SOUND ABSORPTION COEFFICIENT OF CARVED WOOD PANEL WITH ISLAMIC GEOMETRIC PATTERNS

BY

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ABSTRACT

The use of Islamic geometric pattern is very common in mosques, and very often, the patterns are carved on wood, but because of unavailability of their sound absorption coefficients, these carved wood panels are not used for the acoustic design of the mosque although they contribute to sound Absorption. This research finds sound absorption coefficients of Islamic geometric patterns carved on wood using acoustical simulation software BEASY. This research finds common geometric patterns to find sound absorption coefficient of a representative pattern that can be carved on wood using acoustical package of simulation software BEASY. BEASY is used to simulate sound emitted from a source in front of a wood panel carved with *Rub el Hizb* to find sound intensity in front of the panel, and then using sound intensity technique sound absorption is calculated. Sound absorption coefficients are found by three methods, in the first method an anechoic room with a wood panel carved with *Rub el Hizb* inside it is simulated, sound source in this method is a point source. The second method simulates only the wood panel carved with *Rub el Hizb* in an infinite space with a point source. The third method simulates the panel in an infinite space with a sphere object as the source of sound.

ملخص البحث

إن إستخدام الزخارف الهندسية الاسلامية شيء شائع جدا في المساجد، وكثيرا ما تكون هذه النقوش محفورة على الخشب، ولكن بسبب عدم وجود جداول معامل امتصاص الصوت للزخارف الهندسية الاسلامية، فان هذه الزخارف لا تستخدم في التصميم الصوتي للمساجد بالرغم من أنها تساهم في الامتصاص الصوتي. هذا البحث يجد معامل الامتصاص الصوتي للزخارف الاسلامية المحفورة على الخشب باستخدام برنامج محاكاة الصوت (BEASY). استخدم (BEASY) في محاكاة انتشار الصوت امام لوح خشبي محفور عليه واحد من الزخارف الشائعة وتم قياس شدة الصوت امام اللوح، وبعدها وباستخدام تقنية شدة الصوت تم قياس معامل امتصاص الصوت. واستخدم في هذا البحث ثلاثة طرق لايجاد معامل امتصاص الصوت. تمت في الطريقة الاولى محاكاة اللوح الخشبي المحفور عليه الزخارف الاسلامية في غرفة قياس الصوت مع كون مصدر الصوت نقطة. في الطريقة الثانية تمت محاكاة اللوح الخشبي المنقوش عليه الزخارف الاسلامية في فضاء لامنتهي مع كون مصدر الصوت نقطة. وفي الطريقة الثالثة تمت محاكات اللوح الخشبي في الفضاء ولكن مع كون المصدر مثل كرة مشعة للصوت.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of (Building Services Engineering)

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of (Building Services Engineering)

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DECLARATION

I hereby declare that this dissertation is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Ahmed Omar Ali

Signature ..... Date.....

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ACKNOWLEDGMENT

All praise and thanks are due to Almighty Allah, Who in His infinite mercy and grace enabled me to complete this dissertation. I bow my head with all submission and humility by way of gratitude due to Almighty Allah.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBRIVIATIONS

α , Sound absorption coefficient

α_n , Normal sound absorption coefficient

E_i , Incident sound energy

E_r , Sound energy reflected from objects.

E_f , Sound energy lost by friction action with objects

E_t , Transmitted sound Energy through the wall

E_a , Absorbed sound Energy

I_n , Net sound intensity at quarter wave length from the acoustical material

I_i , Incident sound intensity at quarter wave length from the acoustical material

f , Sound frequency

f_o , Frequency of resonance

m , Surface density of diaphragmatic absorber, N/m^2 of panel surface

d , Depth of air space in meters behind a diaphragmatic absorber

FEA , Finite element analysis

BEM , Boundary element method

RC , Reflection coefficient

Z , Impedance of a medium

λ , Wave length.

