NOISE BARRIER DESIGNS MATERIAL FOR KUALA LUMPUR EXPRESS RAIL LINK (ERL) SYSTEM AT RESIDENTIAL AREA.

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ABSTRACT

This study was to observe the noise produce by ERL train contribute to the noise pollution towards eco system or residential area that located near to the track and this study also involve the lab investigation on material used to design the noise barrier. Study was held 5 days from Monday to Friday. The data were observed at peak hour from 8:00 am until 9:00 am, off peak hours from 12:00 pm until 1:00 pm and night session from 11:00 to 12 midnight. From the observation noise level at peak hours is higher than noise level off peak hours and night hours. This can be seen from the collected data at peak hours 62.84 dBA, 61.24 dBA for off peak hours and 59.44 dBA for night hours. From this collected data proved that the noise levels exceed and over the noise limits for residential area 55 dBA referring to suggested noise by WHO for residential area. Next investigation was held in a laboratory to test the chosen material on impedance tube kit. From the gathered data showed that fiber glass wool suitable to use as infill for noise barrier. Its absorption coefficient show 0.988330 and this value is slightly to 1 (fully absorptive). While, absorption coefficient for insulflex and polycarbonate showed the material were reflective materials 0.47183 for insulflex and 0.28634 for polycarbonate panel. This both value was nearer to 0 therefore this material is fully reflective.

ABSTRAK

Kajian ini bertujuan untuk melihat samada bunyi yang dihasilkan oleh ERL memberi kesan terhadap pencemaran hingar kepada kehidupan atau penempatan yang berada di laluannya dan kajian dilanjutkan dengan melakukan ujikaji makmal terhadap bahan yang sesuai untuk digunakan sebagai bahan pembinaan tembok bunyi. Kajian telah dijalankan selama 5 hari iaitu dari hari isnin sehingga hari jumaat. Bilangan hari ini termasuk waktu puncak iaitu dari pukul 8:00 am sehingga 9:00 am, waktu tidak puncak iaitu dari pukul 12:00 pm sehingga 1:00 pm dan waktu malam iaitu pada pukul 11:00 pm sehingga 12:00 tengah malam. Daripada kajian ini didapati bacaan paras bunyi yang terhasil pada waktu puncak lebih tinggi berbanding waktu tidak puncak dan waktu malam. Ini dilihat daripada purata paras bunyi yang dicerap pada waktu puncak ialah 62.84 dBA, 61.24 dBA pada waktu bukan puncak dan 59.44 dBA pada waktu malam. Daripada nilai tersebut didapati paras bunyi telah melebihi paras yang ditetapkan iaitu 55 dBA. Kajian seterusnya yang dijalankan di makmal kajian seterusnya menunjukkan bahan yang dipilih telah melalui tiga kali ujian tiub impedansi. Data yang diperolehi menunjukkan kapas fiber sesuai dijadikan *infill* kepada tembok bunyi. Nilai koefision penyerap 0.988330 dan nilai ini mendekati nilai 1 (penyerapan sepenuhnya). Manakala nilai koefision penyerap bagi insulflex dan panel polikarbonat menunjukkan nilai 0.47183 dan 0.28634 sebagai nilai tertinggi dan nilai ini menghampiri 0 (pemantulan sepenuhnya)

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CHAPTER 1

INTRODUCTION

1.1 Background

Scientific investigations on community reaction to transportation have been going on for years and the various aspects of the issues are still being debated at international level. As is well known, annoyance is a subjective judgment more complicated than loudness and noisiness due to non-auditory factors influencing both the long and short-term responses of people. When transportation noises are concerned, in addition to the noise related-factors which affect annoyance (for example noise level) and the environmental factors (for example barrier, topography and reflection surface), the individual characteristics, such as social and economic status, education, age, visual influence, meaning of noise, activity type, noise sensitivity, adaptation to noise should be taken into consideration in noise evaluation the noise impacts on a community and in development of noise control strategies (S. Kurra et al. 1999).

The noise level to which the urban population is exposed has been increasing at a substantial rate over the past several years. This has lead to increasing number of complains received by public agencies and to the recent flood of noise-related litigation now taking place in courts. Also federal, state and local government agencies have enacted numerous laws, ordinances, and regulation to control noise. The question of community noise control has, therefore, become an important consideration in urban planning, in construction practice and in public administration (Mastre et al. 1980).

In railway field, railway noise is a multi-faceted phenomenon, in which the infrastructure and the rolling stock interact in a complex way. This fact complicates the splits of responsibilities between the stakeholders in the business: operators, infrastructure owners, vehicle and the track products manufacturers and the governmental bodies for transport and environment. With this fragmentation of responsibility there is obvious risk that effort and money is spent on noise control measures in the wrong place, especially when several kinds of sources are involve (for example wheel, track, aero-acoustic, and cooling fans) the elementary rule in noise control that it is fruitless to reduce non-prominent sources must be observes. This is, of course common knowledge within the community of railway noise experts but it is sometimes difficult to communicate to non-specialist (A Ã Frid et al. 2006).

