EFFECTIVENESS OF BAMBOO PANEL IN REDUCING SOUND

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by

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ABSTRAK

Pencemaran bunyi adalah pencemaran yang sering diabaikan. Ia tidak dapat dilihat dengan mata kasar. Ia juga boleh digambarkan sebagai bunyi yang tidak diingini atau tidak menyenangkan yang memberi kesan kepada kesihatan dan kesejahteraan manusia dan juga spesies lain. Industri pembuatan, pembangunan, pengangkutan, aktiviti komuniti dan aktiviti di rumah semuanya menghasilkan pelbagai jenis kebisingan dalam kehidupan moden. Kajian ini dijalankan untuk mengkaji keberkesanan panel buluh sebagai penyerap bunyi. Selain itu, kajian ini dilaksanakan untuk membandingkan panel buluh dan bahan lain sebagai penyerap bunyi. Alat pengukur bunyi digunakan dalam melaksanakan kajian ini. Disamping itu, Microsoft Excel digunakan dalam melaksanakan kajian ini untuk megira data yang diperolehi dan dimudahkan ke dalam bentuk carta alir dan graf. Data yang diperoleh daripada kajian ini akan menghasilkan data insertion loss. Insertion loss ialah bunyi yang telah diserap oleh panel dan mengurangkan pencemaran bunyi. Kajian ini kemudian membandingkan data yang diperoleh daripada 5 lapisan panel buluh yang berbeza iaitu 1, 2, 3, 4 dan 5 lapis panel buluh serta bahan penganti iaitu papan lapis, kotak telur dan polisterin dalam proses mengurangkan pencemaran bunyi, dan mengsimpulkan data insertion loss. Keputusan itu kemudiannya disimpulkan dan diringkaskan kepada jumlah lapisan dan jarak yang bersesuaian untuk membentuk panel buluh yang mengurangkan pencemaran bunyi.

ABSTRACT

Noise pollution is a dangerous hazard that is often overlooked. It is invisible to the naked eye, although it exists on land and beneath the water. It may also be described as any undesirable or distressing sound that has an impact on human and other species' health and well-being. Manufacturing, development, transportation, and community and home activities have all produced many types of noise in modern life. This research was conducted to investigate the effectiveness of bamboo panel as sound barrier. Beside, this study is carried out to compare the bamboo panel with other material as a sound barrier. The sound level meter are tool uses to measure the noise. Microsoft Excel are uses to calculate and generate table and graph for the study data. From the result obtain using bamboo panel and other materials as tool for the sound barrier, thus will generate comparable data of insertion loss. Insertion loss of sound are the sound that being reduce to lessen the noise pollution. This research then compare the result obtain from five different layer of the bamboo panel which is 1, 2, 3, 4 and 5 layer with other materials that is plywood, egg tray and polystyrene uses as sound barrier, and generate data on which data have the most insertion loss value. Thus, result to advise more suitable layer and distance for the bamboo panel.

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LIST OF SYMBOLS

dB	Decibel
dB(A)	A-Weighted Decibel
L_{eq}	Equivalent Sound Level
L_{max}	Maximum Sound Level
L_{min}	Minimum Sound Level
L_{Aeq}	A-weighted, Equivalent Sound Level

LIST OF ABBREVIATIONS

WHO	World Health Organization
DSG	Dewan Serbaguna
SLM	Sound Level Meter
SPL	Sound Pressure Level
USM	Universiti Sains Malaysia
UK	United Kingdom
EU	European Union
END	Enviroment Noise Directive
EEA	European Enviroment Agency

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Sound is creating when an object is moving. Vibrations of object molecules caused by the movement and reaching our ears are called sound. However, noise is categorized as unwanted sound that regardless of its volume can have a negative physiological or psychological effect on a person or a group of people. The level of sound that exceeds the appropriate threshold and causes agitation is referred to as noise (Madu et al, 2018).

From the World Health Organization (WHO), noise pollution is the third most dangerous form of pollution after water and air pollution. Increasing environmental noise be giving a negative impact on people's wellbeing. On recent research, even a 5 dB increase on the roadside noise it will increase the risk of hypertension by 3.4 percent (Basu et al., 2020).

Industrial noise, community noise, and road noise are the three main types of noise. However, many studies have shown that traffic is the most frequent and widespread source of noise. The amount of noise is directly linked with the degree of traffic and travel speed. Traffic noise has been linked to a variety of negative health and well-being effects in humans. It also has negative socio-cultural, aesthetic, and economic implications for the future generations. (Ozyavuz & Sisman, 2017).

