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Noise distribution change of the backside urban blocks depending on the plans of the roadside buildings

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ABSTRACT

It is necessary to investigate the noises of backside blocks which are transmitted through the roadside buildings since many old residences and shops are located in these areas. The noise of the backside roads is influenced by the following factors such as the height of the roadside buildings, the distance between the road and the backside streets, distance among adjacent roadside buildings, and the difference of the adjacent building heights.

The present paper aims to investigate the influence of these factors on the noise of the backside area of the roads. In order to this, the noise levels were measured in 9 urban blocks of a city. The both noise levels on the road and the backside street were measured simultaneously at the designated points of each urban block.

As the results, there is no significant noise reduction due to the width of the buildings in general. However, in the cases of buildings arranged on one axis beside the road, it was found that the average noise reduction was 12dB on the basis of the building height of 4m. Also, it was found that for each 4m increase of the building height, noise reduction occurred by 2dB. In general, it was proved that the noise of the back streets is mainly affected by the lowest height of the roadside buildings. It was found that noise is increased by 1dB for each 4m increase of the height difference between adjacent buildings. Also, it was revealed that for each 0.5m increase in the distance between roadside building, noise is increased by 1dB.

Finally, the equation for calculating the reduced noise level at the backside area is suggested. Through the experimental verification, it was revealed that the suggested formula can be a g ood method for predicting the reduced noise levels at the backside area of an urban block. Also, it was confirmed that the noise of the backside area is affected by the plan and buildi ng dimensions of the roadside buildings.

Keywords: Road traffic noise, Urban block, Backside area, Roadside buildings, Noise levels

1. INTRODUCTION

Noises from the main roads reach backside area through the roadside buildings. However, the noise of the back district is important (1) since many shops and residences are located in these areas. The noise of the backside roads is affected by the following factors such as the height of the roadside buildings, the distance between the road and the side streets, distance among adjacent roadside buildings, and the difference of the adjacent building heights. The present paper aims to investigate the influence of these factors on the noise of the backside area of the main city roads.

Many software programs for predicting noises are easy to present the 3D mapping with the inclusion of many variable, however they are not sufficient for considering the reflection and diffraction effects of the noises in the real environment. That is why there is not little difference between the predicted noises and real measured noises in the complex city where many buildings are concentrated in a city block.

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2. MEASUREMENT OF THE ROAD TRAFFIC NOISES

2.1 Target Urban Blocks Investigated

The urban blocks are built in lattice type by the intersection of the roads. In urban blocks, there are various types of buildings with different shapes so that they may have their own characteristics in transmitting the noises through them to backside area. Also, there are many spaces among buildings which can be the passages of noise transmission to the backside area. (2)

In order to investigate the influence of the roadside buildings on the noise of backside area, 9 blocks were selected in a busy city in Korea. All the blocks have traffic noise levels of more than 10dB in comparison with the background noise levels. Table 1 shows the road width, speed limit, and traffic volume of each target areas investigated. The geometric and space information of roadside buildings was obtained through the Spatial Open Platform of the National Geographic Information Institute (3,4). Traffic volumes were investigated by the camera for 5 minutes.

Table 1 – Road width and traffic volume in the 9 target urban blocks.

Target blocks	Speed limit	Road width	Traffic volume (for 5 min)	
			light vehicle	Heavy vehicles
A	50 km/h	21.8 m	142	22
B	50 km/h	15 m	105	12
C	50 km/h	15.4 m	98	10
D	60 km/h	15 m	115	23
E	50 km/h	20.1 m	112	17
F	50 km/h	13.2 m	67	5
G	30 km/h	13 m	108	16
H	60 km/h	34 m	358	31
I	60 km/h	34.2 m	342	21

2.2 Road Traffic Noise Measurements

Noise measurements were carried out during the daytime at the 9 blocks. The noise levels on the both roadside road and backside streets were measured simultaneously. Leq for 10 seconds were measured during the vehicles' driving. Noises were measured at the several points including the center and end points of buildings and the point in between adjacent buildings. Microphones were place 1m away from the outer wall of buildings with height of 1.5m from the floor. Fig. 1 displays the noise measurement points of each block and the division of the backside area (X and Y).

