

Research on the Law of Traffic Noise Influence

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ABSTRACT

It is well known that noise has been listed as one of the public hazards. As the number of cars goes up, the noise on the roads has been a serious disturbance to the surrounding buildings and citizens. So in this paper, some measurements of the noise assessment of road vehicles were discussed, like using noise calculation software to simulate the real situation on the road and using tables and charts to contrast data. Line chart was used to analyze the noise made from each part of a car. It is found that many factors have influences on noise and this paper also finds main sources of vehicle noise (burning noise, machinery noise, inlet and outlet noise, tyre noise). After using these methods to measure road noise, some noise treatment measures can be applied to reduce road noise and protect residents from noise interference. For instance, the height of public facilities should be increased in advance on the premise of not blocking the lighting of residential buildings.

Keywords: Traffic noise, affecting factors, measuring ways, different layouts.

1. INTRODUCTION

Nowadays, the figure for vehicles has increased drastically, which brings much more annoying traffic noise to the vicinity of the road. Urban traffic noise has been listed as one of public hazards[1]. Noise is very aggravating that it cannot be seen or be touched but can only be heard, which no doubt brings difficulties to the measurement and evaluation of it. So in this paper, line charts and statistical tables are used to visualize the impact of noise on the roads. Quantities of data are listed in this paper to help us understand the impact of traffic noise more visually. We aim to find the influencing factors of noise and whether buildings with different layouts are affected by different levels of noise.

2. METHODOLOGY

Instead of calculating equivalent noise levels, the original version of CRTN calculated L10 levels[2]. L10, indicating that 10% of the time (or the number of samples) exceeds the sound level within the specified time, which is called the cumulative percentage level. If $L10 = 60\text{dB}$, it means that the noise exceeds 60dB in 10% of the measurement period. L10 levels are used for low flow roads or high emission variations, with high levels of about 3~5dB. Meanwhile, the CRTN model has additional corrections for low flowing roads. An institution in France called "Guide du Bruit des Transport

Terrestres" also gives the distinction between constant and accelerated traffic. As for driving at a low speed of 30-50km/h, there is a 3~6dB gap between light vehicles and heavy vehicles. The Dutch calculation also corrected for areas near intersections or high-speed ramps[3]. These calculations make additional adjustments for a variety of road noise emissions. These corrections are usually in 2~3dB range and can reach a maximum of 6~10dB at the lower end. The noise measurement standards of different countries also provide certain guidance and reference for the study of traffic noise law in this paper. In this paper, the noise calculation software Cadna/A is used as a tool to establish different traffic models, and a series of data tables are obtained by controlling different parameters. Finally, the rough traffic noise law is obtained by comparing the data.

3. THE INFLUENCING RULES OF TRAFFIC NOISE ALONGSIDE THE ROAD

3.1. Noise at different distances from the road

To explore the influencing laws of traffic noise, this paper uses a very professional German noise calculation software called Cadna/A to establish a model of a city road to compute and analyze the influence of noise at different points in the horizontal section and vertical section in the surrounding open area. The main calculation parameters are: road width 30m, traffic flow

1000pcu /h, speed 50km/h, heavy vehicle proportion of 20%. The calculation results are shown in Table 1 and Table 2 respectively.

Table 1 The influence value of traffic noise at different distances on both sides of the road

Distance from the center of the road(m)	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
influence value of traffic noise(dB)	64.0	62.5	61.1	60.3	59.4	58.9	58.5	57.8	57.4	56.9	56.5	56.0	55.7	55.3	55.1	54.8	54.4

According to the calculative results in Table 1, we can see that the influence degree of traffic noise at different

distances on both sides of the road decreases with the increase of distance.

Table 2 Vertical propagation regularity of road traffic noise (50 m and 100m from road center)

Altitude above ground	Number of building floors	Noise value at 50m (dB)	Noise value at 100m (dB)
1.5	First floor	62.1	58.6
4.5	Second floor	63.4	59.0
7.5	Third floor	64.2	59.3
10.5	Fourth floor	65.3	59.8
13.5	Fifth floor	65.5	60.1
16.5	Sixth floor	65.6	60.5
19.5	Seventh floor	65.7	61.0
22.5	Eighth floor	65.8	61.3
25.5	Ninth floor	65.8	61.6
28.5	Tenth floor	65.7	61.9
31.5	Eleventh floor	65.5	62.0
34.5	Twelfth floor	65.4	62.1
37.5	Thirteenth floor	65.2	62.1
40.5	Fourteenth floor	65.1	62.2
43.5	Fifteenth floor	64.9	62.2
46.5	Sixteenth floor	64.7	62.1
49.5	Seventeenth floor	64.6	62.1
52.5	Eighteenth floor	64.4	62.0
55.5	Nineteenth floor	64.2	61.9

According to the calculative results in Table 2, we can see that the influence value of traffic noise on different floors on both sides of the engineering line presents a trend of "increasing - peak - decreasing" with the increase of the height.

