IMPROVING THE INSERTION LOSS OF TRAFFIC NOISE BARRIER IN URBAN AREA

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ABSTRACT

Noise barriers are the common acoustic measures which are used to minimize the disturbance of traffic noise to residents, especially in suburban and rural areas, these barriers are an effective measure. In a denser built up environment though, they are less effective. It is essential to have an accurate prediction scheme for barrier designs. Poor prediction schemes will lead to an undesired performance of barriers or waste of money for over design. There are often many conflicting design factors that have to be considered when specifying a barrier. The limited space there leads to small source-barrier and barrier-building distances. The latter gives rise to multiple reflections of sound waves between barrier and building. Especially the noise at lower frequencies, are built up by these reflections and could lead to high sound pressure levels. Having a way to reduce these low frequency levels would be interest for many cases where barrier have been applied. Evaluating barrier performance periodically is an important issue for assuring the efficiency of barrier. The international standards state methods for evaluating the performance of a built barrier. The American National Standards Institute ANSI S12.8-1998 has been applied in field measurement for the highway that acts as equivalent site without noise barrier. The noise level measured exceeded the noise limit set by DOE Malaysia. In this study, the empirical formula from ISO 9613-2 has been used to predict the performance of barrier by using the geometry of existing noise barrier for the residential area on the same highway. Similarly, the same method ANSI S12.8-1998 was used to measure the noise level behind the noise barrier at urban residential area. Some of the data obtained still exceeded the noise limit for residential area in urban area. The difference of sound pressure level between prediction and field measurement was then added to the ISO 9613-2 formula to recommend the improvement of insertion loss in term of barrier geometry and the shape of barrier's top.

ABSTRAK

Penghalang bunyi adalah langkah akustik biasa yang digunakan untuk mengurangkan gangguan bunyi bising trafik kepada penduduk, terutama di kawasan pinggir bandar dan luar bandar, penghalang bunyi ini adalah langkah yang berkesan. Halangan bunyi adalah kurang berkesan dalam persekitaran yang berpadatan tinggi. Itulah penting untuk mempunyai satu skim ramalan yang tepat untuk reka bentuk halangan. Skim ramalan yang teruk akan menyebabkan performasi halangan yang tidak diingini atau kos pembaziran untuk reka bentuk terlebih. Seringnya terdapat banyak faktor reka bentuk yang bercanggah yang perlu dipertimbangkan apabila menentukan penghalang bunyi. Ruang yang terhad mengakibatkan jarak yang kecil antara sumber dengan penghalang dan penghalang dengan bangunan. Ini juga menimbulkan pelbagai pantulan gelombang bunyi antara halangan dan bangunan. Terutamanya, frekuensi bunyi yang lebih rendah, yang ditinggikan oleh pantulan dan boleh menyebabkan tahap bunyi kebisingan yang tinggi. Cara untuk mengurangkan tahap frekuensi rendah akan diminati untuk banyak kes di mana penghalang bunyi telah digunakan. Penilaian prestasi penghalang secara berkala merupakan satu isu penting bagi menjamin kecekapan penghalang. Piawaian Antarabangsa menerangkan kaedah untuk menilai prestasi penghalang yang dibina. The American National Standard Institute ANSI S12.8 tahun 1998 telah digunakan untuk bunyi pengukuran bagi lebuh raya yang bertindak sebagai tapak bersamaan tanpa penghalang bunyi. Tahap bunyi bising diukur melebihi had bunyi yang ditetapkan oleh Jabatan Alam Sekitar (DOE) Malaysia. Dalam kajian ini, formula empirik dari ISO 9613-2 telah digunakan untuk meramalkan prestasi penghalang bunyi dengan menggunakan geometri penghalangn bunyi sedia ada bagi kawasan kediaman di lebuh raya yang sama. Begitu juga, kaedah yang sama ANSI S12.8-1998 telah digunakan untuk mengukur tahap bunyi di sebalik penghalang bunyi di kawasan perumahan bandar. Beberapa data yang diperolehi masih melebihi had bunyi bagi kawasan kediaman di kawasan bandar. Perbezaan tahap tekanan bunyi antara ramalan dan ukuran dari

bidang kemudiannya dimasukkan kepada formula ISO 9613-2 untuk mengesyorkan peningkatan IL dari segi geometri penghalang bunyi.

