〈研究発表〉

Current Trends and Future Issues of Traffic Noise Barrier in Korea

IL-HO KIM, GWANG-SOO KIM

Construction Environment Research Division, Korea Institute of Construction Technology / Department of Construction Environment Engineering, University of Science & Technology (283, Goyangdae-Ro Ilsanseo-Gu, Goyang-Si, Kyonggi-Do, 411-712, Republic of Korea, E-mail: ihkim@kict.re.kr)

Summary

Because of the change in understanding the noise recently, the investment for noise reduction accounts for a considerable portion of overall R&D investment. The noise generated from the traffic, among other noise, causes the complaints by the residents. These complaints for noise damage have been increased year by year. Traffic noise reduction measures are classified into the primary reduction measure to the vehicles and the secondary reduction measure to block the noise path. The study is intended to describe the traffic noise management policy and the development of noise barrier as the secondary reduction measure.

Keyword: Noise barrier, Traffic noise, Transparent type, Active Noise Control (ANC)

1. Introduction

Shortage of the housing site resulting from rushed urban development has led to building the high-rise apartment complex along the roadside, causing the increasing number of population to be exposed to the traffic noise. Increase in number of vehicles in line with increased income level is also one of the factors increasing the noise damage. On the other hand, demand for calming environment by the residents has been increasingly growing on the back of recognition of well-being and thus the need for eliminating the element damaging the living environment is more than ever. Noise is very critical element in determining the quality of life because it may cause the mental damage such as disturbed sleep, difficulty concentrating and stress. To prevent the noise damage, environment noise monitoring network has been installed at 1,766 locations in 357 districts over 44 cities including Seoul. Viewing the outcome of such monitoring network in 2010, environmental standard achievement rate at roadside district (daytime: 06:00~22:00) was 59% at residential area, 93% at commercial area and at nighttime (22:00~06:00), it was 25% and 42%, respectively, indicating the half at the daytime (2010 outcome of environmental noise monitoring network, the Environment Ministry), which was attributable to increasing noise source in urban area such as population and vehicles because of urban redevelopment and expansion. Achievement rate at general area was significantly lower than roadside area, which was also decreased from 2009 as indicated in Table 1. Based on investigation result, various policies together with legislation and revision of the law for noise reduction have been developed in Korea. Among the laws relating to traffic noise are environment policy basic law, noise & vibration management law and homebuilding promotion law. Though slightly different limits in traffic noise have been applied, the limit in residential district near roadside shall be 65dB (A) The district where the noise limit is required is designated as noise limit district so as to provide the noise barrier for noise reduction. Technology development for noise barrier in Korea has made the slow progress because of poor regulation and limited capacity of design & construction companies. The study on effect of noise barrier on residents living near the roadside has yet to be implemented in earnest. Then amidst people's growing concern on noise damage, technology development for noise barriers has been put on track. In this study, traffic noise management in Korea and Japan is introduced, which is then followed by technology development tendency. Noise barriers include transparent type (reflection), noise-blocking type, noise-absorbing type and the mixed type, and the study focused on transparent type, among others. Finally, active noise control (ANC) technology is summarized in this study.

2. Management statue of Traffic noise

Viewing the traffic noise environmental standards according to the environment policy basic law in Korea, residential and semi-residential district at daytime is 55 dB(A) and at midnight is 45 dB(A) and at roadside district, residential and semi-residential district at daytime is 65 dB(A) and 55 dB(A) at nighttime, indicating that 10dB(A) is lower than other area as shown in Table 2, considering the characteristics at roadside district. Reducing the noise generated by the transport means is the most fundamental measure,

among others, to reduce the traffic noise and thus the system to crack down the excessive noise by heavy vehicle, illegally-remodeled vehicle and motorcycle has been under review now. Besides, the study on development and distribution of low-noise vehicle such as electric car without engine noise and necessary infrastructure has been underway.

Traffic noise management guideline of noise & vibration management law will also be further supplemented to make it stricter to the level of roadside noise standard of Environment Policy Basic Law (65dB at daytime and 55dB at nighttime) from current level (68dB at daytime and 58dB at nighttime) Since the noise is dependent on type of vehicle, speed and traffic hours, it's difficult to achieve the noise reduction target with technical prevention measure (noise barrier, tunnel and low-noise pavement) alone and thus other management system to control the traffic and speed limit at the traffic noise control district will also be implemented. "Standard for performance and installation of noise barrier facilities (the Environment Ministry) legislated in 1996 was amended in 2011 to strengthen the noise barrier performance in a way of evaluating the appropriateness of the design and installation by the experts and performing the performance evaluation every 5 years regularly. About a 1.221km-long noise barrier was installed as of 2009 throughout the nation, but as some of them have spoiled the aesthetic landscape, recommendation to consider the aesthetic view was given to the municipal governments.

