STUDY OF TRAFFIC NOISE LEVELS IN SINGAPORE

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Abstract

Environmental noise generated by traffic is an area of environmental concern especially with the rising vehicle populations and the near proximity of housing to the roads. The study of traffic noise affecting public housing in Singapore is of great importance. This study seeks to obtain detailed noise measurements at the various locations chosen in order to ascertain the actual noise levels and characteristics and the degree of the problem faced. This paper intends to present the field measurements results which will eventually be used in a detailed comparison study where the measured values are compared against those calculated using commercially available predictive software to understand the causes for the variations between the two sets of results.

Introduction

As a country progresses with industrialization, more vehicular traffic will be added to the roads resulting in higher levels of environmental noise. This is no different with Singapore. With a pollution of about four million, and being a small island state of about 650 km^2, land is scarce, and therefore to maximize land usage, high density high-rise buildings are built close to major highways. The government is aware of the environmental noise that might result from an increase in transportation noise and in the 1993 green plan they have committed to reduce the impact of such transportation noise on the overall environment [1].

The high Singapore GDP leads to high level of car ownership, and over the years, more highways have been constructed around the island to cater to the increase in road traffic. Some highways were also expanded to increase the number of lanes. Residents of high-rise flats which are built along the edge of these highways are subjected to high levels of road traffic noise. This has resulted in an increase in the number of public complaints.

Literature survey shown that transportation noise has caused major concerns to the governments of various European countries, and efforts have made to develop a better understanding of environmental noise so that it can be considered in the town planning process [2, 3, 4]. A number of predictive software have been developed and marketed commercially for the prediction of environmental noise, but there were concerns on the inaccuracies between the predictive values and the actual values [5, 6].

This study is designed to assess the noise profile and to compare the actual values against those calculated using commercially available predictive software and also to eventually enhance the accuracy of the predictive models so as to give accurate predictive measurements to assist in future town planning works. This paper discusses the actual noise levels as measured in the locations under study.

Methodology and Instrumentation

Since this study aims to investigate acceptability of using software prediction, there has been emphasis on traffic noise and we have tried to avoid measurements in areas with high non-traffic noise e.g. Construction noise, aircraft noise etc. The sites were selected based on traffic density and the possible impact of the road traffic noise on the environment. A total of eight sites were considered for this study (Table 1). Four of the sites were at public high-rise flats located along major expressways, and the other four sites were along the edge of major roads and expressways. Two typical examples of these sites are shown in the location maps of Figures 1 and 2.