c , Speed of sound

SP , Sound intensity in front of the panel

SRP , Sound intensity in front of the reflective plate

SE , Sound intensity in the empty room

CSP , Corrected sound intensity in front of the panel

LIST OF EQUATIONS

CHAPTER ONE

INTRODUCTION

1.1 PROBLEM STATEMENT

Sound absorption panels are used for acoustical design of buildings to improve the acoustics of the building by achieving the most suitable reverberation time for speech (Everest, 1994). There are many types of sound absorption panels; one of them is perforated panels. Perforated panels are aesthetically accepted and they improve the acoustic of the building by absorbing sound. Islamic patterns on carved wood are used as a decoration for buildings especially in mosques, but until now they are used as decoration panels only and we do not know anyone published sound absorption coefficients of wooden panels carved with Islamic patterns to be in hand for acoustic engineers.

This research determines the sound absorption coefficients of wooden panels carved with Islamic geometric patterns using acoustic simulation software (BEASY). This will inspire acoustic engineers to use these panels as sound absorbers in buildings, and it will facilitate the improvement of the acoustic design of mosques and buildings that have these panels by calculating their contribution to sound absorption.

1.2 AIM AND OBJECTIVES OF THE STUDY

i. To study the Islamic geometric pattern used on carved wood panels in mosques.

ii. To find a reliable and easy method for calculating sound absorption coefficients of carved panels using numerical simulation softwares, which

will enable acoustic engineers calculate the contribution of any panel exist in their design without ignoring it.

iii. To determine sound absorption coefficient of a typical Islamic geometric pattern carved on a wood panel.

1.3 SIGNIFICANCE OF THE STUDY

The prophet Mohammad (PBH) says "if someone of you was in the prayer, then he is talking with his Lord, so pay attention to what you say in your prayer, and don't loud your voice with Quran so you do not harm the believers" (Sahih Bukhari). From this Hadith we see the importance of keeping mosques quiet and a place for Muslims to meditate and supplicate their creator. This research determines the sound absorption coefficient of direct pierced carved wood panel with Islamic patterns, which will help to use the wooden ornaments in the mosques as sound absorbent panels. This research is a step for reviving the Islamic art by introducing tables of sound absorptions coefficients of panels of wood carved with Islamic patterns to be in hand for architects to use them in acoustic design

1.4 METHODOLOGY

i. Conduct a literature review on Islamic geometric patterns.

ii. Determine common geometric pattern for simulation

iii. Install the software and test it.

iv. Perform the modeling of the geometric pattern.

v. Determine normal sound absorption coefficient (α_n) of the sample.

vi. Analyze the results and improve them.

CHAPTER TWO

ISLAMIC GEOMETRIC PATTERNS

2.1 GEOMETRIC PATTERN IN THE ISLAMIC ART

Geometric patterns make up one of the three non figural types of decoration in Islamic art, which also include calligraphy and vegetal patterns. Geometric patterns are usually attributed to Islamic art; Muslim artists used the geometrical shapes like the circles, squares, triangles and other geometrical shapes to create some complex and sophisticated ornamentation unknown previously. These shapes were interlaced, intertwined, and repeated in a regular pattern to form ornaments. These ornaments were used to adorn all types of surfaces, like walls of Muslim monuments, textiles, carpets, door frames, pulpits, screens ....etc. Geometric patterns come in two ways; either combined with other ornamentations like calligraphy and floral pattern or they come alone where only geometric shapes are used in a creative way to form an aesthetic pattern that gives beauty and solemnity.

Geometric patterns were used by other ancient cultures like Romans, Greek and Chinese, but under the Islamic state geometric patterns blossomed and reached a pinnacle in beauty and complexity (The Metropolitan Museum of Art 2004). Muslim artists took key elements from classical and traditional art of the previous civilizations, but they elaborated upon what they took and they invented their own style. Islamic geometric patterns are characterized by unity, logic and order (Abas and Amer, 1995). The unique style of Islamic patterns comes from the contributions of Islamic astronomers, mathematicians and other scientists whose ideas and technical advances are indirectly reflected in the artistic tradition.

