BALTIC-NORDIC ACOUSTICS MEETING 2021

PROCEEDINGS

ISSN 2245-4365
ISBN 978-87-995400-4-4

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On the road to silent waste collection

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Biography:
Marko Antila works as a Senior Scientist at VTT. His research activities include real-time noise modeling, machinery noise analysis, and augmented reality design methods. He has been a project coordinator or a participant in several projects improving citizens' and workers' noise-related conditions. The application areas have included vehicles, moving machinery, elevators, shipyards, wind turbines, rock crushing stations, and harsh mining conditions. Marko Antila is an author and a co-author of over 50 publications in the areas of psychoacoustics and human experience, machinery audible models, Active Noise Control (ANC), and electro-acoustics. He is a life-time member of Acoustical Society of Finland.

Waste collection is a significant noise source in a modern urban environment. To minimize the disturbance to the society, there is an increasing pressure to move the waste collection to the off-peak traffic hours of the day. To achieve this, as silent as possible ways to collect waste are required. A way to accomplish this is to use electrical trucks for waste collection. Simultaneously, the containers and the handling of containers must be made more silent than now. We are currently developing new concepts for electrical trucks, their compaction systems, as well as for the containers and their handling. As the first step, we have evaluated current situation with conventional trucks, containers, and waste collection methods in urban environment, by recording the noise and video of typical waste collection procedures. The most annoying noise comes from the impulsive noise sources, such as waste container transport on uneven surface, as well as from the waste container emptying to the waste collection truck. In addition to the expected lower inherent noise with electrical trucks, we have found out that significant decrease in noise levels and annoyance are possible in the handling of the waste containers.

Road traffic noise spectra - the need for updates

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Biography:
The Author has more than 35 years of experience in the area of road traffic noise. The work includes measurements of vehicle noise, tyre/road noise (both SPB and CPX), and calculation of road traffic noise. He is active in standardisation work (ISO) and has been involved in a wide range of European projects, funded by EU, CEDR and EEA Norway Grants. Currently, he is the Chair of the Task Force on Measurement Uncertainty within UN ECE GRBP.

In Norway, calculations of indoor traffic noise levels are currently based on normalised traffic noise spectra defined in the current Norwegian methodology. These spectra are based on measurement of road traffic noise more than 30 years old. In the meantime, the permissible noise emission levels for vehicles have been strengthened. In addition, there has been a technological development of the vehicles. Power-train noise sources like engine noise and exhaust noise have been considerably reduced, especially for heavy vehicles. This development has been driven more by customer-demand and competition between vehicle manufacturers, rather than by regulations. However, this development has raised concern by the authorities and consultants, that the current spectra no longer were representative for the present vehicle fleet on Norwegian roads. On the request from the Norwegian Public Roads Administration, SINTEF has made a literatures study of recent investigations which included measurement of traffic noise spectra, both on individual vehicle classes and on mixed traffic. In addition, a small measurement program on light and heavy vehicles (pass-by measurements) has been performed. Based on this study and measurement results, a new road traffic noise spectrum for mixed traffic in the speed range 30 to 50 km/h has been proposed.

A suggestion to repeatability assessment in random incidence sound absorption measurements

Senior Acoustical Specialist Mads Bolberg[1], Mr. David Duhalde Rahbæk[1]
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Biography:
Mads Bolberg is a trained acoustical engineer, who have worked with the field for the past ten years. Currently he is employed as senior specialist in the acoustical laboratory of ROCKWOOL International A/S and takes active part in ISO and CEN standardization work through his membership of the Danish mirror committee.

In recent years, efforts to increase comparability in random incidence sound absorption measurements have been studied in relation to updating of ISO 354. New and faster measurement setups have improved efficiency in laboratories. These setups also give the possibility to make more measurements on the same sample without much more effort. The uncertainty related to the repeatability in laboratories can hereby potentially be improved. Using combinations of multiple empty room measurements and multiple measurements with a sample, a range of results for αs, αp, and αw for exactly the same sample can be reached. This holds a potential in research for dealing with the influence from pure measurement randomness. A look into this is presented.

