Understanding noise exposure on high rise residential buildings Through Noise Mapping- A case of Kerala

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Abstract

Noise pollution is one of the most prominent, yet underrated environmental stressor. It has evolved to become a character trait of any typical urban setting, and the individuals exposed to acute and chronic environmental stressors are likely to develop physical and psychological setbacks in the long run. The dense population levels in Thiruvananthapuram, and the rising demands for living convenience, result in more and more high-rise dwellings shifting to major transit corridors. One of the most affected category of urban dwellers are the residents of high rise apartment buildings, situated along these roads. To have a better understanding of the complexity in noise distribution over an urban area, this study focuses on the vertical profile noise distribution affecting high-rise buildings in the city of Thiruvananthapuram, with the aid of field measurements like L10, L90 and Leq values.

Here, we present two cases within existing residential zones as per the proposed land use plan for 2031 Thiruvananthapuram Corporation. The noise levels experienced during the peak hours are recorded from different heights. Further, the influence of various parameters like ground cover, meteorological factors, traffic volume, vehicular composition, traffic speed, honking intervals, position of the source and receiver, etc. are studied. This is followed by an attempt to generate noise maps of the selected cases using Sound plan software. Along with the environmental parameters the behavioural patterns of the residents also attribute to noise ingress, and has been discussed to understand the dynamic nature of noise propagation along a vertical profile, in the context of Thiruvananthapuram.

Keywords: Road traffic noise, Transit corridor, façade mapping, vertical profile, noise distribution, high rise apartment, mitigation, noise ingress

1. Introduction

Urbanization in Kerala is growing at a pace faster than that of the country. So is the growth in the demand for housing and transportation. In Order to cater to the ever-rising housing demand in Kerala, vertical housing development is growing rapidly in most developing cities. In the context of ribbon development that is taking place in cities like Thiruvananthapuram, high rise residential buildings are often placed along major traffic arteries. This implies that a significant number of urban dwellers are exposed to traffic noise. However, the inhabitants in these building, over time, tend to adapt themselves to this environmental stressor and often ignore the adverse effects of environmental noise.

According to the World Health Organization (WHO) Regional Office for Europe, after air pollution, noise pollution originating from roadways is the second most hazardous issue that directly or indirectly affects the health and well-being of a population.

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Consequently, it has set the acceptable noise intensity threshold at 53 dB (A) during the daytime (WHO, 2018). Despite of the existing regulations in noise levels, the recorded levels are significantly high in the urban context of Kerala. Prolonged exposure is likely to have long term repercussions on individuals exposed to these noise levels on a daily basis.

This calls for a critical evaluation of noise exposure on residential buildings abutting major transit corridors, in the urban context of Kerala. Understanding the impact of multiple parameters on Noise propagation is integral to determining effects of vehicular traffic noise on high rise structures, especially in the case of residential buildings. This will further aid planning and architectural design.This paper is an attempt to understand noise exposure on high rise residential buildings through noise mapping, in a context very specific to the heterogeneous traffic conditions in Kerala. Sound Plan Essential 5.1 software has been used forgenerating the noise map for the selected cases.

2. Objectives and Methodology

The goal of the study is to understand noise exposure on high rise residential buildings through facade noise mapping, in the context of Kerala. The following are the major objectives addressed.

- To study the noise propagation at different heights, in different urban contexts in Trivandrum, (Commercial, Residential, Silent zones)
- Facade noise mapping at different levels
- Understanding heterogeneous character of traffic in Trivandrum
- Influence of occupant behaviour and noise exposure, through subjective questionnaire survey.

The study can be broadly divided into 3 parts. The first part includes identification of the study areas and representative buildings based on proposed landuse plans, existing literature, traffic volume data etc.Accordingly the proposed residential zone in Srikaryam, abutting NH66 was chosen as the first case. The second case was located along a smaller district road connecting Srikaryam to Kulathur. 2 apartment buildings of heights 40-50 were identified along the transit routes.

The second part include field measurements from the the identified case studies. The instrument used for measurement was the KUSAM-MECO Digital Sound Level Meter Model Type-KM928 MK-1. The following parameters were measured from the live case:

- Number of Vehicles
- Type of vehicles (heavy/ light)
- Speed of vehicles
- Honking (interval, number)
- Sound pressure levels at different heights measured simultaneously
- Subjective Questionnaire survey
- Meteorological Parameters

With the live measurement data, and existing literature study, various parameters that contribute to noise propagation along a vertical profile were identified.In a study conducted in Milan, Italy, it was found out that the characteristics of the urban context in which a specific building is located, determine the noise level profile with the height, with higher noise exposure at higher floors. To have a better understanding of this complexity in noise distribution over an urban area, this study focuses on the vertical noise profile distribution affecting high-rise buildings in the city of Trivandrum.

