EVALUATION OF THE ACOUSTICS PERFORMANCE OF THE KAED MAIN AUDITORIUM

BY

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ABSTRACT

The main auditorium in the Kulliyyah of Architecture and Environmental Design (KAED) serves as a vital venue, functioning as a multi-functional hall. However, acoustic quality is the main issue challenging the KAED Main Auditorium. The current acoustics performance of the KAED Hall is not desirable as a multi-functional space. There are many significant contributors to the acoustic quality of the KAED Main Auditorium, such as undesirable acoustic design, unpleasant geometric shape, wrong reverberation time, uneven distribution of sound, and physical performance of the hall. Moreover, there are several other causes like surface finishing, lack of diffusers, the layout of the boundary surface (balanced horizontal ceiling and concave wall), seating cloth, and stage wall that further contribute to the auditorium's poor acoustic quality. All of these factors reduce the intelligibility of speech. In addition, they cause poor communication between speakers and audiences in some parts of the space, such as rear rows and the centre-back area of the auditorium. Thus, students may get fewer benefits from lectures held there, which subsequently affects the students' educational quality. This research, which is presented as a dissertation, studies the aspect of acoustic quality (causes, effects, and preventive strategies) of the KAED Main Auditorium to evaluate its acoustics performance. The main agenda is to identify a viable solution to the acoustic issue of the multi-purpose auditorium. For this purpose, data were processed and evaluated in two stages. The first stage involved three types of survey measurements on the acoustic quality of the site. The first of the three was a sound level reading by the sound meter, the second involved identification of the areas and volume of the KAED Main Auditorium (i.e., approximately about 620 square meters and 3141.23 cubic meters, respectively), and the third measurement was designed to examine the absorption of each surface finishing. The second stage was a survey questionnaire to 50 students at the Kulliyyah of Architecture and Environmental Design. The result and findings are explained and analysed by figures, drawings, tables, and column graphs. Eventually, the research forwards several recommendations to improve the acoustic performance of the KAED Main Auditorium.

خلاصة البحث

تلعب القاعة الرئيسية في كلية الهندسة المعمارية والتصميم البيئي (KAED) دورا محوريا كونها قاعة متعددة الاستعمالات. ومن المشاكل المعقدة المتعلقة بالقاعة والتي تشكل تحديا مشكل جودة الصوتيات حيث إن النظام الصوتي الحالي لا يصل إلى المستوى المرغوب فيه لقاعة متعددة الاستعمالات. عوامل كثيرة تؤثر على جودة الصوت في القاعة الرئيسية الخاصة بكلية الهندسة المعمارية والتصميم البيئي، منها: التصميم الصوتي غير اللائق، والشكل الهندسي غير الجيد، وزمن الترديد الخاطئ، والتوزيع غير المتساوي للصوت، والأداء البنيوي للقاعة. ومن العوامل أيضا التي تؤثر سلبا على جودة الصوت التشطيب غير الجيد للأسطح، وعدم وجود ناشر الصوت، وتشكيل الأسطح الداخلية (سقف مستو وجدران مقعرة)، وفرش المقاعد، وجدار المنصة. كل هذه العوامل تؤثر على وضوح صوت المتحدث، بالإضافة إلى أنها تؤدي إلى ضعف التواصل بينه وبين المستمعين الجالسين في بعض الأماكن المحددة، مثل الصفوف الخلفية والوسط الخلفي للقاعة مما يؤثر سلبا على استفادة الطلبة من المحاضرات وبالتالي على جودة تعليمهم. درس الباحث في هذه الأطروحة جودة الصوتيات لتقييم الأداء الصوتي للقاعة الرئيسية التابعة لكلية الهندسة المعمارية ولإيجاد حلول للمشاكل المطروحة. تمت معالجة المعطيات وتقييمها على مستويين. خصص المستوى الأول لجمع قياسات الموقع وهي ثلاثة أنواع: قياس مستوى الصوت، قياس مساحة وحجم القاعة، وهما على التوالي 620 متر مربع و3141.23 متر مكعب، ثم قياس معامل امتصاص الصوت لكل سطح من أسطح القاعة. أما المرحلة الثانية فقد خصصت لاستبيان شارك فيه 50 طالبا من كلية الهندسة المعمارية والتصميم البيئي. وقد تم استعمال كل من الأرقام والرسوم والجداول والمخططات الشريطية لتحليل النتائج. وفي الختام عرض الباحث عددا من التوصيات التي من شأنها تحسين الأداء الصوتي للقاعة الرئيسية لكلية الهندسة المعمارية والتصميم البيئي KAED.

