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AN ACOUSTIC SURVEY OF KOREAN SCHOOL CLASSROOMS

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ABSTRACT

This study presents the findings of a recent acoustic survey aimed at evaluating the acoustic environment in classrooms across various schools in Korea. Data were collected from 16 classrooms across four schools, encompassing both occupied measurements during 27 active classes and unoccupied measurements of acoustic properties and sound insulation performance. The analysis highlights significant differences in speech and noise levels across varying classroom activities and school types. Elementary school classrooms were found to exhibit higher speech and noise levels—4 to 5 dBA greater than junior high, high, and special schools—likely due to the younger age group and the nature of group-based activities. A notable 19 dBA difference was observed between the quietest and noisiest classroom activities, with group discussions generating the highest noise levels. These findings underscore the influence of acoustic design on classroom environments and emphasize the need for implementing acoustic standards to enhance learning conditions in Korean schools.

Keywords: *classroom acoustics, acoustic standards, speech and noise levels, reverberation times, active classroom.*

1. INTRODUCTION

International standards such as ANSI and BB93 provide guidelines on background noise, reverberation times, and sound insulation for unoccupied classrooms − criteria essential for optimal speech intelligibility [1-2]. In Korea, the maximum permissible sound level of noise from external sources outside school premises and internal sources within school premises is 55 dBA [3]. However, there is currently no standard or design guideline in place regarding the acoustic performance criteria for school buildings.

This paper presents the findings of a recent noise and acoustic survey conducted with the objective of providing information on the acoustic characteristics of school classrooms in Korea. The survey provides unoccupied data on acoustical conditions and noise isolation performance. It also included occupied speech and noise levels in 16 classrooms across four schools with a range of student ages.

2. MEASUREMENT PROCEDURES

2.1 Measurements of unoccupied classrooms

A total of 16 classrooms in four schools (one elementary, two junior high/high, and one special schools) were used for the measurements. The room acoustical parameters were determined from the measured impulse responses in 16 unoccupied classrooms in the four schools. A 1.37 s logarithmic sine sweep signal was employed as the source signal and was radiated into the classroom from a dodecahedron loudspeaker (Norsonic, Nor276). A single centre source position at a height of 1.5 m was used, situated in the location typically occupied by the talker. Room acoustical measurements were conducted at the four receiver positions using 1/2" free-field microphones (G.R.A.S, Type 46AF), at a height of 1.2 m. The reverberation times (T_{30}), and the early-to-late energy ratios (C_{50}), were measured in accordance with ISO 3382 [4] using the Dirac software V.6.0 [5]. Background noise levels were measured using a sound level meter (Tango plus, Sinus) at the location of maximum noise intensity, namely at a height of 1.0 m above floor level, with and without the HVAC systems in operation.

The airborne sound insulation of single or composite walls between adjacent classrooms and between classrooms and corridors was measured using the SAMURAI building

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acoustics software [6] and the results were converted into two single number ratings: the weighted apparent sound reduction index (R'_w), and weighted standardized level difference ($D_{nT,w}$) [7]. In addition, the impact sound insulation of floors located above classrooms was also measured in the same eight classrooms. Three single-number ratings were obtained: the weighted normalized impact sound pressure level ($L'_{n,w}$), the weighted standardized impact sound pressure level ($L'_{nT,w}$), and the reverse A-weighted maximum impact sound pressure levels ($Li_{,Fmax,AW}$) [8-9].

2.2 Measurements of speech and noise levels in active classrooms

Speech and noise levels were measured in 27 actual class sessions in 14 classrooms using two sound level meters. Observations during the classes revealed that teaching activities could be roughly categorized into four types: plenary lessons, group work, individual work, and watching videos. The two sound level meters were installed at a height of 1.2 m, evenly positioned among the seated students in the front and back of each classroom, close to the ears of the students. The sound level meters measured and recorded 1/3 octave band sound pressure levels at 250 ms intervals throughout each class, and using the statistical method proposed by Hodgson et al. [10], mean octave band speech and noise levels (in dBA) at the listener's position were derived from the combined speech and noise sounds.

