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Full Length Research Paper

An application of a noise maps for construction and road traffic noise in Korea

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Noise has become a serious social concern due to the rapid urbanization brought on by rapid industrial development and economic growth. This study is on the construction noise caused by construction of a building and the road traffic noise resulting from increased traffic volume. A noise map was used to control these sources of noise. Also, this paper examines the influence on nearby areas of the increased road traffic noise resulting from a land development project. A prediction of the noise distribution and a noise map was made using the software SoundPLAN; according to the results, a plan was created to reduce construction noise and the road traffic noise that increases after the completion of a construction project. This study revealed that the increased traffic volume caused by the development of an industrial area had a greater influence on the nearby areas than the industrial area itself. The changes to the traffic routes and movement pattern were identified as well.

Key words: Road traffic noise, noise map, grid noise map, façade noise map, construction noise, land development

INTRODUCTION

Because of the rapid growth of the urbanization, the construction noise and the road traffic noise causes annoyance and a wide range of negative effects on the health in many urban areas (Yoshida et al., 1997; Onuu, 2000; Ouis, 2002). This matter becomes so critical that it is necessary to establish an adequate global noise policies, regulations, and laws physically (ISO 11819, 1997; ISO 15666, 2003). Likewise, in Korea, there has been widespread urbanization as a result of the rapid industrial development and economic growth that has occurred since the 1970s. In particular, there is a high population density that appeared along with the introduction of skyscrapers in 2000 to effectively utilize the limited land available. The social problems related to pollution have been augmented due to the construction and development in the city, land development projects and the construction of new towns around the cities. Among the various types of pollution, noise pollution has a considerable influence on the urban life environment and is on the rise as serious social problem, affecting people both mentally and physically (Lee et al., 2002; Kim et al., 2004; Oh et al., 2004).

Road traffic noise has become a serious concern as indicated by the increasing number of civil appeals since 1996 related to the noise and vibrations caused by construction and vehicles that travel on the newly constructed roads that pass through residential areas (Im et al., 1996; Kim et al., 2007; Jeong et al., 2008; National Environmental Dispute Resolution Commission, 2008). The number of appeals in 2007 was 172, a 2.9-fold increase compared with the 60 cases in 2000. Automobiles have become increasingly popular since 1997, when the number of cars in Korea surpassed 10 million; by January 2008, the number of cars reached 16.5 million, and this trend is accelerating (Korea National Statistical Office, 2008). Given this context, road

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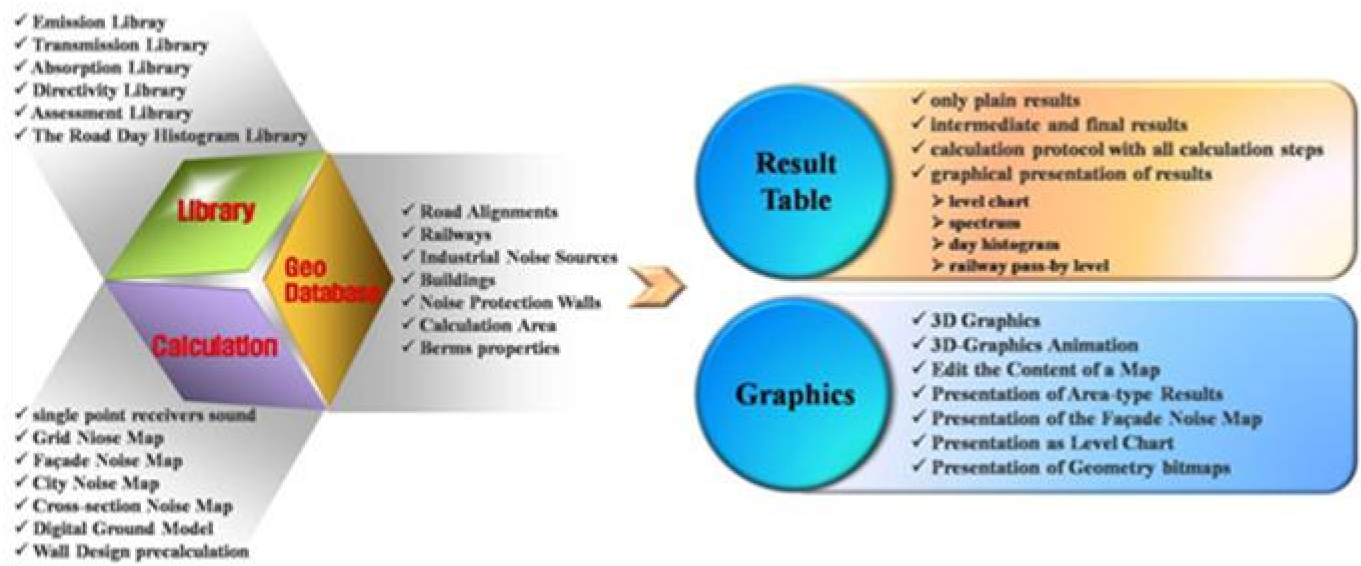


Figure 1. The procedure for creating a noise map.

traffic noise is one of the most sensitive topics of civil appeals, and Kim (2004) and Ko et al. (2005) claimed that road traffic noise should be considered when expanding roads, building a new road and developing land.