In the normal train, one of the major problems is to prevent noise and vibrations generated by exterior sources, such as the wheel–rail rolling noise and the braking noise. Like the normal train, the major source of noise on the Kuala Lumpur Express Rail Link (ERL) that pass thru residential area is from the rolling noise, impact noise, squeal noise and from the braking system. As a result, this study is going to focus on designing the noise barrier to reduce noise level by identifying the suitable types of noise absorptive and reflective material to design the barrier, so that the noise level at this chosen location will be reduce.

1.2 Problem statement

Railways are proven to be a sustainable and climate friendly means of transport. However, railways do influence the environment. The most important effect is the noise produced by them. As a result, the noise propagation has become one important concern of railway operating environments due to the influence of rolling noise, impact noise and also squeals noise. Therefore, this noise propagation made by railway operation need to overcome, in order to ensure that the environmentally-friendly aspect of the railways is maintained, the noise level of ERL has to be in a moderate level that none residential area would be exposed to noise levels which endanger health and quality of life. Therefore, this study will be conducted to mitigate the noise produced by ERL coach/car using noise barrier by identified the suitable material that can be use to design the noise barrier.

1.3 Objective

i. To determine the noise level produce by ERL using Sound Level Meter.

ii. To identify the suitable type of material for noise barrier.

iii. To determine the noise reduction on the chosen material.

1.4 Scope of study

The scopes of this study are:

i. The material use should be noise absorptive or reflective.

ii. The material use should be available in the market.

iii. At least two material would be identifying for noise barrier material.

iv. This noise level investigation site will be held at University Putra Malaysia (UPM) while material test will be conduct in Laboratory.

1.5 Significance of study

The importance of this study is to determine a suitable material that can be used to design the noise barrier because the material will going to identify reduce the existing noise level produce by running ERL. By reducing the external noise propagation of the ERL coach, it will have significant improvement of the noise level at residential area and that will have a positive impact for the resident. Since the noise propagation has turned out to be one of the problems happen in any of residential area that placed beside track. Therefore, the noise level obtain in this study will also have good effect on the environmental noise generated by the ERL.

1.6 Expected result

The expected results that will be obtained from this study are:

i. Low noise compare to the existing noise level produce by running ERL toward residential area.

ii. The chosen material will be a good reflective and absorptive material.

iii. Environmental noise reduction.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, the noise issues have become a serious problem of environmental pollution. Thus, to prevent this issues become more serious the Malaysian Parliament has approved the drafting of an Act known as the Environmental Quality Act, which covers the entire management environment throughout the country. Furthermore, to make this act more effectively used the amendment to the act has been created in 1985 and revised in 1996.

Generally, sound is an acoustic signal that can be heard by human ear. Noise is the signal received by humans at high altitudes and undesirable which must be controlled or avoided. However, this definition is difficult to accept because it is related to the difficulty on measuring and evaluating objectively sound (Kerse, 1975) according to receipt of individual on a different sound. Often noise case in Malaysia is due to the sound produce by vehicles on the roads highways, railways, power stations, factories, airplanes, entertainment center, human activity and others. If sounds from these sources are not controlled effectively it will cause noise and annoyance. Indirectly, it will not only result negative effect to humans and animals but also will affect the daily activities and economic.

Several studies have found that the railway is the second significant source of noise in cities, (road traffic is the first significant source of noise in the city) railway noise causes much disturbance to the nearby residents (Sayed Abas Ali, 2005). However, in the last decade the number of trains and line has increased because people consider that traveling on trains is the most comfortable and time saving transport option. Therefore, the noise reduction has become one important concern of railway operating environments due to the influence of increased the rail line crossing the city and residential area.

In this chapter we are going to outline about definition of noise, annoyance, noise exposure, and impact of noise toward human hearing, noise produce by railways and some information about ERL system and its schedule.

2.2 Noise

The recognition of noise as a source of annoyance began antiquity, but the relationship, sometimes subtle (Bies, *et al.*, 2009). Noise is a type of sound, sound refer to mechanical waves of pressure allow us to hear and listen. Where noise is a loud or unpleasant sound that someone or something makes and annoyance is something that is a source of irritating (Merriam Webster, 2015). Environmental noise is unwanted sound received at an outdoor location from all sources in community that sometime irritating and harmful. Major sources of environmental noise include road, rail, air traffic, industries and public works (Paul D.Schomer, 2005).

