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Importance of Acoustic Implementation for High-Rise Residential in Malaysia

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Abstract

Acoustic relates to the sense or organs of hearing or (popular music or musical instruments) not having electrical amplification. The aim of this study is to improve the acoustic implementation in high-rise residential in order to alleviate the noise pollution. Nowadays, worldwide population growth leads to a rapid urbanization of urban area, cities and the development of infrastructure, especially transportation. The strong urbanization in the cities or urban area of developing countries leads to the issues of noise pollution adversely influencing residents especially in high-rise residential area. A fact in Malaysia depicts that road traffic and railway noise contribute the highest number of complaints in noise pollution, which mainly due to the industrialization and urbanization in the area of Klang Valley Selangor, Malaysia. In this study, data were collected via fieldwork study and table study. Also, quantitative research was adopted to obtain an adequate number of samples and distributed to the 152 number of targeted respondents that reside in the high-rise residential of Klang Valley through convenient sampling method. Based on the results from this research, the most detrimental impact of noise pollution was Sleep Disturbance, whereas, theRoad and Railway Traffic was the most significant causes of noise pollution.In the view of this, the most effective method to improve the quality of acoustic implementation in high-rise residential was the Material Used to Construct a Building, which generally obtained based on the results obtained from the respondents. In a nutshell, according to this research, the major issue of noise pollution affecting the high-rise residential was road and railway traffic, which inducing detrimental sleep quality among the residents, thus, appropriate material used to construct a building has to be planned carefully in the design stage so as to mitigate noise pollution effectively.

Keyword: Acoustic, High-Rise Residential, Noise

Introduction

Acoustic is “relating to the sense or organs of hearing or (of popular music or musical instruments) not having electrical amplification” (Oxford English Dictionary, 2017). Likewise, acoustic is also known as sound. There are two types of sound, which is airborne sound and impact sound. Airborne sound is the sound wave that transmitted via a medium, for example: barking of dogs, singing or conversations. Generally, the airborne sound waves transmit through the air or a medium and reach a building component and causing it to vibrate. These vibrations travel through the building or structure and radiated it out to another side of the building or structure is known as airborne sound.

Whereas, for impact sound, it is transmitted in the event that sound is deriving from the actual impact of an object on a building element such as floor, wall or ceiling. Impact sound occurs when the impact induces both sides of the building element to vibrate, generating sound waves. Typical impact sound transmission sources are footsteps of a person or the sound of an object falling on the floor. When sound is loud and unpleasant, this is known as noise or can also be explained as ‘unwanted sound’. Thus, the design of residential requires the consideration of the acoustic implementation, especially high-rise

residential in order to avoid noise that arising from external road traffic, construction site, air conditioning plant, lift, pipes and so forth. From the view of the acoustic implementation, the issues of acoustic design and noise control system must be addressed in the early design stage before the building is being constructed.

Noise is accepted as the fastest growing type of pollution in high-rise building across the last 15 years. In the view of this, it is important that the noise pollution issues should be addressed, highlighted and resolved before a residential building is being constructed, otherwise, the resident would be the one who suffers.

Problem Statement

Noise pollution has been adversely influencing residents, especially in high-rise residential building. Chin (2016) reported that the previous LRT project in Malaysia - The Star and Putra lines in Klang Valley causes several complaints regarding the noise pollution. During the construction stage of the public transport in Malaysia such as MY Rapid Transit (MRT) & LRT, the noise generated in those projects have been adversely affecting the public especially high-rise residential. According Leong (2011), noise generated from the operation of the MRT line(s) are typically generated from the rolling of the wheels interact with the rail, brake squeals during braking at the station as well as the curved segments of the rail alignments. These noises would have a direct effect to the receiver (residents) in the absent of noise barrier. The source of noise from the MRT (lines) will typically affect the residents of the high-rise residential that located at the same level or higher than the tracks of MRT. In this case, the residents with a line of sight directly to the tracks would have a direct noise transmission to them. Hence, acoustic implementation is vital to be improved in the high-rise residential in order to mitigate sound pollution against residents.

