Applied Acoustics 139 (2018) 165–173

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

On-site measurements for noise reduction through open windows of classrooms with different building dispositions

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ARTICLE INFO

Keywords:
School
Classroom
Road traffic noise
Noise reduction
Open window
Environmental impact assessment

ABSTRACT

In Korea, mitigation measures for traffic noise at schools are implemented during urban planning to meet the acceptable level (less than 65 dBA at a building façade) stipulated by the Environmental Impact Assessment (EIA). Meanwhile, traffic noise at schools is managed to satisfy the acceptable level (less than 55 dBA in a classroom with open windows) indicated by the School Health Act (SHA). This variation indicates the possibility to exceed the acceptable SHA level for EIA-approved schools if noise reduction through open windows is less than 10 dBA. Thus, this study carried out onsite measurements for noise reduction through classrooms' open windows at 19 schools to suggest the appropriate EIA level to meet the acceptable SHA level. The building dispositions were categorized into four types as; (1) Parallel disposition between road and classroom (P type), (2) Perpendicular disposition between road and classroom (V type), (3) Cross-sectional disposition between road and classroom (PV type), and (4) Parallel disposition between road and hallway (H type). The results showed different noise reduction through open windows according to the type of building dispositions in the order of H (16.9 dBA), V (9.2 dBA), PV (8.4 dBA), and P (6.7 dBA) types, attributed to the change in incidence angles between the road and open windows, confirmed by measurements using a speaker. In conclusion, the acceptable noise level on SHA could be exceeded especially for the P, PV, and V types, indicating the need for different noise mitigation measures according to building dispositions.

1. Introduction

School facilities are spaces where educational activities are carried out. Thus, the appropriate acoustical environment needs to be created inside and outside school buildings for teaching and learning activities [15]. However, as the location of school facilities is selected considering accessibility to public transportation, they end up being built adjacent to roadsides. For this reason, measures to reduce road traffic noise are needed to satisfy relevant regulations on the acceptable noise level at school facilities.

To prevent learning disruption caused by road traffic noise at school facilities, noise reduction measures could be established regarding noise sources, propagation paths, and sound-receiving points through an environmental impact assessment (EIA) prior to project approval. In post-developmental stages, whether or not the acceptable noise level is exceeded should be determined by onsite measurements in accordance with relevant regulations, and then additional noise reduction measures might be established. Thus, systematic noise reduction measures and management plans should be established by setting up management stage noise regulations associated with the EIA stage noise regulations.

In Korea, the acceptable road traffic noise level in roadside-adjacent school facilities is less than 65 dBA at daytime and less than 55 dBA at night time on the EIA according to the Framework Act on Environmental Policy [10]. During the EIA, project approval in new residential development districts is received after setting up noise reduction measures through the prediction of noise in front of the building façade, with consideration for the expected school building disposition and traffic conditions. After construction completion of school facilities, whether or not the acceptable noise level of less than 68 dBA at daytime and less than 58 dBA at night time are exceeded is determined by measurements in front of the building façade, in accordance with the Noise and Vibration Control Act [11]. If the acceptable noise level is exceeded, additional outdoor noise reduction measures might be established. Apart from this, additional noise regulations for school facilities are specified in the School Health Act (SHA), and whether the acceptable indoor noise level (less than 55 dBA) is met or not is determined through onsite measurements in classrooms with all classroom windows and doors open [9]. Further, the Green Building

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https://doi.org/10.1016/j.apacoust.2018.04.030
Received 4 February 2018; Received in revised form 31 March 2018; Accepted 22 April 2018
0003-682X/ © 2018 Published by Elsevier Ltd.

