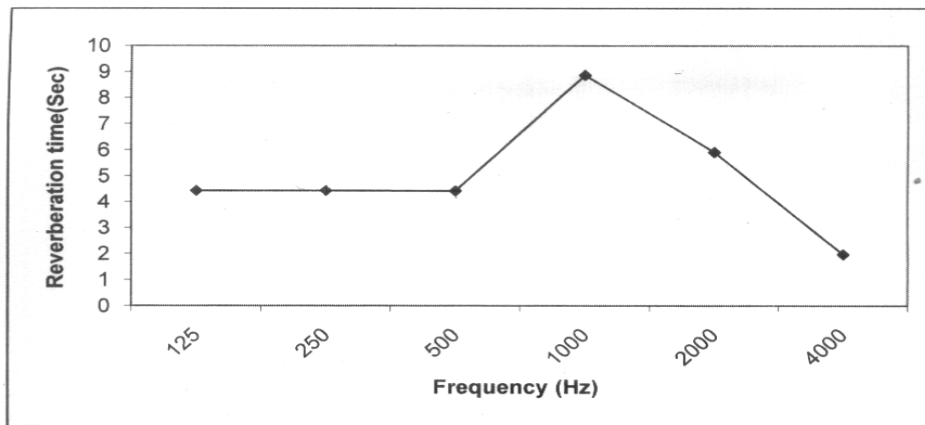


Fig. 40. The relation of RT and octave band frequency in the qibla riwaq of Ahmad b. Tulun mosque

Analysis:

The graph illustrates that the highest RT of 9 sec was at 1000 Hz, while the lowest RT of 2 sec occurred at 4000 Hz. Between the frequencies of 125 Hz and 500 Hz, the RT showed a steady rate of 4 sec which means that the sound intelligibility within the riwaq was very good between both frequencies.

2.6.3 The Qibla Riwaq of al-Azhar Mosque (970-972) (fig. 41)

- The original riwaq measured 85×25 m.
- The main building materials were red bricks and mortar.
- The ceiling was covered with timber wood.
- The total height of the ceiling was 6.92 m.
- There was a dome over the main mihrab which was covered with stucco decoration.

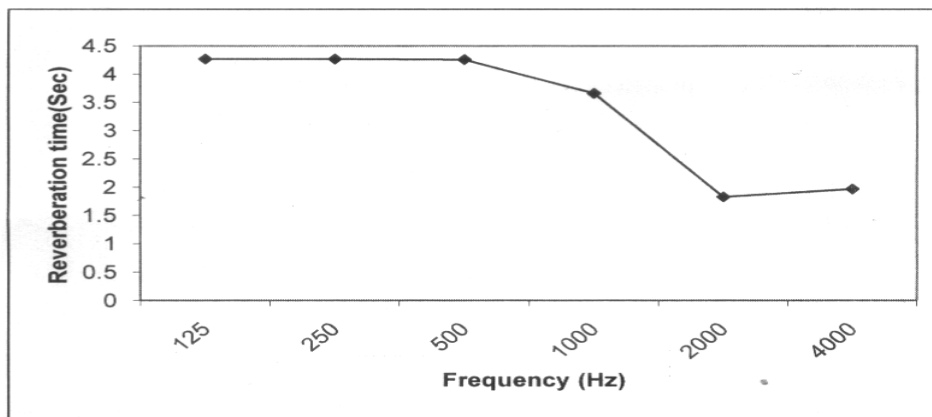


Fig. 41. The relation of RT and octave band frequency in the original qibla riwaq of al-Azhar mosque

Analysis:

The graph depicts that the RT within the qibla riwaq reached its peak of 4.3 sec at 125 Hz. This rate persisted steadily from 125 Hz up to 500 Hz. Such steadiness indicates that the sound intelligibility within the riwaq was very good between both frequencies. At 2000 Hz, the RT fell to its lowest rate of 1.8 sec.

2.6.4 The Qibla Riwaq of al-Zahir Baybars Mosque (1266-69) (fig. 42)

- The qibla riwaq was rectangular in shape and was divided into six arcades parallel to the qibla wall.
- The square area preceding the mihrab was covered by a huge wooden dome.
- The mihrab was covered in marble.
- The arches were supported by marble columns.

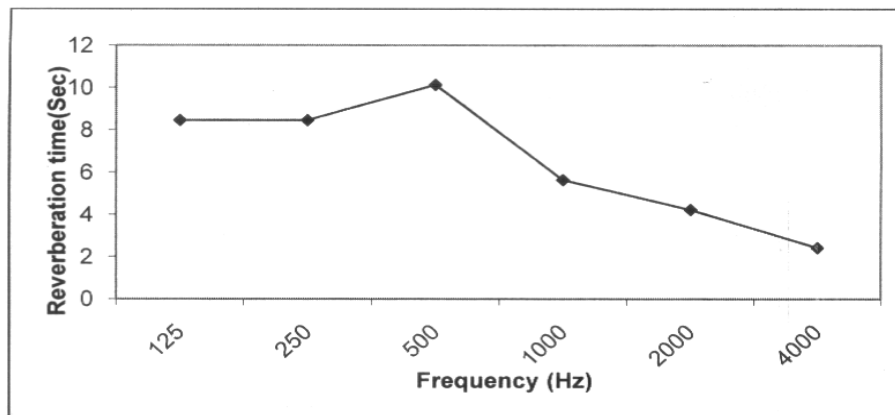


Fig. 42. The relation of RT and octave band frequency in the qibla riwaq of the al-Zahir Baybars mosque

Analysis

As illustrated by the graph, the highest RT rate of 10 sec occurred at 500 Hz. Then, it gently fell down to its minimum rate of 2 sec at the frequency of 4000 Hz. In addition, the graph illustrates a good sound intelligibility due to the presence of a steady RT rate of 8.2 sec between 125 Hz and 250 Hz.