Literature review

Acoustic is related to the perception of noise; noise is subjective that sound to one person might be noise to another person (Wang et al., 2015). According to Oxford English Dictionary (2017), acoustic is "relating to sound or the sense of hearing"; "the branch of physics concerned with properties of sound"; "a guitar without electrical amplification". Likewise, Goelzer, Colin and Gustav (2001) indicated that acoustic energy is the sources and the particles vibrate in the medium where the sound wave propagates. Also, Goelzer, Colin and Gustav (2001) stated that it is the combination of kinetic and potential energy in relation to the acoustic wave.

Noise is defined as "a sound, especially one that is loud or unpleasant or that causes disturbance"; "irregular fluctuations that accompany a transmitted electrical signal but are not part of it and tend to obscure it" (Oxford English Dictionary, 2017). Also, Oxford English Dictionary (2017) defined that noise pollution is known as "harmful or annoying levels of noise". Other than that, Barkokébas et al. (2012) defined that sound is the combination of vibration or mechanical waves that heard by an individual, however, when the sound heard is subjectively interpreted as undesirable and bothersome, it is called noise. In other words, noise is a physical phenomenon that is illustrated by oscillation or variation of undefined pressure in the frequency of an elastic medium (e.g. water, solids, air) that is transformed by turbulent fluid flow or vibrating surface (Goelzer, Colin and Gustav, 2001).

Muralikrishna and Manickam (2017) noted that noise sources are numerous but can be generally categorized into industrial and non-industrial. In the study of Muralikrishna and Manickam (2017), the industrial noises encompass noises from any operating industries in cities, for example, vehicular movement, equipment, explosion and so on. Whereas, non-industrial source of noise comprises loudspeakers, automobile, construction works, radio, etc. (Muralikrishna and Manickam, 2017).Apart

from that, noise can also be categorized into steady noise, non-steady noise, tonal noise and impulsive noise depending on the sound pressure level (Goelzer, Colin and Gustav, 2001).

In general, Goelzer, Colin and Gustav (2001) indicated that noises are categorized based on the way they change in accordance with time. For constant noise, it will remain in the range of 5 dB for a long period of time. For intermittent noise, unlike the constant noise, it is the normal constant noise which starts and stops. Likewise, Goelzer, Colin and Gustav (2001) also pointed that fluctuating noise alters outstandingly but has a stable long-term average. However, impulse noise can only last for not more than and equal to one second (Goelzer, Colin and Gustav, 2001)

Human ear hears sounds among the average frequency of 16 Hz to 20 kHz. Sounds that lower than 16 Hz called infrasound while sound that higher than 20 kHz is known as ultrasound (Katinas, Marčiukaitis and Tamašauskiene, 2016). Noise pollution in the surrounding may take a toll on human health and human communication (Muralikrishna and Manickam, 2017).

Human health has a direct relation with the noise pollution. Noise pollution often harmfully influences the lives of people with adverse consequences on health (Ottoz, Rizzi, and Nastasi, 2018). Basner et al. (2014) clarified that human tends to habituate to exposure of noise and the level of noise habituation may differ for each individual. Also, in his statement, the noise exposure is long term and surpass certain level, can adversely affect health. The effect of noise pollution on human health can be categorized as auditory health effect and non-auditory health effect. Also, noise pollution may affect human daily activities such as human communication.

Research Method

In order to conduct this research, the quantitative research method was adopted for the following reasons. As the quantitative research enables the collection of an adequate number of samples for more accurate data rather than using the qualitative research that focuses on individual interview, participation or observation that result in only a few respondents involved. Also, the data generated by quantitative research arewell structured and fixed,thus analysis can be done easily. In addition, as there is a time constraint in conducting this research, quantitative research is appropriate to enable quick data analysis and collection process. Questionnaires were used as an instrument for this research and distributed to the target respondents in order to obtain details of the information needed. Questionnaire is the listing of questions that have a direct relation to the objectives and answered by target respondents. The questions were dispatched out to the respondentsto answer based on their perception.