Meanwhile, many studies have been carried out to predict the noise level and to monitor the effects of the urban environments in different countries (Kluijver et al., 2000; Li et al., 2002; Calixto et al., 2003; Bhaskar et al., 2007; Tsai et al., 2009). Among reported in relevant studies, the noise mapping approach is the comprehensive ways to predict the environmental noise. A noise map can provide useful information on the environmental impact. With the rapid progress of computer technology, noise mapping tools based on numerical simulation, such as SoundPLAN, have become useful tools for conducting environmental noise predictions and carrying out urban planning processes. In addition, Ono Sokki Co. (2002) reported that SoundPLAN has a high reproducibility of reality showing precise sound power level within 1 dB in the prediction of construction noise. Morris (2007) predicted with the error range of plus or minus 2 dB(A) when predicting railroad noise in Queensland. Rossie et al. (2006) presented the accuracy and reproducibility of SoundPLAN is high with the margin of error of 0.1 - 2.1 dB(A) when comparing the measured result according to each scenario and that of SoundPLAN modeling.

Then, considering the accuracy and reproducibility of the SoundPLAN, this study examines the practicality and the applicability of a noise map by producing one for a new building and land development project in Korea. This paper also examines the construction noise produced during the construction of a building and the increased road traffic noise resulting from the increased traffic volume after the completion of the land development project.

PREPARATION STUDY

Noise map

Traditionally, evaluations of road traffic noise rely on simple numerical expressions. Thus, the influence of the noise on areas outside of the measurement space could not be determined and many people cannot understand the implications of these numerical expressions. However, a noise map can present results using pictures instead of numbers, a method that can be more intuitive. The European Union recently required cities with more than 2.5 million people to produce noise maps (The European Parliament and of the Council, 2002). In particular, noise maps are widely used in the United Kingdom, France, Germany, the Netherlands, the Czech Republic, Spain and Norway (Korean Society for Noise and Vibration Engineering, 2007).

Modeling process

A noise map is produced according to the process described in Figure 1. After a target area is selected, a geo-database containing topographical and characteristic data is then established. The accuracy of this database is determined via on-site inspection. Then, modeling is performed by a noise prediction program that uses the gathered data and applies certain required conditions; then, the output of the calculated result is examined.

Summary of SoundPLAN

The systems of measurement used by common noise level prediction programs are very similar. The standard reference noise level is defined as the noise produced by

Figure 2. A structural map of the area where the new building is constructed.

one car operating under a standard condition at a certain distance; this noise level can be obtained through experimentation and is incorporated into the modeling calculations.

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. In this study, the software soundPLAN was used for the noise map modeling. RLS90, which is used in Germany, was utilized as the calculation formula; it is subdivided into two calculation formulae for the source model and triangle model. Also, RLS90 uses the point source method with spreading, ground attenuation, screening and reflection, where the standard consists of source model and triangle model. The source model uses the traffic data and gives the reference noise level at a distance of 25 meters from the road and 4 meters above the ground. This noise level is called level mean emission ($L_{m,E}$) in SoundPLAN, but it is also referred to as L25. The following data are required for calculating the source level: vehicular data (number of vehicles per hour and the percentage of heavy vehicles), the speeds of the cars and trucks, road surface adjustments, road gradients and multiple reflections (Braunstein+Berndt GmbH/SoundPLAN LLC, 2005).

Thus, the source model is given by:

$L_{m,E} = L_m(25, \text{Basic}) + C_{Speed} + C_{RoadSurface} + C_{Gradient} + C_{Ref}$, where,

$L_m(25, \text{Basic}) = 37.3 \times \log\{1+0.082 \times P\}$

P : Percentages of trucks exceeding 2.8 tons

C_{Speed} : Speed correction

$C_{RoadSurface}$: Road surface addition

$C_{Gradient}$: Road gradient addition

C_{Ref} : Multiple reflection addition

LITERATURE REVIEW

Previous studies on noise maps have made quantitative predictions through modeling and have produced noise maps for drafting noise reduction countermeasures and policies since 2000. For example, Choi (2001) proposed a mathematical model that can predict the sound level given the traffic on the road and its speed. Park (2003) proposed a methodology for making a road traffic noise map using GIS. Also, Chang et al. (2005) studied the use of noise maps in urban redevelopment. Ko et al. (2005) reported a way to evaluate urban traffic noise using a noise map. The study by Kim et al. (2008) evaluated the noise level of an apartment next to a road using SoundPLAN and analyzed the noise level according to the plot. Finally, Jeong et al. (2008) utilized a noise map to evaluate soundproof facilities installed on a road that neighbors an apartment complex.