The reason behind the extensive use of geometrical patterns in Islamic art is the ban that Islam puts on the figurative art. It is narrated that the prophet Muhammad said "The makers of these pictures will be punished on the Day of Resurrection, and it will be said to them, 'Give life to what you have created' (i.e., these pictures)". When he saw a cushion with some pictures on it, and then the Prophet added, "The Angels of (Mercy) do not enter a house in which there are pictures" (Sahih Bukhari 3:34:318). Many nations before Islam ended worshipping idols after being monolithic, when pious men died, their people erected statues in honor of them at their gathering places, they thought that those statues would remind them to do good, but later their successors gradually moved to worship those images of the pious men their predecessors made. This is how prophet Noah's people worshipped idols, the names of idols that are mentioned in Quran in Surat Noah;(Wad, Swaa, Yagoth, Yaook and Nasr) are the name of some monolithic pious men. There are some other reasons that Muslims used geometrical ornaments beside the ban on figurative art, the science of astronomy was the most passionate intellectual activity in the Islamic world. Muslims had to know the five times of prayers a day by the position of the sun in the sky; they had to know when is Ramadan to fast and when is the month of Thul Hijja to go for pilgrimage. Three out of five pillars of Islam are related to the moon and the sun, and the environment of Arabs who lived in the desert required knowledge about the stars and their positions in the sky to guide them to the roads in the desert and the direction of Qiblah at night, God says "*And by the stars, they find the way*" (Quran, *Al Nahl*, 16). All these made Muslims very attached to astronomy and made stars and constellations one of the main characteristic of Islamic art (Abas and Amer 1995).

It is true that the figurative art does exist in Islamic art, but it was mainly used in books for the purposes of education like in anatomy books, or for history recording purposes like recording the events of battles of the Muslim armies. However, the abstract art and especially the geometric art remains one of the most distinct features of Islamic art, especially the decorative art of Muslim monuments.

2.2 DEFINITION OF ISLAMIC PATTERNS

An extensive discussion of Islamic patterns was given by Abas and Amer (1995). Islamic pattern does not mean that the pattern have any religious significance, or that it was invented to serve the Islamic faith or even it was created by a Muslim artist. There are many definitions of Islamic art (Islamic patterns is the major part of Islamic art because of the ban Islam put on figural art). Some scholars limit the Islamic art to that one which was created between 900 A.D and 1500 A.D in a place where the majority of the population where Muslims or at least the ruling element professed the faith of Islam. They limit it to that date because the Islamic art only acquired its distinct personality in the 10^{th} century.

In order to give the opportunity for the Islamic art to grow and to encourage the creation of new Islamic pattern Abas and Amer (1995) give the following definition to Islamic patterns:

An Islamic pattern is one which satisfies one or more of the following criteria:

1- The pattern is transcribed with Arabic calligraphy from the Quran.
2- The pattern was invented between 900 A.D. and 1500 A.D. and was used to decorate architectural surfaces or other works of art for Muslims, in a

culture where the majority of the population, or at least ruling element, professed the faith of Islam.

3- The pattern is derived from one or more patterns, which satisfy criterion 2, and is such that the characteristic shapes from the original (or originals) are recognizable.

2.3 CHARACTERISTICS OF ISLAMIC PATTERNS

Islamic geometric patterns consist of small, repeating geometric shapes. The design radiates symmetrically from a central point and is constructed from a pattern of circles, equilateral triangles, squares, hexagons and/or six-pointed stars. The pattern is not designed to fit within a frame, because each unit is just one small part of an overall pattern that would cover a wall, floor or roof. Most of the patterns are created by repeating the basic unit over a grid. There are two types of grids that are most frequently used; the triangle grid and the square grid, a hexagon grid also is used for some patterns. The basic unit is repeated therefore its left side must coincide with the right side and the top with the bottom.