3.2. Traffic noise produced by different traffic flow

Traffic flow refers to the number of vehicles passing a certain road section in a certain period of time according to the standard of vehicles passing a certain road section[4]. According to the research of Jiang L and Kang J, various traffic flows on the road will also produce different levels of traffic noise[5]. In order to explore the

influence law, I continue to use Cadna/A noise calculation software to establish an urban road model, and measure and calculate the influence value of noise 100 meters away from the road under different traffic flows. The main calculation parameters are as follows: the road width 20m, the speed 50m/s, the proportion of heavy vehicles 20%. The calculation results are shown in Table 3.

Table 3 Influence value of noise 100 meters away from road under different traffic flow

Traffic flow(pcu/h)	influence value of traffic noise(dB)
700	49.0
750	50.5
800	52.1
850	53.7
900	55.6
950	57.3
1000	58.5
1050	59.3
1100	60.4
1150	61.2
1200	61.8
1250	62.5
1300	63.1
1350	63.8
1400	64.6
1450	65.1
1500	65.3
1550	65.4
1600	65.4

It can be seen from Table 3 that, with the increase in distance, the influence value of noise at 100 meters away from the road center keeps increasing. When the traffic flow is small, the influence value of noise increases rapidly. While when the traffic flow is large, the influence value of noise increases slowly, and finally tends to a stable value.

3.3. The influence of noise on buildings with different layouts

The investigation shows that the residential areas being developed at present often adopt the layout way of setting up public buildings along the road or building residential buildings directly[6]. In this paper, the following four typical layout conditions are set

respectively in the established road model in Cadna/A noise calculation software.

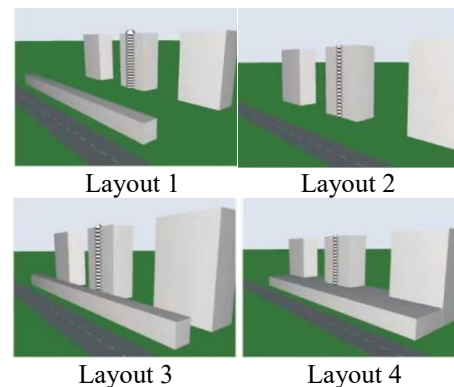


Fig.1 Allocation of typical residence area along the road

Layout 1: A three-story public building (parallel to the road) near the road, 20 meters away from the road center line, and a 20-story building inside the road, 100 meters away from the road center line.

Layout 2: Residential buildings will be built directly along the road with a height of 20 floors and a distance of 50 meters from the center line of the road.

Layout 3: A three-story public building (parallel to the road) near the road, 20 meters away from the road center line, and a 20-story building inside the road, 50 meters away from the road center line.

Layout 4: There is a 20-story building with a 3-story public podium and tower (mainly for residential functions) near the road. The podium is 20 meters away from the center line of the road and the tower is 50 meters away from the center line of the road.

In the model, the height of the residential building is set as three meters, and the public building and podium floor are set as four meters. See Fig.1 for the relative position of the above four residential buildings and roads.

According to the calculation of the above model, the influence value of road traffic noise at 1 meter from the window of the first row of residential buildings near the road in the four layout forms is shown in Table 4. See Fig.2 for 3D isosound level diagrams generated by software.

Table 4 Noise impact on residential area for different layout forms

Building storey	Layout 1	Layout 2	Layout 3	Layout 4
First floor	52.7	62.5	50.3	—
Second floor	53.0	63.4	50.6	—
Third floor	53.2	64.4	51.1	—
Fourth floor	53.4	65.3	51.7	51.3
Fifth floor	53.7	65.8	52.9	52.7
Sixth floor	53.9	65.9	54.2	54.0

Seventh floor	54.2	65.9	55.7	55.5
Eighth floor	54.4	66.0	58.3	58.1
Ninth floor	54.7	65.9	59.7	59.9
Tenth floor	54.9	65.8	61.0	61.3
Eleventh floor	55.1	65.7	63.1	63.4
Twelfth floor	55.5	65.5	63.9	64.3
Thirteenth floor	56.1	65.2	65.1	65.5
Fourteenth floor	56.7	65.0	65.2	65.1
Fifteenth floor	57.3	64.8	64.8	64.7
Sixteenth floor	57.6	64.7	64.5	64.4
Seventeenth floor	59.9	64.5	64.3	64.2
Eighteenth floor	60.0	64.3	64.2	64.0
Nineteenth floor	60.2	64.2	64.1	63.7

In the case of layout 2, the noise influence value of each floor is basically consistent with the vertical section noise value calculated in the open space, and the residents near the road in this type of community are more seriously affected by traffic noise than other layout methods.

