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A Study on the Characteristics of Railroad Traffic Noise

Hyung-Il Choi, Sang-Ill Park and Dong-Ick Yeom
Division of Environmental Engineering, Chosun University, Gwangju 501-759, Korea
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This study has been conducted to achieve the following objectives:

First, in order to understand the horizontal propagation and attenuation characteristics for the railroad traffic noise, we selected areas within 100 meters away from the railroad and then selected Saemaul-ho and Mugoongwha-ho as the subjects for our experiment. In this way, we analyzed the horizontal propagation and attenuation characteristics for the traffic noise occurring in diversified areas.

Second, in order to understand the vertical propagation and attenuation characteristics for the railroad traffic noise, we measured and analyzed the distributional characteristics of vertical sound pressure levels on each floor of multi-storied apartment buildings according to changes of traffic load and types, and the existence or nonexistence of soundproof walls. For the case of the railroad traffic noise, we also selected Samaul-ho and Mugoongwha-ho as the subjects for our experiment, and we measured and analyzed the different noise levels on each floor of multi-storied apartment buildings from the soundproof wall.

The results of Horizontal propagation and attenuation characteristics for the railroad traffic noise are as follows: In cases of the flat land, cutting land, and bridge area, as distance increases, the sound pressure level steadily decreases. The sound pressure level for the bridge area is higher than that of the flat land with a measurement of 5.5 ~ 10.2 dB(A).

Vertical propagation and attenuation characteristics for the railroad traffic noise are as follows: The amount of sound pressure level decrease is 14.2 ~ 14.8 dB(A) for Samaul-ho and 13.5 ~ 14.3 dB(A) for Mugoongwha-ho when measuring the vertical sound pressure levels at heights lower than 4.5 m, which indicates a fairly large decrease. At 6 m, the amount of decrease is 8.6 dB(A) for Samaul-ho and 8.2 dB(A) for Mugoongwha-ho, which indicates a small decrease.

Key Words : Railroad traffic noise, Attenuation characteristics

1. Introduction

Rapid industrialization and fast population growth in an urban area have reflected on various environmental problems. Traffic noise is especially becoming one of the serious facts that threaten the residents' sound and stable life as the number of automobiles and volume of physical flow is remarkably increasing.

The traffic noise that distresses the residents can be classified into road traffic noise and railroad traffic noise. The road traffic noise occurs consistently and irregularly, while the railroad traffic noise occurs intermittently caused by a frictional sound only when a train passes.

Though the government has designated the area that is deemed necessary to be regulated as the noise-restricted area in an effort to promote a sound and stable living condition for residents, it is currently facing many difficulties in regulating the traffic noise effectively and providing the ideal solution due to the lack of preceding studies and reliable data.

In general, in order to protect the residents against traffic noise that probably causes serious damage, a soundproof wall is an alternative solution. For this, the effects and any possible problems caused by such soundproof walls should be considered in depth, but the amount of research conducted so far concerning this issue is insufficient.

In general, a soundproof wall should be installed after fully considering the sound-related capability -

Corresponding Author : Hyung-Il Choi, Division of Environmental Engineering, Chosun University, Gwangju 501-759, Korea
Phone: +82-62-230-7152
E-mail: hichoi@mail.chosun.ac.kr

its capability to absorb sounds and the visual and psychological effects on the residents - so that the most effective soundproof wall with various shapes and materials can be installed.

Based on the outcome of this study, we believe that computer simulation may be a useful tool to predict the traffic noise accurately if more research is conducted in many different measurement conditions and accumulated to sufficient data. With the help of this data, we will be able to provide an improved solution for controlling the traffic noise more effectively.

2. Experimental

2.1. Measurement Apparatus and Method

This study was conducted in order to understand the horizontal and vertical propagation and attenuation characteristics for the railroad traffic noise. The area and measurement points were chosen in accordance to the purpose of the study, and measurements and analysis were obtained.

Components of the measurement instrument (CESVA SC-30) are the following.

1. Microphone ; CESVA, Type C-130
2. Microphone Preamplifier ; CESVA, PA-13

In order to understand the horizontal and vertical propagation and attenuation characteristics for the railroad traffic noise measurement method, a Microphone was placed 1.2 m from the surface of the earth and was directed towards the sound source. In order to minimize the influence of the reflection, the microphone must be placed 30 cm away from the observer and all other subjects.

This experiment was conducted between July 1, 2004 and Sept. 30, 2006 on weekdays during the day because the volume of traffic does not change drastically during daytime hours (06:00-22:00). Other factors that could influence the outcome of the study were avoided during the process of obtaining measurements and analysis.

