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Study on the Role of Spatial Acoustics and Noise Control in Building

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Abstract: *The acoustic environment is given a great deal of importance today. Throughout developing an acoustically friendly environment, noise control and its values play an important role. This can be accomplished when the noise frequency is lowered to a degree that is not disruptive to human ears. It is possible to obtain a pleasant environment by using different techniques that use different materials. Such techniques are through noise absorption, computational acoustic modeling, and simulation, modifying the plan or layout of the building. This review incorporates those scientific works of many scholars and many other acoustic scientists, as well as the author's innovative ideas.*

Keywords – *Acoustic improvement, Acoustic modeling, Building acoustics, Noise absorption, Noise control.*

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I. Introduction

The science of managing sound in buildings is building acoustics [1]. This includes minimizing the transmission of noise from space to space and controlling the sound characteristics within spaces. The geometry and volume of a room, sound absorption, sound transmission and sound reflection of objects, sound generation inside or outside the space, airborne sound transmission and impact noise can affect building acoustics. This review discusses those researches that can be converted into improvements in space's acoustic conditions and adds information about the effect of the sound environment on people indoors and outdoors. Sound absorption technology will be addressed in this study for noise reduction [2] using renewable acoustic absorbers which results in the efficient acoustic performance of the building. Some effective measures were needed to tackle the noise problem and acoustic conditions. General requirements for effective measures will be discussed in the following sections for each class of room acoustics parameters. This study aims to collect and analyze those studies that combine acoustic data with the subjective response to address acoustic comfort.

II. Methodologies adopted to improve acoustics and noise reduction

Most of the open-plan offices have poor speech privacy conditions due to low partitions between workstations. It is usually necessary to use high-cost acoustic treatment to improve this condition. The acoustic condition can be improved by rearranging the office layout through computer simulation to improve speech privacy without raising the installation cost. Referring to the measurement set-up and calculation guidelines as established in ISO 3328-3:2012, ray-tracing simulation was performed to find this optimal state [3]. Results reported by Sarwono et al. show that by modifying the layout, workstation or screen partition, the acoustic condition can be improved.

Azimi .M realized that sound-absorbing materials absorb and reflect very little of the sound energy that strikes them [4]. Many natural products for acoustic applications have been recently developed and tested. Sound-absorbing materials have therefore been found to be very useful in controlling room noise.

The lack of land in cities allows most buildings to be constructed very close to expressways after decades of rapid growth, exposing inhabitants to extreme noise pollution. Sustainable cities have found in recent years that greenery is a key element in combating this noise pollution, making vertical greenery systems common. There are two aims for this project. The first includes the evaluation of separate vertical greenery systems installed in HortPark, Singapore to assess the impact of their acoustics on building wall integration failure. Due to the absorbing effect of the substratum, the experiment shows a larger attenuation at low to medium frequencies while a smaller attenuation is observed at high frequencies due to greenery scattering. The second objective is to assess the sound absorption coefficient of the vertical greenery system built in the reverberation chamber, one of the highest values relative to other building materials and furniture. In contrast, the sound absorption coefficient increases as frequencies rise [5]. Wong et al. reported that the coefficient of sound absorption increases with greater coverage of greenery.

Arranging office space in a single open room provides advantages in terms of simple information exchange and coworker communication, but limits confidentiality and acoustic comfort. The purpose of this work was therefore to assess the acoustic quality of a real open-plan office and to propose changes in the space to enhance this office's acoustic conditioning. The office's computational model understudy was calibrated based on measurements of reverberation time (RT) and sound transmission index (STI). Passero et al. [6] showed that by inserting dividers between work stations and increasing the noise insulation of the walls enhances the office's acoustic conditions.

In some residential buildings in Korea, field experiments are conducted to determine nearby levels and forms of noise. Noise measurements are conducted in unoccupied conditions at each home. It was found that the most commonly happening adult walking, kids running, furniture shifting, and falling of small items, accounted for about 80 percent of all noise occurrences. Children's noise level from jumping and dropping small items was greater than others. The walking of adults demonstrated greater variation in levels of noise than other studies. In contrast, it was found that slab thickness and major sources of noise did not impact indoor noise levels [7]. By discussing non-acoustic causes, Park et al. evaluated that it is possible to improve the personal perception of building noise.

As an objective criterion for space acoustics, a basic procedure for identifying audible echoes is introduced. This approach tests the perceptibility of sound reflections produced by an impulsive sound source and recognizes harmful reflections perceived as echoes from the reflectograms. The masking impact of reverberation is taken into account, in particular with this approach, which cannot be sufficiently handled by the current objective criteria. The applicability to the acoustic design of the room is verified by evaluating the impulse responses measured in real halls where there were audible echoes. Studies by Yamada et al. [8] proposed a method that detects audible echoes with more than 90 percent accuracy and would be appropriate for practical use.

Fuchs et al. investigated that the noise problem created in small to medium-sized rooms by lingual or musical communications is sometimes underestimated and often inadequately handled by traditional measures such as fibrous or porous suspended ceilings and other absorbent surface linings[9]. This emerges from a reverberation of the space that blurs the tone of low frequency. Broadband bass absorber elements provide a solution that can be mounted only at a few edges of the room. These preferably cover less than 20 percent of the ground surface along the walls and leave the ceiling for other installations or energy-saving tasks completely untouched. This new design and concept allow for acoustically efficient and visually attractive measures with rigid closed surfaces requiring the minimal cost of investment, maintenance, and renovation. Examples of schools, restaurants, workshops and multi-purpose assembly halls show the effectiveness of modern passive or reactive edge absorbers.