There are three factors that determine whether the sound we hear is noise or not:

1. Magnitude or quantity of sound
2. Sound quality
3. Attitude toward the listener or receiver noise

The attitude of the listener or receiver will vary depending on the time and circumstances. Therefore, sound that having the same quantity and quality may be needed on daytime but considered disturbing during night. For example, a song maybe pleasant to hear during daytime when we're in the car, but if the song played on the same volume at night it will consider disruptive because the attitude has changed.

In other hand, some people can receive sound a bit strong but some are not able to receive it. Situation happened when musicians play music normally heard a loud sound produced from musical instrument will consider the sound isn't noise but for those who do not like loud sound of the instrument will assume it as a noise. Similarly for construction workers who everyday dealing with noise from construction activities, to them noise is not annoyed and they can accept such conditions but this situation will not be accepted by the public.

There are three sources that led to instances of the noise. Three sources were pointed source, the region source and a line source (Md Rajuna Ahmad Shakri, 1996). Pointed source is the sound coming from a known source. Examples of pointed source are radio noise, fan and also the sound of pilling work and others. While the sound emitted from an area or place, such as the sound of disco, the factories, construction sites and other resources are categorized in the region source. The sound emitted from a line source is like sound of a movement train, movement of vehicles on the road and so on.

Noise pollution had less attention from the public or the authorities. The reasons of this situation because of noise happened only for a short time (for a few minutes or several hours) compared to air and water pollution, applied to long term or ongoing. Plus, not everyone considers sound as a noise. For example, the manager of a large wind tunnel liked to hear, from the back porch of his home, the steady hum of his machine 2 km away, for to him the hum meant money. However, to his neighbors it meant only annoyance and he eventually had to do without his evening pleasure (Bies *et al.*, 2009). Physiological or psychological effects caused by noise pollution occur slowly and takes many years. Therefore, it quite difficult to the parties involved to relate the effects with noise problems.

Apart from causing harmful effects such as deafness, sound can also help geologist and earthquake researches. They work based on sound waves to determine the nature of the rocks in the earth (Fader, 1981). Two important characteristic of sound in the normal pressure is frequency and amplitude (Mansor & Mohd Asri, 1997).

2.2.1 Frequency and amplitude

Frequency is defined as the number of oscillations or cycles of waves that occurs within one second with unit Hertz (Hz). The frequency range of the sound signal can be heard by human ear are between 20 Hz up to 20,000 Hz (Mohd Jailani Mohd Nor, 1999). Frequencies below 20 Hz known as infrared, while above 20,000 Hz are called ultrasound. Amplitude is a magnitude measurement of a changing pressure. (Mansor & Mohd Asri, 1997). Wavelength is the distance traveled by a sound wave or a vibration in one cycle or rhythm.

2.2.2 Decibel

Normally the sound signal is measured in unit decibels with a weighting A (dBA). Scale measurements performed in logarithmic scale. Therefore, mathematical operations to measured sound levels cannot do the same as the usual mathematical operations.

Sound power is an energy that brought together when the sound pressure wave travels through the air. It is estimated that the sound will move 350 meters per second in air. Because sound is acoustic signal, then every sound will deploy its power. In a logarithmic scale, the sound power level is determined according to the following equation:

$$L_W = 10 \log_{10} \left(\frac{W1}{W0}\right) \qquad (2.1)$$

Where, L_W = Noise level

W_1 = Distributed power

W_0 = Reference level

Scale levels of power and noise power varies depending on the source. Tables 2.1 and Table 2.2 show the scale of sound power level and sound pressure. The sound pressure is measured with microbar unit (μ bar). And the normal vibrations can be heard by the human ear is in the proportion of 2 × 10-4 μ bar to 2 × 10 2 μ bar. Sound pressure is usually vibrated in multiples of 10. Therefore, the following equation is used to facilitate the counts in determining the sound pressure level in decibel units (dB),

$$L = 20 \log \left(\frac{P}{P0} \right) \quad (2.2)$$

Where, L = Noise level (dB)

P = A measurement of sound pressure (μ bar)

P_0 = Sound pressure standards

Decibel unit is not a linear scale but it is representative point on increasing curvature. For example, 10 dB is ten times greater than 1 dB, while the amplitude level of 20 dB is a hundred times greater (which 10 × 10) from 1 dB and beyond.

Table 2.1: The relationship between sound power and sound power level

(Utusan Malaysia, 1990)

Sound Power (watt)	Sound Power Level (dB)	Source
25 million – 40 million	195	Rocket
100 000	170	Taking off airplane
10 000	160	Turbo jet engine
1 000	150	Airplane with 4 turbine
100	140	Huge orchestra
10	130	Pipe organ
1	120	Piano
0.1	110	Loud radio
0.01	100	On the road vehicle
0.001	90	Awful sound
0.0001	80	Normal conversation
0.00001	70	
0.000001	60	

0.0000001	30	whispering

Table 2.2: Relationship between sound pressure and sound pressure level

Sound pressure (Pa)	Sound Pressure Level (dB)	Source
6.32	110	Near to railroad
2.00	100	Bottle factory
0.632	90	Huge orchestra
0.200	80	Inside of the car
0.0632	70	Town environment
0.0200	60	Speech at the ceremony
0.00632	50	Office environment
0.00200	40	Living room
0.000632	30	Condition inside the room during night

2.2.3 Measurement and Assessment Scheme

The basic tool used to measure the noise level is the sound level meter. Currently, there are various types of sound level meters available in the market. A unit used in measuring the sound level is in units of decibels (dB).