The closed questions (options are given for selection) were set in the questionnaire rather than the open-ended questions (own opinion can be expressed) as the open-ended questions may involve uncertainty in the result. In the questionnaire, part of the questionswas rated by respondents using the 5-point and 4-point Likert scale. Likert scale is a psychometric response scale mainly utilized in questionnaires in order to understand the respondents' preferences or the extent of a statement with an agreement or a list of statements.The closed-ended survey format of questionnaire was employed with an online distribution approach to the target respondents that staying in high-rise residential and located in the area of Klang Valley. In this research, the target respondents were individuals who staying in high-rise residential in the vicinity of Klang Valley. The requirement was set whereby, the respondents shall have stayed in the particular high-rise residential for at least 6 months. The sampling size of this research was designed to 150 persons. Convenient sampling method was adopted in this research because there is a limited time period given in completing this final year project. Based on Dörnyei (2007)'s research, convenience sampling method (also called Haphazard Sampling or Accidental Sampling) is a sort of non-likelihood or non-random sampling, where target respondent that meet certain pragmatic criteria, for example,

geographical proximity, accessibility, availability at a given timeframe, or the ability to take an interest are incorporated with the end goal of the study

Descriptive Statistics technique is the most straightforward method for analysis, which demonstrates a general overview of the outcomes (Naoum, 2013). It applies numerical and graphical procedures to summarize the data gathered in a clear and easily understood way. Furthermore, ranking approach using the mean value of a fuzzy number and an interval relation for ranking real intervals. In this case, mean value refers to the mean score of each variable under study, whereas the interval relation indicates the situation or circumstances under study.

Discussion

Importance and Satisfaction of Acoustic Implementation in High-rise Residential

Table 1.1: Importance and Satisfaction of Acoustic Implementation in High-rise Residential

	Descriptive Analysis	Count	Percentage (%)
Importance of Acoustic Implementation in High-rise Residential	Not Important	1	0.7%
	Average	14	9.2%
	Somewhat above Average	63	41.4%
	Very Important	74	48.7%
Satisfaction towards Acoustic Implementation in High-rise Residential	Not Satisfied	29	19.1%
	Less Satisfied	48	31.6%
	Quite Satisfied	65	42.8%
	Satisfied	10	6.6%

Table 1.1 depicts the descriptive analysis of the respondents' perception toward the importance of acoustic implementation and the satisfaction of the acoustic implementation in their high-rise residential. Based on Table 4.5, majority of the individuals perceived that acoustic implementation in high-rise residential was very important which accounted for a percentage of 48.7% out of 152 respondents. Annoyance is the most predominant group reaction when exposed to environmental noise (Basner et al., 2014). Also, Basner *et al.* (2014) indicated that noise annoyance causes disturbance to daily activities, thoughts and feelings, sleep or rest and probably associated with adverse responses, therefore majority of individual perceived the acoustic implementation in high-rise residential is very important.

Apart from that, there were only 6.6% of respondents satisfied with the acoustic implementation in their high-rise residential. Nevertheless, majority of the individuals, with a 50.7% of them were dissatisfied with the acoustic implementation in their high-rise residential. As can be seen from Table 4.5, there were 19.1% of the individuals were not satisfied and a 31.6% of individuals were less satisfied towards the acoustic implementation in their high-rise residential, in turn, a total of 50.7% of respondents dissatisfied

the acoustic implementation in their high-rise residential. Halim et al. (2017) stated that urban residential areas in the Klang Valley region, "DesaTunRazak" and "Taman SentulUtama" suffer high levels of noise pollution of contributed by road and railway noise.

Mean Ranking on Causes of Noise Pollution

Table1.2: Mean Ranking – Causes of Noise Pollution

	Causes of Noise Pollution	Mean	Median	Mode
Mean Ranking	**Road or Railway Traffic**	4.13	4	5
	Construction Activities	3.94	4	4
	Housing Related Factors	3.52	4	4
	Human Related Factors	3.51	4	4
	Machinery Operations	3.17	3	3
	Industrial Operations	3.08	3	3
	Aircraft Noise	2.9	3	3

Mean ranking on the causes of noise pollution were shown in Table 1.2. According to the Table 1.2 above, the most significant causes of noise pollution was Road and Railway Traffic with a mean value of 4.13 among other causes of noise pollution. The mean score that exceeds a mean score of 3.00 is considered as a cause of noise pollution. In city center, there is a large portion of the population is exposed to high level of noise and for the majority of these, road traffic is the principal noise source (Ögren, Molnár and Barregard, 2018). Also, they highlighted that there are high levels of road traffic noise are increasing at the most exposed building facade due to the continuing urbanization and population growth, traffic noise is a growing problem. Besides that, traffic noise has been recognized as a serious threat to the quality of life in most industrialized nations (European Environmental Agency, 2014).