The third part of the study include preparation of noise maps and façade noise maps in the SoundPlan Essential 5.1 software. Both the cases are modelled using the software and simulated for day time defined as 6:00 am to 10:00 pm. The results are compared with the live measurements, and the noise control standards set out in the Noise Pollution (Regulation And Control) Rules, 2000.

Further the results are integrated with the occupant behavior patterns obtained using the subjective survey from the residents in the apartments from where live measurements were taken. This is then used to draw general trends/ relationships in noise propagation vertical profile and occupant behavior patterns.

Figure 1 outlines the methodology adopted for this study.

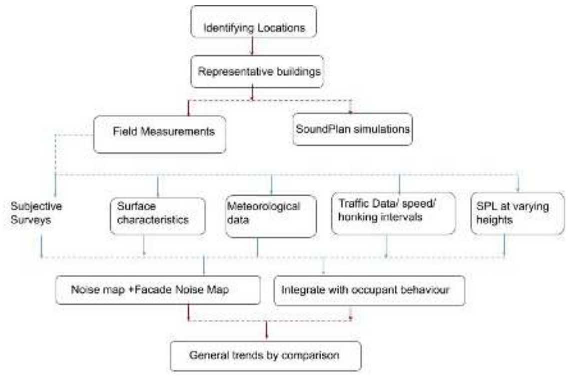

Figure 1 : Methodology

Figure2 : Instruments used

3. Field Measurements

3.1 Case 1 – Apartment Building, Kallampally, Trivandrum

This apartment complex, located in Kallampally, near Srikaryam abuts the National Highway 66. The NH66 connects IT hub of Kazhakoottam, institutional zone around Srikaryam, and the Government Medical College at Ulloorto the Thiruvananthapuram Central. Hence the 15 m wide road abutting the apartment complex experience a traffic volume of around 4000 vph. The building is 12 storeys tall and has an extended commercial block in the ground and first floor. The residential block is set 21m away from the road and the commercial block stretches 15m further towards the road.

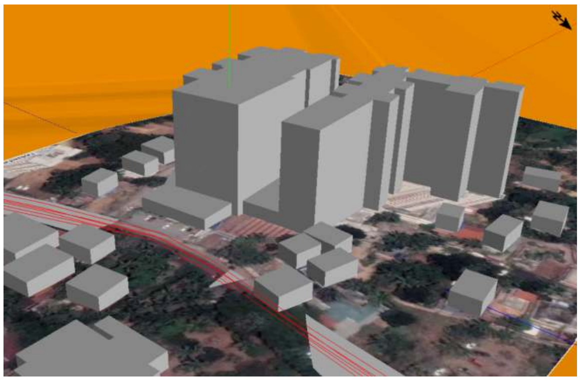

Figure 3 Case 1

In order to evaluate the traffic noise exposure in the apartments, field measurements were taken during the peak hour on a working day. The noise level readings were taken simultaneously from four different heights on the front and rear sides of the apartment complex. The live readings of traffic noise level were taken so as to validate the results from SoundPlan software. The readings were taken in three shifts for a duration of 15 minutes each, as in Table 1. Apart from Noise level readings, meteorological parameters were recorded from each floor as given in the Table 2. Live traffic data was collected through video recording and subjective surveys were conducted from each apartment chosen for the study.

The next step was to generate Grid noise map using the SoundPlan. This would predict the noise received at all the levels alonghorizontal and vertical profiles.The correction factors used by noise prediction programs include the type of vehicle, traffic volume, average speed, distance, type of pavement, surface absorption, crossroads and screening effects by obstacles.(Din, 2010)

3.2 Case 2 – Apartment Building, Srikaryam- Kulathoor road

This apartment complex is located along Srikaryam- Kulathoor road in

Thiruvananthapuram. Unlike the previous case this is smaller district road through a residential zone, connecting Kulathur to NH-66 Bypass road and is 7.5 m wide. The traffic volume during the evening peak hour is estimated to be 1200 vph. The traffic noise level readings were taken from the front façade alone and supporting data were collected and recorded as in the case 1.

