Brief Discussion of Computer Simulation Analysis for Acoustic Parameters in Radio and Television Media Building

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ABSTRACT.

The article provides a brief exploration of the methods and feasibility of using computer simulation techniques to analyze acoustic parameters in radio and television media buildings. By simulating the impact of various acoustic parameters on the internal sound environment of the buildings, it offers a theoretical foundation and technical support for achieving optimized acoustic design and enhancing acoustic performance. The research results indicate that computer simulation technology holds vast potential for application in the acoustic design and analysis of radio and television media buildings.

Keywords: Point sound source; radio and television media building; speech transmission index; reverberation time; frequency characteristics; SPL distribution; early decay time; acoustic defects.

1. INTRODUCTION

With the continuous development of radio and television media buildings in modern society, the design and optimization of their acoustic environment have become crucial. This paper aims to explore the relationship between the acoustic design and acoustic performance of radio and television media buildings through computer simulation techniques. We will establish a digital acoustic model, incorporating the acoustic properties of building structures, materials, and the layout of sound sources and measurement points. Based on this foundation, utilizing computer simulation techniques, we will simulate the impact of variations in different acoustic parameters on the internal sound environment of the building. These parameters include, but are not limited to, reverberation time, frequency characteristics, and Speech Transmission Index [1]. Through the analysis of simulation results, we aim to provide a scientifically practical validation method and optimization strategies for the acoustic design of radio and television media buildings.

2. RESEARCH OBJECT

The main technical rooms with strict acoustic requirements in radio and television media buildings can be broadly categorized into the following three types.

Audio recording and broadcasting rooms, which are divided into three main sections: language recording studios, literary recording studios, and live broadcasting rooms. The language recording studios consist of standard recording rooms, recording rooms, and control rooms. The literary recording studios include recording studios and their corresponding recording control rooms.

Studio clusters, categorized into extra-large, large-medium, and small studio complexes, each equipped with a director's control room. Additionally, they include observation rooms and screening rooms.

Video post-production technical rooms, which encompass editing rooms and dubbing studios.

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3. SIMULATION PROCESS OF BUILDING ACOUSTICS

3.1 Main Acoustic Performance Parameters

3.1.1 Reverberation time

The Reverberation Time (T30) is one of the most important physical indicators for evaluating sound quality [2]. It is related to the fullness and clarity of the sound. Early Decay Time (EDT) is defined as the time it takes for the sound pressure level to decay by 60dB extrapolated from the decay rate of indoor sound energy from 0dB to 10dB.

3.1.2 Frequency characteristics

Typically referring to the optimal reverberation time frequency characteristics curve, representing the distribution of reverberation time within the building hall between 125Hz and 4000Hz. The frequency characteristics of the reverberation time reflect various aspects of the indoor sound quality, such as tonal richness and spatial clarity.

3.1.3 Speech Transmission Index (STI)

The Speech Transmission Index (STI) is another important indicator in architectural acoustics used to evaluate the intelligibility of speech within a room. The specific meaning of STI is the proportion of listeners in a room who can accurately understand the speech spoken by a speaker [3]. The STI values range from 0 to 1, with higher values indicating higher speech intelligibility in the room, meaning listeners can accurately understand a larger proportion of speech information.

3.1.4 SPL distribution

Usually observed and calculated in scenarios involving simulations at multiple measurement points, SPL distribution is used to assess the unevenness of the indoor sound field on various frequency bands.

3.1.5 Acoustic Defects

In the simulation process of acoustics, besides paying attention to conventional acoustic performance indicators, we should also strive to identify potential acoustic defects in acoustic design. Acoustic defects include sound focusing, echo, flutter echo, sound coloration, sound shadow, and other acoustic phenomena harmful to indoor sound quality. For example, sound focusing refers to the concentration of reflections formed by concave surfaces, enhancing sound at a specific point while diminishing other parts, causing unevenness in the sound field. Echo is one of the common acoustic defects indoors, occurring when the reflected sound differs from the direct sound by more than 50 ms or when the path length difference exceeds 17 m, resulting in possible echo for listeners or sound collectors. When indoor spaces are large with extensive parallel walls, the flutter echo phenomenon arises from multiple reflections between parallel walls, constituting a serious acoustic defect that leads to unstable volume and significant fluctuations in sound quality. Sound coloration refers to the additional tonal characteristics imposed on the original sound due to variations in the indoor frequency response.