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 dissertation for the degree of Master of Science in Building Services Engineering.

……..
Aliyah Nur Zafirah Bt. Sanusi
Supervisor

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 dissertation for the degree of Master of Science in Building Services Engineering.

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This dissertation was submitted to the Kulliyyah of Architecture and Environmental Design and is accepted as a fulfilment of the requirement for the degree of Master of Science in Building Services Engineering.

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Abdul Razak Sapian
Dean, Kulliyyah of
Architecture and Environmental
Design

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 the International Islamic University Malaysia or other institutions.

Nik Mohammad Aimaq

Signature…… Date…….

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LIST OF ABBREVIATIONS

KAED	Kulliyyah of Architecture and Environmental Design
dB	decibel
Hz	Hertz
NC	Noise Criteria
NR	Noise Rating
PNC	Preferred Noise Criterion
RC	Room Criterion
RT	Reverberation Time
SIL	Speech Interference Level
SNR	Signal-To-Noise Ratio
SPL	Sound Pressure Level

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The main auditorium in the Kulliyyah of Architecture and Environmental Design (KAED) is a significant place as a multi-purpose hall. It mostly functions as a performance venue, a seminar or conference location, or a lecture hall. This research focuses on evaluating the current acoustic performance of the KAED Main Auditorium since acoustic performance is one of the significant elements for the auditorium and auditorium users, including audience members. The venue in question (i.e., KAED Main Auditorium) suffers from questionable acoustics quality due to the lack of acoustics designing and consideration at the initial stages of its design. This has further resulted in uneven sound distribution and undesirable reverberation time. A sound acoustics performance is vital to promote effective communication, which is, in this case, between the speaker or performer and members of the audience. This study is more concerned with the nature of the KAED Main Auditorium as a lecture hall. Any acoustic issues in the auditorium may be detrimental to the educational quality of students when attending lectures or talks in the venue.

This chapter introduces the research context (both theoretical and conceptual) to understand the study. Aside from providing its background, the chapter details the goals and objectives of the current study along with the formulated research questions. Further established in this chapter are the scope and limitations of the study. The chapter ends by presenting the structure and organisation of the main chapters. An explanation of the research methods employed in this research will be presented in a later chapter. It serves

as a foundation for a thorough research direction firmly fixed on a well-defined methodology of the research.

1.2 BACKGROUND OF THE STUDY

Acoustics in enclosed spaces have been a critical factor in building design since the ancient periods. As this factor was subjectively comprehended at the early stages of designing, an understanding of speech intelligibility, sound intensity, and sound clarity was mainly considerable. Although the mathematical instrument was insufficient to illustrate some acoustic parameters as late as the twentieth century, it necessitated further prediction and computation. The progression of human information and knowledge on certain sound phenomena and the human ability to explain them have aided the development of acoustic space. Thus, it is possible to confirm this subjective criterion in the company of objective principles. Due to its replicability, noticeable results, and capability to apply at the design stage, an objective basis has privilege over a subjective basis.

The standard of room acoustics is one of the primary contributors to a pleasurable performance in a hall where the live implementation of various kinds of sounds is applied. Lecture theatres and auditorium halls in any learning environment are part of the category of spaces in which acoustic conditions must be considered and tested for acoustic quality at the project stages or renovation time. Such a procedure will assist in preventing any design inaccuracy that may unfavourably impact the room's sound quality. Applicable requirements and rules must be confirmed at the design stages so that effective acoustic parameters can be elected for the inner component of the room.