Malaysia has introduced the DOE Guideline on Noise in 2004. The first set of guidelines for minimizes environmental noise. Previously, the UK standard was used, which is the L10 18h maximum of 68 dBA where the amount approaches 10% of the time measured hourly between 0600 and 2400 hours. Noise levels established by the World Health Organization were also listed (Haron et al., 2019).

1.2 Problem Statement

As a result of speedy urbanization and motorization of transportation in recent decades, a variety of environmental problems has arisen, affecting the urban quality of life and sustainable development, especially in city centres where human activities and mobility are typically focussed. Traffic noise has been identified as a significant contributor to the degradation in citizens' quality of life and general well-being, with the worst impacts happening in densely populated and congested urban centres. (Nourmohammadi et al., 2021). Malaysia's economy relies heavily on transportation to achieve its target of becoming a developed nation by 2020. The value of transportation is shown by the 11 percent rise in registered vehicles from 22,616,106 in 2012 to 25,101,192 in 2014 at a 45 percent annual pace. The claim for transportation is expected to rise in the future, as the population is expected to develop at a rate of 0.8 percent per year from 28.6 million in 2010 to 41.5 million in 2040 (Haron et al., 2019).

Increased urban traffic has long been a point of concern for the environment. If modal change measures such as transferring traffic from highways to railways, as well as pedestrian and cycling traffic, are helpful in minimizing road traffic, the problem can be solved in the future. Road traffic, on the other hand, is also will and is likely to do so for some time (Ögren et al, 2018). Road traffic has contributed the largest proportion of noise pollution reports worldwide since the twentieth century, owing to industrialization and urbanisation. Many components influence to traffic noise, including noise created by a vehicle's engine, emissions, contact between tyres and ground surface, and interaction between moving vehicles and the air that passes through, traffic volume, traffic composition, road quality, and traffic management (Halim et al., 2017). Noise also can cause anxiety, disturb sleep, disrupt routines, impair work, and make it difficult to learn. As a consequence, noise pollution has always been a serious environmental problem for people. It is described as an obtrusive sound that disrupts people's everyday activities (Sulaiman et al., 2018).

1.3 Objectives

The aim of this research is to determine the reducing level of noise. This research is being conducted in order to meet the following objectives:

1) To measure the artificial sound level at selected sites and compare the absorption rate of noise by bamboo, polystyrene, plywood and egg tray

2) To determine the effectiveness of different layer of bamboo panels as sound reducer.

1.4 Scopes of Study

The scope of the study covers the in-situ measurement of traffic noise at location with and without the presence of the noise barrier in order to evaluate the effectiveness of the noise barrier.

This research is conducted to monitor the noise level can be reduce with a barrier which is a bamboo panel. This research is conducted in front of Dewan Serbaguna (DSG) USM on a night time. The research conducted on a night time is to reduce the unwanted sound from disturbing the research. The scope of works focuses on collecting data of noise and the different distance of sound to the sound receiver.

Smartphone are use as the sound resource for the research as the experiment is a controllable research. Sound Level Meter (SLM) is being use as the sound receiver to record the sound produce. The measurement data is taken on different base of distance with the presence of the sound barrier and without it.

1.5 Justification of the Research Project

Chapter 1 provides an introduction of this research with an overview of noise pollution and traffic noise worldwide including the problem statements and objectives of the research. Chapter 2 reflects on the literature review of noise and its sources. Furthermore, related studies on noise barrier are also present. Chapter 3 explains the materials and methods involved in research. This chapter provides information on the study area, sampling strategies and data collection as well as the way the data has been analyzed. Chapter 4 explains the results obtain from this study. Next, this chapter also explain the insertion loss of noise barriers in study sites. Chapter 5 conclusion of the research and lists of the recommendation for the further work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction Noise Pollution

Noise pollution has become a major problem for humans, and World Health Organization (WHO) has elected it as the world's second most dangerous pollutant. Noise pollution has long been a main environmental concern for humans. It is described as any unwanted sound that interferes with people's everyday activities. In both urban and rural areas, traffic is a major source of noise (Sulaiman et al., 2018). Traffic noise is described as an obnoxious sound produced by vehicles when driving on public roads. In 2014, the European Environment Agency (EEA) classified urban noise as one of the most serious public health risks in Europe (Pahat et al., 2020). It is instantly recognisable that, noise had a direct effect on public wellbeing about six decades before (Abdullah et al., 2019).

In overall, the auditory environment consists of natural sounds, such as animal noises and sounds originating from the geophysical atmosphere as wind, thunder and others and also the ambient sounds produced by humans are caused by various human activities (Han et al., 2018). Noise pollution caused by traffic is the most popular and most talked about. Because of insufficient city planning, traffic is a serious issue. Residential areas, schools, commercial zones, hospitals, and other buildings are constructed close to the main road without creating a perfect buffer zone and adequate or soundproofing. Increases in traffic volumes in recent years have intensified the issue. This alarming rise in traffic volume is actually inversely linked to environmental degradation (Manea et al. 2017).