2.2. Horizontal Attenuation for Railroad Traffic Noise Measurement Area

The designated measurement area is between Junnam S. city's Junra-sun D. station and S. station. Four different land conditions exist in this area - flatland, cutting land, raising ground, and bridge - and measurements were obtained by conducting experiments on all four.

As shown in Fig. 1, there are six measuring points that are 10, 20, 30, 50, 75 and 100 m from the railroad. Samaul-ho and Mugoongwha-ho, which are

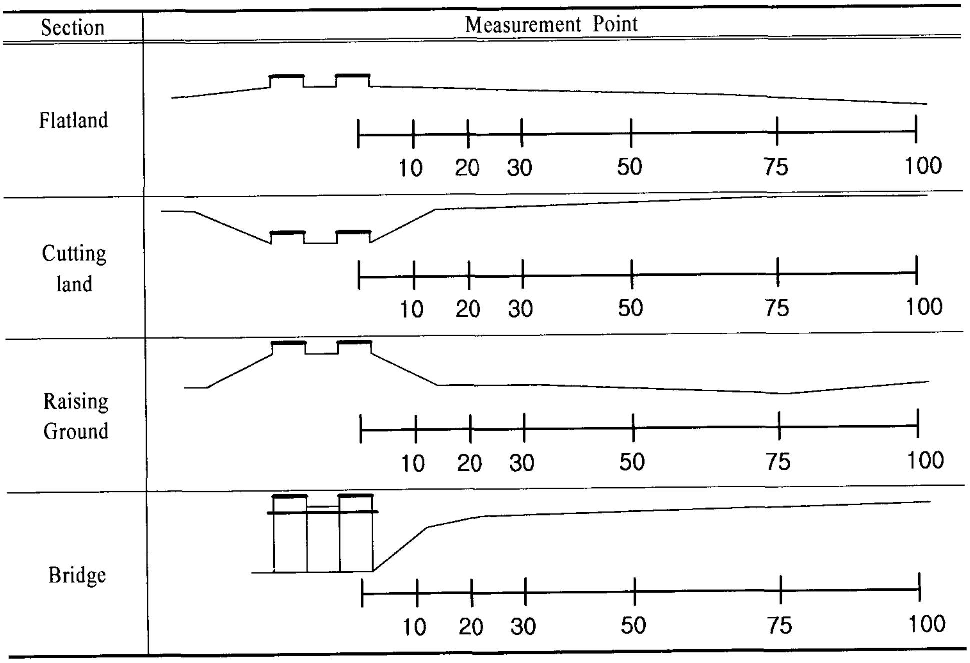


Fig. 1. Cross section of horizontal train traffic noise measurement point.

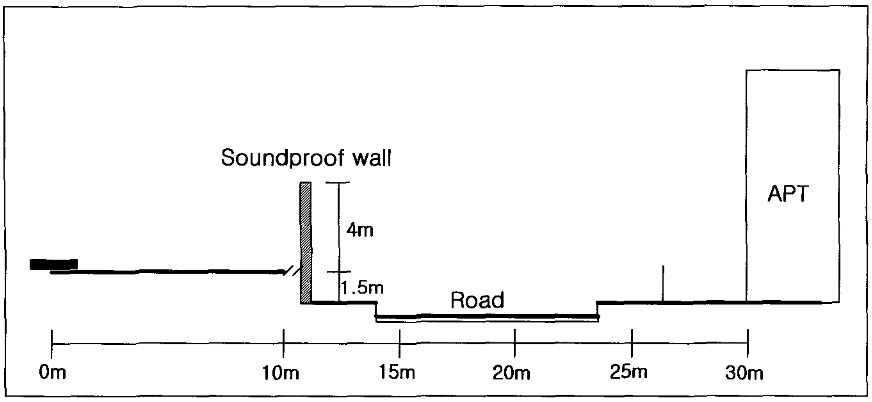


Fig. 2. Cross section of vertical train traffic noise measurement point.

two trains that run on the railroad, were used to obtain measurements five times, each lasting 20 sec and analysis of the frequency range was 31.5 ~ 16000 Hz.

2.3. Vertical Attenuation for Train Traffic Noise Measurement Area

The measurement area selected is a part of the Junra-sun line, which passes through the center of Junnam S. city and which is near S. station. This selected area is 1 km from the station and was chosen as the object of this experiment.