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LIST OF SYMBOLS

dB(A)	-	Decibel (A-Weight)
Ψ	-	Diffracted sound pressure amplitude
r_s	-	Distance between source and the top of the plane
r	-	Distance between the top of the plane and the reception point
k	-	Free-field wave number
$Q(\phi, \phi_s)$	-	Function of the edge of the plane radiates sound as a directional sound source
℃	-	Celsius
f	-	Frequency
ρ_s	-	Surface density
λ	-	Wavelength
e	-	Distance between the screens in the direction of the source and receiver
K_{met}	-	Correction factor for meteorological influence
d_{ss}	-	Distance from the source to the diffraction edge, in meters
d_{sr}	-	Distance from the (second) diffraction edge to the receiver, in meters
a	-	Distance parallel to the screen measured between source and receiver
d	-	Direct distance from source to receiver
h	-	Height of barrier
Z	-	Path length difference
C	-	Speed of sound
D_z	-	Barrier attenuation

LIST OF ABBREVIATIONS

A	-	Attenuation
ANSI	-	American National Standards Institute
BS	-	British standard
CAL	-	Calibration
DOE	-	Department of Environment
FHWA	-	Federal Highway Administration
ISO	-	International Standard Organization
IL	-	Insertion Loss
L_{Aeq}	-	Equivalent Sound Level (A-weight)
MMD	-	Meteorological Department
P	-	Proposal
SPL	-	Sound Pressure Level
TL	-	Transmission Loss

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Noise is an undesirable by-product of today's modern ways of life. It is defined as unwanted or excessive sound. Various noise surveys show conclusively that road traffic is at the present time is the predominant source of annoyance. Road Traffic disturbs more people than all other forms of noise nuisance combined. Such a finding is not surprising because of the large number of automotive vehicles are produced to meet the demand today. Traffic noise exists at and around every road around the world.

Traffic noise is not continuous. As a vehicle approaches an observation point, the noise level raises, reaches peak, and then when the vehicle drives away, it decreases. Traffic is of course made up a wide variety of vehicle types using the roads at the same time. The noise they collectively produce is complex, irregular, and constantly changing. It varies in pitch and loudness and continually fluctuates.

1.2 Background

There are generally three common effects of traffic noise. They are speech communication, effects on sleep and health effects. Traffic noise levels will not normally be intense enough to cause hearing damage but may disrupt speech communication and interfere with enjoyment of radio, television, and the use of gardens or outdoor activities. It restricts the comfortable use of houses by the need to keep windows closed in hot weather. The inability to hear warning sounds will increase the likelihood of accidents.

Although traffic density tends to die down during the sleeping hours, it can nevertheless cause disturbance particularly in more densely trafficked areas. Experiments have been carried out in which sleeping people were subjected to a recording of noise from a passing truck. It has been shown that the level of noise has a bearing on the speed with which people fall asleep, that sensitivity to noise varies with the individual. Some could be awoken by low levels of noise and others could be awoken by high levels of noise. There is also a need to protect sensitive groups and shift workers who sleep during the day. Sleep disturbance from noise exposure will lead to long term health impacts. It produces the relationship between noise and the stress responses. Those stress built up is linked to hypertension, cardiovascular disease, and other medical problem.

Noise barrier have become a very common feature of urban landscape. It is one of the noise controls to the receiver. Any form of solid obstacle between source and receiver can comprise a noise barrier. If the barrier is well designed then it can reduce the noise level in residential area. Barriers should be impervious to sound without cracks or holes and of sufficient height to provide sufficient noise attenuation. Barriers are most effective if placed near to the source of noise or the receiver and are generally ineffective for low-frequency noise. In some instances, sound absorbing material is placed on or in the source side of the barrier to reduce noise builds up there. The majority of barriers are installed in the vicinity of transportation and industrial noise sources to shield nearby residential properties. Unlike building insulation, noise barriers are designed to protect the external as well as the internal environment at a dwelling. Noise barrier has hardly been used for the protection of individual properties because it is more cost effective for the protection of large areas including several buildings. Noise barriers of usual height are generally ineffective in protecting the upper levels of multi-storey dwellings.