Remarks

The presence of marble columns was possibly a significant factor in improving the acoustic qualities of the mosque for two reasons; first, the roundness of those columns acted as a convex surface which was primarily responsible for boosting the sound diffusion phenomenon within the hall because, acoustically, sound diffusion happens when a sound wave reflects off a convex or uneven surface. The sound energy, then, is

distributed evenly rather than being confined to be just a reflection.³⁰⁹ Second, marble is considered a highly sound reflective material that helps in increasing the RT.³¹⁰

2.6.5 The Qibla Riwaq of al-Mansur Qalawun Madrasa (1284-85) (fig. 43)

- The riwaq was divided into three spaces; the largest space with the highest ceiling was the middle.
- The ceiling was made of wood.
- The mihrab's hood was covered in gold mosaic while the lower part was clad with marble in the form of small mihrabs (resonating cavities).

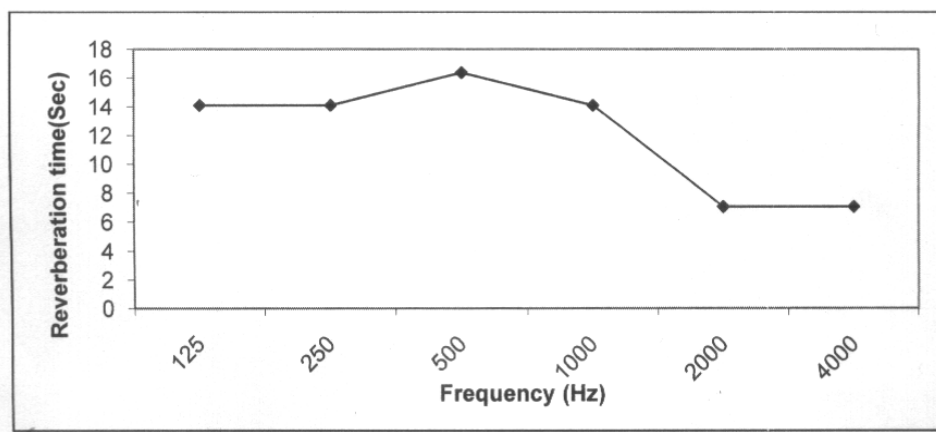


Fig. 43. The relation of RT and octave band frequency in the qibla riwaq of al-Mansur Qalawun madrasa

Analysis

From the graph, it is clear that the RT rate peaked at sound frequency of 500 Hz to reach 16 sec. However, it gradually dropped to its lowest rate, i.e., 8 sec at 2000 Hz to maintain a steady level up to 4000 Hz. Consequently, the riwaq featured a good sound propagation pattern along with an acceptable sound intelligibility at low frequencies.

³⁰⁹ Borham, *Environmental Aspects*, 71.

³¹⁰ Hossam Eldien and Al-Qahtani, "Acoustical Performance," 591.

2.6.6 The Qibla Riwaq of al-Nasir Muhammad Mosque at the Citadel (1318-35) (fig. 44)

- The qibla riwaq featured four arcades that run parallel to the qibla wall.
- Each arcade was supported by marble and granite columns.
- The square area which preceded the mihrab was covered by a large wooden dome.
- The ceiling was covered by octagonal wooden coffers that had once displayed gilded ornamentation.

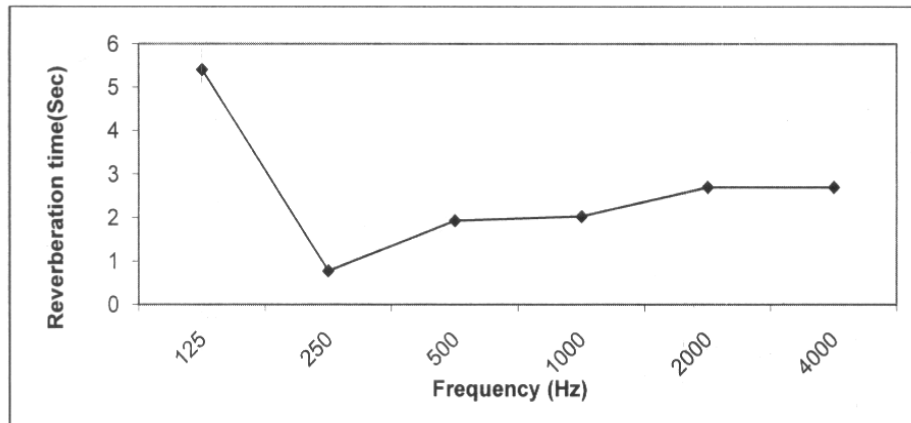


Fig. 44. The relation of RT and octave band frequency in the qibla riwaq of al-Nasir Muhammad mosque

Analysis

The graph illustrates that the RT rate was at its highest level of 5.5 sec at 125 Hz. Then, it featured a sharp drop to reach its lowest rate of 0.5 sec at 250 Hz which means that the qibla riwaq generally enjoyed an acceptable sound intelligibility except between 250 Hz and 1000 Hz.

Remarks

It is believed that the wooden ceiling of the qibla riwaq contributed to improving the acoustic quality across the hall. It takes the form of an octagonal-patterned ceiling with incorporated hemispherical coffers. The basic design of this style is composed by an octagonal star pattern. Tiny planks of wood form each hemispherical dome which is placed above an octagonal opening.³¹¹ Those hollow wooden coffers played a pivotal role, as porous focal surfaces, in absorbing a good amount of the generated sound waves

³¹¹ Wardani, *Wooden Ceilings*, 41.

in the qibla riwaq.³¹² Such absorption possibly helped in reducing excessive sound reflections and undesired echoes which were caused by the presence of other reflecting surfaces such as the marble columns and walls.³¹³ Accordingly, such acoustic balance between the sound reflection and absorption probably resulted in enhancing the sound intelligibility level within the riwaq.