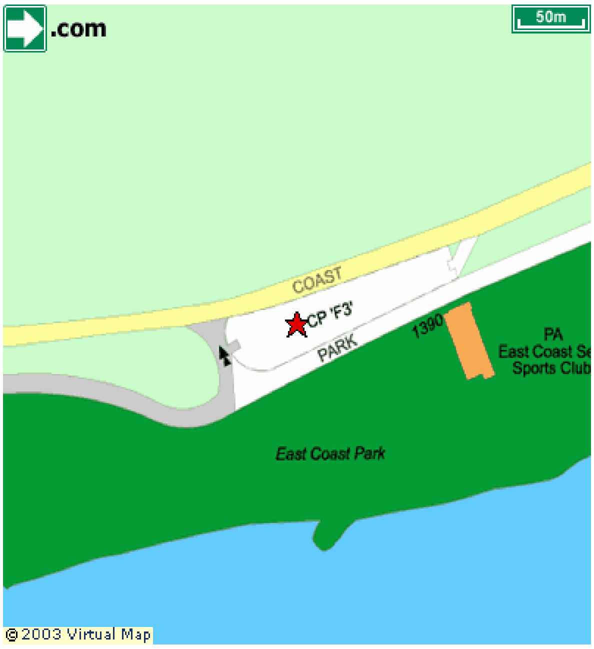

Figure 1. An example of a site without obstruction

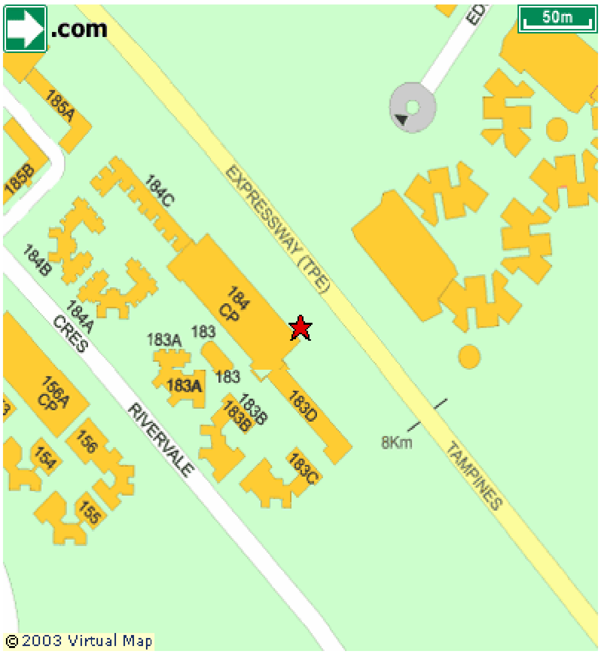

Figure 2. An example of a site with obstruction

A Type 1 precision integrating sound level meter with 1/3 octave analyzer was used in this study. Calibration of the microphone was carried out at the beginning and at the end of each session to ensure validity of data recorded. Continuous measurements (up to 12 hours) required for this study was taken and the data collected was downloaded into a computer for data analysis. The sampling period was 17 seconds throughout the entire 12 hour measurements from 0900 hrs to 2100 hrs. Hence, all the data obtained were analysed statistically for the average, maximum and percentages to yield the summarised results of Table 1.

For measurements taken at mid and high levels of the flats, the sound level meter was mounted on a tripod with the microphone set on an extension boom to ensure that it was more than 1 meter from the parapet of the building to avoid reflected noise from the wall when measurements were taken (Figure 3). For measurements taken at ground level, the sound level meter was mounted on a tripod 1.2 meter above ground to avoid ground reflection (Figure 4).

Typical elevation from ground level to mid level ranges from 15 to 18 metres. Typical elevation from ground level to high levels ranges from 29 to 33 metres. The exact elevation for each location will form part of the input data for the predictive analysis.

Similarly, horizontal distances from the edge of the roads to the measurement points were measured and such distances will also form part of the input data for the predictive analysis. In this paper, however, comparison

Figure 3. Typical SLM setup at high floor

Figure 4. Typical SLM setup at ground level

is made only between West Coast Blk 711 and Sengkang Blk 183D which have similar distances of about 30 metres from the expressways as a case example.

For recording of the traffic flow, traffic conditions were recorded for the duration of the noise measurement using a DVD recorder for playback at a later date to accurately count the traffic flow. Traffic condition was classified under two major categories viz heavy and light vehicles. Heavy vehicles would include buses, lorries and trucks.

The weather conditions and any abnormal events (such as aircrafts over flying and sirens from ambulances) at the time of measurements were noted to assess the impact on the measurements.

Distances from the sound level meter to the edge of the road and the surrounding environment were mapped out and input into the predictive software for further analysis.

Results And Discussion

The results of the measurements taken at the eight sites are presented in Table 1 showing the traffic volume and the average and maximum L_{eq}, L_{10} and L_{90} noise levels over time. Also presented are the percentage of exposure to above 65 dB, 70 dB and 75 dB respectively. From the data, it was noted that the 0900 hrs to 1900 hrs traffic density recorded was representative of day-time measurements normally regarded as from 0700 hrs to 1900 hrs. However, the traffic density recorded from 1900 hrs to 2100 hrs was not considered representative of the night-time measurements from 1900 hrs to 0700 hrs the next day because it was observed that the traffic density generally reduced in the later hours of the night, and it could be reasonably assumed that this traffic density would be rather low in the middle of the night from 0000hr to 0500 hrs.

The results show that the traffic volume will affect the noise levels significantly. For example, although both the Sengkang Blk 183D and West Coast Blk 711 are of similar distances from the expressway, the difference in traffic volume (about 5 times more in Sengkang) has resulted in about 4 times increase in noise exposure for L_{eq} exceeding 65 dB. This 5-times difference in traffic volume would normally result in a 7 dBA noise level difference, but this was not realized due to the significantly higher heavy vehicle percentage adjacent to West Coast Blk 711 (40+% vs 20+%).

For approximately the same traffic volume, traffic type and at the same level (ground level), it was noted that the noise measured at Clementi Blk 426 registered a higher level as compared to the Sengkang Blk 183D. This is due mainly to the distance of the residential buildings from the edge of the expressways.

Comparing the noise level at different floors of the building, it was observed that the noise measured at low floors (i.e. ground or 2nd storey) were lower than that recorded at mid floor (i.e. 5th to 7th storey) and at high floors (i.e. 11 or 12th storey) by about 1 to 2 dB.

Although these general observations were noted from the field measurements taken, it was not possible to actually assess the effect of the traffic volume, the reflection from surrounding structures and buildings, and height on the noise levels. This is because in the field measurements, it was not possible to individually isolate the effect of the various elements that could have a contribution on the overall noise levels. However, with commercial predictive software, individual contributing factors such as traffic volume and reflective index of surrounding structures can be input into the software to better understand its individual impact on the overall noise levels [7]. Further work is being carried out using available commercial predictive software to have better understanding of the various contributing factors to the overall traffic noise, and also to determine the accuracy of such predictive values against the measured values so that further enhancement of the predictive software can be made to improve its accuracy.