With regard to environmental noise standard, International Standardization Organization (ISO) recommends the guideline as described in Table 3. According to ISO noise management, noise is defined as the noise all other sources than industrial environment, and particularly recommends the guideline for environmental noise.

In Europe, USA and Japan, noise standards are classified into road, railroad and aviation. As indicated in Table 3, the requirements in residential district were 45dB(A) at daytime and 35dB(A) which were stricter than 50dB(A) and 40dB(A) in Korea. When it comes to urban area, they were 55dB(A) at daytime and 45dB (A) at nighttime which also stricter than 65 dB(A) at daytime and 55 dB(A) at nighttime by 10dB(A). The standards in Korea was similar with UK's but lowered than Japan and Germany (residential district) by 5dB(A).

According to noise standards in Article 16-1 of Environment Basic Law (#91 in Heisei 5) in Japan, the standard for roadside district is as Table 4. As a result of evaluating the environmental achievement rate by 179 municipal governments in Heisei 22, the region exceeding the environmental standards at daytime (06:00 ~ 22:00) or nighttime (22:00 ~ 06:00) was 499,000 houses (9%) among total 5,759,000 houses and 248,000 houses at both daytime and nighttime (on Dec 22, Heisei 23 for traffic noise in Heisei 22 by automobile environment department of air pollution bureau, Environment Ministry) When calculating by type of road, highway was ranked the top in exceeding the standards at daytime or at nighttime and 8000 (17%) among 47000 houses

A regular monitoring of traffic noise has been implemented in a bid to systematically control the traffic noise at each local and central government since Heisei 12. To accomplish the environmental goal, road structure plan, traffic flow measure and year-on-year plan have been constantly implemented comprehensively jointly by road management agency, police, traffic & transport industry and environment department. However, accomplishment rate has been slowly improved and the complaints on traffic noise still remain unsolved, despite of slight reduction. To deal with such situation, "Guideline to deal with traffic noise in future" was developed by the Environment Ministry in collaboration with the concerned agencies including police, Economy & Industry ministry and the Land &Traffic Ministry" (June 30, Heisei 21, Air Pollution Bureau, Environment Ministry) Further measures include 1) Measure to deal with the source, 2) Measures to deal with traffic flow, 3) Measures for road structure, 4) Year-on-year measure, 5) Other measures. Measures to deal with the source include pre-certification of muffler, review of regulations including test method and noise regulation method and low-pollution vehicle. Measures to deal with traffic flow include road network improvement, traffic reduction and control. Further study includes automobile noise reduction technology, promotion of effective use of public transport, technology development of road structure and reinforced year-on-year measures.

3. Development status of noise barrier as traffic reduction tool

3.1 Transparent type noise barrier

Aluminum or extruded cement noise barrier used for reducing the traffic noise has high acoustic performance but can hardly be matched with the surrounding environment, causing negative impact on urban landscape, oppressed feeling to the drivers or residents and blocking the view. Because of such reasons, transparent noise barrier has been increasingly used. Transparent noise barrier will provide the wider view and eliminate the oppression sense so as to

prevent the accident caused by view-blocking. Moreover, it may be able to solve the road surface freezing caused by the shade. But traditional transparent noise barriers which were mostly fabricated with plastic material are vulnerable to yellowing, discoloring, pollutants and scratching which deteriorates the transparency and rather spoils the urban landscape. Despite such shortcomings, demand for transparent noise barrier is expected to grow further because of more advantages than disadvantages.

Technologies for developing transparent noise barrier in Korea recently are mostly, 1) Transparent noise barrier using various materials and 2) noise barrier panel and frame structure. In this chapter, review of the material used for the noise barriers was made. Transparent plastic materials such as polymethylmethacrylate (PMMA), polycarbonate(PC) were commonly used and recently, the glass which has advantage in weather resistance and light permeability is also used.

PMMA, among transparent plastics, has the highest light permeability and because of its light stability and surface gloss, it's been commonly used for lighting, optical parts and auto parts. It also has a low loss rate by light absorption or diffraction with less wavelength dependency of refractive index. When it comes to PC, as it has a high impact and heat resistance, it's been used for electric/electronic appliance and medical equipment and transmission coefficient of visible ray is as much as 80~90%. But on the other hand, as it's vulnerable to yellowing and deterioration by ultraviolet ray, light stabilizer is a must when used outdoor to prevent it from yellowing.