2.2 Source of Noise

The development of cities or countries leads to an increase in the number of vehicles, including those used for ground transportation. This is due to the growth in population, and many people use transportation to get to work or their destinations. Increases number of cars on the road, resulting to rising of traffic noise levels and urban pollution (Segaran et al., 2019). Railways, airports, factories, and traffic are among the most common sources of noise in cities. The latter is thought to be the source that has the greatest effect on people, especially in densely populated areas. The frictional effect between the road surface and the tires produces the majority of traffic noise, which has a significant negative impact on urban areas and the surrounding environment. The dominance of traffic noise in the local area has an effect on population sleeping, resting, learning, and contact, and together with traffic noise irritation, they constitute threatening impacts (Segaran et al., 2020).

Similarly, due to the exponentially rising air traffic, the local population has become very noise-conscious in recent years (de Luque-Villa et al., 2020). Traffic noise, second only to particulate air pollution as an environmental risk factor in Europe, has been related to a rise in the incidence of cardiometabolic diseases, sleep disruptions, depression and anxiety, poor birth outcomes, and quality of life impairments due to noise irritation and interference with activities (Dzhambov et al., 2021). The increasing in noise pollution is unsustainable because it has both immediate and cumulative negative health implications. It also has negative socio-cultural, aesthetic, and economic consequences for future generations. One of the most effective methods for identifying vulnerable locations in residential, commercial, and industrial areas is noise monitoring under various road and environmental conditions (Alam et al., 2020).

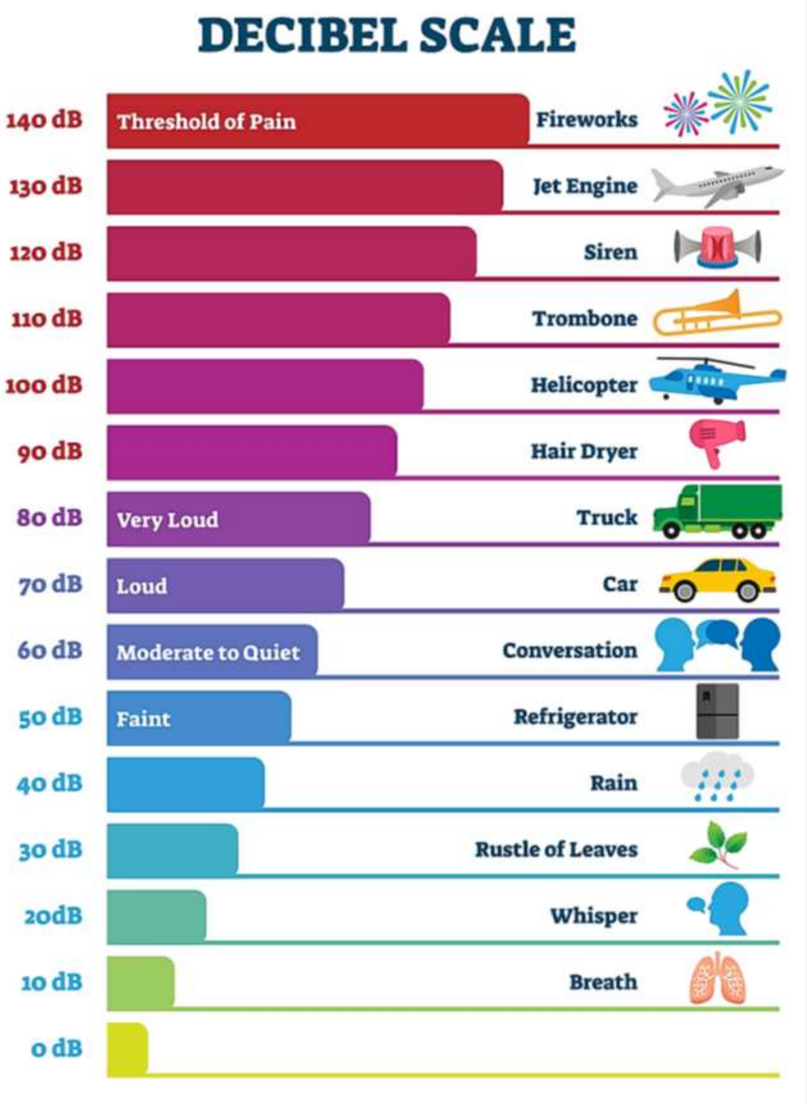

Figure 2.1: Noise level produced by various sources (WorldAtlas, 2021)