2.6.7 The Qibla Iwan of Shaykhu al-Nasiri Mosque (1349) (fig. 45)

- The qibla iwan had an irregular shape (unparalleled walls).
- The ceiling was made of wood.
- The upper part of the mihrab was clad with marble, while the lower part was covered with ceramic tiles.

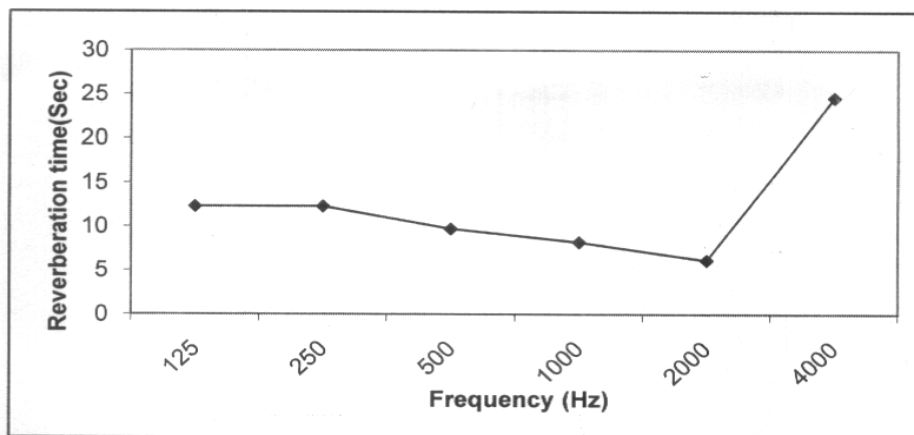


Fig. 45. The relation of RT and octave band frequency in the qibla iwan of Shaykhu al-Nasiri mosque

Analysis:

The graph indicates that the RT peaked to reach 25 sec at high frequency of 4000 Hz, while its lowest rate of 6 sec occurred at 2000 Hz. Such high RT is twofold. First, it enclosed a cogent sound diffusion pattern. Second, it resulted in accelerating the sound intelligibility, at high frequencies, within the iwan.

³¹² Borham, *Environmental Aspects*, 68.

³¹³ Yusuf, *al-Sulūk al-Şawţī*, 33.

Remarks

Based on the principles of modern acoustics the size and shape of the building determine the sound distribution pattern within its space.³¹⁴ It is believed that the irregular shape of the qibla iwan helped in improving its sound quality as modern acoustic scholarships proved that the reflected sound waves within rooms with symmetrical and parallel hard surfaces tend to attenuate faster if compared to other sound reflections which occur within rooms or halls with irregular shapes.³¹⁵

2.6.8 The Qibla Iwan of Faraj b. Barquq Khanqah (1400-11) (fig. 46)

- The qibla iwan was rectangular in shape and was divided into three arcades parallel to the qibla wall.
- The iwan ceiling was engaged with multiple shallow domes which were built in red bricks and faced off by a layer of stucco plaster.
- The iwan featured a semi circular stone mihrab which was covered by a dome which is larger in size than the other shallow domes.

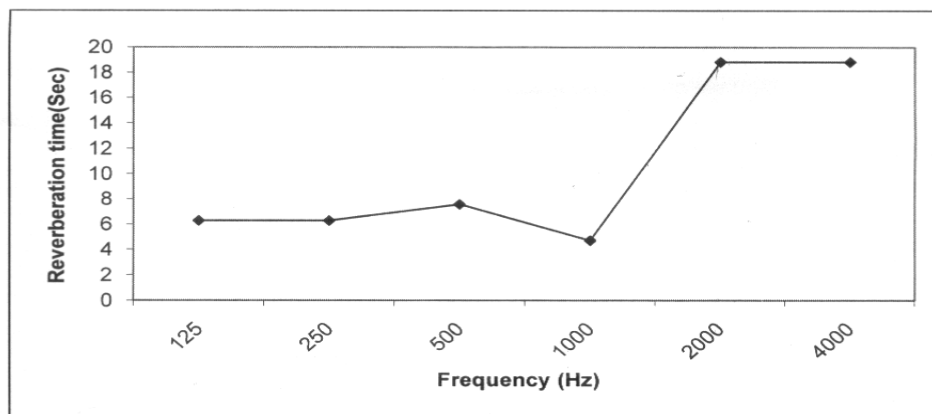


Fig. 46. The relation of RT and octave band frequency in the qibla iwan of Faraj b. Barquq khanqah

³¹⁴ Borham, *Environmental Aspects*, 70.

³¹⁵ Harun et al., "Speech Intelligibility," 24; Interview with acoustician Dr. Hany A. Shawky at the Egyptian National Institute of Standards, November 4, 2015.

Analysis

As shown, the RT rate reached a peak of 19 sec at 2000 Hz, such high rate resulted in a dynamic sound diffusion pattern, and then the RT maintained its steadiness up to 4000 Hz, such constancy contributed to improving the sound intelligibility. On the other hand, the RT reached its lowest rate of 4.2 sec at 1000 Hz. Thus, it could be permissible to state that the iwan featured a good sound intelligibility at both low and high frequencies.

2.6.9 The Qibla Iwan of al-Ghawri Madrasa (1503-4) (fig. 47)

- It consisted of a rectangular area.
- The walls were made of limestone and were covered with marble.
- The iwan was roofed with a wooden ceiling.