Several models to predict the acoustic barriers have been developed since the pioneering works on barrier diffraction of Sommerfeld, Macdonald, and others[1]. Design charts of Fehr, Maekawa, and Rathe plus the physical and geometrical theories have made possible the development of some equations and convenient algorithms to predict the attenuation of simple barriers. Kurze and Anderson have simplified the calculation of attenuation by the use of geometrical parameters, such as Fresnel number.

In 1957, Keller proposed the geometric theory of diffraction (GTD) and he stated that the set of diffracted sound rays from the barrier edge, the ray that reached the reception point corresponds to the ray that satisfies Fermat’s principle[2]. It combines with the practicability of Kirchhoff’s approximations with the greater accuracy of the Sommerfeld-type solution. His assumption is the barrier is infinite, very thin semi plan and no reflection on the ground.

In 1971, Researcher Kurza and Anderson presented one algorithm based on the experimental results of Rathe and Redfearn, geometric theory of diffraction from Keller. Maekawa presented a chart based on the physic theory of diffraction and the experimental results[3]. His chart shows the attenuation of sound from a point source by a rigid screen as a function of Fresnel number. Another modified algorithm was then presented by Kurze-Anderson to obtain analytical empirical equation. In 1977, K.Fujiwara, Y,Ando, and Maekawa have presented a more accurate method to calculate the attenuation base on the thick barrier.

In 1996, the International Organization for Standardization (ISO) published ISO 9613-21 that describes a general method of calculation of attenuation of sound during propagation outdoors. This standard has been adopted widely for practical predictions of the noise barrier insertion loss.

A national ambient noise monitor was carried out by Department of Environment (DOE) Malaysia in year 2009. For monitoring purposes, ‘a single 60 minutes sample’ on noise level was measured in the morning, afternoon and evening.

Figure 1.1 and figure 1.2 shows the L_{Aeq} noise levels recorded for selected areas in the various states and selected Urban Residential Areas in various states.

Most of the traffic noise level data collected in the morning, afternoon and evening at commercial business zones and urban residential areas in various states by the Department of Environment (DOE) Malaysia exceeded the noise level specified in The Planning Guidelines for Environmental Noise Limits and Control, 2004[4].