The construction of public facilities on the road side of the residential district has a good shielding effect on traffic noise, and the noise value behind the building can be reduced by more than 10dB compared with that on the road side. The distance between the residential buildings in Layout 2 and Layout 3 and the center line of the road is 50 meters, but the influence value of the noise in layout 3 is significantly lower than that in Layout 2.

The noise reduction effect of the residential buildings in Layout 3 is slightly worse from the 13th floor to the 15th floor, and basically does not decrease below the 15th floor.

The height of public buildings set in Layout 1 is the same as that in Layout 3, but residential buildings are far away from public buildings, and more floors are in the area of sound and shadow, so the noise reduction effect of public buildings is more obvious.

There is no significant difference between Layout 3 and Layout 4, indicating that the shielding effect of public facilities adjacent to the road is only related to the height of public buildings and the distance between residential buildings and public buildings.

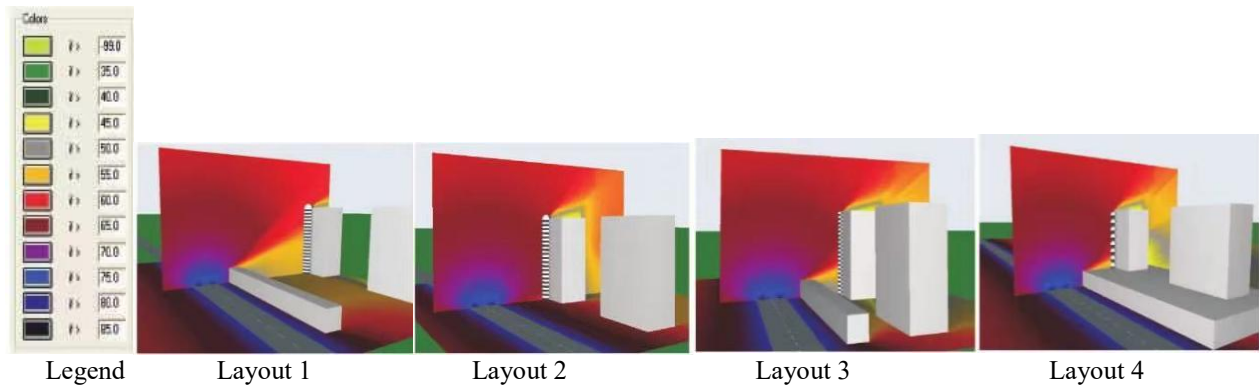


Fig.2 3D diagram of noise effect at various allocations

4. ANALYSIS OF TRAFFIC VEHICLE NOISE

4.1 Sources of road vehicle noise

Noise sources of road vehicles are: First: engine/pulsating noise, including ventilation system and exhaust; Second: Tire/road noise; Third: Aerodynamic noise.

All of these sources of noise are more or less speed-related. Tyre/road noise and aerodynamic noise generally increase as vehicle speed increases. Engine noise has more to do with engine speed. Figure 3 shows engine noise and tyre/road noise emissions relative to speed. Aerodynamic noise is noticeable at operating speeds of 200~250km/h.

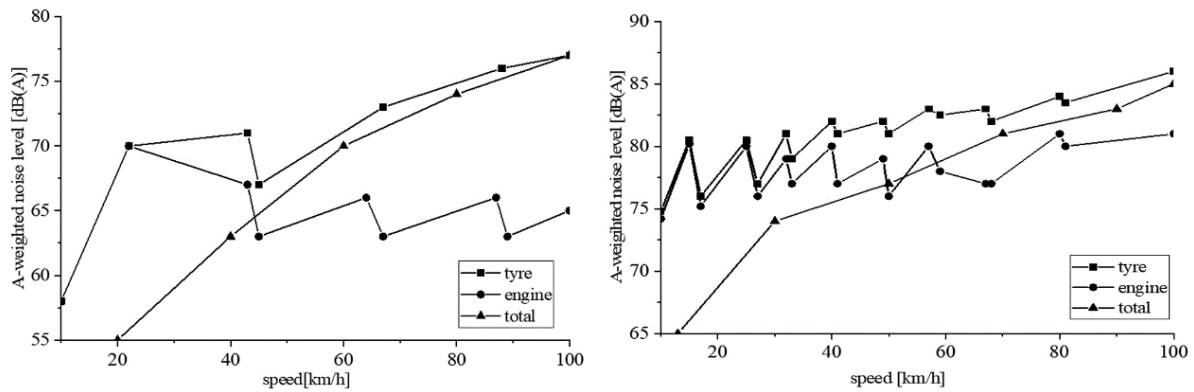


Fig.3 Relationship between vehicle speed and engine noise and tyre/road noise of light and heavy vehicles

As can be seen from the figure, the tyre/engine noise of light vehicles is lower than that of heavy vehicles at the same speed. Light vehicles produce more tyre noise than engine noise at higher speeds, while heavy vehicles produce similar tyre and engine noise at all speeds.