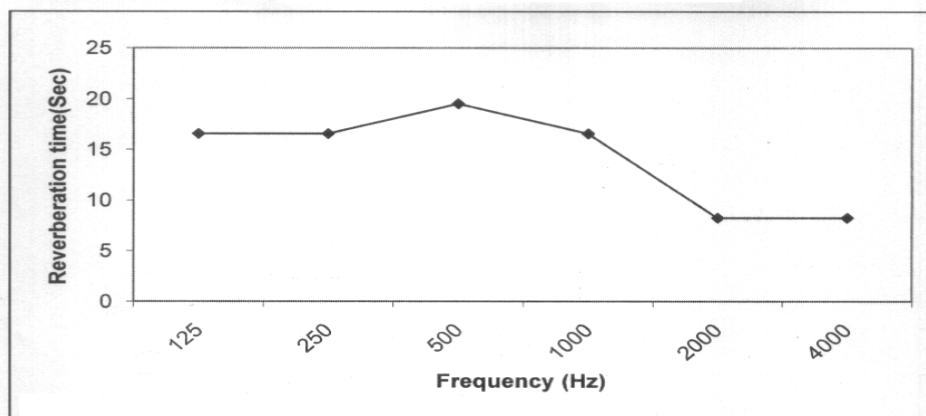


Fig. 47. The relation of RT and octave band frequency in the qibla iwan of al- Ghawri madrasa

Analysis

The graph shows that the RT rate reached its highest point of 18 sec at frequency of 500 Hz; such high RT value indicates that the iwan featured a good sound propagation pattern along with a decent level of intelligibility. However, this figure dropped to its minimum level of 8 sec at 2000 Hz to maintain its steadiness up to 4000 Hz. In addition, it is clear that the RT has also maintained a steady rate of 16

sec between low frequencies of 125 Hz and 250 Hz. The RT steadiness at different sound frequencies signals a good level of sound intelligibility.

2.6.10 The Prayer Hall of Sulayman Pasha Mosque (1528) (fig. 48)

- The prayer hall measured 185 m².
- There was a central *durqa'a* surrounded by 3 iwans.
- There was a central dome over the *durqa'a*.
- There was a semi dome over each iwan.
- The deepest iwan was the qibla iwan.
- The mihrab was covered in marble.
- The walls were covered in marble.
- Limestone was used for building the walls, domes and semi-domes.

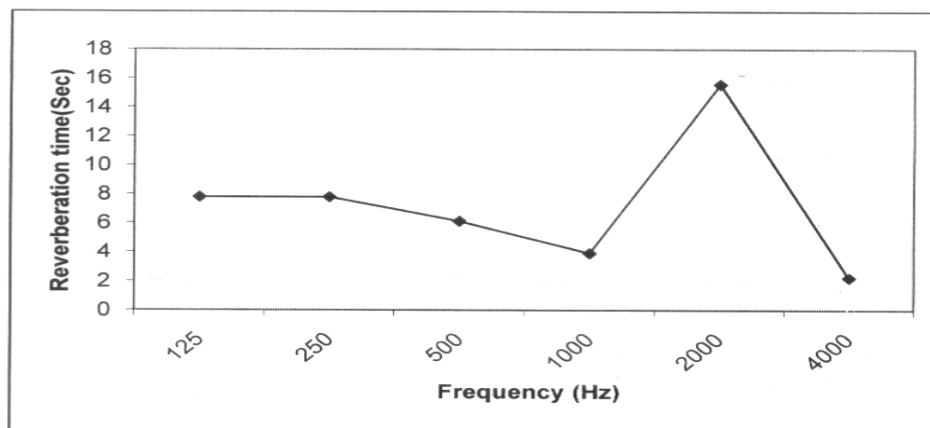


Fig. 48. The relation of RT and octave band frequency in the prayer hall of Sulayman Pasha mosque

Analysis

The graph depicts that the RT was at its highest level of 16 sec at 2000 Hz, thus, the prayer hall possibly enjoyed a good sound dissemination paradigm, while it dramatically dropped to its lowest point of 2 sec at high frequency of 4000 Hz. In effect, the prayer hall enjoyed a good level of sound intelligibility.

2.6.11 The Prayer Hall of Muhammad ‘Ali Pasha Mosque (1830-48) (fig. 49)

- The prayer hall, which measures 1825m², consists of a square area with four huge piers in the center. Over the piers, there are four arches on which the central dome rests. It is surrounded by four semi-domes. Furthermore, there is a dome in the four corners of the prayer hall.
- In the south-eastern side of the prayer hall, there is an iwan covered by a semi-dome. The huge mihrab is found in the back of this iwan. It is a semi circular niche decorated with gilded ornaments.
- The walls are covered with fine alabaster slabs.

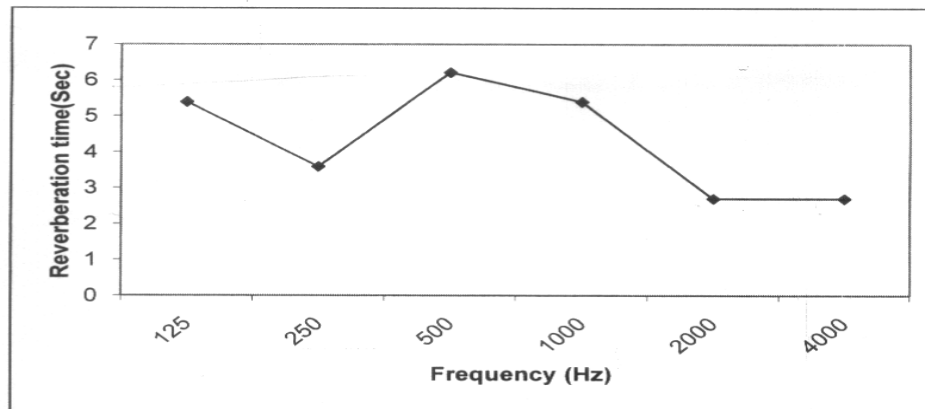


Fig. 49. The relation of RT and octave band frequency in the prayer hall of Muhammad ‘Ali Pasha mosque

Analysis

As can be seen from the graph, the RT was at its highest point of 6 sec at sound frequency of 500 Hz. However, it dropped to its minimum rate of 2.8 sec at 2000 Hz. This rate continued in a steady fashion up to 4000, such constancy indicates the presence of a relatively good sound intelligibility and diffusion pattern within the prayer hall.