Room acoustic conditions in primary schools

Erlend Bolstad[1]
[1]*Cowi, , Norway*

Biography:
Erlend Bolstad has been an acoustician in COWI, Trondheim since 2018. He graduated as MSc in acoustics from NTNU in 2019. Besides from his engagement with acoustics, he has working experience with sound engineering and as a teacher in upper secondary school.

Through measurements of sound pressure levels during educational activities (LAeq and LA90) in classrooms, relationships between activity sound levels and room acoustic conditions have been investigated. The study is based on measurements from 40 lectures in 20 different classrooms in 8 different primary schools in Trondheim, Norway. Reverberation time is a key parameter in building regulations, but no significant correlation was found between LAeq or LA90 and RT in these classrooms. For the other key parameter, unoccupied background noise, significant correlation was found with signal-to-noise ratio (LAeq ÷ LA90) in plenary activities. The sound levels in Norwegian classrooms are generally lower than what is found in similar studies in other countries. RT is also lower, but it is suspected that rating RT of 0.4 s as superior conditions, as in the Norwegian building regulations, can be misleading. Allowing a slightly higher RT increases vocal comfort, and with the results in this study in mind, such an increase could be considered. Significant correlation was found between activity noise and room height, indicating that room height is also a critical parameter.

Impact forces and -noise from weights dropped on concrete floors in gyms

Senioringeniør Anders Buen[1]
[1]*Brekke & Strand akustikk AS, OSLO, Norway*

Biography:
20 years experience as an acoustics consultant, mainly in building and environmental acoustics. I am also an amateur power lifter spending much time in gyms, both to train, learn and observe about different solutions as an user. I'm educated in experimental physics and took the master (siv. ing) on vibration modes in violins using a TV-Holography system. A laser based interferometry method.

Impact noise and vibrations in buildings are common from weight drops in gyms. There are no design manuals available to deal with the assessment nor any standardized method to measure the impulse noise and vibration. However, there are a growing emphasis and literature on the matter, often supported by the floor or mat-industry. An emphasis will be put on theoretical modelling and measurements of impacts from free weights, cable machines and mitigation means with mats, resilient materials, springs, different designs of floating floors and weight plates. Reference noise and force levels from weight drops of typical sources are given. Realistic potential energies and impact forces are discussed along with information on the insertion losses up against the amount of padding on the sources and the test floors. The differences between impact sources like bumper plates, grip plates, hand manuals and kettlebells, as well as the physics and nature of some of the typical lifts are discussed, leading to suggestions for possible drop energies, resulting impulse forces, and noise levels from weight drops in gyms.

Some aspects of the acoustics of the Hardanger fiddle compared to the violin

Senioringeniør Anders Buen[1]
[1]Brekke & Strand akustikk AS, OSLO, Norway

Biography:
20 years experience as an acoustics consultant, mainly in architectural and environmental acoustics. I am also a hobby Hardanger fiddle maker since 13 years of age learning from grandpa and took the master (Siv. Ing) in experimental physics on vibration modes in violins using a laser based interferometry system called TV-Holography. I also practice and perform a little on the HF occasionally.

The Hardanger fiddle (HF) is a highly decorated, baroque-like Norwegian folk music instrument with four or five sympathetic strings. Compared to a violin, it has shorter and lighter gut, G, D and A, and E steel strings, a flatter bridge and fingerboard, longer f-holes and the top has a flatter cross arch, mainly between and above the f-holes. Acoustically it is closely related to the violin. Its "ringing qualities" relate it to other bowed string instruments with free vibrating string designs, like the Swedish folk drone fiddle and the nyckelharpa, and also to the more "distant relative" the Viola d'amore. Acoustic properties and the construction of the HF are compared to the violin, showing close similarities in the lower frequency range. The bridge design and the tonal ideals are different, especially for the higher frequencies. A Hardanger fiddle will in general be a little quieter than a violin, but it may sound more "intense". Scordatura is often in use and the HF is traditionally played solo. The tuning of the A-string can be any frequency between A4-D5 (440 Hz - 587 Hz), with B4 (494 Hz) being the most typical pitch.