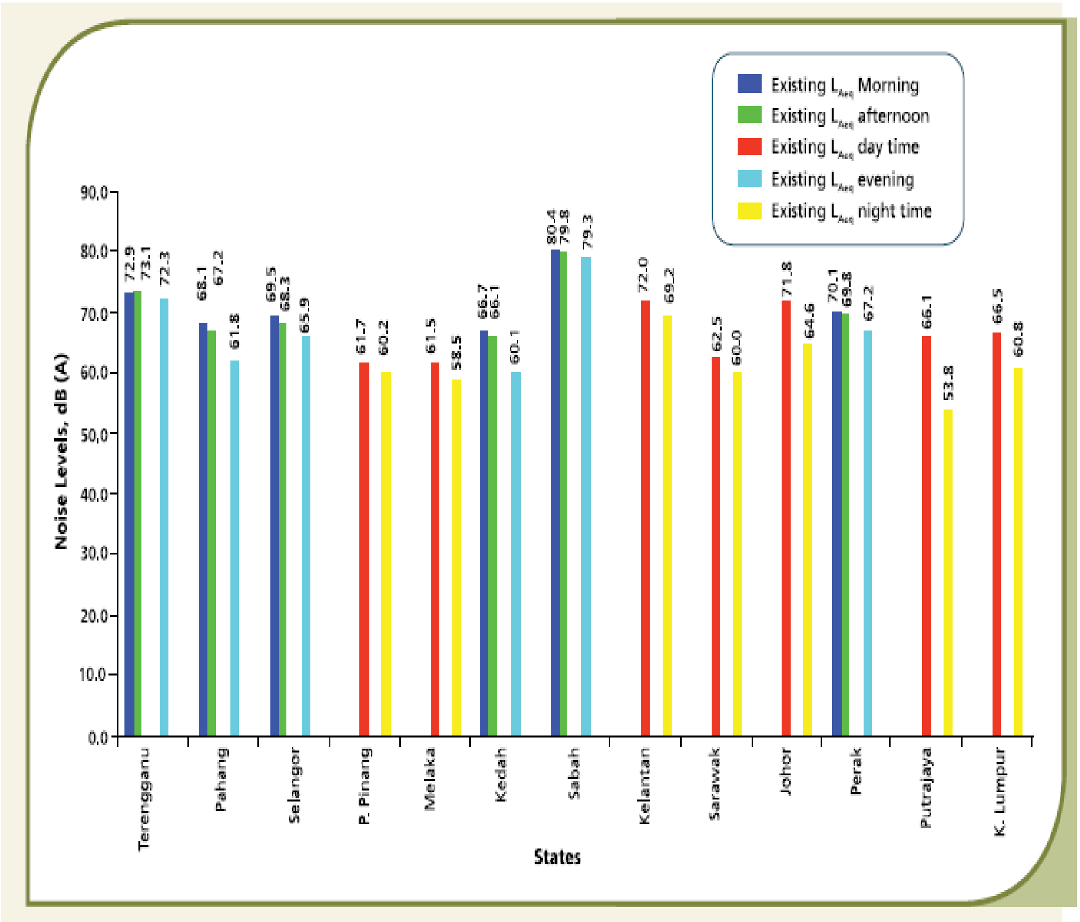

Figure 1.1: Noise level due to traffic for selected areas in various states[4]