Because of soft surface, hard coating is required for improving the surface hardness. Coating materials for noise barrier include polymer hard coating and hydrophilic photocatalyst (TiO_2) Recently silica glass coating material with high surface hardness has been developed. Polymer coating material has advantage of easy manufacture and low cost, but is vulnerable to deterioration by ultraviolet ray and has disadvantage such as hydrophobic property and the function limited to gloss-protection only.

When it comes to hydrophilic photocatalyst, organic pollutants on panel is removed by TiO_2 but hydrophilic function is reduced in linw with decomposition of TiO_2 over the time, which requires supplementary application. Glass has many advantages than any other materials in terms of light permeability, weather resistance, chemical resistance and Abrasion resistance, but the problems is broken fragment when damaged. To supplement such shortcomings, two plates of glass can be laminated using adhesive film. Polyvinyl butyral (PVB)is most commonly used as adhesive films.

3.2 Active noise control technology

Passive noise control technology using noise barrier has been most commonly applied thanks to constant research effort and institution, despite of limit in reducing the diffracted sound. On the contrary, the research and development of active noise control technology has been at a standstill due to rising acoustic pressure at high frequency resulting from the lack of signaling technology, despite of effective outcome at a certain f¥low frequency. Thus either the active noise control which is vulnerable to reducing noise at high frequency or passive noise control which is vulnerable to reducing noise at low frequency cannot create the comfortable living environment, if using only one of the two technologies.

Viewing the patent application with regard to active noise control technology for reducing traffic noise, active noise control technologies totaled 42 cases from 1992 till 1997, accounting to the greater portion and the application since then has been continued. By type of technology, railroad vehicle noise control totaled 57, ranked the top, which was followed by road noise control 42 and automobile noise control 11. In Japan, patent application reached to 1,520, indicating the most active research & development activity. The search was carried out from Jan 1, 1985 to Jan 31, 2009 and the DB used was WIP DB.

Various materials have been applied to transparent noise barrier technologies but if the panel is discolored by pollutants on road or tainted with dirt, it rather causes the damage to landscape. So it's necessary to invest in developing the transparent noise barrier which is simple and easy for maintenance. Low frequency noise from 200Hz or below which has been addressed in advanced nations would possibly cause the problems in Korea too. Thus the Environment Ministry has been developing the measures to deal with such low frequency noise. 60dB or some low frequency noise was reportedly detected during fact-finding investigation[3] which indicated the need for developing the noise barrier to deal with such low frequency noise which might be another challenge to noise barrier technologies.

In contrast to Japan, development of noise barrier (active noise barrier) using active noise control technology in Korea was not so active. In one study, active noise control technology which was designed to reduce the noise was applied to the top of noise barrier to deal with the increased noise on rear side which was caused by the noise diffracted on top at low frequency (Fig. 2(a)[4]). However, this active noise control system was able to deal with the changing

noise environment such as the change in surrounding environment or the change to noise distribution by temperature variation because the control source with same phase is emitted by multiple number of speakers. To supplement the problem, active noise barrier which is highly effective in reducing the noise by focusing the noise control territory in a way of adjusting the phase of control source from the multiple number of speakers (Fig. 2(b)[5]) Korea Institute of Construction Technology has been working on combined noise reduction system by combining the active noise control system with the transparent noise barrier which is matched well with surrounding road landscape.

4. Conclusion

Noise barrier installation has been increasingly growing in line with expanding road network and traffic but the noise barrier has been used as the device to isolate the noise because of poor understanding of environment-friendly system and institution. Though the efforts to diversify the system in color depending on design and application, technology development of noise barrier has been at infant stage. Thus it's necessary to develop the diversified noise barriers, considering domestic ecosystem and aesthetic landscape. In addition, noise barrier using low carbon material, instead of metal or plastic material, complex noise barrier with the function to collect the carbon at roadside or surroundings or combined noise barrier which combines active noise control device with the traditional system need to be further developed in the future.

References

1) Outcome of Environment Noise Monitoring Network operation, The Ministry of Environment Ministry (2010)
2) Article 2 of Enforcement Ordinance of Environment Policy Basic Law, #1, Rev Aug 17, 2000
3) Investigation of low frequency noise in living environment and management measures I, KRISS (2009)
4) Active Sound Proofing Wall System, Patent Application No. 10-2010-0017735
5) ACTIVE SOUNDPROOFING SYSTEM AND ACTIVE SOUNDPROOFING BARRIER USING THE SYSTEM, Patent Application No. 10-2008-0090313, Patent Registration No. 10-0986610-0000