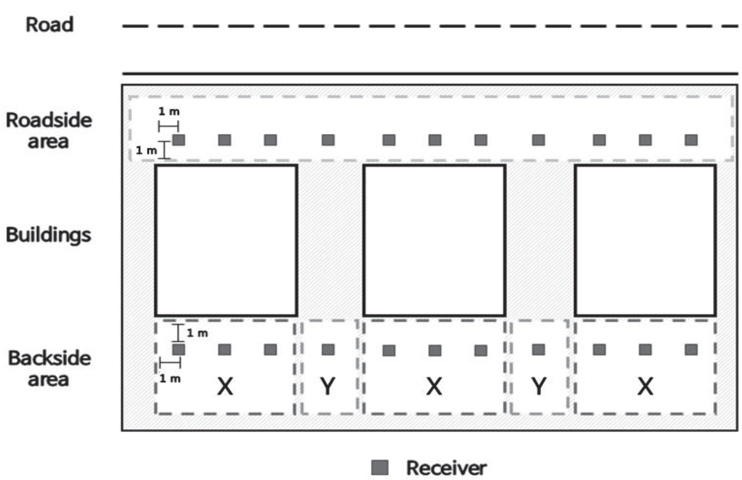

Figure 1 – Location of noise measurement positions and the division of backside areas (X and Y)

2.3 Results of the Noise Measurements

As a result, the roadside noise levels of the 9 urban blocks were from 67.0dB to 75.6dB in average, meanwhile backside noise levels were from 49.3 dB to 57.2dB. Table 2 lists the average noise levels of each roadside and backside streets of the 9 blocks. It was examined that roadside noise levels exceed the noise criteria of 65dB in all the blocks, while backside noise levels exceed the noise criteria of 55dB in A,C,D,E,H blocks. The maximum noise reduction at the backside area was occurred at I block with 19.2dB.

Table 2 – Measured average noise levels of the roadside and backside area. dB(A)

Target block	Roadside noise [dB(A)]	Backside noise [dB(A)]	Noise difference [dB(A)]
A	71.4	56.0	15.4
B	67.0	53.0	14.0
C	71.0	55.7	15.3
D	69.6	55.9	13.7
E	71.4	56.6	14.8
F	69.0	52.7	16.3
G	67.1	49.3	17.8
H	71.9	55.5	16.4
I	71.8	52.6	19.2
Average	70.0	54.1	15.9

3. NOISES ANALYSIS IN THE BACKSIDE BLOCKS

3.1 Noise Analyses

Fig. 2 shows the definition of the dimensions of the roadside building which affect the noise levels at the backside area. Through the noise analysis, it was shown that noise levels at the backside region (X) of buildings and the region in between buildings (Y) are different. Noise levels at the center point and end points of the backside region (X) of building are also different since noises are diffracted at the edge of the buildings. Nevertheless, the average noise levels of X are used for analysis.

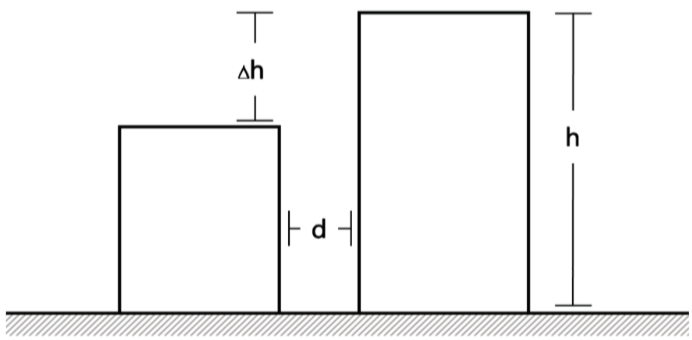

Figure 2 – Roadside building dimensions affecting the noise level of the backside area.

