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The Effect Analysis of Applying Active Noise Control Technology To Public Works

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ABSTRACT

Noise barrier which is one of the soundproof systems to deal with road noise has the limit because of high cost, aesthetic problem and ecological disturbance. In this study, active noise control technology is proposed to cope with the limit of existing soundproof system and analysis of economic effect when applying active noise control technology to the road was conducted. In economic analysis, expected effect after commercializing electronic and combined sound barrier technology was analyzed so as to evaluate the economic effect for 5 years from 2017 till 2021. As a result of estimating the final economic effect after summing up noise benefit cost based on cost for 5 years from 2017, maintenance cost and total installation length, it's totaled 256.3 billion won in minimum to 512.6 billion won in maximum, which has proven the economic effect of active noise control technology when applying to public works.

Keywords: *Road traffic noise, active noise control, noise barrier, economic analysis, public works*

1. INTRODUCTION

The number of people exposed to road noise has been arisen, particularly in industrialized urban area which hascaused the civic complaints against the noise. The complaint against the noise and vibration in 2010 totaled 53,71, up by 26.7% from 2009 and the noise is the cause that accounted for 35.4% of environmental complaints. Noise barrier is one of the typical soundproof systems to deal with road noise but has a number of problems. Existing noise barrier is costly in installing and maintaining and has the negative effect on landscape. Transparent noise barrier is used to reduce the aesthetic problem which however causes ecological disturbance with the birds. Besides, noise barrier has the spatial limit in installation, that is, the higher the building the less the noise reduction effect [1].

In this study, active noise control technology is proposed to cope with the limit of existing soundproof system and analysis of economic effect when applying active noise control technology to the road was conducted.

2. DEFINITION OF ACTIVE NOISE CONTROL TECHNOLOGY

Active noise control is the technology that reduces the noise by generating antiphase frequency to noise source and has been applied to in-car noise or headphone and is at the stage of basic noise source and lab test to apply to the road.

Active noise control was first introduced by Leug in 1936 but failed to draw attention because of low electronic device technology, but in 1980s when related technologies began to develop, the study on application technologies has been put on track. Theoretically it may be applied to all audio systems, but it's generally used to reduce the low frequency noise in limited space and thus it's necessary to expand the use in a wide range [2].

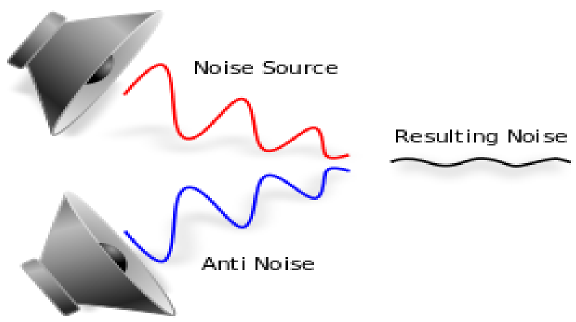

Figure 1: Graphical depiction of active noise reduction[3]

3. ECONOMIC ANALYSIS METHODOLOGY

3.1 Costs-Benefit Analysis

Cost benefit analysis is conducted in various ways depending on project goal and characteristics. When project goal is to create new business, market advance or technology development of which specific output is market good, it predicts the market volume and share and estimates the added value ratio so as to analyze the direct benefit.

Evaluation was conducted based on value calculated by dividing the sum of the benefit by period which was converted to market value by the sum of cost by period. According to the Ministry of Strategy & Finance's 2014 Guideline for preliminary feasibility study (Article 34), it is economically feasible when B/C ratio exceeds 1. In case of the project to which cost-benefit analysis is not applicable, economic, social, scientific and technical ripple effect are estimated and Cost-Effectiveness Analysis is conducted accordingly[4].

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The area where systematic economic feasibility analysis was conducted among non-R&D field is the preliminary feasibility system that started in construction project and the area has been expended from transportation and water resource to information and cultural facilities [5].

When it comes to transportation, direct benefit from transportation and social benefit (indirect benefit) from improved transportation are used as basic pool and as indirect benefit, environmental cost reduction, regional development effect, market area expansion and industrial structure reformation are included. When it comes to road, direct benefit includes reduction in vehicle operation cost, travel time and traffic accident and increase in comfortability, punctuality and stability and the items that be converted in monetary value include reduction in vehicle operation cost, travel time and traffic accident and subjective satisfaction includes improved comfortability of traffic, punctuality and stability. Direct benefit includes reduction in environmental cost (pollution, noise), non-station development, increase in market area and industrial structure reformation.