As shown in Fig. 2, there are distance measuring points that are 10, 15, 20, 25, 30 m from the railroad, height measuring points of 1.5, 3, 4.5, 6 m and fifteen measuring points of 1~15 stories that are distributed throughout a multi-storied apartment building 30 m from the railroad. These measurements were taken five times, each lasting 30 sec.

The measuring points were designated using the railroad's center line as reference. The area between the reference point and the 10 m mark represents the area inside a soundproof wall (railroad side), and the area past the 10 m mark represents the area outside soundproof wall.

The type of wall that was placed in the measurement area is an absorption soundproof wall.

3. Results and Discussion

3.1. Horizontal propagation and attenuation characteristics for the railroad traffic noise

3.1.1. Distance attenuation characteristics for area conditions

By comparing the distance decrease characteristics of Samaul-ho and Mugoongwha-ho using dB(A), the results in Table 1 and Fig. 3 were obtained.

As seen in Table 1 and Fig. 3, the sound pressure level decreases in constant intervals as distance increases for both Samaul-ho and Mugoongwha-ho in cases of flatland, cutting land, and bridge, but the highest distance decrease can be seen in the cutting

Table 1. Sound pressure level for area conditions [dB(A)]

Train	Area \ Point	10m	20m	30m	50m	75m	100m
Samaul-ho	Flatland	80.3	77.7	74.0	72.8	69.2	66.1
	Raising Ground	76.9	73.7	72.8	69.6	69.4	65.2
	Cutting land	78.1	73.5	70.2	66.8	62.7	57.7
	Bridge	88.4	85.0	81.6	78.3	74.7	72.8
Mugoongwha-ho	Flatland	84.7	81.5	78.7	77.5	75.2	72.9
	Raising Ground	81.3	78.7	75.5	73.9	70.5	66.9
	Cutting land	81.8	77.4	72.9	69.2	65.8	60.3
	Bridge	93.8	91.7	88.2	86.6	83.7	81.2

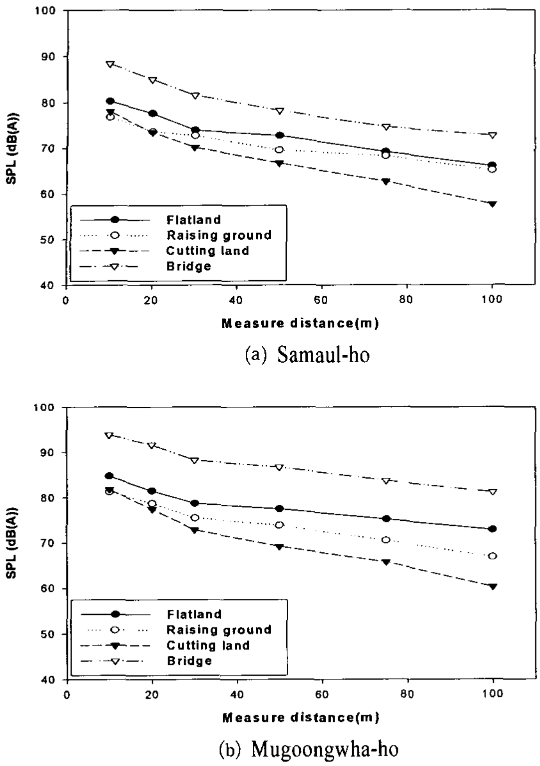


Fig. 3. Sound pressure level for area measurement point.

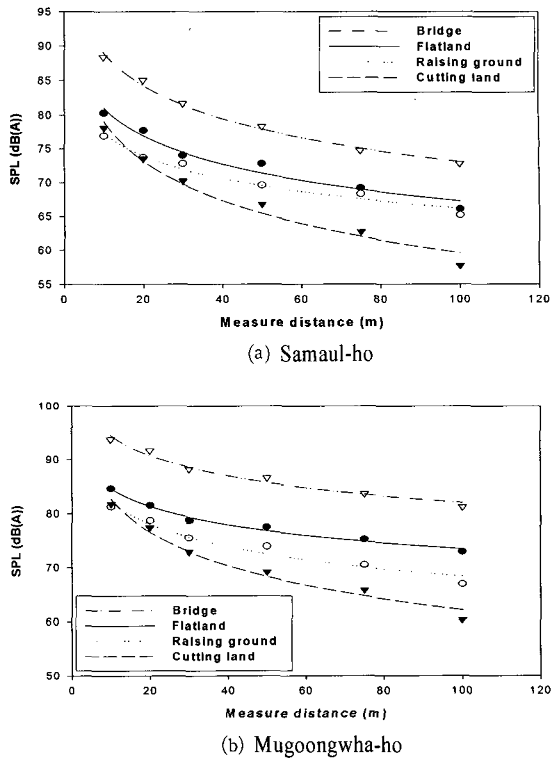


Fig. 4. Estimate correlation equation for area conditions.

land area. Also, the sound pressure level is 5.5～10.2 dB(A) higher in the bridge area than in the flatland area, and it generally decreases in a constant manner as distance increases.