It was analyzed that noise levels in X region are being decreased with increasing building height. Fig. 3 displays the average reduced noise levels at X region according to the height of the roadside buildings. It was found that for each 4m increase of the building height, noise reduction occurred by 2dB in average. Table 3 shows the round-off noise levels deduced by the roadside building height.

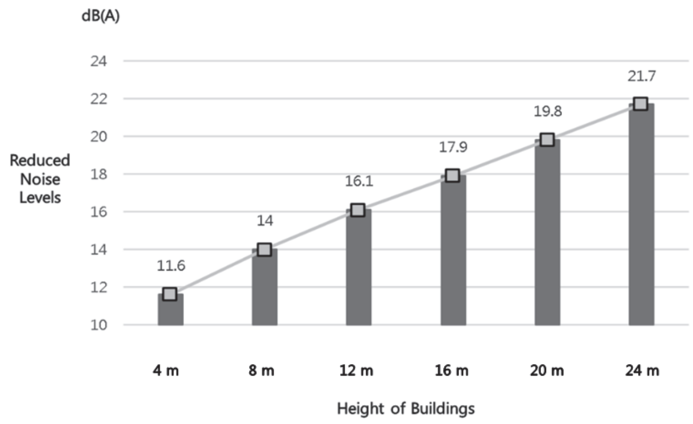

Figure 3 – Reduced noise levels at the backside area (X) by the building height (h).

Table 3 – Reduced noise levels in the backside area (X) by the building height (h).

Building height (h)	4 m	8 m	12 m	16 m	20 m	22 m
Reduced noise level (H)	12 dB(A)	14 dB(A)	16 dB(A)	18 dB(A)	20 dB(A)	22 dB(A)

The noise levels in Y region are different with the levels in X region. It was analyzed that noise levels in Y region are affected by three factors of the roadside buildings.

1) Height of the adjacent buildings (h)
2) Distance between adjacent buildings (d)
3) Difference of building height of adjacent buildings (Δh)

First, in case of that adjacent buildings have same height, the noise levels in Y region are also being decreased with increasing building height. Fig. 4 displays the average reduced noise levels at Y region according to the height of the roadside buildings when adjacent buildings are separated by 1.5m. It was found that for each 4m increase of the building height, noise reduction occurred by 3dB in average. This value is bigger than the reduced noise level at P region while the absolute values at Y region is still greater than those of P region.

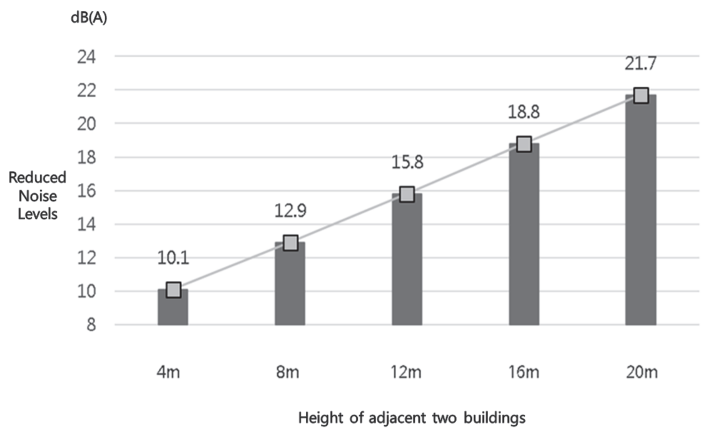

Figure 4 – Reduced noise levels at the backside area (Y), when the adjacent buildings have same height.

Secondly, when adjacent buildings have same height, the noise levels in Y region are increased by the separation distance between two adjacent buildings. Fig. 5 displays the average reduced noise levels at Y region according to the distance between two adjacent buildings with same height of 12m. It was revealed that for each 0.5m increase of the separation distance (d), noise increased by 1dB in average. This value is bigger than the reduced noise level at P region while the absolute values at Y region is still greater than those of X region.