3.2 Sound Sources

3.2.1 The location of the sound source and the measurement points

For a better computerized sound field simulation, it is necessary to optimize the placement of sound sources in the field, following the principles outlined below. (1) Simulate a single steady-state sound source, considering the background noise in the scene as steady-state. (2) Set up 9-12 measurement points for uniform distribution throughout the field.

3.2.2 Types of sound sources

In the Odeon software, three types of sound sources can be chosen: point sources, line sources, and area sources. After determining the noise source, considering the characteristics of sound emission from various devices, all sources are set as omnidirectional point sources to simulate human speech.

3.2.3 Arrangement of sound sources

Place the aforementioned noise sources at corresponding locations in the field, with random placement as illustrated in Fig.1. The sources are positioned 1.2 meters above the ground.

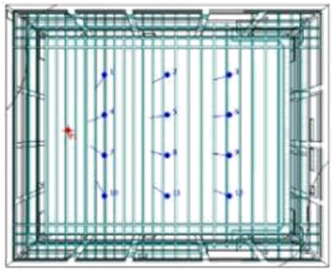

Figure.1 Distribution of sound source point and measurement points

3.3 Measurement Point Processing

To understand the characteristics of the indoor sound field, two approaches can be employed. The first is called the single-point observation method, which involves simulating the acoustic parameter values at multiple receiving points inside the room. Then, the average and standard deviation of these acoustic parameters for the receiving points are calculated. The average and standard deviation reveal the distribution characteristics of the receiving points and the indoor sound field. The second approach is referred to as the area averaging method, which involves dividing the indoor space into a grid. It assumes that the sound field characteristics within each grid are the same, enabling the study of the sound field characteristics in each grid area to understand the overall spatial sound field characteristics. This can be visually depicted in the form of a color grid map [5].

Each method has its advantages and disadvantages. The advantage of the single-point observation method is that it can obtain simulated data for various acoustic parameters at different points. Through data processing, more information about the sound field can be obtained. However, its drawback is that when a small number of receiving points are selected, it may not fully and comprehensively reflect the characteristics of the entire sound field. On the other hand, the area averaging method excels in providing an overview of the entire sound field, but it cannot extract acoustic parameter data for each grid point, leading to a lack of useful information for subsequent data processing. In the simulation process mentioned in this paper, where the sound source and background noise are set as steady-state and there are special spatial forms that could cause anomalous sound distribution, such as domes and regular grids, it is essential to thoroughly examine the overall acoustic characteristics of the space. Therefore, the calculations are conducted according to the second method.

3.2 Surface Material Processing

The setting of absorption coefficients for model materials mainly comes from two sources: using the absorption coefficient library provided by the Odeon software or customizing a material library as needed.

Based on the actual conditions of radio and television media buildings, various acoustic materials and constructions correspond to different interior surfaces, such as: floor - rubber; ceiling - metal perforated plate with attached glass wool; absorptive wall - wooden perforated plate with attached glass wool; absorptive wall - FC perforated plate with attached glass wool; reflective wall - aluminum plate; hard wall surface - wood veneer; stage absorptive ceiling - glass wool. The absorption coefficients assigned to these surfaces are reliable data measured in the laboratory and corrected in practice.

4. DATA ANALYSIS AND CONCLUSIONS

4.1 EDT and T30

The frequency characteristics of reverberation time within the field are illustrated in Fig. 2.