Apart from that, train transits were nevertheless raised particular attention also to the noise sources pertaining to railway operations like maneuvering, loading and unloading, truck movements, braking, squeals and whistles (Licitra et al., 2016). In addition, based on European Environmental Agency (2014), railways alone were still the most dominant source of environmental noise in Europe, with approximately 22 million people exposed to levels above 55 dB. Generally, road traffic and railway noise contribute the highest number of complaints in noise pollution due to industrialization and urbanization in the area of Klang Valley Selangor, Malaysia (Halim et al., 2017).

Construction Activities was also the major concern of the respondents as it had ranked in the second place with the mean score of 3.94. Construction activities provokes complaints as it became a common source of environmental noise in China and other developing countries worldwide (Liu et al., 2017). According to Liu et al. (2017), their results indicate that a large number of people dislike construction noise; the noise level ranges between 60 dB and 80 dB was generated from construction activities has affected individual from 15%-20% to 30%-40% over the range. Furthermore, Lee, Hong and Jeon (2015)

also reported that construction noise is a common source of noise pollution, with 68% of noise complaints caused by construction noise.

Furthermore, the following causes of noise pollution was Housing Related Factors followed by Human Related Factor, Machinery Operation and the Industrial Operation with the mean value of 3.52, 3.51, 3.17 and 3.08 respectively. From this point of view, these causes were considered as the sources of noise due to the mean values of these causes have exceed the mean value of 3.00 (which is the mean value of neutral) among the other 5-point Likert scale.

Last but not least, Aircraft Noise with a mean value of 2.90 had hit the lowest among the other 7 causes of noise pollution based on the table above. A mean value of 2.90 for the aircraft noise illustrated that majority of the respondents do not perceive that aircraft noise was the sources of noise pollution, therefore, it was no longer a cause of noise pollution as the mean value of 2.90 had not exceeded the mean value of 3.00. According to Kroesen et al. (2010), the aircraft noise is found to be dramatically small problems when in comparison to other environmental noise. Aircraft noise is not a strong noise sources of residential satisfaction, moreover, there is considerably weak link between aircraft noise and residential satisfaction.

Mean Ranking on Effects of Noise Pollution

Table1.3 :Mean Ranking – Effects of Noise Pollution

Effects of Noise Pollution		Mean	Median	Mode
Mean Ranking	**Sleep Disturbance**	4.17	4	5
	Annoyance	4.05	4	4
	Effect on Human Communication	3.47	4	4
	Cognitive Performance	3.32	4	4
	Physiological Response	3.02	3	3
	Tinnitus	2.97	3	3
	Acoustic Trauma	2.72	3	3
	Temporary Hearing Loss	2.72	3	3
	Cardiovascular Disease	2.68	3	3
	Permanent Hearing Loss	2.33	2	2

The mean ranking on the effects of noise pollution were shown in Table 4.6. According to the results shown in Table 1.3, Sleep Disturbance was the most detrimental effect with a mean value of 4.17 which reached the highest among the other effects. Sleep Disturbance was considered as an effect of noise pollution as the mean value of 4.17 had exceeds the value of 3.0.Environmental noise, especially traffic

or railway noise in particular, has been shown to have a significant effect on sleep (World Health Organization, 2011; Pirrera et al., 2014).Also, noise is described as a detrimental cause of exogenous sleep disturbances, after somatic problems and day tensions (Basner, Müller and Elmenhorst, 2011). Moreover, nocturnal environmental noise influences health consequences in the form of its synergistic direct and indirectly via sleep disturbances acting as a mediator which affects biological systems (Halperin, 2014).

Apart from that, the adverse negative effect of noise pollution involved the annoyance as well with the mean value of 4.05 (exceed 3.0) which ranked in the place of number 2 as compared to others. Annoyance is often a common impact of noise pollution when individuals are exposed to environmental noise and often annoyance is associated with cardiovascular diseases (Hahad et al., 2018). In Hahad et al. (2018)'s study, data shows that there are 80% of the participants were annoyed by noise up to a certain degree. Also, Brown and van Kamp (2017) indicated that annoyance is one of the most common negative effect of chronic exposure to environmental noise. However, the annoyance level relatively depends on individual and contextual factors pertaining to the types of noise exposure (Sieber et al., 2018).

