

Architectural Acoustics Handbook

Ning Xiang, Editor

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The title of the book would suggest an all-encompassing reference, which it is not. Instead, editor Ning Xiang has assembled a collection of current architectural acoustics topics written by specialist academics, researchers, and practitioners knowledgeable in their specific field. Several topics have been published only in journals or conference proceedings and having these in a single compendium is most welcomed. Of interest to this reviewer were chapters on acoustics of long rooms and room-related sound representation using loudspeakers.

The book comprises 15 chapters by 17 authors subdivided into two parts: architectural acoustic essentials (Chapters 1 to 11) and architectural acoustics practice (Chapters 12 to 15). Each chapter concludes with a reference list. A brief biography of each author appears at the beginning of the book.

Chapter 1 by U. Peter Svensson, Jonathan Botts, and Lauri Savioja introduces the reader to basic acoustic concepts in computational room acoustics using wave-based modeling including analytic and numerical solutions. The chapter presents a brief, yet concise, summary of these topics.

Geometrical aspects of computational room acoustics modeling by U. Peter Svensson, Samuel Siltanen, and Ning Xiang is the subject of Chapter 2. This chapter complements the first chapter and covers geometrical acoustics, specular reflections and diffraction, and statistical modeling. Practitioners using commercial room acoustics modeling software will benefit from the information in this chapter.

Chapter 3 by Jian Kang summarizes much of the work this author has contributed to the acoustics of long rooms which are characterized as non-Sabine spaces. Covered are the acoustic theory, simulation and calculation methods, design factors, and case studies relevant to these unique spaces. Information in this chapter is directly applicable to the design of long corridors, tunnels, and subway stations.

The acoustics of coupled volume systems, Chapter 4, is explained by Ning Xiang. Topics include wave theory modal analysis and modal expansion methods, statistical and geometrical room acoustics, diffusion equation based techniques, Bayesian energy decay analysis, and scale models. This material is applicable to the design of variable acoustic concert halls, large spaces with niches, and worship houses with connected chapels.

Chapter 5 by Wolfgang Ahnert and Stefan Feistel covers advanced measurement techniques in architectural

acoustics with examples from commercial acoustics measurement software. The chapter starts with measurement basics using Fourier analysis followed by applications to room acoustics and sound reinforcement systems. More specific topics include excitation signals, measurement errors and optimization, time and frequency domain measurements, speech intelligibility, modal analysis, and in-situ sound absorption measurements. Those involved in acoustic measurements will gain insights to the theory behind their measurement platform with this chapter's contents.

Room-acoustic energy decay analysis by Ning Xiang is reviewed in Chapter 6. Starting with Schroeder's integration method for sound energy decay, the concept of a non-linear regression model avoiding background noise is discussed. The chapter concludes with considerations for evaluating coupled volume spaces with dual decay slopes using a combined Bayesian and Schroeder integration analysis.

Chapter 7 by Carl Hopkins addresses sound insulation in buildings. The chapter covers the direct transmission paths but emphasizes sound flanking paths that often control sound isolation. Both airborne and structure-borne noise transmission are addressed. Included are many data illustrating direct and sound flanking attenuations as well as typical laboratory test data for a variety of wall and floor constructions. The one omission that would have broadened the chapter's content would have been a summary of rain noise transmission prediction methods that the author has developed. The importance of sound flanking paths and the need for control to avoid compromising sound isolation are key factors in this chapter.

Aspects of auditory perception in rooms written by Jonas Braasch and Jens Blauert are the topics of Chapter 8. Basic concepts for binaural hearing to include time and intensity cues are defined first before progressing to more advanced topics such as spatial impression and the role of early reflections and reverberation, and finally the precedence effect. Binaural room impulse response measurements are covered and metrics such those in ISO 3382-1, as well as the limitations of the room impulse response, are described. The chapter concludes with how the acoustics of a space are processed by humans to determine preference judgements for that space. A new concept, the Quality-of-the-Acoustics, which is used to determine the adequacy of a venue for a specific performance genre, concludes the chapter.

Chapter 9 by Michael Vorländer provides a summary of auralization techniques, the auditory simulation of sounds derived from computer data. Starting with elementary definitions and signal processing techniques, the author then reviews auralization concepts. Covered are source characterization, filter construction for the room impulse response, airborne and structure-borne sound

transmission, and finally, spatial sound reproduction. Limiting aspects of this technique are described as requirements for real-time processing. Like Chapter 2, practitioners using commercial room acoustics modeling software will benefit from the chapter's contents.

