Contents

Preface xi

About the Authors xv

Acknowledgments xix

Chapter 1 Introduction to Architectural Acoustics and Basic Principles………1

WILLIAM J. CAVANAUGH

1.1 Introduction 1

1.2 Basic Concepts 2

1.3 Design Criteria 23

1.4 Selected Standards in Building Acoustics 31

Further Reading 31

CASE STUDY: Fogg Art Museum Lecture Hall, Harvard University (1895–1973) 33

Chapter 2 Acoustical Materials and Methods ................................. 41

REIN PREN AND JEFFREY L. FULLERTON

2.1 Introduction 41

2.2 Sound Attenuation 41

2.3 Sound Absorption 44

2.4 Common Building Materials 47

2.5 Acoustical Materials 50

2.6 Special Devices 54

2.7 Performance Tables 58

References 59

Further Reading 70

Selected Web Resources 70
CONTENTS

CASE STUDY: Duke University Chapel: A Lesson on Acoustical Materials 71
CASE STUDY: Boston Waterfront Development Under a Flight Path: Sound-Isolating Façade Constructions to Reduce Intrusive Noise 75
CASE STUDY: Berklee College of Music: Sound-Isolating Constructions Between Percussion Studios 79

Chapter 3 Building Noise Control Applications ............................ 83
GREGORY C. TOCCI
3.1 Introduction 83
3.2 Acoustical Analysis 84
3.3 Standards Organizations for the Building Industry 85
3.4 Overview of Building Noise Control Design 86
3.5 Heating, Ventilating, and Air-Conditioning System Noise Control 111
References 120
Further Reading 120
CASE STUDY: Mechanics Hall, Worcester, Massachusetts: Cooling Tower Sound Isolation 121
CASE STUDY: Field Impact Insulation Class Rating Measurements of Condominium Floor/Ceiling Construction 123
CASE STUDY: Noise Insulation Class Rating Measurements of a Hotel Guestroom Door 125
CASE STUDY: 500 Atlantic Avenue Hotel/Condominium Building Vibration Isolation 126

Chapter 4 Acoustical Design: Places for Listening ......................... 133
L. GERALD MARSHALL
4.1 Introduction 133
4.2 Sound Outdoors and Transition to Indoor Acoustics 133
4.3 Concert Halls and Recital Halls 136
4.4 Opera Houses, Theaters, General-Purpose Auditoriums, and Worship Spaces 145
4.5 Other Places for Speech and Music Activities 155
References 158
Further Reading 159
CASE STUDY: Holy Cross Church, DeWitt, New York 160
CASE STUDY: Mitchell Hall at the University of Delaware, Newark, Delaware—Historic Renovation 162
CASE STUDY: The New Hitchcock Presbyterian Church, Scarsdale, New York 164
CASE STUDY: Katherine M. Elfers Concert Hall at the Esther Eastman Music Center, Hotchkiss School, Lakeville, Connecticut 165
CASE STUDY: Ozawa Hall, Tanglewood Music Center, Lenox, Massachusetts 167
CASE STUDY: Hollywood Bowl Stage Redesign, Los Angeles, California 169
Chapter 5 Sound Systems ................................................................. 175
Matthew J. Moore

5.1 Introduction 175
5.2 Loudspeaker Systems 178
5.3 Equipment 181
5.4 Examples of Sound Reinforcement and Reproduction Systems 186
5.5 Special Sound System Installations 190
Further Reading 191

CASE STUDY: Hanover Theatre, Worcester, Massachusetts 192
CASE STUDY: Agganis Arena and Boston University Fitness and Recreation Center, Boston, Massachusetts 194
CASE STUDY: Ave Maria University Oratory, Ave Maria, Florida 197
CASE STUDY: University of Connecticut Student Union, Storrs, Connecticut 199
CASE STUDY: Rhode Island Senate Chamber, Providence, Rhode Island 201
CASE STUDY: Rhodes Arts Center, Northfield Mount Hermon School, Gill, Massachusetts 202
CASE STUDY: Tufts University Granoff Music Center, Medford, Massachusetts 205
CASE STUDY: Jay Pritzker Music Pavilion, Chicago, Illinois 206

Chapter 6 Recent Innovations in Acoustical Design and Research ......... 209
Gary W. Schellen and Bertram Y. Kinsey, Jr.

6.1 Introduction 209
6.2 Understanding and Measuring Room Acoustic Qualities 211
6.3 Acoustical Modeling and Aural Simulation 231
6.4 Other Directions in Architectural Acoustics Research 233
6.5 Conclusions 238
References 239
Further Reading 240

CASE STUDY: Recent Halls for the Performing Arts and Acoustical Model Studies 241
CASE STUDY: Segerstrom Hall, Orange County Performing Arts Center, Orange County, California 242
CASE STUDY: McDermott Concert Hall, Morton H. Meyerson Symphony Center, Dallas, Texas 245
CASE STUDY: Evangeline Atwood Concert Hall, Alaska Center for the Performing Arts, Anchorage, Alaska 249
CASE STUDY: Bass Performance Hall, Fort Worth, Texas 253
CASE STUDY: The Esplanade Concert Hall, Theaters on the Bay, Singapore 255
CASE STUDY: Tokyo Opera City Concert Hall, Takemitsu Memorial, Tokyo, Japan 257
CASE STUDY: Walt Disney Concert Hall, Los Angeles, California 260
CASE STUDY: Computer Model Tests 264
Chapter 7 Sustainable Design and Acoustics ................................ 273

ETHAN SALTER, LEED AP

7.1 Introduction 273

7.2 Organizations Leading the Green Building Movement 274

7.3 Acoustical Challenges of Green Design 277

7.4 Postoccupancy Evaluations of Green Buildings 281

7.5 Examples of Building Types Designed for Green Ratings 281

7.6 Conclusion 285

References 285

Further Reading 286

Internet and Web Resources 286

CASE STUDY: Global Ecology Research Center at Stanford University,
Palo Alto, California 287

CASE STUDY: Dougherty Valley High School, San Ramon, California 289

CASE STUDY: Charles Salter Associates Tenant Improvement Office,
San Francisco, California 291

Appendixes ................................................................. 295

Appendix A: Conversion Factors, Abbreviations, and Unit Symbols 295

Appendix B: Acoustical Societies Throughout the World 297

Appendix C: Selection of an Acoustical Consultant 303

Appendix D: Self-Study Guide for Using this Book 305

Glossary 311

Index 317