3.2 Sensitivity Analysis

Sensitivity analysis is intended to predict the unexpected variable used in feasibility analysis process and the variables include ridership, construction cost and discount rate. In case of construction cost, sensitivity analysis is conducted on assumption that the cost may vary because of using special construction method or change to construction volume and the range of changes is set considering the scope of work and characteristics of the project site. Social discount rate is assumed to be fixed but to effectively incorporate the drastic change to exchange rate or interest rate due to external factor, social discount rate will vary for sensitivity analysis. Sensitivity analysis is usually conducted by adjusting the variable by a certain percentage (%) but more practical and advanced method is to conduct the probabilistic analysis of future risk so as to predict in advance the potential change of feasibility analysis result. The cost is usually occurred at early stage of the project while the benefit is generated over analysis period constantly and thus, when discount rate is lowered, present value of the benefit to be occurred in future rises, thereby having positive effect on economic feasibility such as B/C [6].

4. ECONOMIC FEASIBILITY ANALYSIS

4.1 Estimate of Benefit

4.1.1 Estimate of Noise Cost (Benefit)

Information on change to noise and unit requirement of noise is necessary to estimate the value of the noise. After estimating the noise level before and after project implementation, maintenance cost method is applied to estimate the maintenance cost (including noise barrier installation cost) required to reduce the unit noise (1dB) and then converted to monetary value by multiplying the unit requirement. As noise cost is based on potential maximum noise level, noise level at the peak traffic time only is estimated. But in case of building the new road, traffic when not implementing the project is not predictable and noise prediction equation is not applicable. In such a case, noise level when not implementing the project is assumed 45dB for provincial road and 55dB for urban road. Unit requirement of noise value considering effective noise damage was 3,026 won for urban section and 1,306 won for provincial section or average 1,540won as of 1999 and to convert them to the value in 2011, following average unit requirement of noise value was estimated by multiplying benefit correction factor using consumer's price index.

Table 1: Average unit requirement of noise value (2011) (in won/dB·year·m)

Classification	Urban	Provincial	Mean
Mean unit requirement of noise value	4,308	1,860	2,193

The equation to estimate the noise cost (benefit) caused by the project is as follows.

$$\mathrm{EVNS} = \mathrm{EVN}_0 - \mathrm{EVN}_c$$
$$\mathrm{EVN} = \sum_i \sum_j (P * l_{ij} * L_{ij})$$

Where,
EVNS: Noise cost (benefit) EVN_k: Noise cost (0=when project not implemented, c=when project implemented)
P: Unit requirement of noise value, l_{ij}: Length of the route
L_{ij}: Predicted noise level, i: Road category (highway, expressway and so on)
J: Individual link within influential zone

4.2 Estimate of Economic Feasibility

4.2.1 Procedure

Figure 2 shows the process to evaluate the economic feasibility analysis after commercializing the electronic and combined noise barrier technology.Economic effect that may appeared over 5 years from 2017 till 2021 was evaluated.

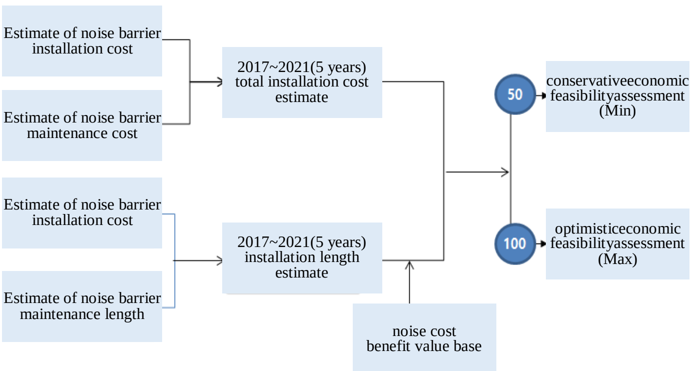

Figure 2: Economic feasibility analysis process

Installation cost and maintenance cost were estimated based on latest data of Environment Ministry.

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Installation of noise barrier and maintenance length were applied based on prediction. Economic effect was estimated after summing up the installation cost and maintenance cost and based on noise cost and benefit value depending on installation length. Finally, economic effect was evaluated by categorizing it to conservative evaluation and optimistic evaluation based on occupation ratio 50% in minimum and 100% in maximum.