2.3 Worldwide Noise Pollution

Environmental noise, also known as community noise, is an obnoxious sound generated by a variety of sources, including traffic, industry, construction sites, and residential areas. It is classified as a toxic pollutant by the World Health Organization (WHO) that has ill impacts on public health. The European Union (EU) has introduced the Environmental Noise Directive (END), which focuses on evaluating the population exposed to community noise, reducing unhealthy noise levels, and mitigating the burden of adverse public health caused by noise. Urban noise is commonly recognised as an environmental stressor, and the World Health Organisation (WHO) has listed noise as a pollutant, reporting that more than 80 million residents in Europian Union (EU) countries are subject to outdoor noise levels above 65 dB(A) (Zambon et al., 2020).

Traffic noise is the most pervasive and dangerous of the noise sources associated with transportation. Statement from the European Environment Agency (EEA) said that urban noise was classified as a significant public health problem in Europe in 2014. From the survey that have been made, road traffic is a major source of environmental pollution, with an estimated 125 million residents impacted by noise levels higher than 55 decibels dBA, accounting for roughly 40% of Europe's population (Segaran et al., 2020). In addition, some European countries such as the Netherlands have created numerous windmill systems to produce energy for their national needs. This situation has caused noise that will disrupt the harmony of public life in the country. (Park et al., 2018)

From a statement made by World Health Organization (WHO), “at least one million healthy life years are wasted per year in Western Europe due to traffic-related noise.” According to the literature, “sleep disturbance and distress, often related to road traffic noise, constitute the primary burden of environmental noise.” (Brambilla et al., 2020). Despite international and national noise reduction laws and rules, road traffic noise is the most diffuse noise source in urban areas, ranging widely in space and time. As a result, people's perception of the negative health effects of road traffic noise is growing (Brambilla et al., 2020).

2.4 Noise in Malaysia

Transportation is a key factor to the growth of Malaysia's economy in fulfilling the nation's goal to achieve the 2030 shared vision of prosperity. The importance of transportation is shown by the rise in the number of vehicles registered, which grew by 11% from 22,616,106 in 2012 to 25,101,192 in 2014, reflecting a 45 percent annual growth rate. The population is expected to increase at a rate of 0.8% per year from 28.6 million in 2010 to 41.5 million in 2040, resulting in increased demand for transportation (Haron et al., 2019). Malaysia is one of the developing countries affected by this noise pollution issue as a result of the rapid speed of growth and the growing number of road transportation networks enabling the development process. Noise pollution perception is not a recent concept; it was first called to the attention of Malaysian authorities in 1979 (Segaran et al., 2020).

In Malaysia, noise pollution is the most widely neglected form of pollution while water and air pollution are considered necessary to life because noise pollution is just an inconvenience to certain people (Halim et al., 2019). And according To Star Online (2016), 132 noise emission concerns were registered to Malaysia's Department of Environment in 2015. The rest of the concerns were about noise from commercial and building projects. Other noise pollution concerns have been registered, including noise from manufacturing and transportation systems (Segaran et al., 2020). Noise levels are deemed exceedingly high if they meet the World Health Organization (WHO) recommendations of 55 dB(A) during the day and 45 dB(A) at night (Halim et al., 2019). According to the Malaysian Department of Environment's (2007) pollution protection limits for suburban and residential areas, the maximum allowable noise level outside of low-density residential areas does not surpass 55 decibels (dBA) to protect the population from urban noise. According to recent Malaysian research by

Halim et al., noise levels in rural areas near Sungai Besi Expressway are higher than traffic flow on Duke Highway and KESAS Highway.

In Malaysia, vehicles can be divided into multiple groups to make it easier to evaluate the vehicles that come through the lane. Arahan Teknik Jalan (8/86) was the grouping used for each class. The exposure level of noise levels would be affected by the various types of vehicles. All of the vehicles are divided into four categories which are car, motorcycle, light truck, and heavy vehicle (Mohamad Nor et al., 2019).

2.5 Approaches to Reduce Noise pollution

Exposure to such high noise levels can result in a variety of health effects, including: sleep disturbances with arousals, learning disability, hypertension, cardiovascular disease, and irritation. The avoidance of such consequences has been relegated to obligatory action plans for large infrastructures or urban agglomerations and in order to optimize mitigations noise generation systems are of critical importance (Del Pizzo et al., 2020).