Room-related sound representation using loudspeakers is covered by Jens Blauert and Rudolf Rabenstein in Chapter 10. This chapter describes different presentation technologies for creating sound simulations for listeners. Described are intensity stereophony, amplitude-difference panning, surround sound, spherical harmonic synthesis, wave-field synthesis, and binaural cue selection. Descriptions for each simulation conclude with a table summarizing its advantages and disadvantages and should aid the end-user in selecting the most appropriate technique.

Chapter 11 on environmental acoustics is reviewed by Jian Kang. Starting with elementary concepts on sound propagation, barriers, and noise mapping, the material shifts to more advanced models for sound propagation to include image source, ray-tracing, radiosity, wave-based, and scale models. Perceptual aspects of noise and urban soundscapes conclude the chapter. While addressing newer concerns in environmental acoustics, this material does not seem to fit within the context of a book on architectural acoustics.

Sound system design and room acoustics written by Wolfgang Ahnert is the subject of Chapter 12. The author first covers room acoustic properties applicable to sound system design since room acoustics affects sound system performance. Speech intelligibility is reviewed followed by requirements for music reproduction. Sound propagation in open spaces and, by inference, the direct sound field in a room are described followed by sound system limitations. The longest section details design requirements for sound systems. Included are descriptions of the major loudspeaker types, microphones, and signal processing equipment. The last part of the chapter covers calculations and computer simulations for sound systems. A key feature is a summary of the available loudspeaker data formats used by commercial sound system modeling programs. Many color illustrations showing computer modeling output complements the text.

Chapter 13 by Douglas Sturz summarizes noise control in heating, ventilation, and air conditioning systems. Unlike many publications, the author provides a descriptive narrative of the subject matter with little in the way of equations, nomograms, or tables that can be used for HVAC system noise control design. The chapter describes all the major noise sources and transmission paths and would serve as an excellent introduction to those not familiar with HVAC system noise control or those using commercial noise control software.

The late Ewart "Red" Wetherill's chapter on acoustical design of worship spaces contains much material, nearly two-thirds of it applicable to most building types and not just worship houses. Topics include interior and exterior sound isolation, HVAC noise control, requirements for speech and music, sound systems, sanctuary planning, room acoustics, and information on the construction process and different means of project delivery. Only 10 pages in Chapter 14 are specific to worship house sanctuary and choral room design. One factor I found helpful was a graph showing how reducing the background noise level increases the perceived room reverberance.

The last chapter covers in considerable depth the design of performing arts spaces. Written by the late Ronald L. McKay, David Conant, and K. Anthony Hoover, the chapter is subdivided into three general areas: music performance spaces, dramatic arts spaces, and music education spaces. Each section is written by one of the authors. The chapter ends with a glossary of technical terms. Part 1 on music performance spaces serves as a compendium on acoustic design for this performance venue type and includes concert, opera, and multi-purpose halls. Little new ground is broken here, but examples of precedent halls and case studies from the author's consulting practice help convey valuable design concepts. Part 2 covers dramatic performance spaces with emphasis on proscenium, thrust stage, and experimental theater forms. General acoustic design and speech intelligibility requirements are outlined before each venue type is examined to include an example case study from the author's consulting practice. Part 3 addresses the different spaces that comprise the music education suite. Covered are design considerations for sound isolation, HVAC system noise, and room acoustics. Different spaces such as classrooms, faculty offices and studios, practice rooms and ensemble rooms, and critical listening and recording studios are described. A criticism of this chapter is that the section numbering is very complex with up to 7 subdivisions to identify sections or paragraphs. A dedicated chapter each for music performance, dramatic arts, and music education spaces would have simplified the numbering scheme.

There are several aspects that would make this book more useful as a reference source. First, there is no index; however, the table of contents is very detailed which aids in finding a topic. Second, there is no symbols list. Third, symbol usage is not consistent among the different chapters. Lastly, the introductory paragraphs for many chapters are not consistent. Some are titled as Introduction, others use Overview, Abstract, or have no title at all, while some have several introductory paragraphs with different titles before continuing with the body of the chapter. Typographical and editing errors are few, while

page 386 in the review copy was misprinted as a blank page without any text.

Overall, even with my criticisms, this book is valuable resource for those with a background in architectural acoustics. The selection of topics represents the latest work and insights in the field and including subjects not covered in other books makes it a useful addition to the acoustics literature. Instructors teaching a class

in architectural acoustics will find much supplemental material to complement the customary textbook content.

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