The sound is a wave of pressure that a vibrant object produces. It is a mechanised and longitudinal wave that is present at all times. Human beings hear and listen to

sounds all the time, but they may not desire to accept all the sounds as they are. Naturally, the ordinary human cannot escape from noise and sounds. They can close their eyes when they do not desire to see anything. Contrary, they may not be able to prevent the receiving of sound even when they are sleeping. Even in cases where 'complete' silence is attained, the sound is still there – the sound of breathing, the sound of blood circulating, and the many other sounds made by the internal parts and organs of the human body.

The knowledge of sound that deals with the origination of the sound and its distribution are termed acoustics. Mostly, architects and engineers adhere to practical guidelines that may not be successfully applied to auditoriums and other spaces without a close precedent while precise within their limits. The knowledge and science of acoustics significantly improved in the 18th and 19th centuries. By the 20th century, the design procedures and methods of engineering and architectural acoustics in building design turned methodical and quantitative (Bill, 2009).

The KAED Main Auditorium is located at the centre of the Kulliyyah of Architecture and Environmental Design in the International Islamic University Malaysia. The venue is unique as it serves as a multi-functional space. The layout and design of the auditorium permit it to function for presentations, lectures, student assemblies, dramatic productions, conferences, music performances, and many other activities. There are few objects of noise in the circumambient area, and the auditorium is fairly quiet. The hall is equipped with acoustic doors which prevent external-to-internal noise. The cushioned seats are covered with sound-absorbing cloth, and the back wall is inserted with an acoustic fabric panel that absorbs a high volume of sound. Because of the many sound absorbers installed in the auditorium, the acoustic quality is therefore questionable. Students, in particular, have been complaining over the lack of

sound and speech audibility, especially when seated at the back-row seats in attending lectures.

This dissertation evaluates the present acoustics condition of the KAED Main Auditorium as a multi-purpose hall. The research explores and analyses the venue in terms of its acoustics performance, subsequently identifying the causes and effects of the acoustic quality. In the end, the study can forward viable suggestions and recommendations to enhance the quality of acoustic in the KAED Main Auditorium.

1.3 STATEMENT OF THE PROBLEM

1.3.1 Designer's Lack of Awareness in the Field of Acoustics

This study operates on the basis that insufficient design information, as well as consideration of the acoustic requirements of the KAED Main Auditorium at the preliminary stages of its construction, has been detrimental to its acoustic quality. The physical efficiency of the KAED Main Auditorium is one of the apparent factors which contribute as an issue that influences the acoustic quality of the venue. Curved and concave shapes, such as parabolic surfaces, are among the undesirable shapes for a space in which speech is significant. The concave back-wall of the hall causes sound reflections to intersect at the geometric centre of the concave, which is the auditorium's pivot point or move along the curve's plane. Therefore, the sound is being moved at an abnormally long interval or high hotspots within the auditorium. Although combining sound-absorbing fabric panels on the back wall helps regulate the concave's geometry to diminish noise issues, the excessive usage of the sound fabric panels has resulted in other acoustic-related problems in the auditorium.

1.3.2 Uneven Sound Distribution

The propagation and distribution of sound in the KAED Main Auditorium are uneven and imbalanced. The seats are occupied by sound-absorbing cloth, and a high-quality acoustic panel covers the back wall. This panel absorbs much sound and thus makes the back section of the auditorium a quieter place. In contrast, due to a lack of diffusers, sound does not prolong clearly at the backside of the auditorium. Thus, due to the high number of sound absorbers and insufficiency of sound diffusers in the auditorium, the sound is not distributed uniformly. This is a serious issue, especially when the auditorium is fully occupied, as sound does not travel or reach all audience members uniformly. The main chamber is regarded as a general hall, and many types of activities are performed there. However, lack of connection and communication due to low sound pressure and unsuitable acoustical balance for space mostly affects students at the rear row seats. Consequently, these students obtain lesser benefits from the lectures. Throughout the auditorium's lifetime, several practical actions have been implemented to disperse sound during renovations equally. However, those efforts have yet to overcome the multi-functional hall's substantial acoustic quality concerns.