Distributed acoustic acquisition with low-cost embedded systems

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Biography:
Andres Mondragon Clavijo received a bachelor's degree in electronics from the National University of Colombia and a master's degree in Embedded Computing Systems from the University of Kaiserslautern (TU Kaiserslautern) and the Norwegian University of Science and Technology (NTNU). His current interests involve electronic system design and acoustics. He currently works as a software engineer for Texas Instruments (Oslo).

Under some circumstances having an acoustic measurement system handling both reproduction and acquisition becomes very challenging or technically impossible (e.g. long-range outdoor sound propagation experiments or when measuring transmission loss between two rooms). A solution to this problem is distributed acquisition in which the measurement system is not composed of a single measuring device but of separate nodes that communicate wirelessly and which are assigned specific tasks. This paper describes a prototype of such a measurement system for which the main design constraints were cost and portability. The use of the prototype was limited to the measurement of impulse responses with the swept-sine technique since it allows high signal-to-noise ratio while not requiring a tight synchronization between the clocks of the nodes in the system. The quality of the measurements obtained was checked by a reference to a commercial measurement system in a real-world situation. The obtained results suggest that at a lower cost and reduced size, the prototype offers audio quality comparable to that of commercial systems while adding the flexibility associated with distributed acquisition. Nonetheless, node synchronization proved to be a limiting factor in the usability of the system as it was not possible to achieve accurate timing of the beginning of the acquisition below five milliseconds.

The WOODSOL project: summary of the acoustic activities and preliminary results

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Biography:
Simone Conta studied engineering acoustics at DTU,
Denmark obtaining his MSc in 2007. He has been working
as an acoustic consultant at Müller-BBM (Germany) from 2007 to 2017, as he moved to Trondheim to start his PhD at
NTNU. The PhD foucuses on the vibroacoustic properties
of timber hollow box floor elements and related advanced
measurement methods. He now works at SINTEF Community as senior consultant in acoustics.

WOODSOL is a project funded by the Norwegian Research Council that has been running from 2017 and is about to be completed. WOODSOL is a multidisciplinary project aimed at designing a construction system for timber urban buildings based on moment resisting frames and long span floor elements. The acoustic activities started with identifying an assessment strategy for the acoustic properties of the building system and its element. After building a physical prototype of the system, we performed vibroacoustic measurements leading to a clear definition of the acoustic properties of the system. Additional measurements in the SINTEF test facilities in Oslo allowed for the validation of the methods and an evaluation of possible impact sound insulation solutions. In this paper we want to present our activities, give a brief insight in the advanced measurement methods we used and highlight some of the main results we obtained.

Studying acoustics at NTNU

Professor Guillaume Dutilleux[1], MR U. Peter Svensson[1]
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Biography:
Professor of Environmental Acoustics

While it is a well established discipline in academia with a broad range of applications, acoustics is usually not big enough a subject to exist at the department level of a university. Acoustics easily suffers from a lack of visibility in higher education, especially for young students at the start of university studies. Moreover, when the organization of the university is application-oriented, the transverse nature of acoustics makes it difficult to find a suitable place for the discipline. This communication deals with the particular case of NTNU which has a long established activity in acoustics. The current situation of a specialization in acoustics under the umbrella of a master programme in electronics is described. The students in acoustics at NTNU can benefit from a variety of courses offered and have access to topics that are uncommon elsewhere in Scandinavia, like musical acoustics, underwater acoustics and geoacoustics. Alternative tracks are also described for the students with backgrounds in physics or civil engineering. Potential improvements to the current situation are discussed.