2.5.1 Noise Barriers

Globally, noise sources are often similar to receivers in most populated areas, with no noise barriers. As a result, the urban living environment is subjected to a high degree of noise pollution. Persistently elevated levels of noise sensitivity have been linked to physiological and other health consequences (Manojkumar, Basha and Srimuruganandam, 2019). Traffic noise has long been a problem in urban areas, thus certain abatement solutions were proposed for existing roads or roads being redeveloped include forming buffer zones, adding barriers, planting trees, and implementing noise insulation on buildings (Ow and Ghosh, 2017). Noise barriers are civil engineering elements installed along roadways to shield residents from noise emissions. These components, which are often located between high-traffic roads and homes, often have a positive effect on air quality (Reiminger et al., 2020). Some noise controls steps are recommended now in direction toward lessen the effect of road sound on receivers. Sound control on existing roads could include erecting noise walls and handling traffic. Noise barriers are strong barriers that are constructed between the highway and suburban areas (Halim et al., 2018).

According to reports, the noise screening impact of vegetation is generally assumed to be poor unless the plantation is dense and the plantation belt is wide, but where effective, noise barriers have been reported to minimize noise levels by 10–15 dB (Ow and Ghosh, 2017). Other than vegetation, establishing buffer zones along major road areas which is commonly used due to its convenience also can be implemented as the noise and air quality levels are normally higher in these regions (Potvin, Apparicio and Séguin, 2019).

2.5.2 Type of Noise Barriers

The setting up of sound barricades between sound sources and noise-sensitive zones end to end main road and rail network is one of the ways to combat traffic noise (Parida et al., 2001; Jiang and Kang, 2016). The acoustic performance of a noise barrier is determined by its location, length and height, and eventually transmitted characteristic (Weixiong, 1999). Roadway traffic noise can be attenuated by the construction of noise barriers between the roadway and areas adjacent to the roadway. A noise barrier substantially interferes with the propagation of the sound waves from the roadway to the receiver. When no obstacles are presented between the roadway and adjoining areas, sound travels by a direct path from noise source on the roadway to the receiver off the roadway. Figure 2.2 illustrates the fundamental function of a noise barrier.

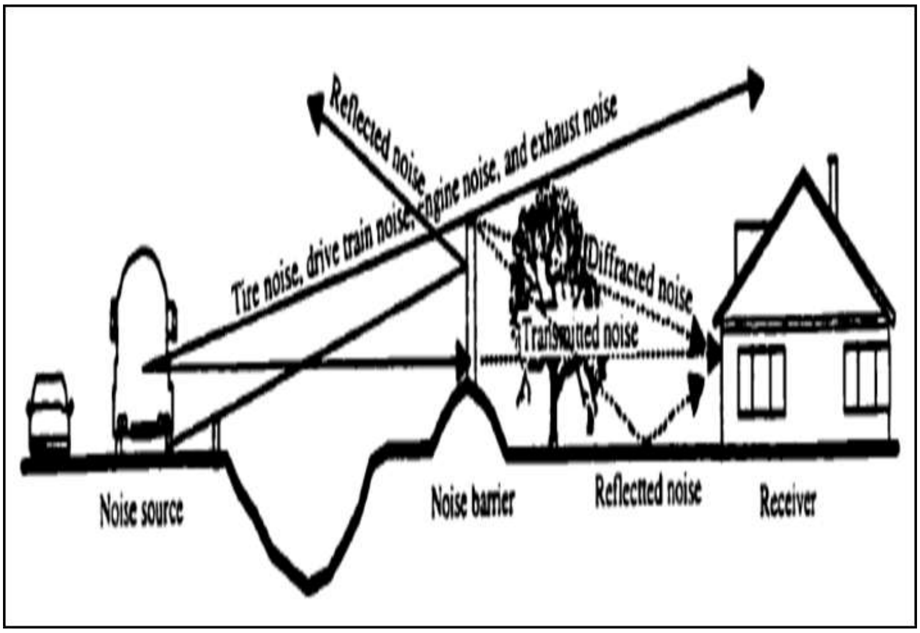

Figure 2.2: Alteration of noise path by a barrier (Weixiong, 1999).

An absorptive barrier works by reflecting some of the energy from the traffic noise up into the air and absorbing some of it into the porous facing. When combined with a reflecting barrier of same height, an effective absorptive barrier can reduce noise by about 3 dB(A). Parida et al. (2001) stated in their research that the absorptive barrier could offer significant benefits in order to achieve more stringent community noise standards.

Traffic noise is reflected upward by reflective barriers to reduce noise pollution. More noise is deflected upward the higher the barrier, and less noise is transmitted laterally toward surrounding homes. For practical purposes, under fair weather circumstances, reflective barriers could reduce noise by 10 to 14 dB(A). (Parida et al, 2001; Jiang and Kang, 2016).

The materials of a barrier is required to have a sufficiently large index of sound insulation, so that the dominant part of noise at the emission location originates from the sound being diffracted over the top of the barrier, and not from the sound penetrating through it. For a properly designed barrier, the level of noise part penetrating through the barrier has to be at least 10 dB(A) lower than the level of noise diffracted over it (Grubeša et al, 2011).