4.2.2 Expected Effect from Installation Cost

Table 2 shows the estimate based on application to the market beginning in 2017 after development of electronic and combined noise barrier based on cost estimated for installation domestic noise barrier. Noise barrier was assumed to be installed beginning in 2017 for 5 years and for first 5 years, Market share was based on conservative 50% and optimistic 100%, respectively.

Table 2: Conservative economical expected effect from installing domestic noise barrier (in million won)

year	length (km)	Cost (million won)	Market share (%)	Economic effect	Social D/C rate (5.5%)
2017	21.2	56,030	50	28,015	28,015
2018	19.1	50,315	50	25,158	23,846
2019	17.1	45,182	50	22,591	20,687
2020	15.4	40,574	50	20,287	17,277
2021	13.8	36,435	50	18,218	14,705
Sum	86.6	228,536		114,268	104,530

Economic effect from applying this technology to public works using noise barrier budget was estimated based on predicted market share and social D.C rate applied was 5.5%. When applying conservative 50% of market share, economic effect for 5 years during 2017~2021 totaled 104.5 billion won. When assuming all installations were replaced with ANC and combined type, the result is as Table 3.

Table 3: Positive economical expected effect from domestic soundproof panel on installation cost (in million won)

Year	length (km)	Cost (in million won)	Market share (%)	Eco Nomic Effect	Social D.C rate
2017	21.2	56,030	100	56,030	56,030
2018	19.1	50,315	100	50,315	47,692
2019	17.1	45,182	100	45,182	40,594
2020	15.4	40,574	100	40,574	35,555
2021	13.8	36,435	100	36,435	29,411
2017~2021	86.6	228,536		228,536	209,282

When applying optimistic 100% market share, economical effect expected for years during 2017~2021 is estimated at 209.3billion won. In conclusion, economical effect on maintenance cost of noise barrier from 2017 is estimated at 104.5 billion won in minimum to 209.3billion won in maximum.

4.2.3 Expected Effect from Maintenance Cost

Table 4 shows economic effect for 5 years after installing the soundproof panel from 2017 based on maintenance cost of existing noise barrier installed in 2017 with 10 years of service life on assumption that electronic and combined noise barrier is developed and applied to the market to replace the existing ones.

Same as installation, market share for first 5 years was based on conservative 50% and optimistic 100%, respectively.

Table 4: Conservative economical expected effect from domestic soundproof panel on maintenance cost (in million won)

year	Length (km)	Cost (in million won)	Market share (%)	Economic effect	Social D.C rate
2017	67.2	78,154	50	39,077	39,077
2018	54.6	63,500	50	31,750	30,095
2019	66	76,758	50	38,379	34,482
2020	51.7	60,127	50	30,064	25,602
2021	43.3	50,358	50	25,179	20,325
2017~2021	282.8	328,897		164,449	149,581

Thus, economic effect when applying this technology to public works in maintenance cost was estimated based on market share and same 5.5% of D/C rate was applied as the case of installation. When applying conservative 50% of market share, expected economic effect for 5 years during 2017~2021 was estimated at 149.6 billion won and when assuming to replace all of them with ANC and combined type, the result is as Table 5 below.

Table 5: Optimistic economical expected effect from domestic soundproof panel on maintenance cost (in million won)

Year	length (km)	Cost (in million won)	Market share (%)	Economic effect	Social D.C rate
2017	67.2	78,154	100	78,154	78,154
2018	54.6	63,500	100	63,500	60,190
2019	66	76,758	100	76,758	68,963
2020	51.7	60,127	100	60,127	51,205
2021	43.3	50,358	100	50,358	40,650
2017~ 2021	282.8	328,897		328,897	299,162

When applying optimistic 100% market share, economical effect expected for years during 2017~2021 is estimated at 299.2billion won.

In conclusion, economical effect on maintenance cost of noise barrier from 2017 is estimated at 149.6 billion won in minimum to 299.2billion won in maximum.

4.2.4 Expected Effect from Noise Cost (Benefit)

Reduction in noise by applying this technology to installation and maintenance of noise barrier for 5 years during 2017~2021was estimated in monetary value.

The estimated was based on government's guideline on traffic facility investment assessment that stipulates the average cost of noise value 2,193 won/dB･year･m. And noise reduction effect comparing to existing ones was 7dB.