There are four weights used in measuring the noise, there are weighting A,B,C and D (Mansor & Mohd Asri, 1997). Figure 2.2 show how the sound level meter reacts at these different weighting, weighting A, B, C and D. for each weighting has a certain sound pressure level, namely:

i. Unit dB(A): sound pressure level below 55dB
ii. Unit dB(B): sound pressure level between 55 dB until 85 dB
iii. Unit dB(C): higher sound pressure level
iv. Unit dB(D): airplane noise

Almost all of the works in civil engineering using a weighting A in the measurement of noise or the abbreviated of dB (A). This is because weighting A can detect sounds similar to human auditory system (Fader, 1981). A weighting network is widely used for the measurement environment because it is similar to the sensitivity of the human ear. Meanwhile, the weighting B and C are not giving a good relationship because contour noise generated is based on pure tone (Mansor & Mohd Asri, 1997). Figure 2.1 shows the reaction sound level meter with weighting A, B, C and D.

Rating scheme set up to show an association between measured noise with the measured time. There are several types of rating schemes which have been used in the measuring noise. Among the schemes are equivalent continuous sound level (L_{eq}), single event noise exposure level (LAX), the statistical level (L_N), the average noise level night-day (Ldn), the noise level (LNP) and index numbers and noise (NNI). Information will only touch on the L_{eq} and L_N only because the proportion of schemes is often used.

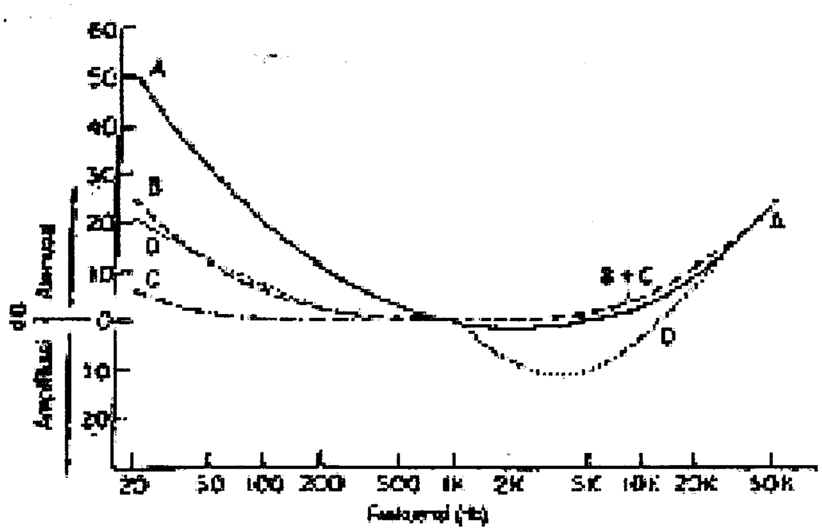

Figure 2.1: Reaction sound level meter with weighting A, B, C and D

(Source: Mansor & Mohd Asri, 1997)

L_{eq} rating scheme is used to measure environmental noise and disturbances that may occur to the public. A weighting is used to measure continuous noise level. This scheme can describe the actual noise level and duration of observation for this L_{eq} is 24 hours / day, with a marked $L_{(24)}$ unless otherwise specified measurement period. For conditions such as the workplace, schools, offices and the like, an average of 24 hours may be substituted with an average of 8 hours, L_8.

The proportion L_N scheme is used to indicate changes to the noise, the noise levels that exceed N% of the measurement time. There is several schemes proportion L_N used such as L_0 / L_{max}, L_1, L_{10}, and L_{90} / L_{95}. L_0 / L_{max} is used to interpret the maximum level and never exceeded. L_1 is used to describe the highest sound level with neglect the peak combination without exceed 1% from the study period. While the L_{10} is used to describe the highest level of sound such as surrounding sound level and the L_{90} / L_{95} is for low noise level description, according to the surroundings and also industrial noise.

2.3 Noise from Transportation

Apart from a number of factors that contribute to the noise, transport is the main cause of this noise problem. The noise source of transportation is more prevalent in urban areas. There are also sources of industrial, construction, noise from human activities and other.

The three main sources of noise arising from transport is road traffic, airplanes and trains.