Roadside barriers itself could also affect the aesthetical perception of both road users and residents (Van Renterghem et al., 2014; Jiang and Kang, 2016). The visual impact of roadside barriers on adjoining communities, as well as on the motorists is a major consideration in the design of roadside barriers (Jiang and Kang, 2016). A tall highway barrier placed next to low rise buildings could have a negative visual impact because it would impede panoramic vistas and cast undesired shadows. The focus should be on the barrier's general shape, colour, and texture on the motorist side of the barriers. At typical highway speeds, little details will not be seen. The focus should instead be on preventing a tunnel effect through a variety of forms and visual treatments. The following factors should be taken into account while building noise barriers:

a) Architectural: By incorporating architectural principles like rhythm, proportion, order, harmony, and contrast, barriers' overall look could be further expressed.

b) Visual impact: It is crucial to design the barriers with an appropriate scale and character that are compatible and complement the surrounding area (Jiang and Kang, 2016).

c) Compatibility with local features: To some extent, locals are likely to accept obstacles that fit in with their surroundings and complement the neighborhood next door's aesthetic.

d) Transparent Barriers: When a barrier is needed to shield nearby houses from highway noise, the loss of vision, loss of daylight, and enclosure effects are likely to have a negative impact.

e) Use of Color: It is well accepted that the use of colour can make a barrier stand out as a dramatic and highly visible addition to the environment or be softened to help it blend in with its surroundings.

The overall cost of a noise barrier is determined by a variety of elements, such as height, length, material type, construction method, maintenance requirements, etc. The literature contains some instances of the typical price of various environmental obstacles (Arenas, 2006). Unfortunately, barriers' acoustical effectiveness is typically diminished when they are deployed in the field because of weather conditions like wind or temperature gradients above the barrier. Research from the past has demonstrated that vegetation can lessen the effects of wind (Van Renterghem et al., 2002).

For many years, a barrier should only need little care, such as cleaning or damage repair, according to a proper design. The ideal service life is 40 years, with a 20-year period of no substantial maintenance (Arenas, 2006). Therefore, care should be taken while choosing the materials for barrier construction, especially in places prone to extreme weather. Earth, concrete, masonry, wood, metal, plastic, and other materials, alone or in combination, can be used to build noise barriers (Kotzen and English, 1999). According to a survey, up until 1998, the majority of barriers installed in the US were formed of concrete or masonry blocks and ranged in height from 3 to 5 m slightly more than 1% of barriers were built using absorptive materials (USDT, 2000). While Malaysia tends to build plain barrier, studies shows that multiple barriers, one behind the other leads to better noise protection (Crombie and Hothersall, 1994; Martin & Hothersall, 2001).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the processes used to conduct the research and collect data before analyzing the data. In order to carry out this report, several steps were taken in planning and preparing the scope of works. Figure 3.1 below depicts the procedures involved in achieving all of the study's objectives.