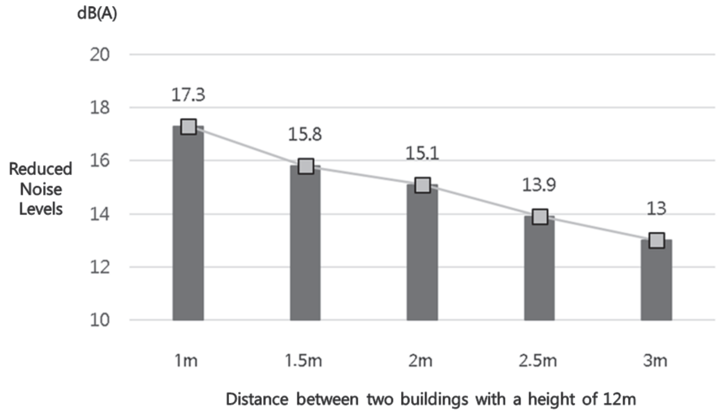

Figure 5 – Reduced noise levels at the backside area (Y) depending on the separation distance (d).

In order to find the variation of the noise levels in Y region affected by the buildings height (h) and the separation distance (d), the difference of the reduced noise levels at the X and Y region by those two factors are listed in Table 4.

Table 4 – Difference of reduced noise levels (D) at the backside area X and Y by two factors; separation distance(d) and the height (h) of adjacent buildings [dB(A)]

Items		Adjacent two buildings height (h)				
		4 m	8 m	12 m	16 m	20 m
Separation distance (d)	0.5 m	0	1	2	3	4
	1 m	-1	0	1	2	3
	1.5 m	-2	-1	0	1	2
	2 m	-3	-2	-1	0	1
	2.5 m	-4	-3	-2	-1	0

Lastly, when adjacent buildings have same separation distance, the noise levels in Y region are increased by the difference of the building height (Δh) of the two adjacent buildings. Fig. 6 displays the average reduced noise levels at Y region when one building with 4m height is adjacent with different heights of buildings. It was found that for each 4m increase of the difference of adjacent building height (Δh), noise increased by 1dB in average. Table 5 shows the averaged reduced noise levels at Y region depending on the height difference of adjacent buildings. It was also known that the noise levels in Y region are determined by the lower height of building when two adjacent buildings have different heights.

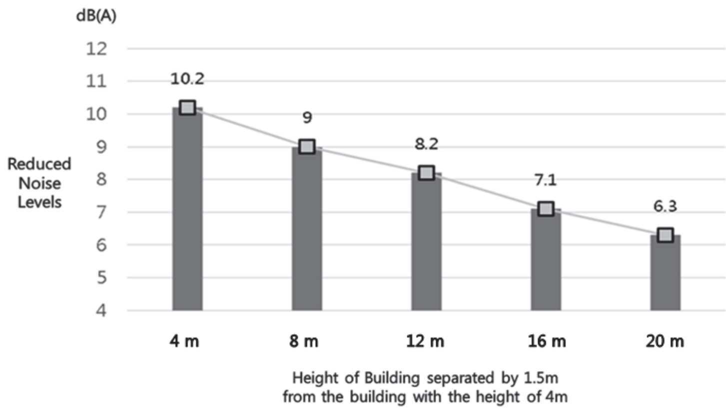

Figure 6 – Reduced noise levels at the Y region by the height difference (Δh) of the adjacent buildings, when the lower building is 4 m high with the separation distance of 1.5 m.

Table 5 – Reduced noise levels at the backside area (Y) depending on the height difference (Δh) of the adjacent two buildings.