3. UNOCCUPIED ROOM ACOUSTICAL CONDITIONS

Table 1 presents the mean values of the acoustical parameters, T_{30}, C_{50}, and L_{Aeq} with their standard deviations (σ) for 16 unoccupied classrooms in the four schools. Acoustical measurements were conducted in furnished and unoccupied classrooms, revealing that the mid-frequency T_{30} value ranged from 0.58 s to 1.07 s. The room volumes varied from 122 m^3 to 205 m^3. Of the 16 classrooms, those at the special school had a mid-frequency T_{30} value of 0.69 s, which is shorter than in the other three school classrooms. This discrepancy could be attributed to the smaller room volumes characteristic of special school classrooms. The mean mid-frequency T_{30} value in the elementary, junior high, and high school classrooms, exceeds the standard requirement of 0.6 s [1]. In the special school, the T_{30} value exceeds a value of ≤ 0.6 s at every octave band [2]. In accordance with the Italian standard UNI 11532 [11], the minimum mid-frequency C_{50} is recommended to exceed 2 dB. The mean value for mid-frequency C_{50} ranged from 1.7 dB to 3.3 dB, indicating that 69% of the classrooms met the Italian guidance for C_{50}.

The mean background noise level in L_{Aeq} with HVAC systems operation is 43.8 dBA. In the elementary, junior high and high school classrooms, the mean background noise levels exceed the standard requirements of $L_{Aeq} \leq 37$ dBA [1]. In the special school, the background noise level exceeds a L_{Aeq} value of ≤ 30 dBA [2].

Table 1. Mean T_{30}, C_{50}, and L_{Aeq} values with their standard deviations (σ) for 16 unoccupied classrooms in four schools.

School	$T_{30\ (500\text{-}2k)}$, s	$C_{50\ (500\text{-}2k)}$, dB	L_{Aeq}, dBA
Elementary	0.86 (σ=0.24)	2.0 (σ=2.0)	42.9 (-)
Junior high	0.94 (σ=0.19)	1.7 (σ=1.5)	47.1 (σ=0.3)
High	0.77 (σ=0.05)	2.7 (σ=0.6)	45.1 (σ=0.8)
Special	0.69 (σ=0.12)	3.3 (σ=0.9)	40.1 (-)

Table 2. Sound insulation performance values (ASTC, AIIC) for walls and floors adjacent to the core learning spaces.

School	Walls		Floors
	Adjacent classrooms	Corridor	
Elementary	39 (σ=5.1)	18 (σ=0.4)	67 (σ=0.0)
Junior high	29 (σ=1.7)	20 (σ=2.4)	47 (σ=2.8)
High	32 (σ=1.3)	20 (σ=0.0)	51 (σ=1.4)
Special	39 (σ=0.7)	16 (σ=0.0)	61 (σ=2.1)

Table 2 presents the measured mean ASTC, and AIIC values along with their standard deviations for both walls and floors. The ASTC ratings for eight single walls between the classrooms and adjacent spaces ranged between 28 and 42. The mean value of ASTC for composite walls between the classrooms and corridors ranged from 16 to 23. The mean $D_{nT,w}$ value for both single walls and composite walls in the special school classrooms was 43 dB and 20 dB, respectively. The AIIC ratings for the eight floors above the classrooms had a range between 45 and 67. The $L'_{nT,w}$ value for the floors in the special school classrooms was 43 dB, which met the requirements of BB93 for special schools [2].