2.3.1 Road Traffic

Rapid development in Malaysia has led a lot of road construction and highways to facilitate the daily activities of the population. Beside many advantages there are also disadvantages of this situation, when it referring to the increasing of noise level in the area. Indirectly, it will increase the number of traffic flow, traffic speed and number of using vehicles that use the facility.

The increasing numbers of traffic everyday become the major causes to noise not only in Malaysia but throughout the world. According to study conducted by Malaysia Department of Environment in major cities in this country, shows that road traffic is the major contribution to the environmental noise (Goh, 1984). Figure 2.2 shows the bar chart on the percentage of the noise annoyance for the population in the old states of Germany and Table 2.3 shows the result in table form.

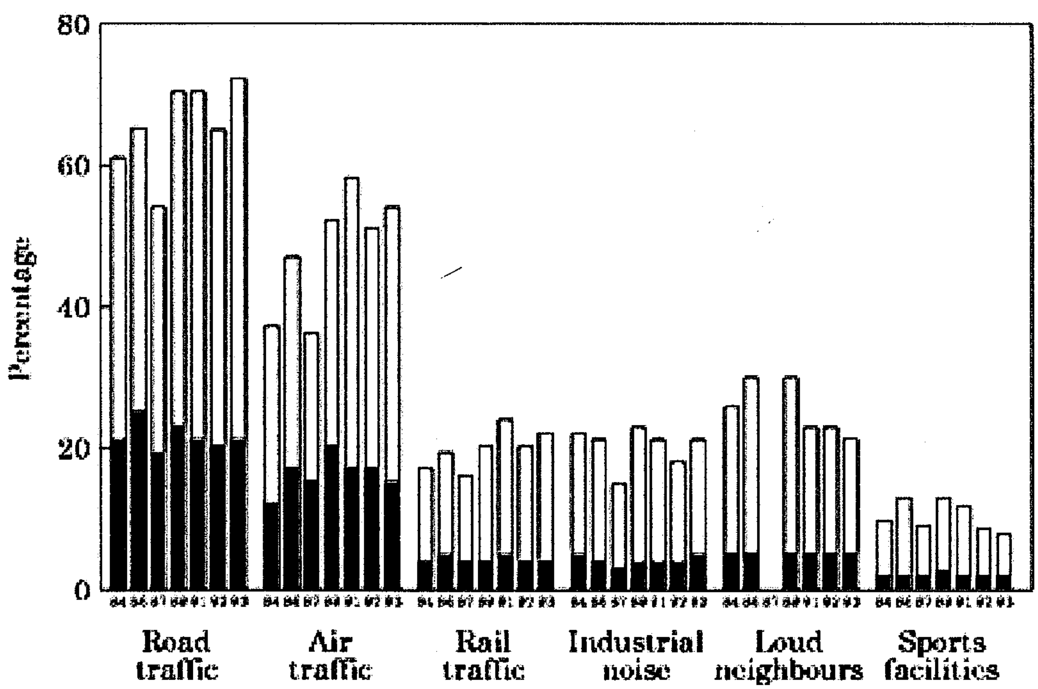

Figure 2.2: Noise annoyance for the population in the old states of Germany

(Source: Obermeyer Planen.1996)

Table 2.3: Noise annoyance for the population include the town size in the old states of Germany (Obermeyer Planen, 1996)

Noise Source	Degree of annoyance	Total (%)	Annoyance by town size (no. inhabitants)			
			<5000	<20000	<100000	>100000
Road traffic	Strongly annoyed	21	16	19	25	22
	Annoyed	51	48	52	48	57
Air traffic	Strongly annoyed	14	14	16	14	11
	Annoyed	41	44	42	38	38
Rail traffic	Strongly annoyed	3	2	3	6	3
	Annoyed	19	14	25	16	21
Industrial noise	Strongly annoyed	4	3	4	3	4
	Annoyed	17	11	18	22	17
Loud neighbors	Strongly annoyed	4	3	5	4	4
	Annoyed	17	10	17	18	22
Sport facilities	Strongly annoyed	1	1	1	1	1
	Annoyed	6	5	7	5	6

The development of building that too close to the street can affect the increasing noise level. The resulting sound will be reflected by the surface of the building because the building surfaces not able to absorb all of the sound produced. In addition, type of engine, tires, cooling and exhaust system also a combination of vehicles that contribute noise. Noise from vehicles will increase if the sound absorption or other equipment installed on the vehicle to reduce noise fail to function properly.

Noises generated from the highways are can be accepted. Varieties of vehicle use the highway every day with a variety of purposes leading to an increased noise problem. Communities live near the highway will be interrupted at any time, day or night for unlimited use of the highway

2.3.2 Airplane

Airport that builds near to the residential area will cause the noise at the area. This inconvenience generated from the loud airplane engine either during landing or taking off. However, the noise level depends on the type and power of the engine as well as operating conditions at the airport.