4.2. Simulation of tyre/road noise and engine noise

Tyre/road noise and engine noise are more affected by vehicle acceleration, and generally, the greater the acceleration, the greater the noise[7]. The coordination/imagination calculation method gives separate algorithms for simulating tire/road noise and

engine noise. This separate method allows us to calculate at nodes with different parameters.

Figures 4a and 4b show a simulation of an intersection. The simulation is based on a simple intersection where all vehicles need to stop. Due to the small traffic flow and the shielding effect of buildings, it is assumed that the influence of traffic on one side of the intersection is relatively small, which can be ignored when determining the considered road level. The effective source distance of vehicles at the entrance and exit intersection is 5 meters, and only light vehicles (category 1 vehicles) are simulated, as shown in Fig. 4.

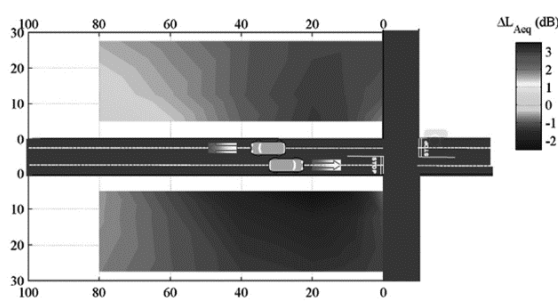


Fig.4a speed:50km/h acceleration:1m/s²

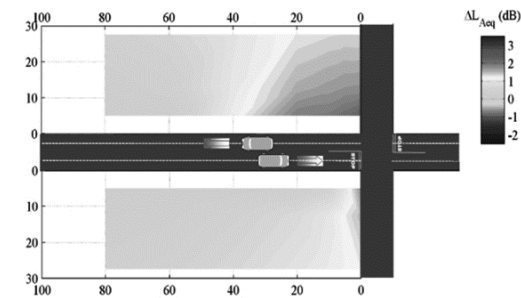


Fig.4b speed:50km/h acceleration:2m/s²

The simulations are unstable as a result of simulating several scenarios based on the assumptions made. The effect of low acceleration on high acceleration is about 4~5dB and is local, so the highest level usually occurs within 15m of the intersection and becomes lower further from the intersection. The results show that the effect of low noise asphalt will be improved with the decrease in the noise of tire pavement.

4.3. Influence of driving behavior

Eco-driving has also been shown to have a significant positive impact on fuel consumption, carbon dioxide reduction and traffic safety[8]. As can be seen from the measurement results in Fig. 3, at a speed of about 40km/h, tyre/road noise dominates. The higher the engine speed, the greater the noise, and the maximum difference in acceleration at road junctions was about

7dB from one sample to ten test vehicles. All vehicles are in top condition with no damage to exhaust. Roughly, the maximum difference between these vehicles at the intersection is about 15~20dB. But the numbers are higher for motorcycles.

Traffic noise increases when accelerating at intersections, at traffic lights, or on bumps in the road or on decelerating ramps, while tire noise is relatively low. Intense driving produces higher noise levels than eco-driving. These noise levels are up to 7dB. If the exhaust system is damaged, there will be a difference of 15~20dB.

5. CONCLUSION

In this paper, the noise calculation software Cadna/A is used as A tool to establish different traffic models. By controlling different parameters, A series of data tables

are obtained. Finally, the rough traffic noise rules are obtained by comparing the data. It can be concluded that under the same other conditions, the farther away from the road's center, the smaller the influence value of road noise.

However, at the same distance from the road center line, with the increase in height, the influence value of noise increases first and then decreases, and reaches the peak value at the thirteenth to fifteenth floors

When other conditions are the same, with the increase of traffic flow, the influence value of traffic noise increases continuously and finally tends to be stable, because with the increase of traffic flow, road congestion may occur, and tire/engine noise may decrease, but horns will take its place.

According to the table of traffic noise influence value of residential areas with different layout situation, this paper suggests that public facilities should be set on the side of the adjacent road as far as possible when planning the new residential area near the road, and should be arranged in a long strip parallel to the road. The height of public facilities should be increased in advance on the premise of not blocking the lighting of residential buildings and meeting planning requirements; The residential buildings behind public building establishment can be distributed in ladder form, namely the residential building near the public building should reduce floor, the floor of the distance increases appropriately.

Light vehicles have lower tyre/engine noise than heavy vehicles at the same speed. Light vehicles produce more tyre noise than engine noise at higher speeds, while heavy vehicles produce similar tyre and engine noise at all speeds.

This paper only explores the qualitative relationship between road noise and a series of factors for the time being, but it is not able to give an accurate function expression, and lacks a good analysis method for the obtained data.

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