Also, the sound pressure level of Samaul-ho, which was designed based on low sound and low vibration characteristics, was low at all measuring point compared to the sound pressure level of Mugoongwha-ho. This shows that the type of engine can determine the difference in sound pressure levels.

3.1.2. Estimate Correlation Equation for Area Conditions

By using the characteristics of each distance decrease according to area conditions, the propagation characteristics for railroad traffic noise can be predicted to be represented by Fig. 4 and the estimate correlation equation by Table 2.

As seen in Fig. 4, Table 2, all areas show an impressive 96.0% of correlation.

Table 2. Estimate correlation equation for area conditions

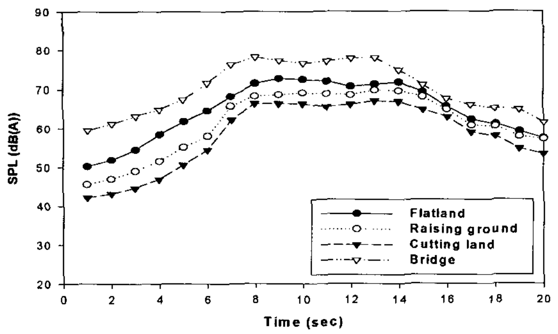
division	Area Condition	Estimate Correlation eq.	R^2
Samaul-ho	Flatland	$y=-5.9873\text{Ln}(x)+94.839$	0.9655
	Raising Ground	$y=-4.8097\text{Ln}(x)+88.345$	0.9731
	Cutting land	$y=-8.4599\text{Ln}(x)+98.530$	0.9741
	Bridge	$y=-6.9545\text{Ln}(x)+105.093$	0.9921
Mugoongwha-ho	Flatland	$y=-4.9089\text{Ln}(x)+96.035$	0.9857
	Raising Ground	$y=-5.9998\text{Ln}(x)+96.000$	0.9607
	Cutting land	$y=-8.9736\text{Ln}(x)+103.440$	0.9773
	Bridge	$y=-5.4394\text{Ln}(x)+107.061$	0.9739

Considering these results, a more detailed experiment and study should be performed for all areas. This will allow a more thorough look into how to better rely on distance to estimate railroad traffic noise.

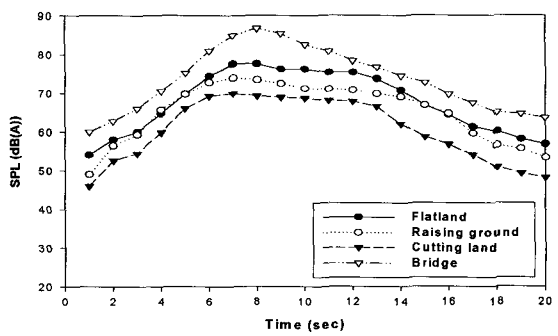
3.1.3. Changing Characteristics of Sound pressure levels over time

As seen in Fig. 5, the changing characteristics of both trains over time were observed in order to analyze each train's change in accordance with the area conditions. The point used for reference is 50 m.

As seen in Fig. 5, results from both Samaul-ho and Mugoongwha-ho show that the changing characteristics over time based on area conditions at 50 m is most drastic in the bridge area. Then the level of change decreases in this order: flatland, raising ground, cutting land. The sound pressure level steadily increases over time, but as the train passes the measuring point, the sound pressure level is very high. After maintaining this high level until it passes this point, the level then decreases. Also, in the case of the cutting land area, the time during which a high sound pressure level is maintained is short and the level itself is low. Compared to other areas, the ability to decrease the effect of noise is greater in the cutting land area. In the case of the bridge, both the ability to decrease the effect of noise and the sound pressure level are high.



(a) Samaul-ho



(b) Mugoongwha-ho

Fig. 5. Changing characteristics of sound pressure levels over time.

3.1.4. Frequency characteristics for bridge area

As seen in Fig. 6, results from both Samaul-ho and Mugoongwha-ho show that the changing frequency characteristics based on bridge area at 50 m.