The predictive software with the all the contributing factors taken into consideration can then be used to confidently predict any locations and new residential or commercial developments for noise impact studies and town planning purposes. Eventually, expensive, time consuming and laborious field measurements can then be done away with or conducted selectively for verification purposes.

From the data (Table 1), it was also observed that for residents living in the high rise flats along the edge of expressways, the exposure to L_{eq} > 65 dB was as high as 40% and this information is useful for town planning purposes.

Oral surveys were also conducted with some residents to have a better understanding of the extent of noise caused by vehicular traffic. It was interesting to note that some of them were very unhappy with the noise from the vehicular traffic and they took the opportunity to complain and requested some control measures to be taken to reduce the noise levels. This was especially obvious in the block of flats facing the Ayer Rajah Expressway (Clementi Blk 426). It was also noted that majority of the windows facing the expressway were closed to keep out the noise. This concern was confirmed from the data that the exposure to L_{eq} exceeding 65 dB was more than 37%.

For some of the residents in Punggol (Blk 137) and Sengkang (Blk 183D), they came to accept the noise and even commented that they have adapted to the noise. From the acoustic point of view, most probably the sensitivity of their hearing has deteriorated and they were no longer disturbed by the noise as compared to that when they first moved into the flats.

A typical set of 1/3 octave data is presented in Table 2 and Graph 1 for Clement flat taken at the 11th storey. It shows typical values of L_{eq}, L_5, L_{10}, L_{50} and L_{90}. The results show that the noise level increases from around 60 dB at low frequency of 12.5 Hz and increasing gradually to as high as around 75 dB before dropping to a low value of around 30 dB at 16 kHz. The same phenomenon was also observed for all readings.

Table 2. Summary of a typical 1/3 Octave measurements at Clementi Blk 426 (11 storey)

Frequency	L_{eq}	L_5	L_{10}	L_{50}	L_{90}
12.5 Hz	60.8	65.8	64.4	58.6	52.8
16.0 Hz	61.0	65.9	64.6	59.4	54.2
20.0 Hz	61.3	65.7	64.6	60.0	55.5
25.0 Hz	63.4	67.7	66.6	62.2	57.7
31.5 Hz	63.0	67.2	66.0	61.9	57.9
40.0 Hz	64.6	69.0	67.8	63.2	59.6
50.0 Hz	69.2	73.3	72.2	68.3	64.7
63.0 Hz	74.0	78.3	77.2	72.9	69.0
80.0 Hz	73.1	77.1	76.1	72.2	68.7
100.0 Hz	69.2	73.5	72.3	68.0	64.6
125.0 Hz	66.5	70.1	69.1	65.8	63.2
160.0 Hz	66.4	69.3	68.6	66.1	63.8
200.0 Hz	67.7	70.6	69.9	67.3	65.2
250.0 Hz	67.6	70.5	69.8	67.1	65.1
315.0 Hz	65.8	68.9	68.0	65.3	63.2
400.0 Hz	66.6	69.0	68.4	66.4	64.5
500.0 Hz	67.5	69.6	69.2	67.4	65.7
630.0 Hz	66.9	68.9	68.5	66.9	65.3
800.0 Hz	63.7	65.8	65.4	63.6	62.0
1.00 kHz	62.9	65.0	64.5	62.9	51.2
1.25 kHz	62.3	64.4	63.9	62.1	60.4
1.60 kHz	60.6	62.9	62.4	60.6	58.7
2.00 kHz	59.1	61.8	61.1	58.6	56.4
2.50 kHz	56.6	59.6	58.5	55.9	53.9
3.15 kHz	54.6	57.5	56.7	54.1	52.0
4.00 kHz	52.7	55.8	55.1	52.0	49.6
5.00 kHz	50.5	53.8	53.0	49.8	47.2
6.30 kHz	47.9	51.5	50.6	47.0	43.9
8.00 kHz	44.6	48.3	47.3	43.7	40.7
10.00 kHz	41.8	46.1	44.8	40.2	36.8
12.50 kHz	36.5	40.9	39.5	34.7	30.7
16.00 kHz	28.7	33.3	31.9	26.5	23.1
20.00 kHz	22.2	23.6	22.7	21.7	21.7

Conclusions

The results of the field data collection has helped to identify the various contributing factors such as traffic volume, distances from the edge of the expressways, height and reflective indexes of surrounding structures on the overall noise levels. It also shows that the road traffic along the expressways cause significant noise problem to residents living in high rise flats along the expressways unless some control measures e.g. noise barriers, can be constructed to deflect the noise back to the expressways.