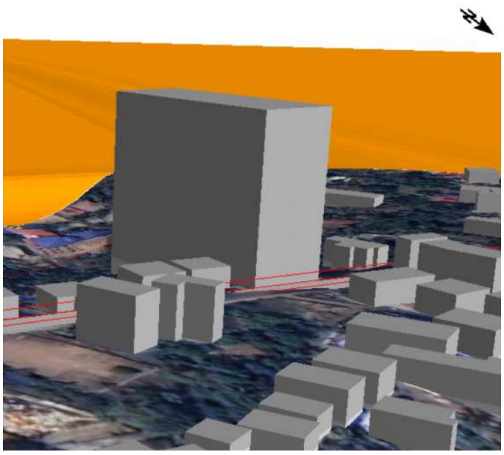

Figure 4 Case 2

The noise level readings were taken from 6:15 pm -6:30 pmduring the peak hour on a working day

Table 1: Climatic Data (Case 1)

Height	Temperature (°C)	Humidity (%)	Wind Speed (m/s)
12	29	77	0.51
20	28.6	77.2	0.57
32	29.1	77.7	0.82
44	29.2	77.9	0.89

Table2 : Field Measurement Plan

Samples	Time Period	Duration (min)	Facade	Heights (m)
1	6:15-6:30	15	Front	12, 20, 32, 44
2	7:00-7:15	15	Front	12, 44
3	7:00-7:15	15	Rear	8, 40

4. Results and Discussions

4.1 Variation along Vertical Profile

The study focuses on the vertical noise distribution and the various parameters that contribute to it. The study shows that there is considerable changes in the noise level profile that can be attributed to the characteristics of the urban context that the building is situated in. The results are presented in the diagrams and tables below.

4.2 Primary Observations from Field Measurements and Simulations

The Leq values in the first shift 75.92dB in the 3rd floor to 70.62dB in the 12th floor. However the value goes up to 74.5dB in the 8th floor. This variation can be attributed to the commercial block and its glass facade that is reflecting the traffic noise upward, thus buffering the lower floors from direct noise. This requires further field measurements on the immediate floors above and below the 8th floor to confirm.

The Leq values in the second shift varies from 72.66dB (3rd floor) to 71.08dB (12th floor) along the front facade which is 21 m from the road. At 90 m from the road the Leq values varies from 52.54dB (2nd floor) to 51.35dB (11th floor). There is a difference of at least 20 dB and can be attributed to the multiple obstructions in between.

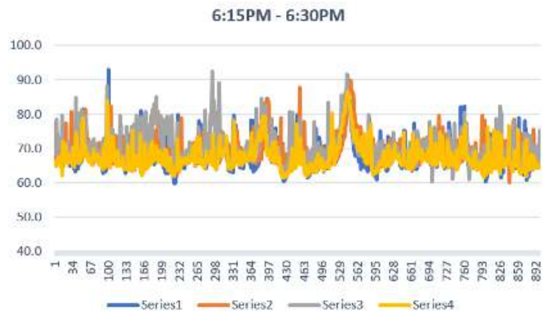

Figure 5 Session 1: SL readings- Front Façade (Field)

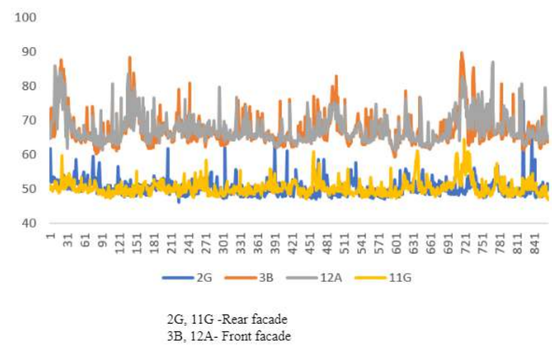

Figure 6 Session 2: SL readings- Front and rear façade (rear)

In Case 2, it can be observed that the Sound Pressure level uniformly varies from 79.9 dBA at 4 m height to 65.57dBA at 40m height. There is a sudden drop at 12 m where it comes down to 70.9dBA, and gradually declines to 67.57 at 40m.

This fluctuation in the 2 cases studied can be attributed to the adjacent buildings, traffic volume and distance from the source.