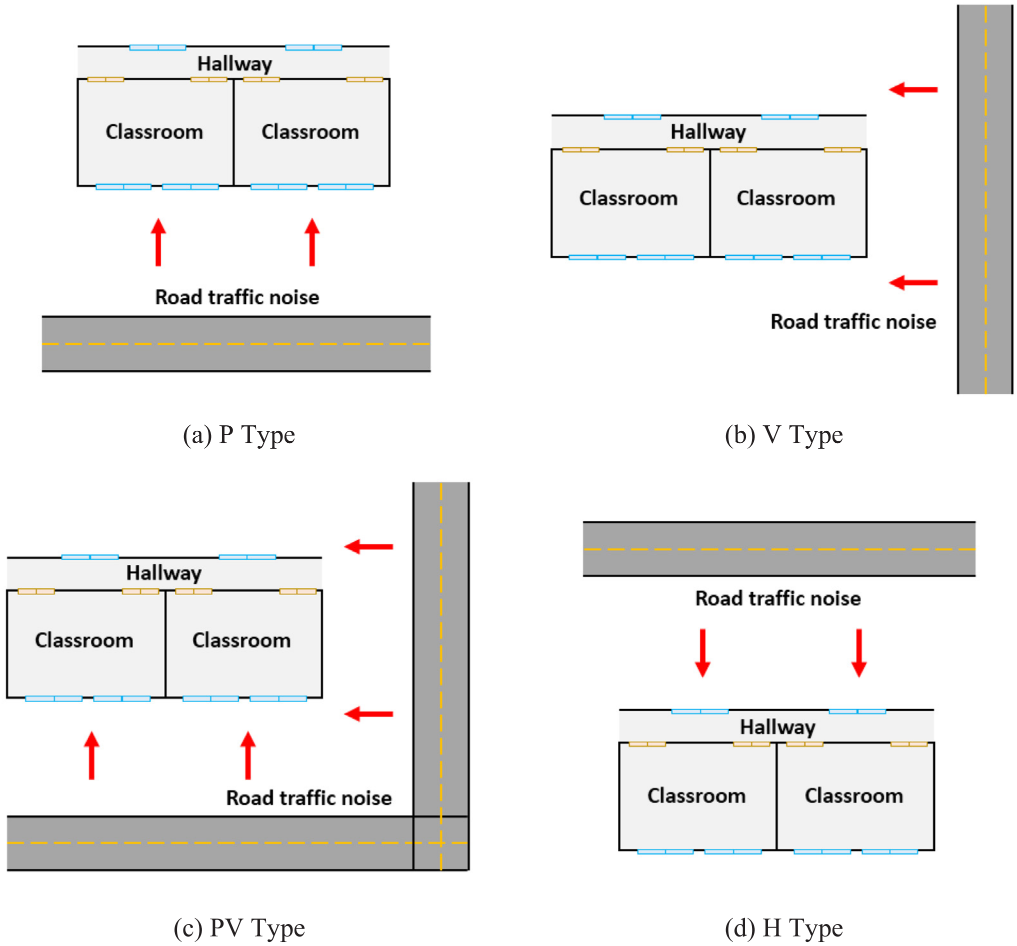

Fig. 1. Type of building dispositions for schools determined by considering the incidence angle between the building and traffic noise source.

Certification standard for school facilities stipulates that noise should be less than 45 dBA in classrooms with closed windows [12]. As reviewed above, it is necessary to establish noise reduction measures that meet one standard in the EIA, and three different standards in the management stage in Korea.

Given the difference of 10 dBA between the indoor (SHA) and outdoor (EIA) noise standards, school facilities that have already passed the EIA could exceed the noise standard of the SHA in the management stage. Thus, it is important to design the building façade with open windows to achieve a noise reduction effect of more than 10 dBA in the planning stage to create pleasant learning environments.

Noise reduction effects of open windows are determined by various influencing factors, such as architectural design (building disposition, window type, interior finishing materials, classroom size, etc.), sound source conditions (road width, traffic volume, percentage of heavy vehicles, etc.), and propagation path conditions (road-building separation distance, soundproof walls, slope conditions, and ground effects, etc.) [6]. Accordingly, fundamental research and product development have been actively conducted for effective noise control under natural ventilation conditions. Ryan et al. [14] reported a road traffic noise reduction effect of 5.4–14.7 dBA through onsite measurement of 11 residential buildings, showing the possibility of noise control through effective open-window design. Waters-Fuller et al. [17] generated noise with a speaker in an open-window laboratory under different conditions of opening area, incidence angle, window shape, and other aspects. Their experiment results revealed a noise reduction effect of 12–18 dBA for road traffic noise based on an opening area of 0.05 m^2, and they reported a maximum difference of 5 dB depending on changes in incidence angles between sound source and window. Locher et al. [8] carried out a series of field measurements on sound level difference for open, tilted, and closed windows at 102 dwellings. The results showed the median outdoor–indoor sound level differences of 10 dBA for open, 16 dBA for tilted, and 28 dBA for closed windows. De Salis et al. [3] presented a hybrid technique for effective noise control in the wide frequency band through analysis of the correlation between natural ventilation performance of openings and noise reduction performance as well as literature review regarding noise control techniques. In addition, numerous studies have been performed on the development of architectural design techniques, products, and prediction techniques useful for noise control while maintaining ventilation performance. Through this, attempts for the construction of low-energy green buildings are being continuously made [13,4,5,16,1]. In addition, WHO (15 dB reduction, partial opening condition) and BS 8233 (10–15 dB reduction) provide guidelines for noise reduction effect by open window for predicting indoor noise in natural ventilation conditions [18,2].

At present, the area and shape of windows for classrooms in Korean school facilities have been designed based on securing natural ventilation performance during summer, while little attention has been given to the noise reduction effect of open windows. Thus, design guidelines and techniques related to noise reduction effect of a building façade under open-window conditions need to be presented to meet a difference of more than 10 dBA between the indoor and outdoor noise standards of the SHA and Framework Act on Environmental Policy.

In this study, which is an initial experimental study for the presentation of control methods, difference between the internal and external noise levels in classrooms due to road traffic noise was measured after selecting 19 roadside-adjacent school facilities, with consideration

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