2.6.12 Conclusion

Based on comparing the given reverberation time rates to Odeon software's standard reverberation time at different sound frequencies, all the graphs demonstrate that the generated sound was intelligible and well propagated so that most worshippers, in the given examples of qibla riwaqs, iwans and Ottoman prayer halls, were mostly able to hear the imam at the front and understand his recitations. In the same context, the analysis shows that there is a proportional relationship between the RT steadiness between different frequencies and the level of sound intelligibility and homogeneity within the historic building.

From a different perspective the analysis illustrates that there is a proportional relationship between the RT and sound propagation rates, however, if the RT exceeds 25 sec the sound waves could possibly continue to be diffused, but in an unintelligible fashion until they attenuate.

Conclusion

The study was primarily designed to explore and analyze the arhcaeoaoustics of the major Cairene Islamic religious buildings from the time of the Arab conquest through the Ottoman period. In this context, the research has also sought to identify the value of acoustics in Islam through analyzing the most prominent acoustic-related rituals which had been performed in Cairo's historic religious institutions, in respect of precisely determining the mutual impact between the sonic dimension of the Islamic liturgy and the religious architecture of Cairo. Accordingly, the study aimed in the first place to answer the following question: to what extent did the architect, throughout the designated time span of the study, take into consideration the acoustic dimension and its improvement in the different religious institutions that he designed and built in Cairo?

In chapter one, the research identified and proved the presence of a robust relationship between Islam and acoustics. This relationship physically started at the birth of Islam i.e., since the very first moment of the Holy Quran revelation by the Archangel Gabriel to the Prophet Muhammad.³¹⁶ The study has shown further that the acoustic essence of Islam has been clearly crystallized in most of its later rituals; namely, prayer,³¹⁷ the *khutba*,³¹⁸ Quranic recitation,³¹⁹ the *adhan*,³²⁰ supplication,³²¹

³¹⁶ Chapter one in this research, 4-14.

³¹⁷ Chapter one in this research, 15-18.

³¹⁸ Chapter one in this research, 18-20.

³¹⁹ Chapter one in this research, 20-26.

³²⁰ Chapter one in this research, 26-31.

³²¹ Chapter one in this research, 31-33.

dhikr,³²² and *tabligh*.³²³ Based on their acoustic nature, all of the aforementioned rituals had been performed, in most of Cairo's major religious institutions, by highly qualified religious personnel who were, in most cases, carefully chosen and appointed by the patrons according to their fine vocal qualifications alongside their remarkable religious education and knowledge.

In chapter two, the study analyzed the various acoustic-related architectural elements and special pieces of furniture that had been employed in most Cairene religious institutions with regards to serving a specific acoustic purpose, whether in a direct or indirect fashion, alongside determining their dynamic role in creating a proper effective soundscape, especially from sound intelligibility and propagation perspectives.

In terms of analyzing the acoustic role of the chosen architectural elements and pieces of furniture, the research arranged and classified them into two groups: A) Sound transmission elements; B) Sound diffusion and amplification elements.

A) Sound Transmission Elements:

This category grouped all the acoustic-related architectural elements and pieces of furniture which had been used by the religious personnel, as a special sonic station from which they delivered their recitation to the faithful. This category includes the minaret which has been proved by the study, through much historical evidence, to be a functional acoustic element that was designated specifically for the *mu'adhdhinin* to deliver the *adhan*. Despite the fact that the minaret was the main official station for *adhan* recitation, the study has shown that, in some cases, other

³²² Chapter one in this research, 33-35.

³²³ Chapter one in this research, 35-36.

unexpected platforms were used by the *mu'adhdhinin*, such as the top of the original *fawwara* dome of Ibn Tulun mosque which was used to perform the *iqama adhan*. Additionally, the research underscored a possible proportional relationship between the number of the religious buildings' minarets and the level of the sound audibility and its dissemination rate. The acoustic role of the minaret was affirmed by al-Maqrizi's account in which he stated that, in some cases, the minaret was dedicated to performing the *takbir*, *tasbih*, and other invocations by the *mu'adhdhinin* at night time.³²⁴

The second element in this group is the *minbar*. The study has substantiated the acoustic nature of the *minbar* from the time it was introduced and used by the Prophet Muhammad in his mosque in Madina onwards. The core notion of the *minbar* was based on having an elevated structure above ground level so as to ensure the imam's audibility and visibility, while delivering his *khutba* to the congregation, especially those who sat in the back areas of the premises. With regards to modern acoustics, the study underscored a proportional relation between the height of the *minbar* and the orator's audibility.³²⁵

The third element is the *dikka*. From the acoustic perspective the study demonstrated that the *dikka* was a distinct utilitarian element that contributed to the improvement of the soundscape of the spacious religious buildings which housed it.

The *dikka* had been primarily used by *mu'adhdhinin* in making the *iqama adhan* and in speaking aloud the responses during the prayer, especially the *takbir* and *taslim*, simultaneously with repeating the ritual postures with the imam so the congregation in the back could follow the imam in a clear fashion. In terms of

³²⁴ Abouseif, *The Minarets*, 10.