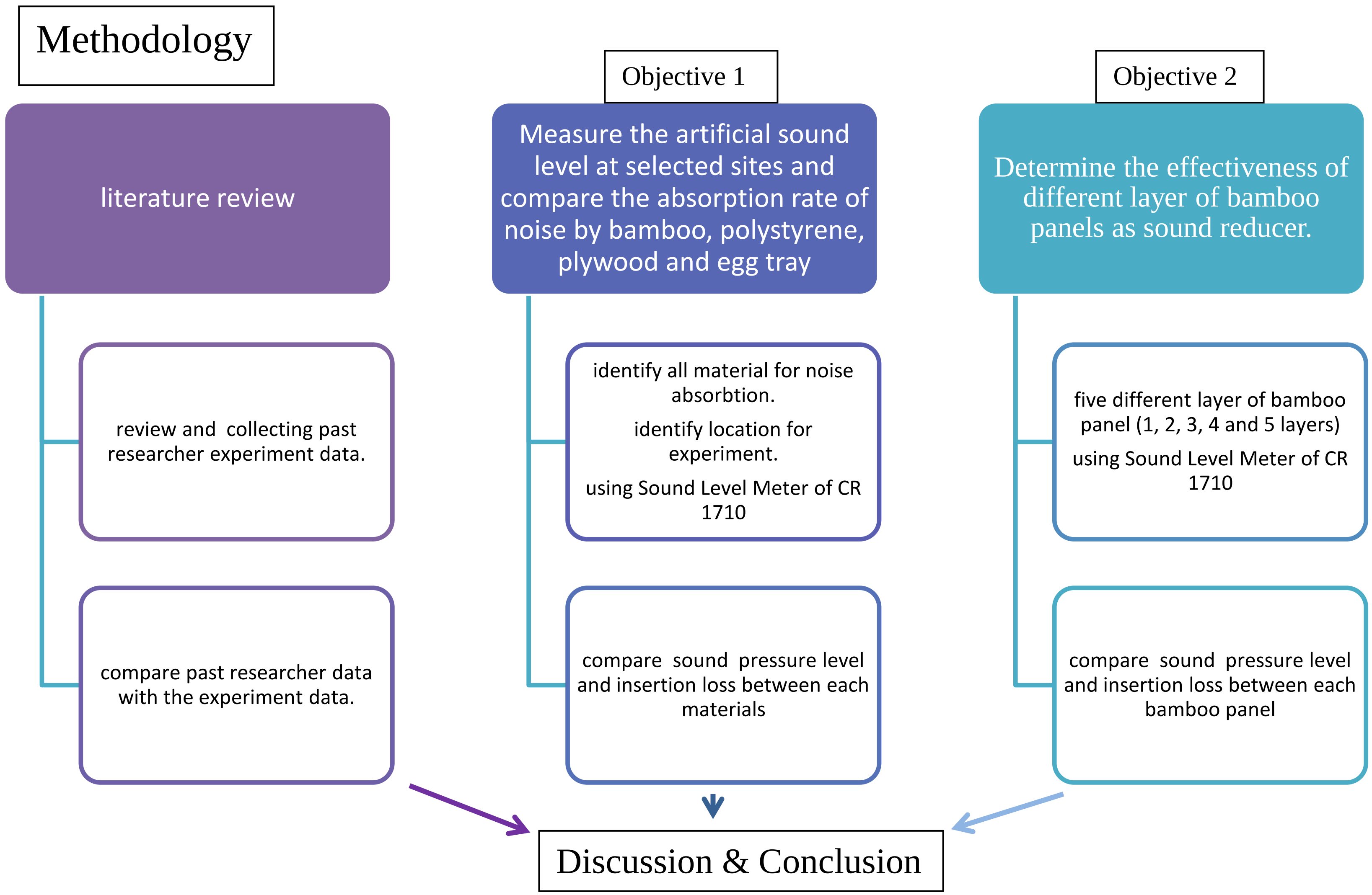

Figure 3.1: Flow chart of the research project

In this research, few hours of field measurement noise level from 11 different distances with and without the presence of noise barriers was carried out at USM Engineering Campus (Figures 3.2). The selected distances involved are 0.5m, 1m to 10m with distance different of 1m in each distance. The justification is that, these sites have the sites of with and without the noise barriers for the insertion loss computation. This approach was applied by many researchers in their studies (Wayson et al., 2003).

Figure 3.2: USM Engineering Campus

3.2 Study Areas

The study sites are located at DSG USM (Figure 3.3.). DSG USM located in the middle of USM Engineering Campus (5°08'55.0"N 100°29'39.9"E). Due to the quiet environment of the site in the night time, this location are perfect for the artificial sound experiment. As shown in Figure 3.4, the quiet surrounding without the disturbing of any other sound resource such as car vehicle at the site the experiment can be conducted easily.

In this study, different distance location of SLM is use in this experiment. As show in Figure 3.5 the distance are varied from 0.5m, 1m, 2m, 3m, 4m, 5m, 6m, 7m, 8m, 9m and 10m.

Figure 3.3: Location of Dewan Serbaguna USM

Figure 3.4: Experiment location (in front DSG)