Vibration measurements during soil-rock sounding – a comparison between accelerometers and geophones

Editha Ehrmanntraut[1]
[1]*Kth, , Sweden*

Biography:
Editha has been studying Engineering Physics at the Technical University in Berlin, Germany and the Polytechnical University of Tomsk, Russia. During her studies she has been an exchange student at Chalmers University of Technology in the field of Sound & Vibration. After her studies she started to work as an acoustic consultant at Brekke & Strand Akustik and started a PhD at KTH Royal Institute of Technology in Stockholm, Sweden in 2019.

There are many different methods to retrieve information about ground properties prior to building and infrastructure projects. In Sweden the most common method is soil-rock sounding (Jb-sounding) which was developed in Norway in the 1990s. Soil-rock sounding is used for identifying the stratification of soil and the depth to bedrock and can be applied in different classes with different accuracy. It is an effective method with low costs but gives restricted information about the penetrated soft soil strata sequences and its properties. Improved knowledge about the presence of different soil and rock layers is necessary for a cost-effective design particularly of deep foundations.
The purpose of this research project is to perform vibration measurements on the ground during soil-rock sounding to gain more knowledge about the penetrated ground. The measurements can be executed without influencing or affecting the sounding measurements and show that the frequency content of the signal is reflecting the properties of the penetrated soil layers. As an important step for developing the new measurement method vibration measurements with an accelerometer are compared to simultaneous measurements with a geophone in order to evaluate which sensor is most suitable for retrieving soil information. The results and recommendations of this analysis are presented in this paper.

Key words: Ground vibration, geotechnical engineering

Improved hearing in Norway. A comparison of two HUNT cohorts 20 years apart

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Biography:
Born in Umeå, Sweden 1963. Current position, senior researcher at Norwegian Institute of Public Health and acoustic consultant at Brekke & Strand akustikk as. Master of engineering Trondheim 1988, Ph. D. Oslo 1996. About 65 international publications from laboratory studies, clinical and epidemiological studies in the field of Acoustics.

The objective of the study was to obtain updated robust data on age-specific prevalence in hearing loss in Norway and determine whether more recent birth cohorts have improved hearing compared with earlier birth cohorts. Cross-sectional analyses of Norwegian representative demographic and audiometric data from HUNT2 (1996-1998) (N=50,462) and HUNT4 (2017-2019) (N=28,373). Pure-tone hearing threshold levels were estimated using linear and quantile regressions with age and cohort as explanatory variables. Prevalences were estimated using logistic regression models for different severities of hearing loss averaged over .5, 1, 2 and 4 kHz in the better ear. We also estimated prevalences at the population-level of Norway in 1997 and 2018.

There was a significant improvement in more recent born cohorts mean hearing threshold levels for both men and women, with the largest improvement in men. At high frequencies the improvement was particularly pronounced in more recent born 60 to 70 years old men. The improvement at low frequencies was highest among the oldest. The prevalence of disabling hearing loss declined in the more recent born cohort at all ages in both men and women with the largest absolute decline at about age 70 in men and at age 80 in women.

Practical aspects of road noise mapping in Sweden using CNOSSOS-EU

Andreas Gustafson[1], Mr Anders Genell[2]
[1]Gärdhagen Akustik AB, Göteborg, Sweden, [2]Swedish National Road and Transport Research Institute (VTI), Göteborg, Sweden

Biography:
Andreas Gustafson is working as an acoustic consultant, mainly with the calculation of environmental noise from traffic and industries.

The mapping of road traffic noise using CNOSSOS-EU requires more detailed input data than the Nordic Prediction Method for Road Traffic Noise from 1996 (RTN96), which currently is the primary calculation method used in Sweden for the mapping of road noise. Among the differences may be mentioned: the emission model has more vehicle categories that needs to be adapted to Swedish conditions, road surface correction is handled differently, corrections for the use of studded tires can be applied, four instead of two ground absorption classes, and that meteorology can be taken into account. The article presents results from test calculations that were made with CNOSSOS-EU with the aim of producing Swedish recommendations for END noise mapping. Calculated sound levels are compared with corresponding results obtained with RTN96 and Nord2000. Level differences between the methods are moderate at short distances, provided that no screening is present, but increases at longer distances and in shielded positions. For the latter, CNOSSOS-EU and RTN96 often underestimates levels in comparison to predictions made with Nord2000 using realistic weather data.