³²⁵ Chapter two in this research, 56-59.

determining the acoustic effectiveness of the *dikka*, the study has highlighted a proportional relationship between the height of the *dikka* along with its area and the *mu'adhdhinin* sound audibility and its dynamic diffusion.³²⁶

The fourth element in the same acoustic group is the *dikkat al-qari'*. The study has pinpointed the acoustic purpose that was primarily used by the religious personnel in delivering important religious or secular readings such as Quranic recitation, preaching and teaching. The main component in the *dikkat al-qari'*'s acoustic nature is its elevation above the ground level which enabled the reciter's voice to be effectively transmitted and diffused among the seated congregation.³²⁷

The fifth and last element in the sound transmission group is fenestration. From the acoustic perspective, windows in the religious buildings have been regarded as sound conductors between the different interior parts of the premises, especially between the qibla area and the mausoleum, and/or between the building's interior and the surrounding neighborhood and streets. From a different perspective, the study showed that large windows, especially in Mamluk religious buildings, had been frequently used by *qari' shubbak* in broadcasting Quranic recitation to the worshippers inside the premises and the passersby in the surrounding streets.³²⁸

B) Sound Diffusion and Amplification Elements:

In this part the study showed that the elements of this category i.e., the mihrab, the dome, and the muqarnas were not originally introduced to religious premises to serve an acoustic purpose. In other words, each of those previously mentioned elements had been used in the building in terms of fulfilling a specific architectural

³²⁶ Chapter two in this research, 60-64.

³²⁷ Chapter two in this research, 64-66.

³²⁸ Chapter two in this research, 66-68.

role, however, they had also featured an indirect or a partial acoustic dimension that contributed to sound diffusion and amplification processes.

The first element in this group is the mihrab *mujawwaf* which acted as a sound resonator due to its concavity. It has also been shown that the two main factors that control the rate of sound amplification within the niche mihrab are the level of the mihrab's interior concavity and the physical properties of the cladding material which determine the proportion of its acoustic reflectivity.³²⁹

The second element is the dome. From the sonic perspective, the study identified a common feature between the dome and the niche-mihrab, that is to say, concavity which is a determining factor in the sound amplification and dissemination processes. According to modern acoustics, the study singled out a direct proportional relation between the volume of the dome and its elevation and the generated sound amplification, for both factors are responsible for determining the amount of the sound energy that enters the dome. In the same context, the building material of the dome partially contributes as well to the level of the sound amplification and diffusion according to its reflection tendency.³³⁰

The third and last element in this group is the muqarnas. The study demonstrated the acoustic role of the muqarnas with regards to its tendency to diffuse the sound waves which interact with its units. Additionally, in many cases, the muqarnas acted as useful acoustic baffles that decreased the rate of the unfavorable sound echoes. Thus, the muqarnas also contributed to improving sound intelligibility within the premises.³³¹

³²⁹ Chapter two in this research, 69 -71.

³³⁰ Chapter two in this research, 72 -75.

³³¹ Chapter two in this research, 75-77.

With regards to creating an effective soundscape within the historic religious premises, the study has shown that the architect, in many cases, had not just resorted to employing sound transmission, amplification, and propagation elements, but also implemented effective noise abatement techniques in respect of reducing the rate of the noise that found its way from the exterior world to interior of the premises. In this context many noise reduction techniques were underscored alongside determining their dynamic role in abating the noise leakage phenomenon. An example is the *ziyada* of Ahmad b. Tulun mosque which played a remarkable role in protecting the mosque from the noise pollution of the surrounding markets. Also, in some cases, the religious building was established several meters above the street level, increasing the distance between the noise sources and the prayer area. The mosque of al-Salih Tala'i is a good example of this trend.

In the same context, the study pinpointed the usefulness and acoustic effectiveness of the bent entrance and the *majaz* in relatively isolating the building's interior from external noise, at the Sultan Hasan madrasa. In addition to its architectural usefulness in supporting the building, the study has highlighted the acoustic benefits of increasing the wall thickness of the religious buildings in terms of reducing the noise from outside, especially those which are found in busy commercial neighborhoods. All the more, the study demonstrated several partial noise isolation techniques such as the wooden sliding windows (*bab jarrar*) of Abu Bakr Muzhir mosque. During the Ottoman period many Cairene mosques were surrounded by beautiful gardens providing the mosque with a charming landscape along with exploiting its green area as a natural barrier separating the mosque proper from the

exterior world and its unfavorable noises. The mosque of Sinan Pasha in Bulaq is a good example of this.³³²

In the last part of the chapter two, the study partially reconstructed the soundscape of the qibla riwaqs, iwans, and prayer halls of major Cairene historic religious buildings, from the time of the Arab conquest through the reign of Muhammad ‘Ali Pasha, by using Odeon room acoustics software, version 10. The aimed soundscape reconstruction was based on analyzing the relationship between the estimated reverberation time (RT) of the imam's recitation sound in the mihrab and its spectrum of octave band frequencies (Hz). Such acoustic criteria suggested that all the prayer areas which were taken as a case study for this research had a decent level of sound intelligibility along with an effective sound dissemination patterns.

Accordingly, this study could be considered initial specialized research in the field of Islamic art and architecture in terms of providing a detailed analysis with regards to the acoustics of Islamic religious architecture of historic Cairo from both the liturgical and archaeoacoustic perspectives. This study suggests that the created soundscape within Cairene historical buildings was twofold. First, it was partially created as a byproduct of both the general architectural design of the building and a primary set of functional elements which had fulfilled, besides their basic architectural role, an indirect acoustic impact within the building interior; namely, the mihrab, the dome, the fenestration and the muqarnas. Second, the discussed soundscape was also affected by acoustic-related architectural elements and pieces of furniture within the building; namely, the minaret, the *minbar*, the *dikka*, and the *dikkat al-qari*’.

