

Auditorium Acoustics 2023

Proceedings of the Institute of Acoustics Volume 45 Part 2

Athens, Greece
28-30 September 2023

ISBN: 978-1-7138-8473-6

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2023) by Institute of Acoustics
All rights reserved.

Printed with permission by Curran Associates, Inc. (2024)

For permission requests, please contact Institute of Acoustics
at the address below.

Institute of Acoustics
3rd Floor St Peter's House
45-49 Victoria Street
St. Albans, Hertfordshire
AL13WZ
United Kingdom

Phone: +44(0) 1727 848195
Fax: +44(0) 1727 850553

ioa@ioa.org.uk

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

11th International Conference on Auditorium Acoustics,

28-30 Sep 2023

Greece

Vol.45 Pt.2 2023

Contents

- 1 **ACOUSTICAL CHALLENGES IN HORSE SHOE SHAPED OPERA HOUSES**
A C Gade, Gade & Mortensen Akustik A/S; Charlottenlund, Denmark
- 13 **SUBJECTIVE LISTENING STUDIES CONDUCTED BY ARUP AT A LEADING WESTERN OPERA HOUSE**
Matthew Lomax, Philip Wright, Arup, London
- 23 **ABSENCE OF SEAT-DIP IN THE STALLS OF THE TEATRO COLÓN IN BUENOS AIRES**
Gustavo Basso, University of La Plata, Argentina
- N/A **TEATRO SÃO CARLOS – ANOTHER OPPORTUNITY FOR IMPROVEMENT OF THE MAIN PORTUGUESE OPERA HOUSE**
Octávio Inácio, Daniel José, InAcoustics, Portugal
- 31 **The design of the opera theatre auditorium and a reflection on the reciprocal influence between opera house and concert hall design**
Alban Bassuett, Arup, USA
- 43 **Flexible acoustics and sound system design to accommodate programming inside and outside the venue spaces**
Ryan Bizorek, Arup, USA
- N/A **The architectural design of the Stavros Niarchos Foundation Cultural Center**
Vassily Laffineur, RPBW Architects, France
- 55 **Sound isolation and HVAC noise control: design versus practical challenges and constructability**
Rachid Abu-Hanson, Arup, USA
- 64 **SOME THOUGHTS ON WHOLE STAGE IMAGING FOR THEATRES**
Peter Exton, Marshall Day Acoustics, Melbourne, Australia
- 76 **PERCEPTION OF MUSICAL DYNAMICS: ORCHESTRA SPECTRA COMBINED WITH AUDITORY MODELING**
Tapio Lokki, Pedro Llado, Aalto University
- 84 **BIOMETRIC EVOLUTION OF SPACE**
Paul Bavister, The Bartlett School of Architecture, University College London
- 92 **GOOD VIEW OR GOOD ACOUSTICS? CAN I HAVE BOTH?**
Yuxiao Chen, Marshall Day Acoustics, Australia;
Densil Cabrera, The University of Sydney, Australia
- 100 **MUSIC, ROOM, TWO EARS, DESIGN AND PARADIGMS**
Magne Skålevik, AKUTEK and Brekke & Strand
- 111 **THE INFLUENCE OF REFLECTION SURFACE SIZE IN CONCERT HALLS**

Evan Green*, Otavio Colella-Gomes, Jannis Kriz, Vincent Berrier, Thomas Wulfrank,
Eckhard Kahle, Kahle Acoustics, Belgium