Which is the case of Samaul-ho, the sound pressure level was highest for frequency band levels of 125 Hz and less, and the sound pressure level decreased as the frequency band level reached and rose above 250 Hz. The frequency characteristics of Mugoongwha-ho are similar to those of Samaul-ho. The sound pressure level is very high for frequency levels to 125 Hz, especially at 63~500 Hz where this high level is maintained throughout.

Therefore, a change in the high frequency band level can influence the effect on residents and should be considered when establishing a sound isolation counterplan because this consideration is very necessary.

3.2. Vertical propagation and attenuation characteristics for the train traffic noise

3.2.1. Sound pressure level distribution characteristics for vertical height

Analysis of Samaul-ho and Mugoongwha-ho's vertical sound pressure level distribution characteristics in dB(A) are shown in Table 3.

As shown in Table 3, in the case of Samaul-ho, the sound pressure level is high with a measurement of 86.5~90.8 dB(A) when the height is less than 4.5 m

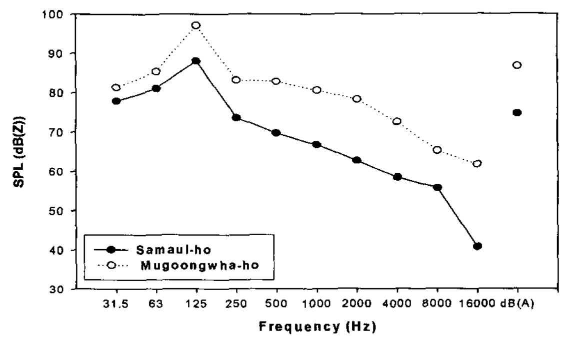


Fig. 6. Frequency characteristics for bridge area. [dB(Z)]

Table 3. Sound pressure level for vertical height [dB(A)]

Train	Height \ Point	10m	15m	20m	25m	30m
Samaul-ho	1.5m	86.5	72.3	70.7	71.5	71.2
	3m	89.2	74.5	72.7	74.2	73
	4.5m	90.8	76.0	75.0	75.9	75.3
	6m	90.5	81.9	76.8	77.4	76.1
Mugoongwha-ho	1.5m	92.9	78.6	79.1	78.7	77.8
	3m	93.5	79.5	80.1	79.7	78.5
	4.5m	95.0	81.5	82.0	82.0	80.3
	6m	94.7	86.5	84.4	83.9	83.2

within the front side of a soundproof wall and the measurement point is at 10 m. When the measurement point is at 15 m, however, there is a large decrease in the amount of noise with a measurement of 14.2~14.8 dB(A) according to the installation of a soundproof wall. This shows that the railroad traffic noise isolation effect is very high due to the soundproof wall, but in the case of measurement points 10 m and 15 m at a height of 6 m that are front side and outside of the soundproof wall respectively, the amount of noise decrease is 8.6 dB(A), which is relatively low compared with measurements conducted at other heights.

The case of Mugoongwha-ho shows similar characteristics when compared with Samaul-ho. When the height is less than 4.5 m within the front side of a soundproof wall and the measurement point is at 10 m, the amount of decrease in noise is 13.5~14.3 dB(A), which indicates a fairly large decrease. However, when the height is at 6 m, the amount of decrease in noise is 8.2 dB(A), which indicates a relatively low decrease.

3.2.2. Sound pressure level distribution characteristics for train

By using an apartment located 30 m from the railroad, the results in dB(A) of the distribution characteristics of the sound pressure level for vertical height concerning Samaul-ho and Mugoongwha-ho were gathered and are presented in Fig. 7.

As shown in Fig. 7, low sound and low vibration based Samaul-ho shows a lower sound pressure level than Mugoongwha-ho with a measurement of 5.2~7.0 dB(A), and as the measurement height increases, the sound pressure level also steadily increases.