Hemp-lime concrete is a natural alternative to regular building materials for buildings. It has excellent hygrothermal properties, some of which originate from its porous structure. In this article [10] the authors Kinnane et al. includes binders developed from hydrated lime and pozzolans as well as hydraulic and cementitious binders to investigate the acoustic properties of hemp-lime concrete. Wall sections are rendered and the resulting impact on absorption is evaluated to assess the acoustic absorption of hemp-lime walls as they are commonly finished in practical construction. Hemp concretes with lime-pozzolan binders exhibit superior acoustic properties compared to more hydraulic binders. When rendered, these are diminished as the open surface porosity is affected, but hemp-lime construction offers the potential to meet standard and guideline targets for spaces that require acoustic treatment.

For retrofit buildings, the current acoustic condition is deliberately assessed using several acoustic criteria. Measurements are taken previously as baseline measurements showed the level of acoustic comfort in the existing situation. The acoustic characteristics of the existing facilities are both measured as well as the actual behavior of the building's existing population. The sound insulation of the external walls is measured, the reverberation times are measured including the current ceilings and furnishings, and the spatial deterioration is described in the open-plan areas of the office over several rows of decay. Vellenga et al. pointed out that the acoustic measurements have made a valuable contribution to building a sustainable office environment with good acoustics within the retrofit building restrictions [11].

Ismail et al. [12] investigated that, by introducing absorptive materials into the monolithic dome structure's internal upper cap, the critical sound components reflected by the dome's upper exposed shell are absorbed and sound energy concentration is minimized. A structural relationship is formed between acoustic treatment and dome radius to provide architects with guidance on the proper range of absorption needed to maintain the acoustic comfort of these unique spaces.

In many cases, designers propose elliptical or irregular geometries for the shapes of these buildings, and indoor surface furniture has inappropriate coefficients of absorption and diffusivity. Thus, serious acoustic problems such as standing waves, flutter echo, sound focusing and intensive late reflections can be observed, which significantly decreases the intelligibility of speech and the effectiveness of early sound energy in that

Italian church. A survey was conducted to evaluate the main acoustic parameters such as Reverberation time (RT) and Sound Transmission Index (STI). An acoustic computer simulation using CATT software was subsequently developed on a church 3D model to calibrate the model comparing measured and simulated data. This procedure made it possible to test the model's reliability and precision. In the simulations carried out revealed that significant improvements can be achieved for each acoustic index by the two proposed acoustic interventions. (e.g RT60 of about 2.5 sec at 1000 Hz and STI of about 40%) [13]. Gagliano et al. say that the scope of the church's acoustic treatment is to reduce the audience-related acoustic quality variability, which mostly affects the mean sound absorption.

Fuchs et al. investigated that the external and internal disturbances in contact environments have become evident that the frequency spectrum far below that protected by building and room acoustic requirements is of the utmost importance for the sound production and speech intelligibility system [14]. In the form of slender compound panel absorbers (CPA), a powerful new tool was invented to be mounted on walls or ceilings as an efficient means to dampen the room's dominant frequencies. This paper was written to educate and alert acoustic consultants in ideally hard-walled office, conference foyer, cafeteria, restaurants or classrooms coping with the often torturing acoustics.

Jang et al. [15] suggest an evaluation technique using a scale model to test the impact of vegetated façades on noise reduction of green residential building designs. A 1:10 scale-model experimental approach is defined to test vegetation's noise reduction effect, including the selection process of materials considering their absorption coefficients. A comparison of simulation results and scale model results were made. Scale models are more powerful and cost-effective than field experiments by simulation as a means of measuring vegetation effects on noise reduction.

Muntiano et al. [16] deal with the study of acoustic properties of the Lecture Hall belonging to the Faculty of Building services in Cluj Nepoca. After the acoustic measurements were performed and the data were processed, it was found that the reverberation time was not within the standard range limits and that several measures were required to improve the acoustics of the hall. The paper provides numerous suggestions to improve the hall's acoustic properties and then the solution's cost analysis.

Haapakangas et al. [17] investigated whether room acoustic architecture, as calculated by the Sound Transmission Index (STI), could influence the deleterious effects of background sound. The experiment was carried out in an open-plan workplace laboratory (84 m2) that physically constructed up until some acoustic situations. Lowering the STI through room acoustic way reduced subjective disturbance, even as the consequences on cognitive overall performance were barely smaller than anticipated. Amongst noise-touchy topics, the results of room acoustic layout on subjective distractions were stronger, suggesting they benefited extra from acoustic improvements than non-sensitive subjects. The outcomes endorse that growing the STI is fantastic for nice and auditory consolation, especially concerning speech from extra distant desks.

III. Conclusion

An overview of the methodological aspects and findings of the 15 papers were included. These papers introduce the concept of sound quality, objective assessment, subjective assessment, and their relationships. We then reviewed the acoustic improvement methods and noise control methods with an emphasis on recent developments in the improvement of sound quality. The results of the experiments carried out by the authors show that it is possible to obtain a pleasant environment by using different techniques that use different materials, such as noise absorption, computational acoustic modeling, and simulation, modification of the design or layout of the building. Overall, the study shows that the applied technologies for acoustic design and noise control help to improve the quality and confidentiality of the atmosphere indoors and outdoors.

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