2.3.3 Railroad

Railway noise is generated from different sources and it can be categorized as air-born and structure-born noises. Rolling noise is established as originating from structural vibrations of the wheel, rail and sleepers resulting from the combined surface roughness of the wheel and running surfaces. Roughness on wheels can be induced by factors such as the use of tread brakes, especially those made from cast iron (Talotte C *et al.*, 2003). However, ground borne vibrations and structure-borne noise mainly occur at low frequencies (< 50 Hz). Frequencies above this are attenuated increasingly rapid. Vibration disturbance is usually caused by the large vertical dynamic forces between wheels and rails. These forces fluctuate in response to wheel and rail roughness over a wide range of frequencies.

In addition, wheel squeal originates from frictional instability in curves between the wheel and rail. Stick-slip oscillations (more accurately referred to as roll-slip) excite a wheel resonance; the wheel vibration radiates noise efficiently. In the study conducted, the accepted model involves top of rail (TOR) frictional instability under lateral creep conditions leading to excitation of out of plane wheel bending oscillations. These are radiated and heard as squeal. The starting point for squeal is lateral creep forces that occur as a bogie goes through a curve and the wheel/rail contact patch becomes saturated with slip (creep saturation) (Donald T. Eadie *et al.*, 2005).

A critical component in all the modeling work is the requirement that beyond the point of creep saturation, further increases in creep levels lead to lower coefficient of friction. This is known as negative friction, referring to the slope of the friction creep curve at saturated creep conditions. In more general tri-biological terms, this would be equated to changes in sliding velocity, rather than the railroad term creep. This leads to roll-slip oscillations between the wheel and the rail which excite a wheel resonance, and the wheel web radiates the noise (Donald T. Eadie *et al.*, 2005).

Table 2.4: Frequency range for different types of railway noise

Noise type	Frequency range (Hz)
Rolling	30 – 5000
Flat sport	50 – 250 (speed dependant)
Ground borne vibrations	4 – 80
Structure- borne noise	30 – 200
Top of rail squeal	1000 – 5000
Flanging noise	5000 - 10000

2.3.3.1 Rolling Noise

As it is well known, rolling noise is caused by structural vibrations of the wheel, rail and sleepers induced by the combined surface roughness of the wheel and rail running surfaces. Therefore, in the recent years the main focus of research into rolling noise has been the application of theoretical models to the design of low noise wheels and tracks (Talotte C *et al.*, 2003).

According to University of Southampton, engineering and environment that make research on Railway Rolling Noise, the major source of noise from railways is due to the rolling of the steel wheel on the steel rail. The sound level, Lp in decibels, of this rolling noise increases approximately according to the formula $Lp = Lp_0 + 30 \log10 (V / V_0)$, where Lp_0 is the noise level at the speed V_0 (Southampton.ac.uk, 2014).

Rolling noise is caused by very small amplitude undulations of the wheel and rail running surfaces noise. Typically, on both surfaces, there are undulations with amplitudes from less than 1 mm up to tens of mm. The undulations of importance for noise have wavelengths of several centimeters. An irregularity of wavelength l (m) causes vibration with a frequency $f = v / l$, where v is the speed in m/s (Southampton.ac.uk, 2014).

2.3.3.2 Impact Noise

The rail surface is not perfectly smooth but contains discontinuities, the most severe of which are rail joints. The geometry of rail joint can be characterized by the gap width and the height difference between the two sides of a gap. The gap width may be typically 5-20 mm and the height difference 0-2 mm (Wu T.X &

Thompson D.J, 2001). Figure 2.5 shows the gap in track joint that cause impact noise.

In addition the rail often dips near a joint by several millimeters. Even welded rail often has such dipped joints. These discontinuities on the rail can generate large impact forces between the wheel and rail when wheels roll over a dipped rail joint (Wu T.X & Thompson D.J, 2001)