The third ranking detrimental negative effect of noise pollution was the Effect on Human Communication, succeeded by Cognitive Performance and subsequently followed by Physiological Responses with a mean value of 3.47, 3.32 and 3.02 respectively.Furthermore, mean value that not more than mean score of 3.00 were not considered as a negative impact of noise pollution. For instance, Tinnitus, Acoustic Trauma, Temporary Hearing Loss, Cardiovascular Disease as well as Permanent Hearing Loss were the effects of noise pollution that inherent a mean value individually not more than the value of 3.00, ranging from the value of 2.97 to 2.33.

Moreover, Permanent Hearing Loss had the lowest mean value of 2.33, in other words, it was no longer an effect of noise pollution as the mean value was not exceeding 3.00.Based on Nelson et al. (2005), it shows that 16% of the permanent hearing loss around the world is attributed to occupational noise. Moreover, Permanent Hearing Loss is influenced by high frequency sound wave of 3k, 4k or 6k Hz or an accumulated repetitivehigh frequency noise, in other words, permanent hearing loss is highly prevalent among industrial community where the workers are highly exposed to various degrees of high amplitude noise as compared to normal noise pollution in high-rise residential building (Nandi and Dhatrak, 2008; Jaafar et al., 2017). Thus, Permanent Hearing Loss was not considered as an effect of noise pollution for residents in high-rise residential with the mean value of 2.33.

Mean Ranking to Methods to Improve Acoustic Implementation in High-rise Residential

Table 1.4 Mean Ranking - Methods to Improve Acoustic Implementation in High-rise Residential

Method to Improve Acoustic Implementation in High-rise Residential	Material Used to Construct a Building	Noise Control Over Windows and Doors	Noise Barrier Implementation Near Residential	Building Envelope Design
Mean	0.88	0.86	0.71	0.66
Median	1.00	1.00	1.00	1.00
Mode	1	1	1	1

Based on Table 1.4, the mean score indicates the respondents' perception towards the method to metigate noise pollution, from which, the nearest the mean score to 1.00, the greater number of individuals perceived that the method can mitigate noise pollution, whereas, the closer the mean value to 0.00, the lesser the individuals perceived that the method can mitigate noise pollution.

Material Used to Construct a Building had been considered as the vital method to rectify noise pollution, from which it had reached the highest 0.88 values of mean score among the rest. From aspect of the word acoustic, building materials can be described as the capability to mitigate noise pollution by absorbing impinging sound waves and the ability to contrast sound transmission (Schiavoni et al., 2016). Also, based on Pedroso, de Brito and Silvestre (2017), the best way to performance acoustic insulation are depending on the materials' sound absorption coefficient and noise reduction coefficient (NRC).

In addition, the following mean score was Noise Control Over Windows and Doors and then succeeded by Noise Barrier Implementation Near Residential with mean score of 0.86 and 0.71 respectively. Nevertheless, the lowest value of mean score was the Building Envelope Design, where it had lowest mean value of 0.66 as it can be seen that Building Envelope Design had been considered as the less significant method to mitigate noise pollution from the perspective of respondents. According to Oral, Yener and Bayazit (2004), Building Envelope Design hit the lowest mean score as it is defined as only part of the component to the optimal acoustic performance.

Summary of results

Mean ranking was adopted to test the causes and effects of noise pollution as well as the steps and methods to improve acoustic implementation in high-rise residential. The results were shown below:

i. As from the perspective of causes of noise pollution, the most significant cause of noise pollution was Road and Railway Traffic with a mean value of 4.13 among other causes of noise pollution. Whereas, Aircraft Noise had hit the lowest mean value of 2.90 which aircraft noise was no longer a cause of noise pollution as the mean value of 2.90 had not exceeded the mean value of 3.00.
ii. From the view of the effects of noise pollution, Sleep Disturbance was the most detrimental effect with a mean value of 4.17 which reached the highest among the other effects. Whereas, Permanent Hearing Loss had the lowest mean value of 2.33, in other words, it was no longer an effect of noise pollution as mean value not exceeding 3.00.
iii. In the case of steps taken to mitigate the effects of noise pollution, Reporting to the Authority had the highest mean value 0.80 which reflected that respondents were more likely to report to the authority when noise pollution arises in their residential area, in contrast, Check Ear Regularly had the lowest mean score of 0.14 which shows it was the steps that would be taken by a minority of individuals when noise pollution occurred.
iv. Likewise, looking at the method to improve acoustic implementation, Material Used to Construct a Building had been considered as the vital method to rectify noise pollution, with the highest value of 0.88. Nevertheless, the lowest value of mean score was the Building Envelope Design with the value of 0.66 as it can be seen that Building Envelope Design had been considered as the less significant method to mitigate noise pollution from the perspective of respondents.

Conclusion

It is vital to understand the several causes of noise pollution in order to improve the acoustic implementation in high-rise residential for the purpose of alleviating the noise pollution.

The causes of noise pollution were acquired from individuals that staying in high-rise residential in the area of Klang Valley and these causes were ranked from the most detrimental causes to the less detrimental as shown below:

i. Road and Railway Traffic

ii. Construction Activities
iii. Housing Related Factors
iv. Human Related Factors
v. Machinery Operations
vi. Industrial Operations
vii. Aircraft Noises

The most significant causes of noise pollution was Road and Railway Traffic as most of the individuals agreed that it is the major sources of noise pollution affect them. However, Aircraft Noise was no longer a cause of noise pollution, from which majority of individual disagreed that it was the causes of noise pollution.Moreover, from the perspective of differences in perception of students and adults toward the causes of noise pollution, Road and Railway Traffic shows a significant difference between students and adults stating that Road and Railway Traffic was the causes of noise pollution. On the other hand, the Machinery Operations had no statistically significant difference between students and adults stating that Machinery Operations was the causes of noise pollution.

Apart from that, it is important to study the effects of noise pollution before enhancing the acoustic implementation in high-rise residential for the purpose of mitigating the noise pollution. The effects were summarized in sequence via the most significant to the less significant in below:

i. Sleep Disturbance
ii. Annoyance
iii. Effect on Human Communication
iv. Cognitive Performance
v. Physiological Response
vi. Tinnitus
vii. Acoustic Trauma
viii. Temporary Hearing Loss
ix. Cardiovascular Disease
x. Permanent Hearing Loss

Sleep Disturbance was the most detrimental effect that affects residents the most. Whereas, Permanent Hearing Loss was not considered as an effect of noise pollution due to a large number of individuals disagreed that this factor affecting them in the event of noise pollution.
In addition, it is essential to study several methods before improving the acoustic implementation in high-rise residential for the purpose of resolving the noise pollution issues.
In order to meet the third objective, the methods to improve the quality of acoustic implementation in high-rise residential had been outlined from the perception of individuals that staying in high-rise residential in the area of Klang Valley. The methods were identified in sequence via the most significant to the least significant as from below:

i. Material Used to Construct a Building
ii. Noise Control Over Windows and Doors
iii. Noise Barrier Implementation Near Residential
iv. Building Envelope design

Material Used to Construct a Building had been considered as the vital method to resolve noise pollution issues since it is very common to have high absorption coefficient material itself in order to achieve sound insulation purpose. Nevertheless, the lowest value of mean score was the Building Envelope Design had been considered as the less important method to mitigate noise pollution from the perspective of respondents since not all the respondents have construction knowledge regarding the building envelope design.In conclusion, the objectives mentioned above had been achieved to meet the aim of improving the acoustic implementation in high-rise residential in order to alleviate the noise pollution.

According to this research, Road and Railway Traffic was the significant causes of noise pollution, while the most detrimental impact of noise pollution was Sleep Disturbance. In the view of this, the most effective method to improve the quality of acoustic implementation of high-rise residential was the Material Used to Construct a Building based on the results obtained from respondents. In a nutshell, according to this research, the major issue of noise pollution affecting the high-rise residentialof Klang Valley wasthe road and railway traffic, which inducing detrimental sleep quality among the residents, thus appropriate material used to construct a building has to be planned carefully in the design stage so as to mitigate noise pollution effectively.

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