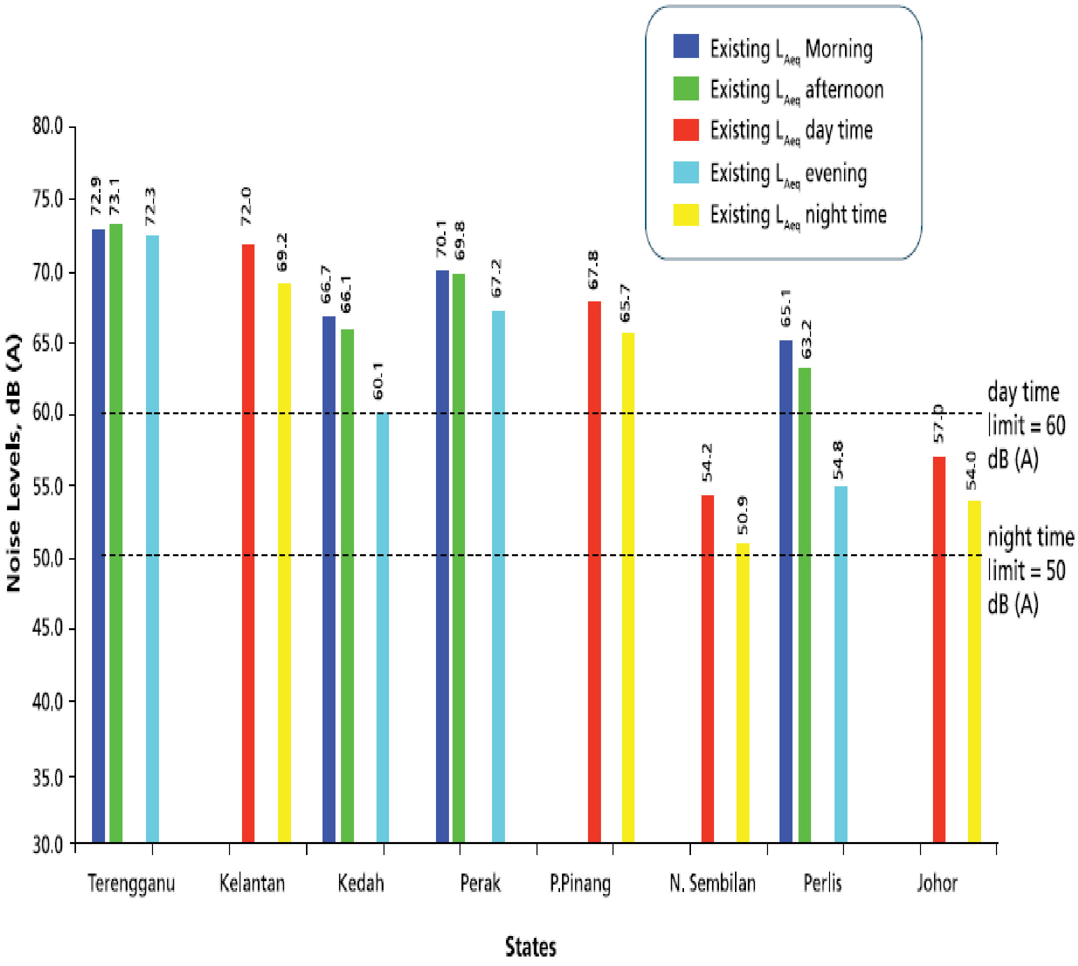

Figure 1.2: Noise level for selected urban residential areas in various states[4]

The previous research showed the analytical approach with certain assumptions to design the noise barrier. However, this does not mean that the barrier design is optimum and archives the desired insertion loss due to the factors such as the geometry of adjacent building, meteorological, wind velocity and traffic condition. Thus, the primary criterion in this research is to evaluate the acoustical performance of existing noise barrier in order to improve the insertion loss.

1.3 Problem Statement

Noise barriers are an often encountered way to reduce the noise exposure at building facade due to traffic noise. These barriers are an effective measure in suburban area. However, these barriers are less effective in a high dense built up urban environment. The limited space there causes the small distance between source to barrier or barrier to source. The increasing of number and variety of vehicle on the road gives rise to multiple reflections of sound waves between barrier and building. There are different frequency of source on the road to be identified, especially the lower frequencies sound wave built up and could lead to high sound pressure levels.

This study shall involve the assessment of existing noise barrier in urban area by taking noise measurement and thereafter evaluate it with the empirical formula to improve its insertion loss.

1.4 Objective

The objective of this project is:

1. To identify the potential improvement of the insertion loss on the existing noise barrier in urban area base on actual noise measurement on site by using a modified form of empirical practical prediction of barrier insertion loss formula.

1.5 Research Hypothesis

Assessment of acoustical performance on the existing noise barrier on site and result obtained from empirical formula published by ISO 9613-2 will not have the similar results whereas the inaccuracy is due to the assumption made in the empirical formula is different with the actual site condition.

1.6 Scopes

The scopes of this project are:

1. To conduct a research on the sources of noise, methodologies for noise measurement and type of traffic noise abatement mean.
2. To collect the data on site selected by measurement using sound level meter.
3. To analyze the data and perform calculation to obtain the acoustical performance of exiting noise barrier.
4. To verify, compare and validate through calculation of international standard formula with an actual source of noise data from the road.

1.7 Organization of Thesis

Chapter 1 Introduction consists of background of the research, the objective of this research, the reason conducting this research, and the hypothesis of the result.

Chapter 2 Literature review describes the theory used in this research, and the researches done so far which is related to this research.

Chapter 3 Research Methodology describes on how this research is done. It includes flowchart, identification of research variable, algorithm, collection and analysis of data, steps for the accuracy and correctness of this research is checked

Chapter 4 Results presents the data held by this research for onsite measurement with calculation and the predicted results calculated from empirical formula.

Chapter 5 Discussions presents the observation of performance of existing noise barrier, comparison and explanation of distinguishes between result of measurement analysis and noise prediction calculation from empirical formula and further elaborate on the other factors affecting the insertion loss of barrier.

Chapter 6 Conclusion and Recommendation

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