- 120 **ACOUSTIC EFFECTS OF LONG-DELAYED REFLECTIONS FROM REAR WALLS IN A SHOEBOX HALL**
Toshiki Hanyu, Akane Kawai, Ryoichi Suzuki, Kazuma Hoshi, Nihon University, Japan
- 126 **WHY DO LARGE CONCERT HALLS NEED TO BE OPTIMIZED FOR EARLY REFLECTION COVERAGE?**
Eckhard Kahle, Yann Jurkiewicz, Evan Green, Vincent Berrier, Kahle Acoustics
- 133 **ZONE TO ZONE REFLECTOR OPTIMISATION USING A GENETIC ALGORITHM**
John O'Keefe, O'Keefe Acoustics, Canada
- 141 **EARLY REFLECTOR GEOMETRY OPTIMIZATION METHODOLOGY**
Konstantinos Dadiotis & A Galatas, ACC Acoustics Consultancy Company, Greece
- 149 **ACOUSTIC UPGRADE FOR THE CONCERT HALL OF THE SYDNEY OPERA HOUSE**
Gunter Engel & Jürgen Reinhold, Müller-BBM Building Solutions GmbH, Germany
- N/A **TRANSFORMING DAVID GEFFEN HALL – A STORY OF THE WORLD'S MOST INFAMOUS CONCERT HALL**
PH Scarbrough & CN Blair Akustiks, LLC, USA
JA Nepomuceno, Akustiks, LLC & Acústica & Sônica, Brasil
- 160 **FINE TUNING OF THE SIBELIUS HALL STAGE ACOUSTICS**
Lehto P, Möller H, Pätynen J, Gómez Bolaños J, Laukkanen ., Vehviläinen S,
Akukon Ltd,
- 169 **LISTENING AND DYNAMICS – SOME CHALLENGES WITH A HIGHLY ABSORPTIVE STAGE ENVIRONMENT**
Svein Folkvord, COWI AS, Norway
- 174 **CONNECTION BETWEEN ICONOGRAPHY AND REVERBERATION PERFORMANCE OF BYZANTINE TEMPLES: EXPERIMENTAL INVESTIGATION**
Panagiotis Karampatzakis, Aristotelian University, Greece
- 182 **HOW DID EPIDAUROS SOUND WHEN IT WAS FULL? DIRECTIONAL MEASUREMENT OF IMPULSE RESPONSE FOR AN IMPROVED COMPUTER MODEL**
Ian Rees, Adrian James Acoustics Ltd, UK
- 193 **OPEN-AIR AMPHITHEATER IN ANDROS**
Konstantinos Dadiotis & A Galatas, ACC Acoustics Consultancy Company, Greece
K Kondylatou & K Loukos, K. Loukos and Partners Architects, Greece
- 201 **THE ACOUSTICS DESIGN OF AMPHITHEATRE “IOANNIS DESPOTOPOULOS” IN ATHENS CONSERVATOIRE, ATHENS, GREECE**
Theo Niaounakis, Theta Acoustics, UK
- 210 **A 350 SEATS CONCERT HALL AUDITORIUM WITH “BUDGET” VERSION CONCRETE SIDE WALLS; ACOUSTIC DESIGN AND PERFORMANCE**
Andrzej K. Klosak, Cracow University of Technology / archAKUSTIK Cracow, Poland,
Anders C. Gade, Gade & Mortensen, Denmark
- 218 **IN SITU ACOUSTIC EFFICIENCY OF VARIABLE BROADBAND ABSORPTION IN MUSIC REHEARSAL STUDIOS AND MUSIC HALLS**
Maarten Luykx, Peutz Consultants, Netherlands
- 226 **OPTIMIZING (TOO) SMALL ENSEMBLE REHEARSAL ROOMS FOR ACOUSTIC LOUD MUSIC**
Bård Støfringsdal, COWI, Norway

- N/A **THE RESEARCH BEHIND THE DESIGN OF A NEW VARIABLE ACOUSTICS TECHNOLOGY**
Niels Adelman-Larsen, Flex Acoustics, Denmark
- 239 **SIZE MATTERS: NEW WAYS OF WORKING WITH SCALE MODELS**
Brian F G Katz, Institut d'Alembert, Sorbonne University, CNRS
Peter Stitt, Institut d'Alembert, Sorbonne University
- 247 **Auralization of orchestra based on 1/10 scale model experiment**
Takayuki Hidaka, Kazunori Suzuki, Shin-ichiro Koyanagi
Takenaka Research & Development Institute, Japan
- 255 **IMMERSIVE AURALISATION FOR CHORAL ENSEMBLES**
Sarabeth S Mullins & Brian FG Katz, Sorbonne University, France
- 263 **A SOFTWARE TOOL FOR AURALIZATION OF SIMULATED SOUND FIELDS**
Jens Ahrens, Chalmers University of Technology
- 271 **MEASUREMENTS IN ROOM ACOUSTICS – HOW GOOD ARE WE AT IT?**
Ingo B. Witew, Michael Vorländer, RWTH Aachen University, Germany
- 283 **LATERAL FRACTION OR CROSS-CORRELATION FOR SPATIAL IMPRESSION?**
Mike Barron, Fleming & Barron, UK
- N/A **REVISITING SABINE'S FORMULA**
Jean-Dominique Polack, Sorbonne Université, France
- 300 **EFFICIENCY AND UNCERTAINTIES OF SOUND ENERGY DECAY ANALYSIS IN AUDITORIA**
Ning Xiang, Rensselaer Polytechnic Institute, USA
Zuhre Su-Gul, Bilkent University, Turkiye
- 307 **COMBINING NATURAL ACOUSTICS AND AUDIO IN A DEBATING CHAMBER**
Bob Essert, Imagine Sound, UK
- 313 **ROUND AND ROUND WE GO: SPEECH INTELLIGIBILITY AND LOCALIZATION FOR IN-THE-ROUND SPACES**
Luca Dellatorre, Charcoalblue LLP, UK
- 325 **ACOUSTIC DESIGN OF THE SHAKESPEARE NORTH, A JACOBAN THEATRE IN LIVERPOOL**
Onur Gulen, AECOM, UK
- 335 **COVID, SEPARATION & ALL THAT JAZZ**
Anne Minors, Imagine Sound Ltd, UK
- N/A **ROOM ACOUSTIC MEASUREMENTS IN HALLS WITH ELECTRO-ACOUSTIC ENHANCEMENT SYSTEMS**
Henrik Möller, Aalto University, Finland
Łukasz Błasiński, University of Adam Mickiewicza, Poland
- 349 **EVALUATION OF A GEOMETRIC APPROACH TO ACTIVE ACOUSTICS**
Volker Werner, Fabio Kaiser, Clemens Frischmann, Amadeus Acoustics, Austria
- 358 **A COMPARISON OF MUSICAL PERFORMANCES IN DIFFERENT ACOUSTIC ENVIRONMENTS CREATED WITH AN ACTIVE ACOUSTICS SYSTEM**
Benedikt Roß, Volker Werner, Clemens Frischmann, Simon Neeten, Amadeus Active Acoustics, Austria
- 366 **THE SIGNIFICANCE OF EXCELLENT CONCERT HALL ACOUSTICS FOR AUDIO RECORDINGS OF CLASSICAL MUSIC**
Pauline Heister, University of Music and Performing Arts, Austria