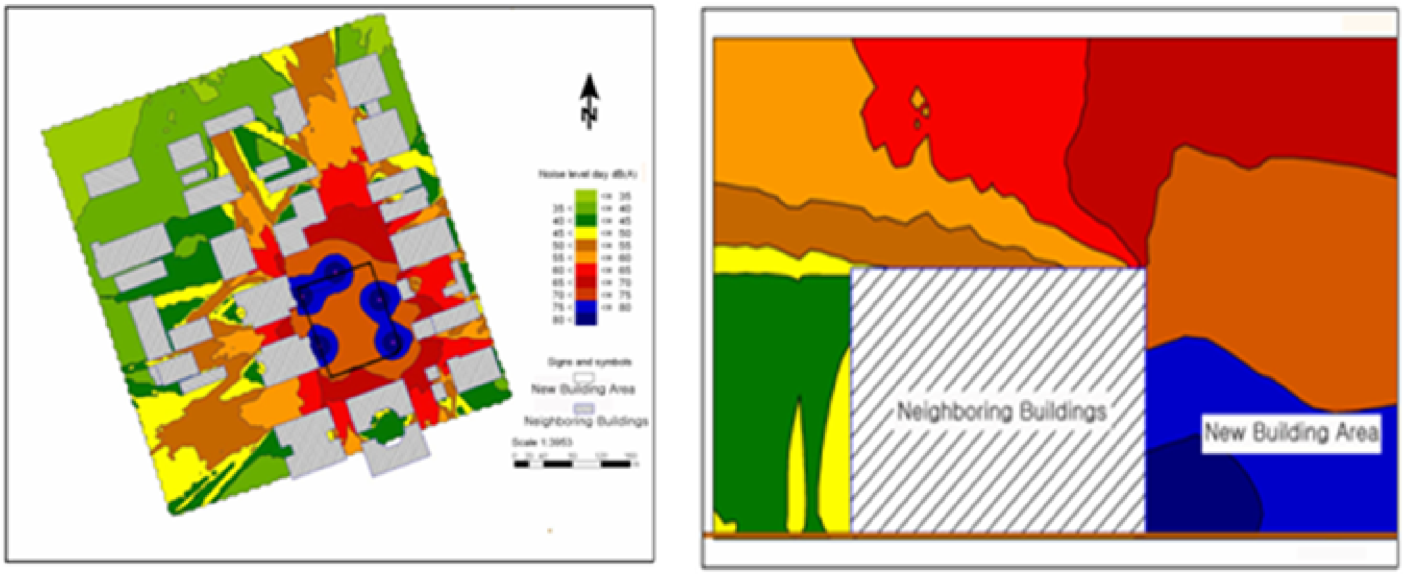
NOISE MAP APPLICATION

New building

In Korea, it is required to predict the noise that will be produced during construction of a building and the road traffic noise that will be produced after completion according to the prior environmental review system[1)]. During the construction, a plan should be established to satisfy the life noise regulate standard[2)]; also, a plan is required to meet the noise environmental standard[3)] for the noise produced by the traffic on the road. Noise predictions are made at certain points; a prediction for the whole target area using a noise map is not made. Accordingly, the possibility of using a noise map for a new building is studied in the present work. This study focuses on the construction of a new studio apartment in downtown Seoul. The location and surrounding environment of the building studied is shown in Figure 2 where is an area with the dense apartment-type factories. The apartment-type factory is a type of factory regulated by the 'Law of industry placement and establishment of a factory' and means multi-story complex building that can accommodate a number of factories at the same time.

The environmental review system requires a plan that indicates the noise levels for the stages of construction. So far, a prediction of the noise has been made at the nearest point of an adjacent building, but for this study, a noise map is used to predict the noise at the nearby buildings according to the construction schedule.

The grid noise map shown in Figure 3a gives a two-dimensional noise map created by SoundPLAN, which divides the space in the plane into 4 $m^2 \times 4$ m^2 pixels where the total number of samples is 11,184. The cross section map in Figure 3b shows the vertical distribution 100 m from the surface using 5 $m^2 \times 5$ m^2 pixels where the total number of samples is 1.302. The grid noise map shows 11 sound levels in the range of 35 to 85 dB(A) in



a. Grid noise map b. Cross section map

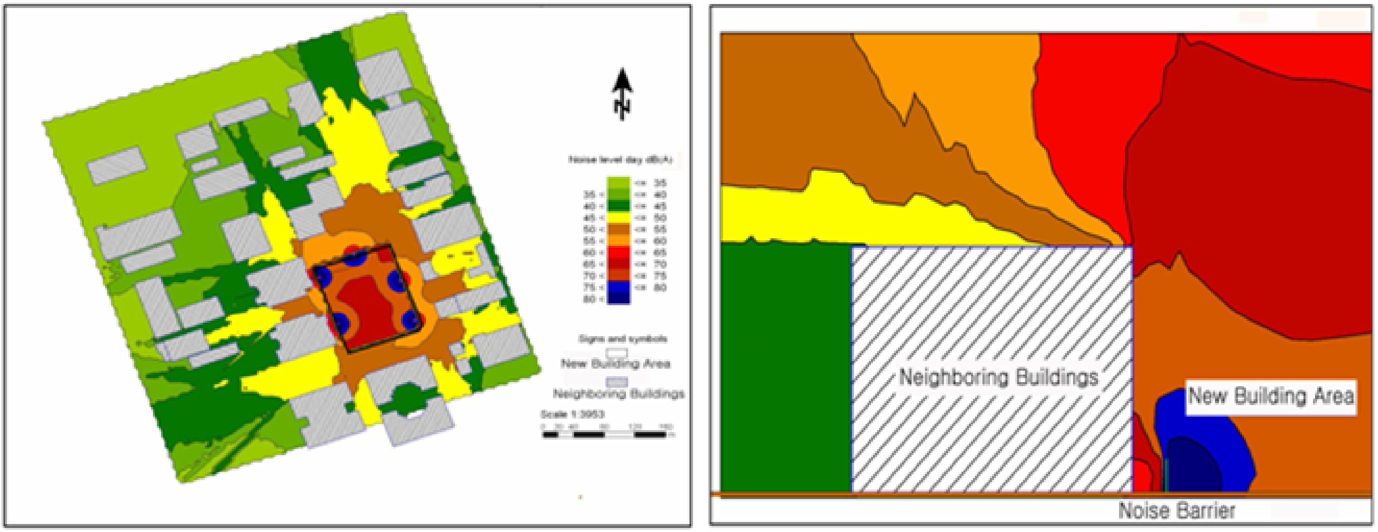
Figure 3. Noise maps of the soil and sand redistributions. (a) Grid noise map. (b) Cross section map.