4.3 Role of Traffic Volume

From the traffic analysis in Case 1, it has been found out that the number of vehicles per hour is around 4000.2 wheelers form the major share of traffic and the frequency of horns is more than 16 per minute. (average). As per literature, if number of horns > 16, the percentage of time occupied by horn sound > 26%, and the increase in Leq is 12dB.

In the case 1 considered, the average number of horns per minute is 16.

Also literature suggests that for Leq, the reduction per doubling of distance varied from

- 4.5 dBA for volumes of 2,001 to 3,000 vph
- to 4.7 dBA for volumes between 1,000 and 2,000
- to 4.9 dBA for volumes less than 1 ,000 vph(Agent, 1981)

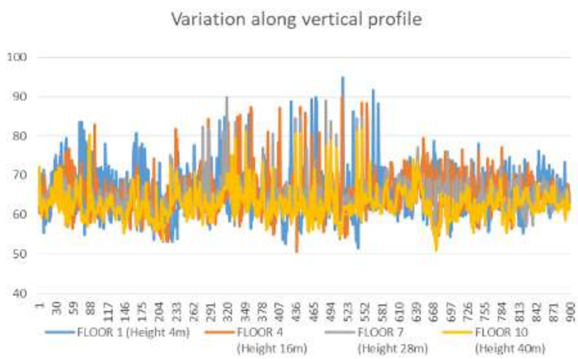

Figure 7 Case 2 Front Facade

4.4 Role of Distance from the Source

In Case 1, the residential block of the apartment complex is situated at 21m away from the road. Whereas in the second case, it is only 7m from the road. This can have significant impact on the noise perceived along the vertical profile. In the first case,the noise at the source (road edge) is 75.8 dB, and it reduces to 72.6dB in the third floor, which is 21 m from the road. This slightly increase in an intermediate floor and then gradually decreases. A similar trend is observed in an adjacent building 75 m from the source.

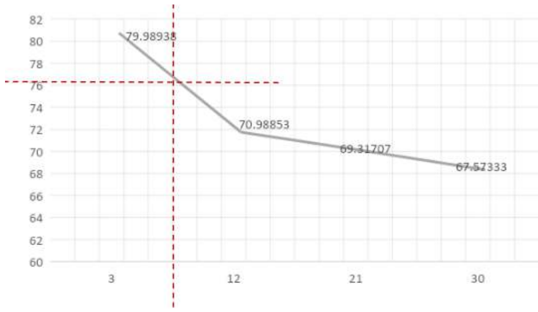

Figure 8 Case 2 Noise Propagation

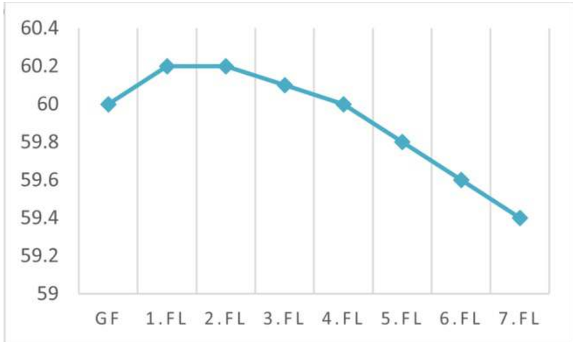

Figure 9 : Adjacent Building at 75m from the source

However the rear side of the building noise propagation seems to reverse in pattern. The readings are gradually increasing from ground floor to the 12th floor at the rear facade, which is 90m from the source.

A similar increase can be seen in the second case also, where the rear façade is around 70m from the source. But here, the noise decreases first and then goes up. This indicates that with increase in the distance from the source, the pattern of noise propagation changes. There could be multiple other factors that contribute to noise propagation along the vertical profile which requires extensive study in the future.

4.5 Observations from the Subjective Survey

From the traffic analysis, it has been found out that the inhabitants in apartments along the front facade have adapted to the traffic noise and are less sensitive to traffic noise. They respond to noise ingress by shutting down windows facing the road, closing balconies using glass panelling etc.65% of the inhabitants on the front facade rarely opens the windows facing the road, and use balconies only for cloth-drying etc. The major source of annoyance was identified as the frequent ambulance services as the apartment is situated along the route to Medical College andis observed to be around 4-6 numbers in an hour, on an average.