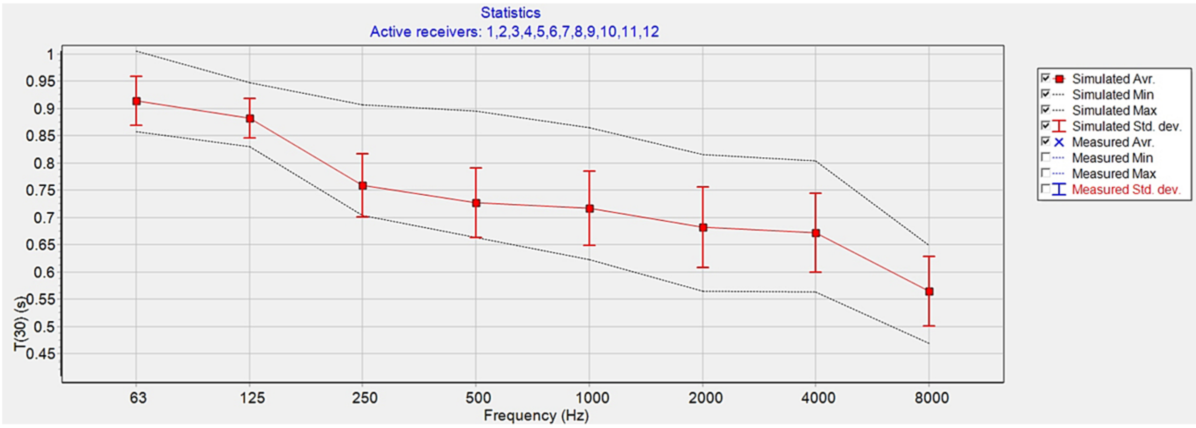

Figure. 2 Frequency characteristics of T30

Table 1. EDT(s)

Frequency	63	125	250	500	1000	2000	4000	8000
Minimum	0.44	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Maximum	1.27	1.23	1.80	2.38	2.49	2.78	1.88	1.48
Average	0.88	0.87	0.94	1.10	0.99	1.03	0.92	0.57

Table 2. T(30)(s)

Frequency	63	125	250	500	1000	2000	4000	8000
Minimum	0.86	0.83	0.70	0.66	0.62	0.57	0.56	0.47
Maximum	1.01	0.95	0.91	0.90	0.86	0.82	0.80	0.65
Average	0.91	0.88	0.76	0.73	0.72	0.68	0.67	0.57

4.2 Data Analysis

4.2.1 Early decay time and reverberation time

Early decay time (EDT) has a mid-frequency value of approximately 1.1s, and the mid-frequency value of Reverberation Time T30 is 0.73s, meeting the acoustic requirements for recording studios and broadcast studios. This is highly suitable for recording language and music programs, showing favorable trends in frequency characteristics. The minimal variation from low to mid to high frequencies indicates a well-balanced consideration of the relationship between absorbing and diffusing low-frequency sound during the design process, making it widely applicable for various acoustic uses.

4.2.2 STI and SPL distribution

Other key acoustic performance data in the building include the distribution of sound pressure levels (SPL) at various measurement points, frequency characteristics of reverberation time, STI, and more.

The uniformity of SPL distribution within the field is depicted in Fig. 3.

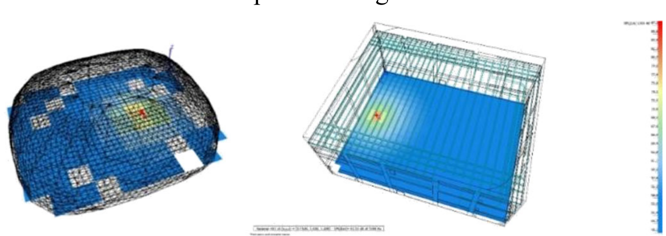

Figure. 3 Simulation of the SPL distribution

STI values at each measurement point are illustrated in Fig. 4.