Table 1. The construction noise with and without soundproof panels in units of Leq Db (A).

	Floor	No panels	Soundproof panel height			Life noise regulate standards
			2 m	4 m	6 m	
A Building	1	75.0	64.9	59.3	57.7	70
	5	71.4	71.3	71.2	67.9	
	10	67.0	66.9	66.8	66.8	
	14	64.8	64.6	64.6	64.5	
B Building	1	75.8	63.6	58.9	57.8	
	5	71.4	71.4	67.8	63	
	10	66.3	66.3	66.3	66	
	14	63.8	63.8	63.7	63.7	
C Building	1	66.3	57.5	53.2	51.3	
	3	66.6	60.3	58.3	57.2	

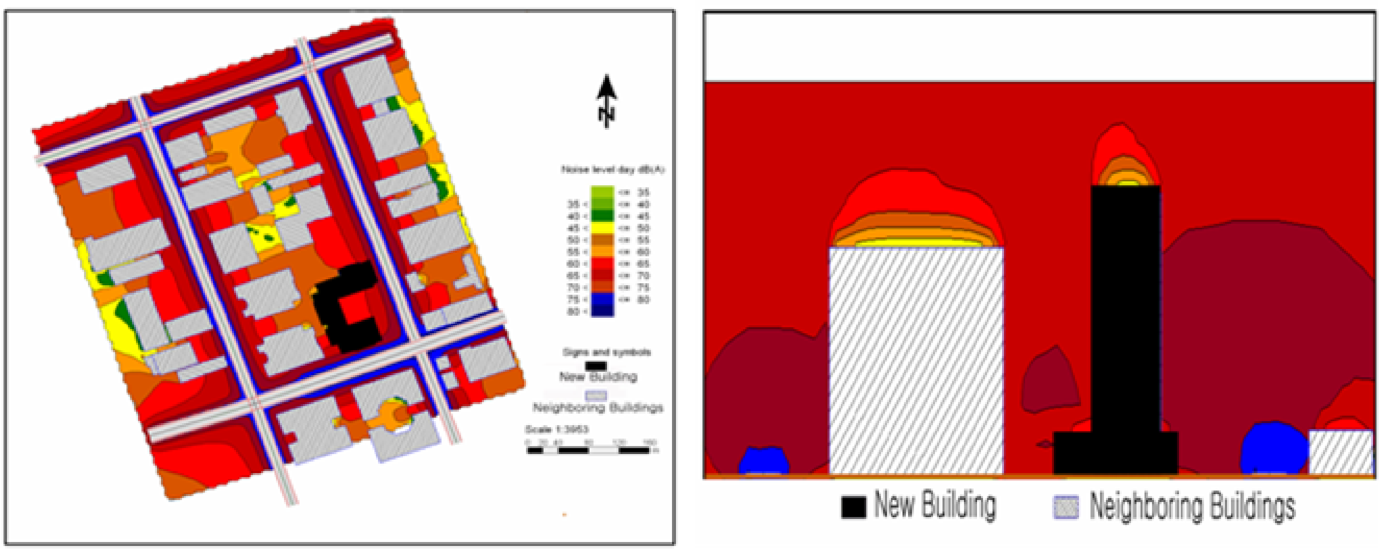
5 dB(A) intervals using an RBG scale according to KS I ISO 1996-2 (Korea standards Information Center, 2008).
First, the construction noise produced by conveying soil and sand[4)] was predicted, which produces the most noise during the construction progress. According to the results, a nearby building exceeded the life noise regulation standard (70 dB(A)). So, to calculate the proper height of the soundproof panels for the building that exceeded the life noise regulation standard, the noise level was first measured for soundproof panels located 2 m from the ground level; then, an additional 2 m was added until the noise regulation standard was met. Consequently, the height of the sound proof panels required to reduce construction noise generated by the construction equipment at the boundary line of the construction site was determined to be 6 m as shown in Table 1 and Figure 4.

Before the installation of the soundproof panels, the noise level caused by the construction at the outer wall of the nearby building exceeded 70 dB(A); after installation, the level decreased by a maximum of 18dB(A), where the noise level reduction afforded by the panels was reduced for the upper stories. In this way, the noise map indicates the influence of the construction noise on the adjacent areas and makes it easy to establish plans to reduce the construction noise.



a. Grid noise map b. Cross section map

Figure 4. Results soundproof panel installation. (a) Grid noise map. (b) Cross section map.