5. Noise maps using Sound Plan Professional 9.0

Case 1 – Apartment Building, Kallampally, Trivandrum

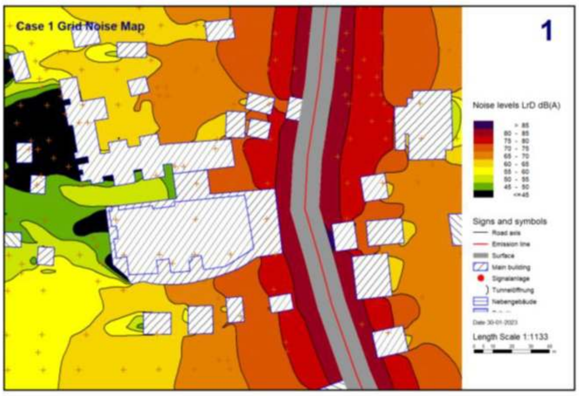

Figure 10 Case1 Grid noise Map

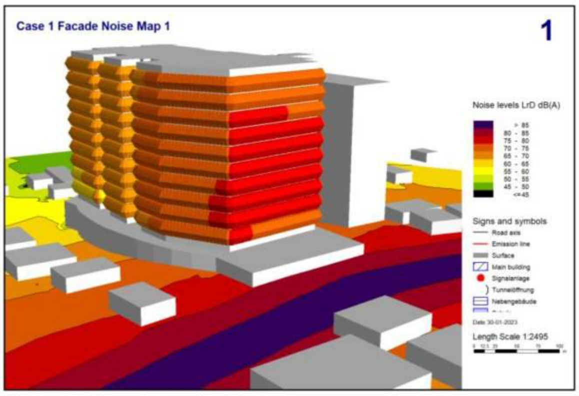

Figure 11 Case 1 Facade Noise Map

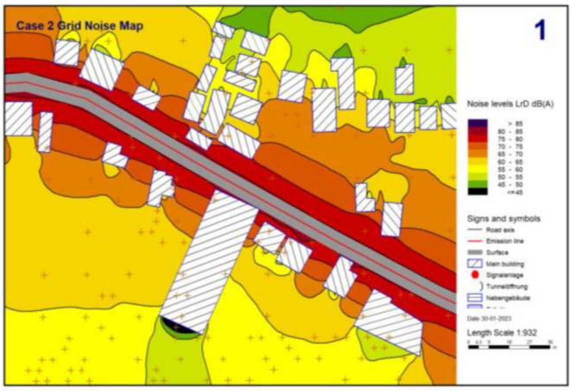

Figure 12 Case 2 Grid noise Map

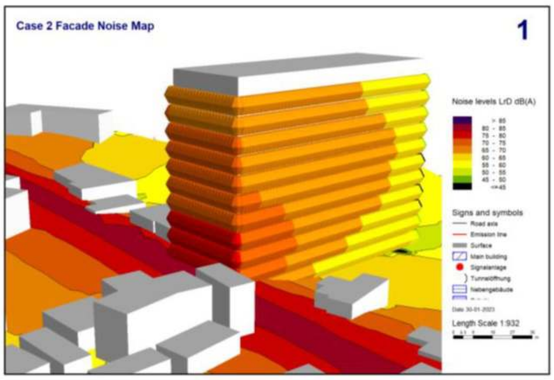

Figure 13 Case 2 Facade noise Map

6. Conclusion

From the study it has been understood that the propagation of traffic noise varies significantly with distance from the road, adjacent buildings, façade materials, traffic volume, vehicular distribution on road, honking intervals, etc. The study indicates that the noise propagation near the roads tend to decrease with increasing height. Whereas, as the receivers shift further away from the source, the pattern changes. At the rear façade of buildings, the traffic noise level could reverse its pattern of propagation and could increase with increasing height. This trend need further investigation in the context of Kerala.

All these factors together contribute to the noise that is being experienced within the living quarters. However the interventions architects can make is limited to the built infrastructure. Further studies on the various parameters affecting noise propagation along a vertical profile, including meteorological factors are much needed. This study is an attempt to understand the impact of traffic noise distribution on the behavioral aspects of inhabitants in high rise residential buildings. It has been found out that people incorporate mitigative measures to reduce noise exposure. In the worst case scenario, people develop a sense of learned helplessness, wherein they adapt to the high noise level exposure and are no longer sensitive to noise. This long term exposure to noise can have serious repercussions on the physical and psychological health of individual residing in these high rise buildings. Thus further research on these grounds can bring light into the concept of ‘acoustic comfort’ while designing high rise buildings in the context of Kerala.

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