1.3.3 Unintelligibility of Speech

As the auditorium lacks acoustic diffusers, the elongated sounds produced can be especially uncomfortable for audience members. Verbal communication is not fairly intelligible to all students, and these students cannot grasp the lectures properly from the back-row seats. This conundrum is particularly apparent when capacity is high with the auditorium filled with audience members. Due to incomprehensible speech among audiences at the rear seats, there is thus an unfair level of communication between

lecturers and students during the lectures or between students themselves in their presentations.

For this reason, students seated at the back-row seats tend to lose focus and interest during the lectures. It is also not an abnormal sight to witness students dozing off and falling asleep as they could not follow the speaker or presenter, which is an unfavourable and unfortunate observation. Often, students would apologise and excuse themselves from the venue, resorting to leaving the hall in order to grab a cup of coffee or tea in an attempt to stay awake, or they would visit the washroom to refresher themselves. Hence, students' attentiveness towards the lectures is compromised, and the delivery of information is distorted and made ineffective. If the acoustic-related issues in the KAED Main Auditorium continue to persist, there will be dire consequences in the education quality of KAED students in general.

Therefore, this study aims to explore and analyse the KAED Main Auditorium's acoustic performance, identify the causes for the problem, determine the effects of the questionable acoustic quality, and suggest recommendations to enhance the quality of acoustics in the venue.

1.4 RESEARCH GOAL AND OBJECTIVES

This paper examines the existing acoustic quality of the KAED Main Auditorium through Reverberation Time due to the uneven sound distribution and unintelligibility of speech in the venue.

This study aspires to attain the following objectives:

1. To identify the main and primary factors affecting the sound quality of KAED Main Auditorium.
2. To evaluate the acoustic efficiency of the present KAED Main Auditorium.

1.5 RESEARCH QUESTIONS

To achieve the objectives, the study seeks to answer the following questions:

1. What are the main and primary factors affecting the sound quality of the KAED Main Auditorium?
2. Is the sound distribution in the KAED Main Auditorium desirable as a multi-functional and multi-purpose hall?
3. What are the most efficient methods to enhance and improve the acoustic quality of the KAED Main Auditorium?

1.6 SCOPE OF STUDY

The study sets a certain scope or boundary in achieving its objectives. The scope of the study is thus addressed in this section. This dissertation pays special attention to investigating the current acoustic situation of the KAED Main Auditorium. It attempts to analyse the influence of uneven sound distribution and unintelligible speech through the means of Reverberation Time. Eventually, the study proposes a reasonable solution to enhance the acoustic performance of the KAED Main Auditorium.

1.7 SIGNIFICANCE OF THE STUDY

1.7.1 Significance toward Education

The findings of this study are essentially crucial to any educational field and contribute to university privilege, considering that a standard acoustics design in university auditoriums and lecture halls plays a vital role in the direct communication between students and lecturers through lectures and presentations. Accordingly, this study evaluates and analyses the existing acoustic system of one of the university's multi-

purpose auditoria and strategically proposes techniques to modify and improve the acoustic quality of the hall of interest in this study. Consequently, an even sound distribution and required reverberation time can result in a better acoustic system and performance in the venue. A satisfactory acoustics system in the auditorium will enhance the quality of educational delivery and effectiveness via good communication between speakers/lecturers and audiences/students.

1.7.2 Significance toward Design

This work will help designers understand the factors that contribute to acoustics in auditorium design to take steps to mitigate the problems early on in the process. Moreover, the result of this study is useful to any professional in the field of design, construction and renovation of the auditoriums. Thus, the outcome of this paper shows how to avoid the factors which cause poor acoustic quality in the university auditorium and propose the most efficient design and methods for enhancing the acoustic quality and evaluate the acoustic performance of the auditorium.

1.8 PROCEDURE AND STRUCTURE OF RESEARCH

The research process was performed according to the structure and schedule set out in this thesis, and the procedures are divided into five chapters. This section emphasises the research design. As a result, the research structure is specified below, along with a short overview of the study.

1.8.1 Chapter 1: Introduction

Chapter One introduces the research project. This segment also contains the issue raised, which necessitated the need for the study. Subsequently, the research questions