(a) Grid noise map. (b) Cross section map.

Figure 5. Results of traffic noise for the daytime hours. (a) Grid noise map. (b) Cross section map.

Also, a prediction was made for the increased road traffic noise caused by the increased traffic volume of the vehicles using the new building after completion. The traffic volume[5)] was based on the predicted traffic volume in the year when the construction will be completed and the vehicles were categorized as either 'cars' or 'trucks', using a weight of 2.8 tons per vehicle; motorcycles were excluded in this study. The predictions only include the daytime hours from 06:00 to 22:00 (Ministry of Environment Republic of Korea, 2008, Law No. 8976 and 9037) since the building studied is a business facility. Figure 5 shows the results.

Along the roadside of the building, the noise level proved to exceed the noise environmental standard

Figure 6. Map of the research area.

(70 dB(A)), except for the lowest and highest stories. The noise level of the parts that are blocked by the building was lower than 70 dB(A). A nearby building was also subjected to a noise level above 70 dB(A) at some points. This result indicates that soundproofing estimations should be given when planning the construction of windows, doors and the outer wall and the installation of the soundproof facilities along the roadside.

Land development project

The construction of the land development project, residential area and industrial complex will employ the nearby road system. However, the land development project does not establish a plan for reducing the road traffic noise, except for the project area. Therefore, it is essential to establish a proper noise reduction plan by predicting the increased traffic volume resulting from the new development. Steeland, located in the Sihwa National Industrial Complex in Siheung-shi, which has an industrial complex and residential area nearby, was selected as an example of the land development project. Steeland has 223,064 m^2 of surface space, on which facilities for stores, sales and business facilities are located. The results from 2008, when Steeland was completed, and 2007, before it was completed, were compared to determine the influence of the completed Steeland project on the surrounding areas.

First, for the traffic volume, the daily traffic volume of the major roads along Steeland was categorized as either 'car' or 'truck'. The buildings considered were confined to those in the area on the side of the road to produce the roadside[6] noise map as despite in Figure 6. Consideration

Table 2. A comparison of the field sound level and the predicated sound level in units of Leq dB(A).

Location	Field sound	Predicated sound	Increase/Decrease rate
A	75.9	75.4	-0.4
B	76.6	75.6	-1.0
C	76.9	76.1	-0.8
D	73.7	73.1	-0.6
E	73.3	74.1	+0.8
F	70.4	70.7	+0.3
J	68.5	69.8	+1.3
H	70.0	71.4	+1.4
I	72.1	73.2	+1.1
J	69.3	70.3	+1.0

was given to the green tract of the land of the roadside, the soundproof slope, the height of the plants and numbers and width of the lanes, the width of the walkway, etc.

To determine the accuracy of the SoundPLAN model, 10 points were selected where the noise levels were high based on the 2007 prediction. The noise level was measured four times in three days during the weekday daytime hours (06:00 - 22:00). The arithmetic mean of the noise level was then calculated; the results are shown in Table 2.

A comparison between the field sound level and predicted sound level gave a maximum error of 1.4 dB(A) and a minimum error of 0.5dB(A). When compared with the other sound level simulation programs, the sound level predicted by SoundPLAN proved to be similar with the field sound level.

The grid noise map shows the two-dimensional plane of the noise maps generated by SoundPLAN, which divided the space in the plane at the height of 1.5 m from the surface into 9 × 9 m^2 pixels where total number of samples was 248, 811. The facade noise map shows the vertical distribution; the wall was divided into 3 × 3 m^2 pixels and the total number of samples was 267,494.

The results before and after the construction of Steeland are shown in Figures 7 and 8, respectively. The noise levels at the roadsides of Road-1, Road-4 and Road-11, the main roads approaching Steeland, were higher than the other areas, and the values for 2008 were higher than those for 2007. The increased traffic volume is likely the reason for this increase as the new roads became the main paths to Steeland. The increased traffic volume partially increased the noise levels of Road-2 and Road-8. Point 5, located at the perimeter of a subway station, has shown noise levels higher than 2007 as well, due to the increase of the vehicles caused by the increased floating population. The increased traffic volume from Road-1, Road-4 and Road-11 led to the increase of traffic volume of other roads by the Balloon Effect[7)], and changes to the traffic routes of the drivers likely increased the noise level of the entire roadside.