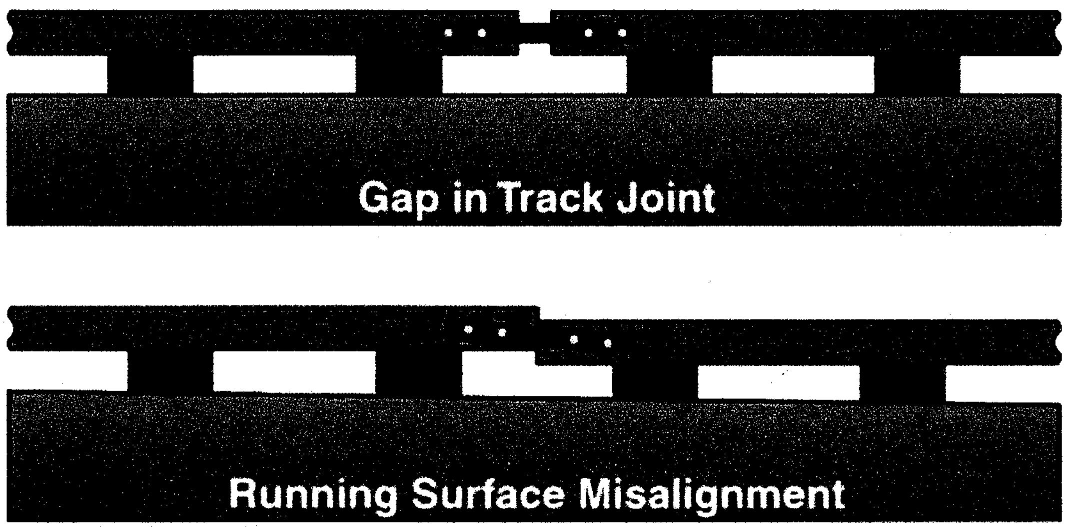

Figure 2.5: Gap in track joint that cause impact noise

(Source: Harris Miller Miller,1995)

2.3.3.3 Horn Noise

Noise from train horns at grade crossings has resulted in the most complaints about train noise in the United States as reported by the Federal Railroad Administration. There are over 150,000 grade crossings in the United States and a new federal law requires the horn to be sounded by every train at every one of them. Currently there are waivers for about 2500 crossings, but under the new law waivers will be permitted only under certain conditions where the grade crossing has been rendered sufficiently safe. Train horns are required to attain a level of 96 dB(A) at 30 m in front of the locomotive, but most horns are set at a level of 115 dB(A). Removing the waivers on the 2500 crossings would expose about 350,000 people to new noise levels that are deemed unacceptable. Concerns for adverse public reaction have led to an ongoing study sponsored by the US Federal Railroad Administration on ways to minimize horn noise at the wayside. Some of the methods being investigated include improved directivity of locomotive-mounted horns and stationary, pole-mounted horns at grade crossings (Sayed Abas Ali , 2005, Gu Xiaoan, 2006, Talotte C *et al.*, 2003). In this case, horn noises are not significant in the investigation.

2.3.3.4 Squeal Noise

Wheel squeal was the initial and major source of the noise emission which was of concern to neighbors. There are several publications that describe the sources of noise from rail transit vehicles. The US FTA's Transit Noise and Vibration impact Assessment report of 1995 provides a good description of how to assess noise from rail projects (Harris Miller Miller & Hanson Inc.1995).

Longitudinal stick-slip is caused by the different translation velocities between the inner and outer rails. The WRNCM advices that wheel taper is usually sufficient to compensate for differential slip at curves in excess of 600m radius, though shorter radii may be accommodated by profile grinding of the rail head (Tickell, Downing & Jacobsen, 2004).

Flange rubbing noise is where the flange of the rail wheel strikes the gauge-face (the inner side) of the rail. Flange noise is common feature that will be known to many rail commuters. Many rail systems use grease pots to lubricate rail at curves to minimize wear and noise. Flange rubbing noise appears to occur mainly around 1400 to 1600 hz, depending on wheel geometry (Tickell, Downing and Jacobsen, 2004). Figure 2.6 shows the wheel squeal creation.

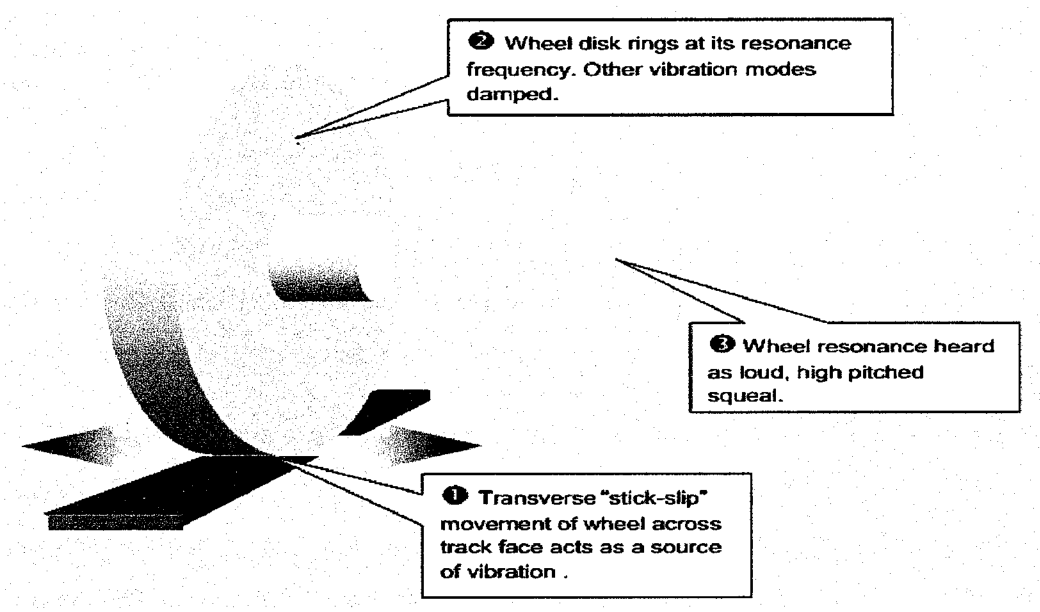

Figure 2.6: Wheel Squeal Creation (Source: mitchamcouncil.sa.gov.au)