Building height difference (Δh)	4 m	8 m	12 m
Reduced noise level (HD)	-1 dB(A)	-2 dB(A)	-3 dB(A)

3.2 Noise Prediction Formula suggested

Through the noise analysis of the three factors which affect the noise levels at the backside area, the equation for calculating the reduced noise level at the backside area is suggested as follow; (5)

$$RN = H + D + HD \text{ [dB(A)]}. \qquad (1)$$

where, RN : Reduced noise level at the Y region [dB(A)]
H : Reduced noise level at the X region by the building height (h) (refer to Table 4)
D : Reduced noise level at the Y region by separation distance of building (d) (refer to Table 5)
HD : Reduced noise level at the Y region by the building height difference (Δh) (refer to Table 6)

H and D are calculated on the basis of the lower height (h) of the two adjacent buildings. Since there are no buildings in front of Y region, reduced noise level (H) at the X region by the building height was used for calculation of the reduced noise level at Y region. It is also because there are almost same value of the reduced noise level at the both X & Y regions taking into account the factor of building height only.

4. VERIFICATION OF THE SUGGESTED FORMULA

In order to verify the suggested equation, two new blocks (P & Q blocks) were selected to be investigated besides 9 blocks. These two blocks have buildings with different height (h), separation distance (d), building t height difference (Δh) in comparison with the existing 9 blocks. The reduced noise level at the backside area of these two blocks were calculated using the suggested equation. Also, noise levels were measured in the same way at the P & Q blocks. Lastly, the measured level difference was compared with the predicted level using this equation.

Table 6 shows the information of the road traffic conditions of P & Q blocks. Table 7 shows the building heights (h) and the separation distance (d) of the four consecutive buildings in each P & Q blocks.

Table 6 – Road traffic conditions of P and Q blocks

Block	Speed limit	Road width	traffic volume (for 5 min)	
			Light vehicle	Heavy vehicles
P	60 km/h	21 m	158	30
Q	30 km/h	9 m	65	8

Table 7 – Building height and separation distance of the consecutive buildings in P & Q blocks.

Blocks	P				Q			
Building height (h)	P1	P2	P3	P4	Q1	Q2	Q3	Q4
	12.3 m	16.4 m	21.8 m	14.3 m	6 m	4 m	8 m	8 m

Blocks	P			Q		
Separation distance (d)	P1-P2	P2-P3	P3-P4	Q1-Q2	Q2-Q3	Q3-Q4
	1 m	0.5 m	1.1 m	2.2 m	2.1 m	1.86 m

Table 8 and Table 9 show the predicted and measured value of reduced noise levels at the X and Y regions of the P & Q blocks respectively. In Tables 8 and 9, it was revealed that the number of error of the predicted values of the reduced noise levels at the backside area is within 1 dB at the both X and Y regions which is smaller than the 3 dB JND of the noise levels.

Table 8 – Comparison of the reduced noise levels at the X region of P & Q blocks both predicted (H) and measured values [dB(A)]

Block		Predicted value (H)	Measured noise difference	Number of error
P	P1	16	15.9	0.1
	P2	18	18.2	0.2
	P3	21	21.4	0.4
	P4	17	16.1	0.9
	aver.	18	17.9	0.4
Q	Q1	13	13.2	0.2
	Q2	12	12.2	0.2
	Q3	14	14.5	0.5
	Q4	14	14.6	0.6
	aver.	13.25	13.63	0.38

Table 9 – Comparison of the reduced noise levels at the Y region of P & Q blocks both predicted (RN) and measured values [dB(A)]

Blocks		Predicted value (RN)	Measured noise difference	Number of error
P	P1-P2	16	17	1.0
	P2-P3	19	19.8	0.8
	P3-P4	16.5	15.9	0.6
	aver.	17.2	17.6	0.8
Q	Q1-Q2	8	8.8	0.8
	Q2-Q3	8	8.3	0.3
	Q3-Q4	12	11.7	0.3
	aver.	9.3	9.6	0.47

5. CONCLUSIONS

The present paper aims to predict the noise levels at the backside area using the only information of the roadside buildings. Through the results and the analyses of the study, it was revealed that the suggested formula can be a good method for predicting the reduced noise levels at the backside area of an urban block. Also, it was confirmed that the noise of the backside area is affected by the plan and building dimensions of the roadside buildings.

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