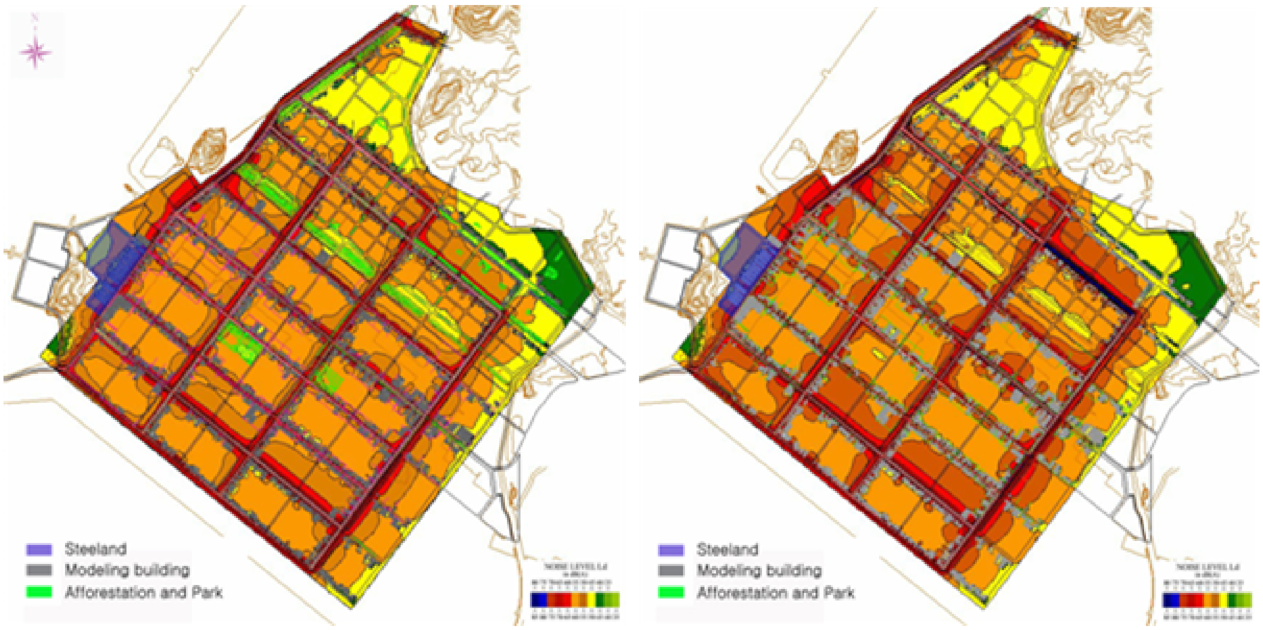
A comparison of the noise levels of 2007 and 2008 is given in Table 3. The grid noise map shows that the proportion of the area above the noise level of 55 dB(A) decreases and that the noise levels decrease as a whole after the completion of Steeland. However, the proportion at the noise level of 55 dB(A) and above increases by a maximum of 2.12%. Thus, a decrease of the proportion below 55 dB(A) was accompanied by an increase in the proportion above 55 dB(A). In particular, there was a larger increase in the noise level range from 55 to 60 dB(A). The facade noise map showed a decrease of the proportion at the noise level 50 dB(A) and below due to the increased traffic volume, but a maximum increase of 0.74% was measured for the noise range of 50 dB(A) and above. Specifically, there was an increase in the noise level range of 50 to 55 dB(A).

As revealed above, the industrial complex built by the land development project caused an increase in the road traffic noise not only for the perimeter of the complex but also for the existing residential area and industrial complex. Although damages to the circumferential area via increased road traffic noise and the resulting civil appeals were expected, countermeasures to decrease the road traffic noise have not been established. It is essential to decrease the road traffic noise inside the project area, and the circumference should be established for the land development project.

Conclusion

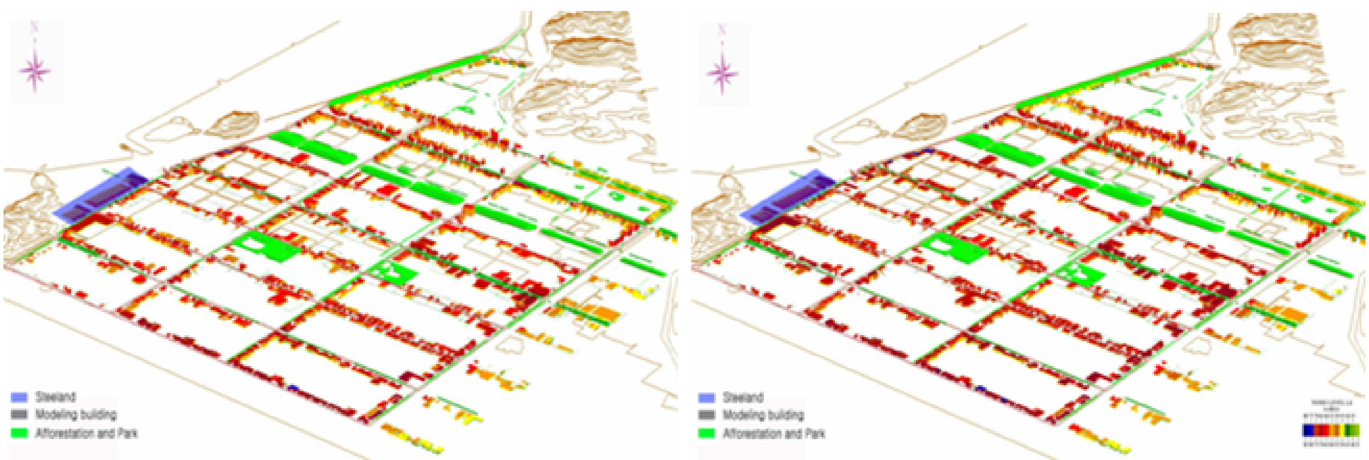
In this study, a noise map was used in Korea for an example construction project. The noise maps were produced for a new building and a land development project.