³³² Chapter two in this research, 77-83.

In consequence, it could be suggested that many architects, throughout the different periods of the Islamic history of Cairo, had enjoyed a remarkable level of acquaintance with the basic, if not advanced, architectural acoustics principles, having succeeded in applying their acoustic knowledge to the various types of the religious building that they designed and built. Finally, the acoustic trend of this study has shown that the field of Islamic art and architecture still has many significant under-researched areas, beyond their visual aspects, that need to be analyzed. This could result in scholarship that will contribute to the priceless repertoire of Islamic art and architecture which, as a field, has proved itself to be one of the greatest in art history.

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Figures

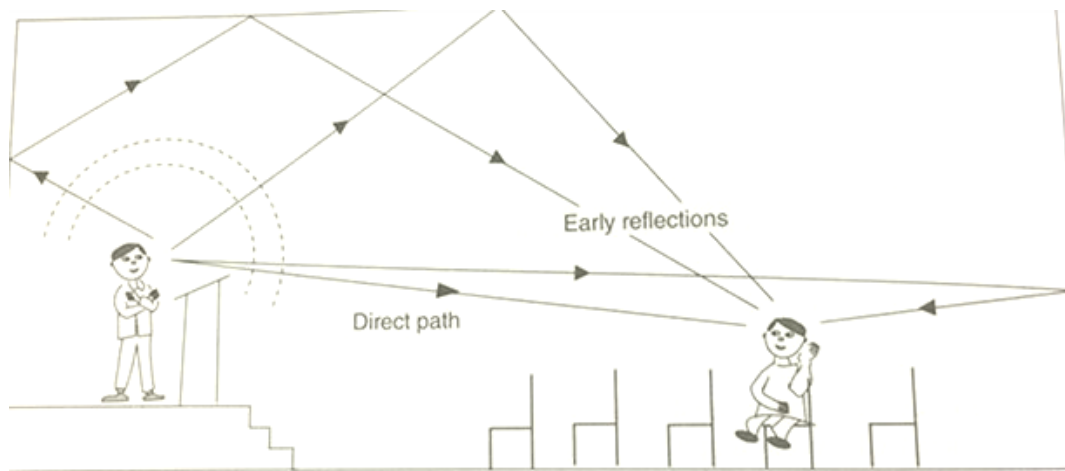


Fig. 1. Paths of direct sound and the few first reflections in a rectangular room from a speaker to a listener, assuming specular reflections from walls

(By Pulkki and Karjalainen)



Fig. 2. The electrified loudspeakers which are mounted on the minarets of Faraj ibn Barquq *khanqah* in the Northern Cemetery

(By the author)



Fig. 3. The symmetrical minarets of Faraj ibn Barquq *khanqah* in the Northern Cemetery
(By the author)



Fig. 4. The minaret of the Qalawun complex
(By the author)

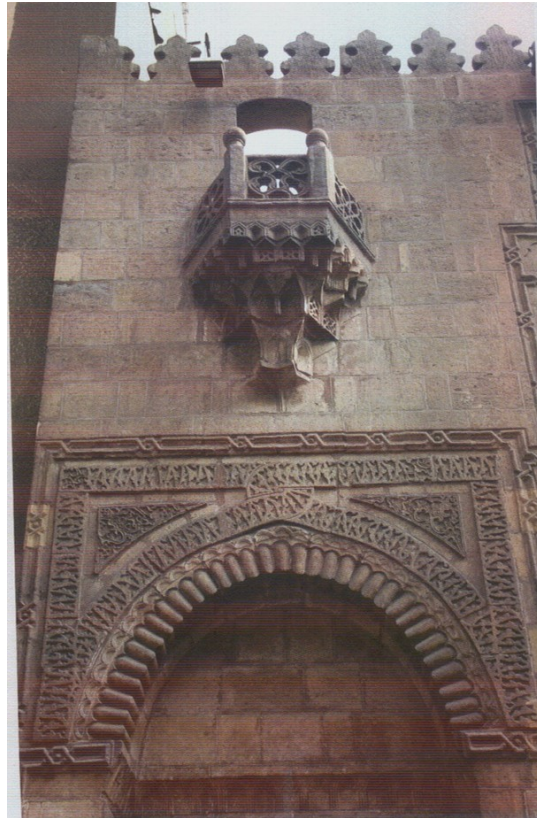


Fig. 5. The balcony which projects from the face of the Amir ‘Abd al-Rahman
Katkhuda mosque (*zawiya*)
(By Doris Abouseif)



Fig. 6. The marble *minbar* of Aqsunqur mosque
(By the author)



Fig. 7. The stone *minbar* of Shaykhu mosque
(By civilizationlovers.wordpress.com)



Fig. 8. The wooden *minbar* of Muhammad 'Ali Pasha's mosque at the citadel.
(By the author)



Fig. 9. The *dikka* of Sultan Hasan madrasa

(By the author)



Fig. 10. The *dikka* of Altinbugha al-Maridani mosque

(By the author)



Fig. 11. The *dikka* of Faraj ibn Barquq *khanqah* in the Northern Cemetery

(By the author)



Fig. 12. The *dikka* of Sultan al-Ghawri madrasa

(By the author)