- 374 **ROOM ACOUSTIC DESIGN OF A 15,000-CAPACITY MULTIPURPOSE ARENA**
P Laukkanen, J Riionheimo & J Pätynen Akukon Ltd., Helsinki, Finland
- 386 **REMEDIAL ACOUSTICS IN MONUMENTAL LECTURE AUDITORIA OF NEOCLASSICISM IN ATHENS**
George Xanthoulis, Atkins; Giannis Karagiannis, George Poulakos, Alexandra Sotiropoulou, National Technical University of Athens
- 393 **ACOUSTIC DISCOVERY OF THE ROMAN THEATRE OF VOLTERRA: TWO RECONSTRUCTION HYPOTHESES IN COMPARISON**
Antonella Bevilacqua, Wladek Fuchs, University of Parma, Italy
- 399 **ACOUSTIC ASSESSMENT OF ARGOS ANCIENT THEATRE**
GeorgeCambourakis,GiannisKaragiannisPanosCoukoutas,AlexandraSotiropoulou, NTUA,Greece
- N/A **HOMERIC SOUNDS: RECORDING, CLASSIFICATION AND COMPARISON OF SOUND PHENOMENA IN ILIAD AND ODYSSEY**
Ilias Papageorgiou, NTUA, Greece
Fotis Papageorgiou, GISMA University of Applied Sciences, Germany
- 406 **CLASSICAL AUDITORIA IN THE MEDITERRANEAN OF UNIVERSALLY ACKNOWLEDGED ACOUSTICS: EVALUATING ELECTROACOUSTIC AMPLIFICATION**
Iasmi Kilaidoni, Actress, Alexandra Sotiropoulou, Giannis Karagiannis*, National Technical University of Athens
- 416 **NEW ACADEMY OF MUSIC IN THE SUBURBS OF ATHENS: ARCHITECTURAL LANGUAGE AND ACOUSTICAL SOLUTIONS**
Aikaterini Bousia Alexaki, Tasis Papaioannou, Giannis Karagiannis, Alexandra Sotiropoulou, National Technical University of Athens, Greece
- 424 **CHOPIN'S MUSICAL SCALES: NEW OPERA HOUSE IN POLAND; ARCHITECTURE AND ACOUSTIC DESIGN OF MULTIPURPOSE 1100 SEAT AUDITORIUM**
Elora Christoula, Kassandra Christoula, Vasiliki Giannoutsou, Vasilios Ghikapeppas
Giannis Karagiannis, Alexandra Sotiropoulou, National Technical University of Athens, Greece
- 432 **SOUND STRENGTH MEASUREMENTS USING A PRE-CALIBRATED OMNI-DIRECTIONAL SOURCE**
George Koutsouris, Claus Lynge Christensen, Antoine Richard, Jens Holger Rindel, Odeon, Denmark
- 440 **DEVELOPMENT OF AN OMNIDIRECTIONAL SOURCE FOR ACOUSTICAL SCALE-MODEL MEASUREMENTS**
Etienne Larochelle*, Vincent Berrier, Thomas Wulfrank, Evan Green, Kahle Acoustics, Belgium * In memoriam
- 448 **ACOUSTIC RENOVATION OF A CIRCULAR-SHAPED SMALL MUSIC HALL**
Ok Cheol Ahn, Youngsan University, Rep. of Korea
Sang Eun Jeon, Pusan National University, Rep. of Korea
Yong Hee Kim, Youngsan University, Rep.of Korea
- 456 **MEASUREMENTS OF AUDITORIUM SEATS "IN THE TIME OF CHOLERA" – CHALLENGES IN DESIGN CONCERT HALL AUDITORIUM SEATS DURING PANDEMIC**
K Klosak, Cracow University of Technology, Poland & archAKUSTIK, Poland
AC Gade, Gade & Mortensen Akustik A/S, Denmark
B Ziarko, Cracow University of Technology, Poland
- N/A **BRAZILIAN PERFORMING ARTS CENTER ACOUSTICAL AND ARCHITECTURAL DATABASE**
José Augusto Nepomuceno, Acústica & Sônica, Brasil and Akustiks, USA