Table 6: Conservative economical expected effect from domestic soundproof panel on noise cost (in million won)

Year	Length (install) (km)	Length (maint) (km)	Total length	dB effect	Noise effect /m (\)	Share (%)	Economic effect	Social D/C rate
2017	21.2	67.2	88.4	7	2,193	50	679	679
2018	19.1	54.6	73.7	7	2,193	50	566	536
2019	17.1	66.0	83.1	7	2,193	50	638	573
2020	15.4	51.7	67.1	7	2,193	50	515	439
2021	13.8	43.3	57.1	7	2,193	50	438	354
2017~ 2021	86.6	282.8	369.4				2,835	2,580

As a result of estimating the economical effect from reducing soundproof panel cost, total maintenance length for 5 years during 2017 ~ 2021 is estimated at 369.4km and economical effect from 7dB noise reduction was estimated and social D/C rate was 5.5%.When applying the conservative rate, total economical effect from noise reduction for 5 years during 2017~2021 was estimated at 2.58billion won.

When assuming to replace all of them with ANC and combined type, the result is as Table 6 below.

Table 7: Optimistic economical expected effect from domestic soundproof panel on noise cost (in million won)

Year	Length (install) (km)	Length (maint) (km)	Total length	dB effect	Noise effect /m (\)	Share (%)	Economic effect	Social D/C rate
2017	21.2	67.2	88.4	7	2,193	100	1,357	1,357
2018	19.1	54.6	73.7	7	2,193	100	1,131	1,072
2019	17.1	66.0	83.1	7	2,193	100	1,276	1,146
2020	15.4	51.7	67.1	7	2,193	100	1,030	877
2021	13.8	43.3	57.1	7	2,193	100	877	708
2017~ 2021	86.6	282.8	369.4				5,671	5,160

When applying optimistic 100% market share, economical effect expected for years during 2017~2021 is estimated at 5.16billion won. In conclusion, economical effect on installation & maintenance cost of soundproof panel for 5 years from 2017 is estimated at 2.58billion won in minimum to 5.16billion won in maximum.

4.3 Economic Feasibility Assessment Result

Economical effect was estimated based on installation cost, maintenance cost and total installation length for 5 years from 2017 when electronic and combined type noise barrier is applied.

The Table below shows conservative economic effect on assumption of 50% of market share of electronic and combined type noise barrier. Installation cost is 113 billion won and maintenance cost is 164.4billion won and noise benefit cost is 2.8billion won and when summing up those by applying social D/C rate, economic effect is estimated at 256.3billion won.

Table 8: Conservative economic effect of electronic & combined noise barrier technology (in million won)

Year	Installati on cost	Maintenance cost	Noise benefit cost	Economic effect	Social D/C rate
2017	28,015	39,077	679	67,771	67,771
2018	25,158	31,750	566	57,474	54,478
2019	22,591	38,379	638	61,608	55,352
2020	20,287	30,064	515	50,866	43,318
2021	18,218	25,179	438	43,835	35,384
2017~2021	114,268	164,449	2,835	281,554	256,303

The Table below shows the summary of optimistic economic effect on assumption of 100% market share and Installation cost is 228.5. billion won and maintenance cost is 328.9billion won and noise benefit cost is 5.7billion won and when summing up those by applying social D/C rate, economic effect is estimated at 512.6billion won.

Table 9: Optimistic economic effect of electronic & combined noise barrier technology (in \mil)

Year	Installation cost	Maintenance cost	Noise benefit cost	Economic effect	Social D/C rate
2017	56,030	78,154	1,357	135,541	135,541
2018	50,315	63,500	1,131	114,946	108,954
2019	45,182	76,758	1,276	123,216	110,704
2020	40,574	60,127	1,030	101,731	86,636
2021	36,435	50,358	877	87,670	70,769
2017~2021	228,536	328,897	5,671	563,104	512,602

In conclusion, as a result of estimating economical effect based on installation cost, maintenance cost and total installation length for 5 years from 2017 when electronic and combined type noise barrier is applied, it's estimated at 256.3billion won in minimum to 512.6billion won in maximum.

5. CONCLUSION

Noise barrier which is one of the soundproof systems to deal with road noise has the limit because of high cost, aesthetic problem and ecological disturbance. In this study, active noise control technology is proposed to cope with the limit of existing soundproof system and analysis of economic effect when applying active noise control technology to the road was conducted

In economic analysis, expected effect after commercializing electronic and combined sound barrier technology was analyzed so as to evaluate the economic effect for 5 years from 2017 till 2021.

As a result of estimating the final economic effect after summing up noise benefit cost based on cost for 5 years from 2017, maintenance cost and total installation length, it's totaled 256.3 billion won in minimum to 512.6 billion won in maximum, which has proven the economic effect of active noise control technology when applying to public works.

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