56 YEARS OF LISTENING «I found, I found!»(orig. invited for YoungAc)

Senior Consultant/Assoc.Prof. Tor Halmrast[1]
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Biography:
b. 1951. Acoustician and Composer. Earlier in Statsbygg, now consultant in Cowi. Assoc. Professor University of Oslo/Musicology and Norw. Ac. of Music.

56 YEARS OF LISTENING «I found, I found»
The most common figure in Norwegian fairy tales is Askeladden (eng.: Ash-lad), a simple kid who digs and blows into the ashes in the fireplace and looks (and probably listens!) at everything on his way, collecting what his bolder brothers find non-important. (“ I found, I found!”) But in the end, Askeladden gets both the “princess and half of the kingdom».
Apart from the fact that I have nice, supporting brothers, and that the princess is otherwise engaged, I find myself something like an Askeladd. I have been given the possibility to dig into all aspects of sound, since I , at the age of 13, formed a rock band in 1964. I did my Civil Service duty in Audiology and Hearing Aids, and went on to 42 years as acoustician at Statsbygg (the “Norwegian State Directorate of Public Construction and Property”), mixed with positions as Assoc. Professor at the University of Oslo/Musicology and at the Norwegian Academy of Music. At night, I am a musician and a composer both for acoustic instruments/orchestras/radio-opera, theatre, jazz and contemporary electroacoustic music for concerts and exhibitions. My presentation will give some examples of “what I heard on my way”. My position as a “state client acoustician” got me involved in almost every interesting acoustic project in Norway, collecting input from the good ears and minds of all the consultants and users in theatre, opera, buildings for music education etc.

CEPSTRUM; a “forgotten” analysis?(org. invited to Musical Acoustics)

Senior Consultant/Assoc.Prof. Tor Halmrast[1]
[1]a)Cowi b)University of Oslo/Musicology, Oslo, Norway

Biography:
b. 1951. Acoustician and Composer. Earlier in Statsbygg, now consultant in Cowi. Associate Professor at University of Oslo/Musicology and Norwegian Academy of Music

“Every” sound/vibration is the result of an impulse trying to move “something”. When this “something” cannot be moved further, it gives a reflection back. This goes for any oscillation, from musical instruments to the stock market. Mixing a sound with a delayed reflection is the “recipe” for building a filter, both in in electronics and in room acoustics. The paper will give an introduction to how a reflection in the time domain gives a Comb Filter in the frequency domain (and possible coloration in room acoustics). When adding feedback, we gradually get a musical instrument (or the annoying feedback in a PA sound system). This general “recipe” could be described as “The Filter That Explains It All”. For increasing feedback, the comb filter gradually changes to an «upside down”-shape, in the transition towards higher Harmonicity/lower Spectral Entropy. The word Cepstrum is of course a deliberate mis-spelling of Spectrum. In the paper we will see how Cepstrum analysis can be used to detect any «rhythmical behaviour» in the frequency domain, giving information regarding Echoes/Delay Time, Timbre/Coloration, Pitch and Rhythm: From Elvis´ Slap Back Echo to reflections in a concert hall. From simple tempo analysis of a march or rock tune to complex poly-rhythmics. If we get the time, we will even dig into the difficult first bars of Beethoven 5th symphony.