First, this paper analyzed the noise produced during construction and after completion of a new building. Consequently, determining the countermeasures to reduce construction noise during the construction was easier. Also, plans for reducing the road traffic noise could be made beforehand using a prediction of the noise



a.2007 b.2008

Figure 7. The grid noise maps. (a) 2007 (b) 2008.



a.2007 b.2008

Figure 8. The facade noise maps. (a) 2007 (b) 2008.

level of the road traffic from the increased traffic volume after completion.

The prediction of the road traffic noise resulting from the development of an industrial complex and a land development project indicates that increased traffic volume has a greater influence on the circumferential area than the industrial complex itself. Also, new traffic routes and changes to the movement patterns of the vehicles can be identified. By easily grasping the area where damages from the road traffic noise increase, countermeasures to reduce the noise level can be undertaken. The road traffic noise in the circumferential area can be reduced by reducing the speed limit, installing soundproof facilities and enforcing traffic time

Table 3. The comparison of noise levels for 2008 and 2007 in percentages.

dB(A)			Grid noise map			Façade noise map		
			2008	2007	Increase/Decrease rate	2007	2008	increase/decrease rate
	-	35	1.29	0.11	-1.18	1.23	1.11	-0.12
35	-	40	0.50	0.37	-0.13	2.38	2.19	-0.19
40	-	45	3.14	2.79	-0.35	6.18	5.65	-0.53
45	-	50	15.40	13.62	-1.78	18.73	16.96	-1.77
50	-	55	38.48	38.04	-0.44	23.32	23.97	+0.65
55	-	60	18.84	20.96	+2.12	17.84	18.15	+0.31
60	-	65	8.81	9.59	+0.78	15.28	15.62	+0.34
65	-	70	5.34	5.59	+0.25	12.84	13.40	+0.56
70	-	75	4.90	5.14	+0.24	2.16	2.90	+0.74
75	-	80	2.56	2.84	+0.28	0.04	0.06	+0.02

limits.

In this study, the construction and road traffic noise of a new building and land development project was predicted by using a noise map. Noise is an important factor to consider in urban planning. If a noise map is utilized during the planning stage, it can be used as effective data to make a low noise city, to settle the noise-related civil appeals that may arise after completion of land development projects and to establish countermeasures to deal with noise. A noise map can be easily produced only if certain data have been recorded beforehand, including map numbering, the construction of a database of the road facilities and traffic volume statistical data.

REFERENCES

Calixto A, Fabiano BD, Paulo H, Zannin T (2003). The statistical modeling of road traffic noise in an urban setting, Cities, 20(1): 23-29.

Bhaskar A, Edward C, Masao K (2007). Development and implementation of the areawide Dynamic ROad traffic NoisE (DRONE) simulator, Transportation Research Part D: Transport and Environment, Volume 12(5): 371-376.

Li B, Shu T, Dawson RW, Jun C, Kinche L (2002). A GIS based road traffic noise prediction model, Applied Acoustics, 63(6): 679-691.

Braunstein+Berndt GmbH/SoundPLAN LLC (2005). SoundPLAN User's Manual, pp. 63-230.

Rossie F, Umberto Di M, Sofia S (2006). "An original method for urban traffic noise prediction", Proceeding of the Euronoise 2006, Tampere, Finland, published on the CD-ROM.

Kluijver H, Jantien S (2000). Noise mapping and GIS: optimising quality and efficiency of noise effect studies, Computers, Environment and Urban Systems, 27(1): 85-102.

Kim HC, Jae-Hun J, Seung-Il J, Heung-Man K (2008). An Analysis of Effect on Road Traffic Noise Reduction Substitute through Traffic Management Improved, J. Acoustical Soc. Korea, 27(8): 403-410.

Kim HC, Woo-Taeg K, Jea-Hun J (2007). A Road Traffic Noise Management Using a Noise Mapping Simulation, J. Acoustical Soc. Korea, 26(7): 353-360.

Park IN (2003). A study on the development of environmental noise map using GIS, The Graduate School Yonsei University, pp. 27-37.

ISO 11819 (1997). Acoustics -- Measurement of the influence of road surfaces on traffic noise - Part 1: Statistical Pass-By method.

ISO 15666 (2003). Acoustics - Assessment of noise annoyance by means of social and socio-acoustic surveys.

Jeong JH, Jin-Ho P, Woo-Taeg K, Hyung-Chul K (2008). Improvement Effects of Road Traffic Noise by The Noise Barrier Facilities Using a Noise Map Simulation, J. Environ. Impact Assess. 17(4): 213-224.

Choi JS (2001). An Numerical Prediction of Road Traffic Noise and Analysis of Pollution in Noise Area, The Graduate School Ulsan University, pp. 3-5.

Joon-Hee K, Seo-Il C, Seung-Il L, Chang-Hyo Y (2005). A Study on the Application of Noise Map in Urban Planning, Proceedings of the Korean Society for noise and Vibration Engineering Conference, pp. 905-910.

Kang-Ting T, Min-Der L, Yen-Hua C (2009). Noise mapping in urban environments: A Taiwan study, Appl. Acoustics, 70(7): 964-972.

Korea National Statistical Office (2008). Statistics document 2008, http://www.nso.go.kr/.