2.3.3.5 Braking System

The braking system also contributes to the noise generated in the normal train as well as in the monorail. However, based on the study the widespread introduction of disc brakes replacing cast-iron tread brakes for passenger vehicles has given significant reductions, typically up to 10 dB. For freight vehicles in Europe cast-iron brake blocks are still widely used. Their replacement by disc brakes is considered both uneconomic and difficult due to the organization of the international traffic in Europe. However, a recent initiative by the international union of railways (UIC) has set out to replace cast-iron blocks by a composite material. These do not roughen the wheels and therefore the rolling noise is reduced. If this can be done by retrofitting vehicles, there need be no additional costs. The Eurosabot project set out to develop such brake blocks but results were rather disappointing and suitable materials for retrofitting are not yet available (Talotte C *et al.*, 2003).

2.4 Noise from Construction and Industry

Usually construction activities are something temporary, but it provides a higher noise level than industrial activities. Noise from construction activities will be gone when the project is completed within a certain period.

Even so, the noise generated by these activities sufficient to give an uncomfortable feeling to the surrounding community. The noise generated by the use of machinery and plants during the construction of the building process conducted as concrete mixer, vibrator tool, lorries and out, power systems used and others.

In addition, pilling works not only produce vibration, it also consumed a lot of loud noise because of the stamping machine during stamping pile. Table 2.5 shows the level of noise for construction equipment.

Noise from industrial activities came from machinery and equipment used. However it depends on the types of industries. Noise levels will be high if the industry such as steel, wood, vehicles and others carried out over the clothing industry, food, electricity, and so on. Because of the wide variety of shapes and sizes, industries, apply pressure to the difficulty in determining the level of noise (Mansor & Mohd Asri, 1997).

Table 2.5: Level of noise for construction equipment (Source: Cunniff, 1997)

Construction equipment	Noise level (dBA)
Material Lorries	88
Cement Mixer Truck	85
Drill	88
Tractor land scrapers	87
Generator	76
Vibrator	98
Pump	76
Ground excavators	85

2.5 Noise from Human Activity and Other Sounds

No matter what kind of activities done, it will produce sound and the sound produced will analyze difference whether it cause noise or just sounds. Therefore, noise caused by human activity is a natural thing that will be faced by everyone in the world averyday, especially in areas with high population (Mansor & Mohd Asri, 1997).

Among the causes of noise is like talking, listening to radio, television, karaoke with a loud voice and so on, as well as the sound emitted by pet like dogs. Apart from the sources mentioned, activities such as garbage collection, in stores activities, during festivals, religious and others also contribute noise.

2.6 Noise Impact

Noise is something that is negative and should be avoided because it can threaten health and comfort of residents in the affected areas. Threats can occur in two forms, it is physical or psychological. Although the noise impact cannot be seen with the naked eye but it will cause problems if prolonged in a long time.

2.6.1 Impact on Health

Stay healthy is a dream of every human kind. It can be seen from their physical condition, mental and social. However, human are not aware about the excessive noise that can be an obstacle to their desire. A person may have hearing trouble if exposed too long to noise.

Human is the main creature that will feel the impact of noise. However it depends on the sensitivity of a person, the more sensitive they are the earlier responds will they get from the noise. A person may lose their hearing in some period of time without noticing it when it exposed too long to the noise. Normally, once they realize when they get symptoms like hearing disability. At this stage, this situation has become quite serious and may cause deafness disease.

Unfortunately, deaf disease caused by long term expose to excessive noise cannot be treated medically. Person will suffer from deafness problem immediately when exposed to loud sound that over 150 dBA. Hearing loss can occur in three cases it is *temporary loss,Presbycusis* and *Sociocusis* (Mansor & Mohd Asri, 1997)

Temporary hearing loss can occurs due to the sound of siren, the sound of an electric bell, a loud radio suddenly switch on and so on. This resulting noise happened just for a temporary situation. Presbycusis is the reduction in hearing sensitivity due to increased aged. This is caused by many cells in the body will dies as a person ages is increasing. While sociocusis is a change in the ability to hear, causing by prolonged exposure toward noise.

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