- 463 **PLACEMENT OF ABSORPTION MATERIAL: DIN 18041 IS MISLEADING**
 Tapio Lokki, Aalto University
 Antti Kuusinen, Turku University of Applied Sciences
- 471 **ROOM ACOUSTICS MISMATCHES OF REHEARSAL SPACES AND CONCERT HALLS AND THEIR IMPACT ON MUSIC PERFORMANCE**
 Giorgos Dedousis, Konstantinos Bakogiannis, Areti Andreopoulou, Anastasia Georgaki, NKUA, Greece
- 480 **SINGLE-VALUE FREQUENCY-AVERAGE MEASURES OF EARLY DECAY TIME AND CLARITY INDEX TO PREDICT REVERBERANCE AND CLARITY**
 Fernando del Solar Dorrego & Michelle C. Vigeant, Penn State University, USA
- N/A **A METHOD FOR AUTOMATED SYSTEM CALIBRATION IN ACTIVE ACOUSTIC SYSTEMS**
 Clemens Frischmann, Fabio Kaiser, Volker Werner, Amadeus Acoustics, Austria
- 489 **HERISSON – AN INNOVATIVE TOOL FOR SPATIAL ROOM IMPULSE RESPONSE (SRIR) MEASUREMENTS**
 Serafino Di Rosario, LINK Acoustique, France; Johan Sick, Matlab, France; Clement Royon, LINK Acoustique, Matlab, France ; Romain Darracq, LINK Acoustique, France ; Sylvain Guitton, LINK Acoustique, France
- 506 **CONCERT HALLS IN VIRTUAL REALITY – FROM AUDIO-VISUAL PERCEPTION TO A COMMON VOCABULARY**
 Jonas Heck, Josep Llorca-Bofí, Michael Vorländer, RWTH Aachen University, Germany
- 510 **IMPROVEMENT OF STAGE-TO-PIT BALANCE USING COMPUTER SIMULATION IN A MULTI-PURPOSE HALL WITHOUT AN ORCHESTRA PIT**
 Sang-Eun Jeon, Pusan National University
 Yong-Hee Kim, Youngsan University
- 518 **FINDING EARLY TIME LIMITS t_e WITH NONLINEAR REGRESSION ON ENERGY DECAY CURVES**
 Changqing Xia, The Hong Kong Polytechnic University
- 526 **USING NON-WAVE BASED MODELLING TO EXPLORE HOW MUCH ACOUSTIC DIFFUSION IS TOO MUCH IN A CONCERT HALL**
 Michael Fort, Ramboll, UK
- 534 **OBJECTIVE ROOM ACOUSTICS PARAMETERS AND THE USE OF SIMPLE MATHEMATICAL FORMULAS AS DESIGN INDUCERS: A PRACTICAL TOOL FOR ARCHITECTS IN THE BEGINNING OF A PERFORMANCE HALL DESIGN**
 Lineu Passeri Júnior, PASSERI Acústica, Brazil; Stelamaris Rolla Bertoli, University of Campinas, Brazil
- N/A **Subjective localisation of a sound source in immersive sound system and stereophonic loudspeakers system**
 Łukasz Błasiński
- 544 **COMPARING MEASURED SOUND STRENGTH TO THEORY AS A FUNCTION OF REVERBERATION TIME AND ROOM VOLUME**
 J Dunham, Tenor Engineering Group, USA