Korea standards Information Center (2008). KS I ISO 1996-2; Acoustics-Description and measurement of environmental noise-Part2: Acquisition of data pertinent to land use.

Korean Society for Noise and Vibration Engineering (2007). A Study on the Making of the Noise Map, National Institute Environ. Res. pp. 12-28.

Ministry of Environment Republic of Korea (2008). Noise and Vibration Control Laws, Law No. 8976.

Ministry of Environment Republic of Korea (2008). The Basic Environmental Policy Act, Law No. 9037.

Myong-Yong K (2004). Improvement Plans for Road Traffic Noise-Related Laws, Korea Legislation Research Institute, pp. 11-12.

National Environmental Dispute Resolution Commission (2008). Statistics document 2008, http://edc.me.go.kr/.

Noel AM (2007). "Queensland Rail – An example in effective noise mapping and noise control implementation for existing rail operations", Environmental Expert.

Ono S (2002). Application case document (In Japanese), available from http://www.onosokki.co.jp/HP-WK/products/keisoku/software/others/soundplan/soundplan.pdf (Last viewed May 2010).

Onuu MU (2000). Road Traffic Noise in Nigeria: Measurements, Analysis and Evaluation of Nuisance, J. Sound Vibration, 233(3): 391-405.

Ouis D (2002). Annoyance From Road Traffic Noise : A Review, J. Environ. Psychol. 21(1): 101-120.

Seo-Il C, Shi-Won L, Younge-Min P, Jin-Wwon C (2005). Utilizing Noise Mapping in Environment Impact Assessment in a Downtown Development Area, Transactions of the Korean Society for Noise and Vibration Engineering , 15(11): 1311-1317.

Si-Wook L, Ho-Chun Y (2002). A Study on the Improvement of the Road Traffic Noise Prediction through the Case Study, J. Architectural Institute Korea, 22(2): 745-748.

Sun-Woo K, Kyung-Mo K, Hyeon-Ku P, Hyung-Ryul K, Tae-Woan K (2000). An Experimental Study on the noise Attenuations Characteristics of Noise Barriers in the Apartment Housing Development, J. Architect. Institute Korea, 16(8): 135-142.

The European Parliament and of the Council (2002). Relating to the assessment and management of environmental noise, Directive 2002/49/EC, Official J. Eur. Commun. pp. 170-199.

Yang-Ki O, Ha-Gun K, Won-Yeul L (2004). Evaluation and Prediction of the Characteristics of Noise Reduction depending on the Shapes of the Tunnel Section, J. Architect. Institute of Korea, 20(8): 181-188.

Yoshida T, Osada Y, Kawaguchi T, Hoshiyama Y, Yoshida K, Yamamoto K (1997). Effects of Road Traffic Noise on Inhabitants of Tokyo, J. Sound Vibration, 205(4): 517-522.

Young-Bin I, Myung-Jin K (1996). Sound Insulation Performance of Noise Barriers for Apartment House Site near Road by Field Measurement, J. Architect. Institute of Korea, 12(8): 185-193.

APPENDIX

1) The noise prediction was executed according to articles 25-27 of The Basic Environmental Policy Act. This Act aims to produce environmentally friendly and sustainable development by examining the feasibility of the project and the development's environmental impact prior to the settlement or approval of the plan, with the development project in the administration plan and preservation purpose areas as the target.

2) Life Noise Regulate Standard (unit : Leq dB(A))

Area	morning and evening (05:00-08:00, 18:00-22:00)	Daytime (08:00-18:00)	midnight (22:00-05:00)
Residential area, Afforestation area, Settlement area as well as Movement-Rest area in a Semi-City area, Natural environment conservation area, Other areas such a Schools, Hospitals, Libraries	less than 60	less than 65	less than 50
The other area	less than 65	less than 70	less than 50

3) Noise Environmental Standard (unit : Leq dB(A))

Area	Application area	Noise Standard	
		Daytime (06:00~22:00)	Night time (22:00~06:00)
General area	School·Library·General hospital (50m from the site within the boundary), Conservation management area, Natural environment conservation area, Forestry area, Green zone, Exclusive residential area	50	40
	General residential area, Semi- residential area, Production management area	55	45
	Business area, Planning management area, Semi- industrial area	65	55
	General industrial area, Industrial area	70	65
Roadside area	School·Library· General hospital (50m from the site within the boundary), Conservation management area, Natural environment conservation area, Forestry area, Green zone, Exclusive residential area, General residential area, Semi-residential area, Production management area	65	55
	Business area, Planning management area, Semi- industrial area	70	60
	General industrial area, Industrial area	75	70

4) In the conveyance progress of the soil and sand, four dump trucks (Hyundai 15ton) and five backhoes (Volvo EW170) were used.

5) Predicted traffic volume in 2008

Section	Vehicle(Veh/h))		Speed average(km/h))	
	Car	Truck	Car	Truck
Road 1	3558	351	60	50
Road 2	972	84	60	50
Road 3	1047	42	50	40
Road 4	1181	34	50	40

6) The roadside area: A traffic lane number × 10m

7) The Balloon Effect: The phenomenon that one problem arises when solving another in the same way that one part of a balloon bulges when another part is pushed.