These contributing factors will be used in the study which is currently being carried out to compare the measured values against the predictive values computed using commercially available predictive software to determine their agreement and the accuracy in the predictive values to enable necessary enhancement of the predictive model.

Graph 1. 1/3 Octave Plot for Clementi Block 426

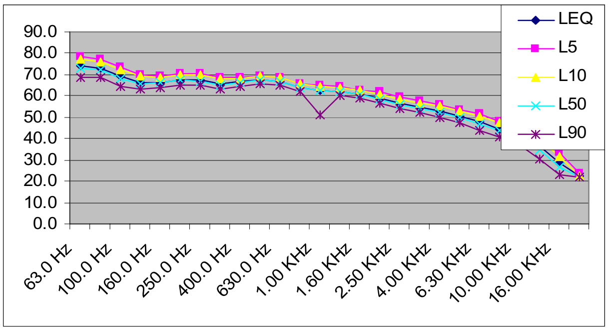

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Table 1. Summary of traffic counts and traffic noise levels at the chosen locations.

Location			**Clementi Blk 426**	**Sengkang Blk 183D**	**Punggol Blk 137**	**West Coast Blk 711**	**Outram Road**	**Lornie Road**	**East Coast Parkway**	**West Coast Highway**
Low Floor	***Time***		***0844-2044***	***0914-2115***	***0849-2050***	***0828-2030***	***0830-2032***	***0837-2037***	***0900-2100***	***0855-2055***
	Light Vehicle		55,273	53,949	61,175	8,836	38,189	46,804	46,626	-
	Heavy Vehicle		16,275	14,745	17,100	6,356	4,185	9,279	8,367	-
	Total Volume		71,548	68,694	78,275	15,192	42,374	56,083	54,993	
	Ave.	L_{eq}	57.8	56.8	57.9	52.5	59.0	64.4	62.5	55.0
		L_{10}	60.3	59.4	60.7	55.3	62.1	67.7	65.5	57.9
		L_{90}	54.0	52.7	53.3	47.8	52.5	55.3	55.4	49.6
	Max.	L_{eq}	79.8	82.2	78.9	78.2	84.5	85.8	85.1	84.8
		L_{10}	83.6	87.4	82.9	82.0	88.8	88.3	87.3	90.5
		L_{90}	74.6	74.1	72.9	71.6	81.3	74.4	73.6	74.4
	$\%L_{eq}$	>65dB	33.1	21.3	33.1	5.4	29.9	59.0	52.9	12.2
		>70dB	12.6	6.2	8.8	0.8	9.9	27.2	21.8	4.0
		>75dB	1.6	0.7	0.7	0.1	3.1	6.2	3.3	1.1
Mid Floor	***Time***		***0827-2029***	***0842-2043***	***0846-2047***	***0900-2109***	-	-	-	-
	Light Vehicle		114,886	53,077	54,830	9,253	-	-	-	-
	Heavy Vehicle		29,801	15,913	14,986	5,325	-	-	-	-
	Total Volume		144,687	68,990	69,816	14,578				
	Ave.	L_{eq}	59.2	57.9	58.8	53.8	-	-	-	-
		L_{10}	61.8	60.4	61.6	56.9	-	-	-	-
		L_{90}	55.4	54.1	54.4	48.3	-	-	-	-
	Max.	L_{eq}	82.7	77.6	78.8	76.2	-	-	-	-
		L_{10}	86.4	82.2	84.3	80.2	-	-	-	-
		L_{90}	77.0	73.1	72.2	70.8	-	-	-	-
	$\%L_{eq}$	>65dB	40.6	36.0	39.3	8.3	-	-	-	-
		>70dB	10.6	5.8	5.9	1.3	-	-	-	-
		>75dB	2.6	0.5	0.2	0.1	-	-	-	-
High Floor	***Time***		***0851-2053***	***0832-2032***	-	***0849-2052***	-	-	-	-
	Light Vehicle		93,125	52,347	-	8,700	-	-	-	-
	Heavy Vehicle		30,867	15,345	-	4,888	-	-	-	-
	Total Volume		123,992	67,692	-	13,588	-	-	-	-
	Ave.	L_{eq}	58.8	57.9	-	52.9	-	-	-	-
		L_{10}	61.3	60.2	-	55.6	-	-	-	-
		L_{90}	55.1	54.5	-	48.5	-	-	-	-
	Max.	L_{eq}	80.2	80.4	-	80.5	-	-	-	-
		L_{10}	85.6	86.3	-	85.2	-	-	-	-
		L_{90}	74.4	72.6	-	75.5	-	-	-	-
	$\%L_{eq}$	>65dB	37.1	36.6	-	9.0	-	-	-	-
		>70dB	8.8	5.2	-	2.3	-	-	-	-
		>75dB	2.1	0.7	-	0.6	-	-	-	-