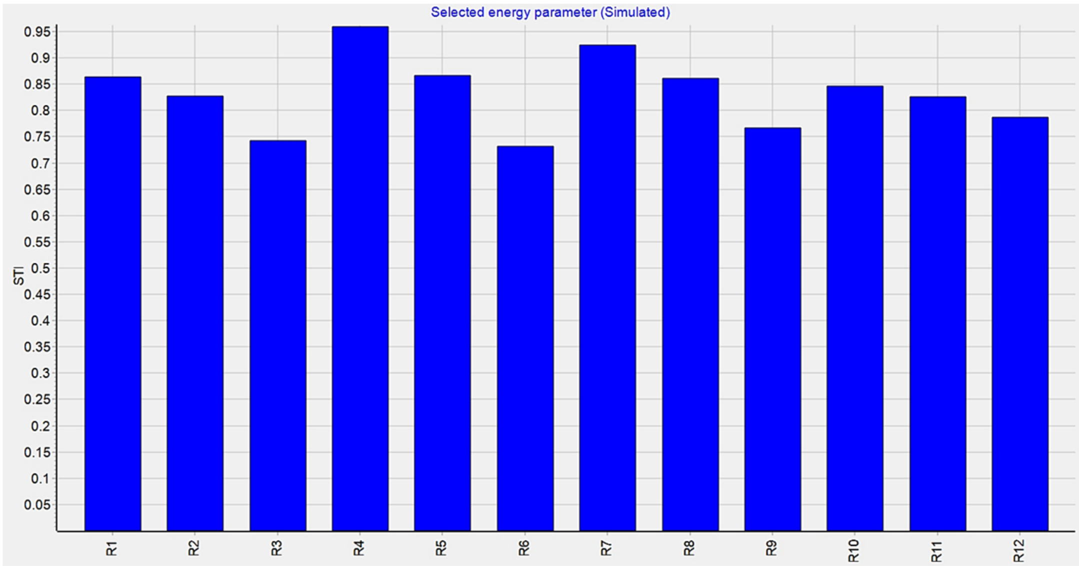

Figure. 4 STI level of measurement points

The STI values at various measurement points within the model are significantly higher than the standard values, and both STI and SPL exhibit excellent uniformity. It indicates that the architectural design has no acoustic defects, the selection of acoustic materials and structures is rational, reflecting excellent language clarity indicators in the architectural space. It is well-suited for both natural and electronic sound environments.

4.2.3 Guiding principles for adjustment and optimization

According to the computer simulation data, adjustments and optimizations can be made for the acoustic design of the interior space in the building.

Firstly, it is essential to ensure the clarity and fullness of language throughout the indoor space. This involves maintaining sufficient sound pressure levels, high language clarity, and fullness at various points inside the room. Controlling the reverberation time within an appropriate range is crucial, beneficial for speech-related activities, and leaves enough adjustability for musical programs. When using a sound reinforcement system, the relationship between reverberation time and sound pressure level distribution can be adjusted as needed to ensure both musical fullness and language clarity.

Building upon the existing architectural design, optimizing the interior decoration materials is necessary. This optimization enables effective reflection of the early direct sound from the ceiling reflector in front of the recording source, ensuring uniform distribution of early sound energy across all points in the studio. Simultaneously, judiciously choosing interior decoration materials and construction methods helps eliminate potential acoustic defects caused by the architectural spatial form. Utilizing early lateral reflective sound appropriately enhances the spatial surround sensation, creating a high-quality audiovisual recording space.

In indoor spaces with numerous electrical devices, additional attention should be given to the absorption of low-frequency sound. Emphasizing the frequency characteristics of reverberation time is also crucial for beautifying and enhancing the sound quality in audiovisual buildings under specific conditions.

Implementing various measures such as soundproofing, vibration reduction, and noise reduction helps control noise from different aspects, including noise sources, transmission paths, and the enclosing structure of acoustic rooms. This strict control is crucial for managing background noise in such buildings, especially in empty conditions.

5. SUMMARY

Through computerized simulation analysis of the acoustic parameters in radio and television media buildings, this paper has undertaken an initial exploration of how to predict the impact of major acoustic parameters on the architectural sound environment during the design phase. The simulation results indicate that computer simulation analysis can effectively estimate and assess the acoustic characteristics of architectural spaces, providing corresponding optimization strategies for the acoustic design and construction of such specialized buildings. Simultaneously, it can serve as a theoretical and practical basis for the acoustic design and construction of similar venues, promoting advancements in architectural acoustics research in related fields.

6. REFERENCES

[1] Hodgson M. Towards a method of acoustic design for theatres. Proceedings of the Institute of Acoustics, 2000, 22(5): 73-81.

[2] Behrens S, Moller H. Room acoustics. Springer Science & Business Media, 2013.

[3] Botteldooren D, De Moor A. Acoustic simulation of Auditoriums: A comparison of measurement and prediction. Acta Acustica united with Acustica, 2012, 98(6): 821-831.

[4] Szelag W, Hodgson M. Odeon - a computer program for room acoustics. Journal of the Audio Engineering Society, 1994, 42(11): 918-927.

[5] Kuehn T A, Rasmussen N C. Modeling and simulation of sound propagation in urban environments. Journal of the Acoustical Society of America, 2012, 132(4): 2345-2356.