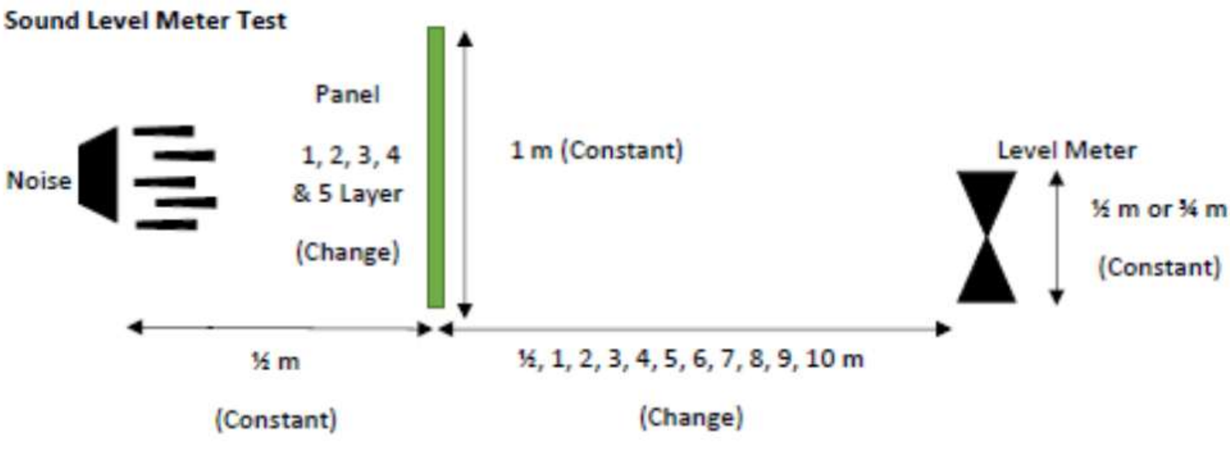

Figure 3.5: Arrangement of Sound Level Meter (SLM)

3.3 Sampling Strategies and Data Collection

The detail explanation of sampling strategies and data collection include classification of observation time, noise level measurement device and insertion loss of the data.

3.3.1 Observation Time

The observation time on this experiment is done on night time with less noise disturbing. This experiment done in front of the DSG on night time to reduce any unwanted source of sound from include in the SLM reading.

3.3.2 Noise Level Measurement Device

Erroneous noise is not edited out as erroneous noise also affecting the effectiveness of the noise barrier. Therefore, in this study, the erroneous noise is not edited out.

The measurement should take place on a hard flat surface of at least 50 m radius and there should be no obstructions of nearby reflecting surfaces, because the presence of walls, obstructions and even the sound level meter operator, can affect the sound propagation. The disturbance in sound field can cause incorrect measurements. These errors are most marked in the frequency range of 200 to 4000Hz, when the physical dimensions of objects are similar to the wavelength of the sound. Errors up to 6 dB may be experienced because of the presence of the operator. The microphone is placed at a height of 0.5 meter above the ground. The microphone must be at least 0.5 meter above the ground.

To accurately measure an outdoor traffic noise source, the background noise level must be limited. If the background level is less than 10 dB of the actual measured sound level, the measurement are not affected. In addition, sound measurements should not be made outdoors when the following meteorological conditions exist: wind speed excess of 12 to 15 km/h; temperature range -10°C to 50°C, humidity exceeds 90%.

High wind speed generates turbulence around the microphone. The turbulence causes pressure fluctuations in this region which the microphone senses as sound. This "pseudo sound" is often of sufficiently high level to mask the actual noise under investigation. In addition, care should be taken not to make sound measurements in conditions where the temperature range of operation of the meter is usually quote in the instruction manual, and sound measurements should not be taken outside this range. Otherwise, high humidity conditions can also make the measurement of sound inadvisable. Most meters are not to be uses if the humidity exceeds 90%.

The primary objective of noise level measurement was to determine the existing noise levels at the selected sites. The noise level monitoring was conducted using sound level meter as shown in Figure 3.6.

Figure 3.6: Sound Level meter used in this study

A microphone transforms sound pressure variations into electrical signals, and is measured by a sound level meter. Foam windscreens were placed at the top of each microphone to reduce the effects of wind-generated noise. Typically, measurement frequencies from 20 Hz to 20 KHz in the 1/3 octave band will satisfy the objective of highway noise study. The brief information of equipment used was briefly describes in Table 3.1.

Origin	UK
Model	CR 1710
Manufacturer	Cirrus Research plc

Table 3.1: Brief Information of integrating sound level meter used for the study

The noise level was measured using the Sound Level Meter (SLM) manufactured by Cirrus Research plc with instrument type CR 1710 as in Figure 3.6. This sound level meter is classified as Class 1 by mean it has the highest level of accuracy with a tolerance limit at +/- 1.9 dB(A) at the frequency level of 1 kHz. In short, for research purposes, the Class 1 sound level meter is the most suitable to be used.

At the height of 1.2 meters above ground level, the sound level metre was set up (Zhang et al., 2019). A calibration was used to routinely calibrate the sound level meter before and after the measurement session (Islam and Kalita, 2017). A calibrator was used to routinely calibrate the sound level meter before and after the measurement session. The sound level meter was calibrated at 94 dB (A).

3.3.3 Insertion Loss

Insertion loss is the different of sound pressure level without the presence of noise level and with noise barrier. Procedures for field measurements in order to determine insertion loss were strictly based on the ANSI standards and the measurement of Highway-Related Noise (Lee, 1996). New variety of noise barriers have been made over past few years using different form of materials. In the past, most of the simple reflecting barriers are made of concrete, masonry blocks, or earth berms were used. Meanwhile modern barriers tend to have absorptive treatments which minimize the level of reflected noise. In recent years, a number of innovative barriers are being developed, such as combined noise and safety barriers (Antonio Barba et al, 2022).