Better hearing rehabilitation for adult first-time users (the BEAR project)

Professor Dorte Hammershøi[1]
[1]*Aalborg University, Aalborg Ø, Denmark*

Biography:
Dorte Hammershøi has a MScEE in biomedical engineering (1989), and a PhD in Acoustics (1995) from Aalborg University. She has since April 1990 worked at Aalborg University, as a professor since 2008. Dorte works in the field of human sound perception with special reference to electro-acoustic applications, incl. audiometric calibration, oto-acoustic emissions, hearing damage, hearing rehabilitation, spatial hearing, and measurement of noise sources close to the ear. From 1996-2004 she was a member of the ISO TC 43/WG 6, which developed the ISO 11904 series. In 2001 she co-founded AM3D, which in 2013 was acquired by Goertek Audio Technologies.

First-time adult hearing-aids users do not always experience the debut with success, and it is known that some give up. For the professional fitting the hearing aid, it is often a difficult detective work to figure out, if the hearing aid is poorly fitted to the individual, or whether it is set for best performance. The purpose of the BEAR is to develop a stronger framework for the diagnostics, fitting an assessment of the aided performance that will allow for a more structured, and personalized approach. The project includes several scientific efforts, incl. 1) the collection of data for almost 2.000 patients fitted according to current practice, 2) development and assessment of new diagnostics for profiling and fitting strategies, as well as 3) development and assessment of methods for measurement of the aided performance. The on-going work includes a proposal for a differentiated fitting based on extended auditory profiles, and is accompanied by both in- and out-of-clinic options for testing and/or reporting on the aided performance experience. Future results will include an experimental validation of the proposed differentiated fitting, as well as a separate effort to investigate common denominators for patients with poor compensation benefits, and options for out-of-clinic application of the proposed methods. The paradigm for auditory profiling will be presented along with tentative results simulated hearing aid. The presentation will also include key results from the analysis of the clinical database will be presented, as well as exemplar results from a field study of the aided performance.

Acknowledgement: Collaboration and support by Innovation Fund Denmark Grand Solutions 5164-00011B, Oticon, GN Resound, Widex and other partners (University of Southern Denmark, Aalborg University, the Technical University of Denmark, Force, and Aalborg, Odense and Copenhagen University Hospitals) is sincerely acknowledged.

The risk hearing damage from earphones

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Biography:
Dorte Hammershøi has a MScEE in biomedical engineering (1989), and a PhD in Acoustics (1995) from Aalborg University. She has since April 1990 worked at Aalborg University, as a professor since 2008. Dorte works in the field of human sound perception with special reference to electro-acoustic applications, incl. audiometric calibration, oto-acoustic emissions, hearing damage, hearing rehabilitation, spatial hearing, and measurement of noise sources close to the ear. From 1996-2004 she was a member of the ISO TC 43/WG 6, which developed the ISO 11904 series. In 2001 she co-founded AM3D, which in 2013 was acquired by Goertek Audio Technologies.

The WHO has in its ”Make Listening Safe” initiative had a strong focus on the risk of hearing damage from excessive use of earphone playback of music. Jointly with the ITU they launched the first international standardized framework including proposals for the display of day and week dose earlier this year (2019). In the present paper, the significance of source spectrum, earphone type, listener habits will be discussed in view of given risk criteria and confounding effects of other exposures, including case examples from previous studies.

Helmholz-based absorbers for low frequencies and large spaces

Prof. Anders Homb[1]
[1]*NTNU, Trondheim, Norway*

Biography:
Senior research scientist and Prof. II with professional focus on education and research on building acoustics. Special expertise on sound insulation of lightweight constructions and timber floor constructions, but also research work related to acoustic treatment of rooms and noise from technical installations.

Requirements concerning universal design imply that acoustic demands must be fulfilled in a number of new building categories and user areas compared to previously. The sound classification standard NS 8175 provides normative requirements for reverberation time and sound absorption, which proves difficulty to satisfy at lower frequencies. To meet this challenge, a well-known method is to use resonant absorbers that might be tuned to more or less narrow frequency bands. Numerous designs have proven that well designed Helmholz resonators are very efficient in terms of adding damping to resonant modes, but in this paper the focus is on shortening the reverberation time. The aim of the work is to develop solutions relevant for large spaces, and absorbing properties in the frequency range between 100 and 300 Hz. Development of Helmholz-type of absorbers is based on existing literature as well as calculations using the WinFlag software. One prototype of absorber without porous layer in the cavity was constructed. In such solutions, a resistive layer play an important role to broaden the frequency response, involving measurements of the flow resistance. Another resonator including mineral wool in the cavity was developed for installing in an existing room for improving the reverberation time at lower frequencies. Finally, a comparison between calculation and measurement results will be given.