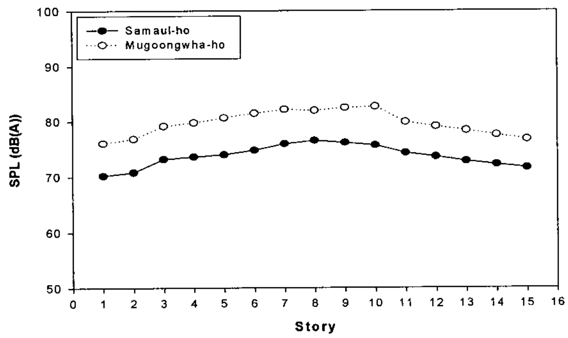


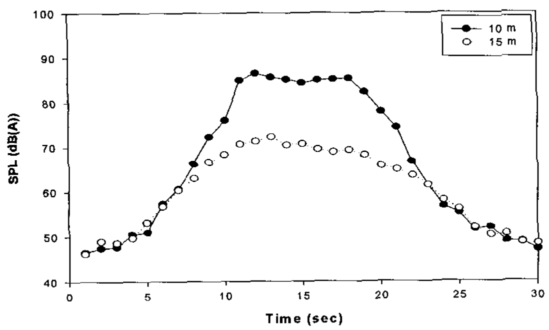
Fig. 7. Sound pressure level for vertical height.

3.2.3. Changing Characteristics of Sound pressure levels over time

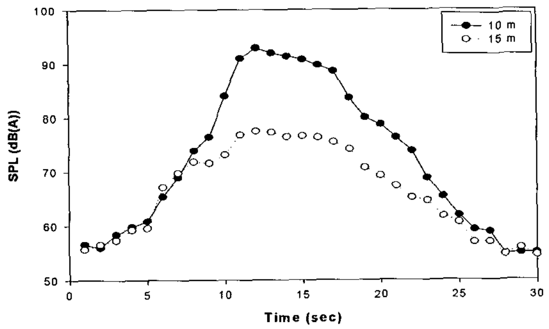
In order to conduct the analysis of the changing characteristics of sound pressure levels over time, a soundproof wall was used as reference, and the points chosen were 10 m from the inside of the wall and 15 m from the outside. Then the change in the sound pressure level was observed at several intervals of time. The results of this experiment are presented in Fig. 8.

As shown in Fig. 8, the change in the sound pressure level is greater at 15 m from the outside of the soundproof wall than at 10 m for both Samaul-ho and Mugoongwha-ho.

Low sound and low vibration based Samaul-ho shows a steady increase in the sound pressure level over time at 10 m, but when a train passes through the measurement point, a high sound pressure level is maintained throughout this time due to the Doppler effect. After the train passes, it decreases once again.



(a) Samaul-ho



(b) Mugoongwha-ho

Fig. 8. Changing characteristics of sound pressure levels over time.

The sound pressure level is lower at 15 m from the outside of the soundproof wall than at 10 m. Also, in the case of Mugoongwha-ho, when a train passes through the measurement point of 10 m, a sound pressure level is maintained throughout this time due to the Doppler effect. After the train passes, it decreases once again. However, at 15 m from the outside of the soundproof wall, the changing characteristics cannot be clearly seen and the changing range is also very small.

Therefore, the installation of a soundproof wall will lower the negative effect of noise on residents.

4. Conclusions

This study was conducted in order to understand the horizontal and vertical propagation and attenuation characteristics for the train traffic noise. Area and measurement points were chosen in accordance to the purpose of this study, and the horizontal distance and vertical height of each measurement area was determined. The results and analysis are as follows.

Horizontal propagation and attenuation characteristics for the train traffic noise

1) The distribution characteristics based on area conditions for Samaul-ho and Mugoongwha-ho show similarities, but the sound pressure level of the low sound and low vibration based Samaul-ho is lower than Mugoongwha-ho. The sound pressure level is especially high in the bridge area for both Samaul-ho and Mugoongwha-ho, causing damage to the residents near the railroad.

2) In cases of the flat land, cutting land, and bridge area, as distance increases, the sound pressure level steadily decreases. The sound pressure level for the bridge area is higher than that of the flat land with a measurement of 5.5~10.2 dB(A).

3) All areas have a correlation measurement of 96.0% and higher, which can be determined by looking at the estimate correlation equation. Therefore, based on the results, if various measurement distances were studied more thoroughly, more accurate and reliable estimate correlation equations would come about.

Vertial propagation and attenuation characteristics for the train traffic noise

1) When comparing the vertical sound pressure levels of Samaul-ho and Mugoongwha-ho, the low sound and low vibration based Samaul-ho has a lower sound pressure level with a measurement of 5.2~7.0 dB(A).

2) The sound pressure level is high on the front side of a soundproof wall and low on the outside for both Samaul-ho and Mugoongwha-ho, and these conditions are maintained throughout a long period of time.

Therefore, if there was more accumulation and application of various data based on study results and various measuring conditions, a more reliable estimate of traffic noise would be possible through the use of computer simulation. The establishment of a sound isolation counterplan that will help control traffic noise would also be possible with more efficiency and success.

Acknowledgement

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