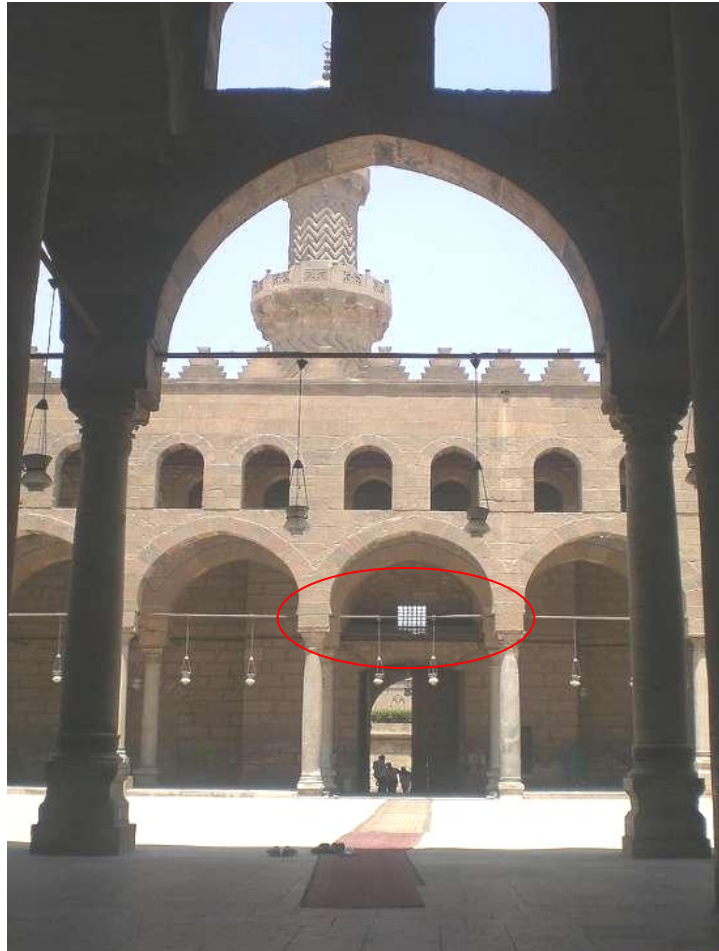


Fig. 13. The small loggia above the northwestern entrance of al-Nasir Muhammad mosque at the citadel

(By www.babonej.com)



Fig. 14. The unique *dikka* of Sulayman Agha al-Silahdar mosque

(By the author)



Fig. 15. The *dikkat al-qari'* of Sultan Hasan madrasa

(By the author)



Fig. 16. The fenestration within the main corridor of the funerary complex of Sultan

al-Mansur Qalawun

(By the author)



Fig. 17. The qibla wall fenestration of Qaytbay madrasa in the Northern Cemetery

(By the author)



Fig. 18. The fenestration technique in the northwestern side of the prayer hall of

Sulayman Pasha mosque at the citadel

(By the author)



Fig. 19. The mihrab of al-Mansur Qalawun's madrasa

(By the author)



Fig. 20. The mihrab of al-Mansur Qalawun's mausoleum

(By the author)



Fig. 21. The marble mihrab of Sulayman Pasha mosque

(By the author)



Fig. 22. The marble mihrab of Muhammad 'Ali Pasha mosque

(By the author)

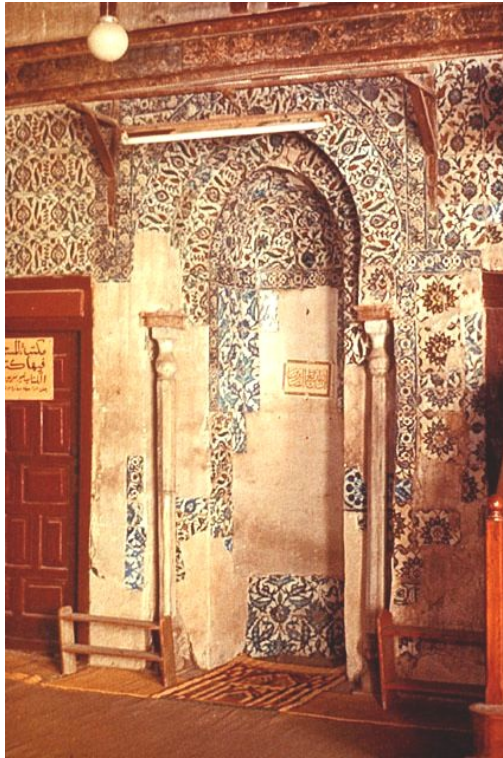


Fig. 23. The mihrab of Alti Barmaq mosque

(By Archnet.org)



Fig. 24. The stone dome of Barsbay's mausoleum in the Northern Cemetery

(By the author)



Fig. 25. The stone dome of Qaytbay's mausoleum in the Northern Cemetery

(By Author)



Fig. 26. al-Fadawiyya dome

(By the author)



Fig. 27. The muqarnas tiers of al-Ghawri mausoleum

(By the author)



Fig. 28. The ziyada of Ahmad b. Tulun mosque

(By the author)



Fig. 29. The elevation of al-Salih Tala'i mosque

(By the author)



Fig. 30. The elevation of Malika Safiyya mosque

(By the author)



Fig. 31. The *majaz* of Qijmas al-Ishaqi complex

(By the author)



Fig. 32. *Bab al-khukha* of Faraj ibn Barquq *khanqah* in the Northern Cemetery

(By the author)



Fig. 33. The courtyard of al-Hakim mosque

(By the author)



Fig. 34. The *bab jarrar* in the mosque of Abu Bakr Muzhir

(By the author)



Fig. 35. The windows with wooden shutters in the facade of Sultan al-Zahir Barquq madrasa

(By the author)



Fig. 36. The surrounding garden of Sinan Pasha mosque in Bulaq

(By the author)



Fig. 37. The elevation of the Nizamiya *khanqah*

(By the author)