Structure borne sound from tunneling works for underground infrastructue

Seniorrådgiver Clas Ola Høsøien[1]
[1]*Multiconsult Norge As, Oslo, Norway*

Biography:
Mr Clas Ola Høsøien has been working as an acoustic consultant for over 20 years He has broad experience in acoustic design and measurements and a special interest in impact sound.

Underground works in dense populated areas is an increasing necessity as the urbanisation process is accompanied with a demand for increased infrastructure capacity. During the tunnelling works for the Follo Line project in Norway, consisting of two 20 km train tunnels, extensive measurements of structure borne sound from the tunnel boring machines (TBMs) were carried out. The goal of the measurements was partly to assess, and potentially modify, the early phase model and calculations. Analysis of the measurement data is presented together with some refinements in the prediction model of sound propagation in hard rock and attenuation effects.

Uncertainties in measurement of impact sound and consequences for conformity assessment

Seniorrådgiver Clas Ola Høsøien[1]
[1]Multiconsult Norge As, Oslo, Norway

Biography:
Mr Clas Ola Høsøien has been working as an acoustic consultant for over 20 years He has broad experience in acoustic design and measurements and a special interest in impact sound.

Fulfilment of requirements in building codes can be documented by predictions and measurements. In the Norwegian "Regulations on technical requirements for construction works" (TEK17), this is given as a qualitative requirement: "Acoustic conditions shall be satisfactory for people inside construction works". Furthermore, it is stated that this qualitative requirement can be met by compliance with class C in Norwegian standard NS 8175: 2012. The regulations do not deal with uncertainty, neither in calculations nor measurements. The standard states that the expected value from measurements is to be compared with the limit value, but at the same time that standard uncertainty with 90 % confidence level for two-sided test according to NS-EN ISO 12999-1 shall be reported, which can lead to confusion about the validity of the results, i.e. whether they are within or outside the corresponding limit value. Based on general uncertainty and risk concepts (such as producers and consumers risk), and results from field measurements and dose-response curves, some consequences of including uncertainty in conformity assessment are assessed, with emphasis on parameters and requirements for impact sound insulation.

The BIM-technology: new challenges and opportunities for Acoustics to obtain buildings with better acoustic performances.

Bart Ingelaere

Biography:
Bart Ingelaere is Deputy General Director of the BBRI where he has been working for almost 30 years

Bart Ingelaere is a civil engineer, he did a postgraduate in acoustics and has been working for most of his career in building acoustics. In 2004 he became responsable for the Department of Acoustics, Energy and Climate. Active in the first BIM research projects in 2008, he started up both the BIM research group in the BBRI and the socalled CLUSTER BIM, regrouping more than 100 companies willing to work together to advance BIM with WGs active in classification, open BIM, BIM protocols, modelling conventions, LOIN, datalinking, BIM and legal aspects, etc. Since 2016, he has been active in CEN TC 442 (BIM) and became the liaison officer between CEN TC 126 (Acoustics) and CEN TC 442 (BIM), actively promoting to go beyond BIM as a mere geometrical (quantities, planning, ...) collaboration tool towards using BIM for technological holistic opimisations, especially in the field of Acoustics. He is also active as the convenor of WG 12 in CEN TC 126 about BIM and Acoustics.