They are made from simple basic geometric shapes; which are triangles, squares, circles and polygons. These shapes are combined, duplicated, interlaced and arranged in intricate combinations to form some most beautiful and complex geometrical ornaments. The most complex ornaments can be disintegrated to its basic shapes.

The prominence of symmetric shapes that resemble stars and constellation is one of the most striking characteristic of geometrical patterns. Patterns without geometrical shapes are very few and are not complex. The most frequent stars are stars with six, eight, ten, twelve and sixteen rays, but there are also stars with other

number of rays, particularly in multiples of eight up to ninety six. The prominence of stars may be due to the contribution of Muslim astronomers to geometric patterns (Abas and Amer 1995).

The geometrical ornaments consist of layers, where there is the background and foreground. This feature of placing a pattern over another pattern gives the impression that the ornament has a depth, sometimes the two layers weave over and under each other in alternate to emphasize the foreground decoration. When the two patterns are different in size, i.e. one is fine the other is big in its element size, the fine one can be observed from a close distance where the observer can't see the other layer, but when it is seen from a far distance the observer will only see the big pattern, this feature is suitable for the façades of buildings.

They have a remarkable freedom, the repetition of the basic unit gives the possibility of infinite growth and they can accommodate to incorporate other types of ornamentation as well, Muslim artist used geometric patterns combined with floral pattern or with calligraphy (Ahmad M. and Ebad 2003).

2.4 COMMON SHAPES IN GEOMETRIC PATTERNS

There are many common strategies in drawing the Islamic patterns and there are many famous Islamic monuments that are adorned with Islamic patterns but Abas and Amer (1995) mention two of the most frequent shapes, the two shapes are described in what follows:

2.4.1 Rub el Hizb:

It is also called Khatam Sulemani or the eight point star. Rub el Hizb is an Islamic symbol which is found on a number of Islamic emblems and flags. Rub in Arabic means quarter and Hizb means party or group. This symbol was initially used in

Quran, where each chapter (*Juz*) of Quran is divided into two Hizbs, and each Hizb is divided into quarters, therefore this symbol was used to indicate the beginning of the quarters of Hizb to facilitate reciting and memorizing Quran. If we are forced to choose on shape that charctarize Islamic geometric patterns then it will be Rub el Hizb, it is an eight point star which can be drawn by drawing two identical squares one inclined by 45 degrees with respect to the other one, as shown in Figure. 2.1

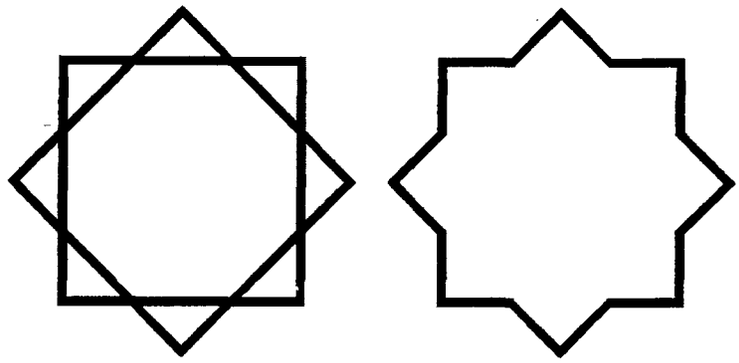

Figure 2.1 Basic shape of Rub el Hizb

It is the most ubiquitous shape in Islamic art; it can be spotted as commonly in Samarkand as in Sahara. This shape was chosen by the former prime minister of Malaysia Dr. Mahathir Muhammad to be the cross section of the twin towers to give an Islamic influence on the design but latter they added extra circular sectors to increase the total floor space.

This shape is used in Masjid Usama Bin Zaid on the carved wood around the Haram of the Masjid, therefore I chose this shape to be simulated for sound **Absorption.**