4. SPEECH AND NOISE LEVELS IN ACTIVE CLASSROOMS

Table 3 presents the mean overall speech levels, noise levels, and speech-to-noise ratios averaged over two receiver positions in each classroom for 27 classes in the four schools. The mean speech levels, as measured at the two receiver positions for the 27 classes in the four schools, exhibited a range of 55 to 76 dBA. It is evident that there are considerable variations in speech levels between different rooms and between different talkers. The highest speech levels were observed in elementary school classrooms, with an average level of 69.3 dBA. This value is approximately 4-5 dBA higher than those observed in junior high, high school, and special school classrooms. Furthermore, the mean noise levels for each class in the four schools exhibited a considerable range, from 40 dBA to 67 dBA. The classrooms in which students were observed working in groups with discussion had the highest noise levels. It can be observed that science classes have higher noise levels. It can be observed that the noise levels in occupied classrooms fluctuate in accordance with the nature of the classroom activities. A notable 19 dBA difference is observed between the quietest (48 dBA) and noisiest (67 dBA) classroom activities in elementary school classrooms. This is largely due to the differing classroom activities.

The classrooms in which students were observed engaged in group discussions exhibited the highest noise levels (62.9 dBA) across all schools. The results indicate a notable 19 dBA difference between the quietest (44.2 dBA for individual work) and noisiest (62.9 dBA for group work) classroom activities in occupied classrooms. These findings are consistent with those previously observed in classrooms with six different classroom activities in UK schools [12]. The quietest and noisiest classroom activities were observed to have a mean noise level of 56 dB LAeq and 77 dB LAeq, respectively. The highest noise levels were observed in elementary school classrooms, which can be attributed to the nature of activities involved in group work and the age of the students. In contrast, special school classrooms had the lowest noise levels, with measurements of 48 dBA. This indicates that noise levels during classes are higher in classrooms with greater numbers of students.

Table 3. Mean and standard deviations (σ) of speech levels, noise levels, and speech to noise ratios averaged over 27 active classes.

School	Speech levels, dBA	Noise levels, dBA	SNR, dBA
Elementary	69.3 (σ =7.3)	55.5 (σ =8.3)	13.8 (σ =4.4)
Junior high	63.8 (σ =4.4)	49.4 (σ =6.0)	14.4 (σ =1.9)
High	64.3 (σ =5.1)	49.3 (σ =5.1)	14.9 (σ =3.4)
Special	65.4 (σ =4.4)	48.0 (σ =5.9)	17.4 (σ =3.8)
Overall	65.1 (σ =5.2)	50.0 (σ =6.1)	15.1 σ = (3.3)

5. CONCLUSIONS

A comprehensive investigation was conducted, encompassing a total of sixteen classrooms across four educational institutions. The findings revealed that none of these classrooms satisfied the stipulated criteria set forth by the ANSI and BB93 standards [1-2] concerning background noise levels ($L_{Aeq} \leq 30$ dBA for special schools and $L_{Aeq} \leq 37$ dBA for other schools) and reverberation times ($T_{30} \leq 0.6$ s at every octave band for special schools, and mid-frequency $T_{30} \leq 0.6$ s for other schools), and airborne sound insulation ($D_{nT,w} \geq 50$ dB for special schools, and STC ≥ 50 for other schools). A total of 69% of the 16 classrooms were found to meet the UNI 11532 [11] recommended minimum mid-frequency C_{50}, which is 2 dB. However, it was observed that all eight classrooms (100%) were in compliance with the impact sound insulation requirement ($L'_{nT,w} \leq 55$ dB for special schools, and AIIC ≥ 40 for other schools). The comprehensive unoccupied acoustic data analysis indicates the necessity for legislation aimed at enhancing the acoustic design of schools in Korea.

A statistical analysis of the data from all 27 classes in the four schools revealed that the mean speech level was 65.1 dBA, the mean noise level was 50 dBA, and the difference between the speech and noise levels was 15.1 dBA. The measurements of speech and noise levels during the 27 classes in the four schools demonstrated that noise levels increased with the number of students and decreased with the age of the students. The highest noise levels were observed in the elementary school classrooms, likely attributable to the nature of activities involving group work and the age of the students. Conversely, classrooms in the special school exhibited the lowest noise levels, indicating that noise levels during classes tend to be higher in larger student populations.

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