The building industry knows important failure costs, a multiple of the profit that a contractor can make. To the contrary of other industries, it is generally not possible to optimize a real prototype before building the real construction. Thanks to the BIM technology, we can build a digital model to do so. But most BIM-models until now only have geometrical data and thus easy clash avoidance is limited to the detection of geometrical errors (e.g. piping running through steel beams). With more effort, a wide variety of software applications import the BIM data, enrich it with technical data and can simulate the performance of the future building. Some acoustic software based upon the EN ISO 12354-series of calculation tools can already do so. This offers interesting perspectives for research: there is no “complication limit” any more to research, ever more detailed, sophisticated and precise calculation models are as such possible to implement in the software, while these will remain relatively easy-to-use in order to obtain buildings with better acoustic performances.

The utopia of the easy-to-use acoustic BIM equivalent of the “spellchecker in word texts” is not immediately within reach. The actual restraints are the manner and level of precision of how the digital model has been built (modelling conventions, Level Of Information Need LOIN), the accuracy of the acoustic performance of objects and especially the burden to attach these data to the objects (data linking) in the model. On-going standardisation work in CEN TC 442 (BIM) and WG 12 (data dictionary, LOIN) of CEN TC 126 is very important in this field. But imagine what easy-to-use tools could mean for the design of new buildings, for the evaluation of their performance to obtain a building permit and for the possibility to correctly choose commercial building products and systems during the tender and construction phase!

Wavebreaker - a new innovative interference damper for railway noise

Founder Tony Johansson[1]
[1]*Wavebreaker AB, Lerum, Sweden*

Biography:
Tony Johansson is the founder and owner of Wavebreaker AB. He has 30 years of experience in the sound and vibration field through various positions in consultancy, product sales and development. Companies he has worked for are Ingemansson, Christian Berner, ÅF among others. Main competences are noise and vibration problems and solutions in the railway segment.

Train noise is a major problem in society and actors are actively looking for better solutions. The reason for increasing noise is due to longer & faster trains and increased traffic causing rising investments in more and higher noise screens. The problem is global. WHO reported in 2020 that 12.000 people in Europe die each year prematurely due to noise. Conclusions are that the problem is increasing, noise screens are getting more costly and higher and, up to now, no new technical solution has been available on the market. A new type of noise damper for urban train noise, that can be used for both new railway projects and existing noise problems, is under development. It uses interference technology and is used and mounted as an additional product on top of the noise screens. The damper reduces the noise going over and above the noise screens and acts as if the walls are about 1-1.5 m higher. This paper presents the potential of an interference damper, compares the analytical optimization studies made in Actran and full-size laboratory tests on a prototype. The analytical results show that an overall noise reduction of 3-5 dB is obtainable. It is assumed to be working within 50-100 m range from the noise screen, whereas longer distances are more dependent on weather conditions. The development work has the aim of tuning the damper to a general railway noise spectrum. Furthermore, as the damper is designed in a modular way, adapting the noise reduction spectrum is possible in the future by changing the acoustical insert. Further steps in the development process are a pilot study with field measurements in 2021 and a ready-to-use documentation for acoustic planners. All is made possible due to cooperation with RISE, SL, Trafikverket and financing support by InfraSweden2030 and Vinnova.

Concert Halls and Opera Houses: how to make them sound. The use of parametric design tools in room acoustics

Eckhard Kahle

Biography:
Eckhard Kahle, acoustician and musician, founder of Kahle Acoustics, a consulting practice specialised in spaces for the performing arts. In Norway, Kahle Acoustics was responsible for the room acoustics of Stavanger Concert Hall and is now working on the renovation of the National Theater in Oslo; other relevant projects include the Philharmonie de Paris, Musikforum Bochum, improvements in Konserthuset Stockholm as well as the KKL Concert Hall in Luzern, Switzerland.

Kahle Acoustics is extensively using 3D-digital models and parametric design tools for optimising the acoustic response of spaces under design or renovation.

W. C. Sabine, the father of reverberation time and modern room acoustics, in his seminal “reverberation” paper from 1900, placed reverberation as third in a list of three factors influencing room acoustic quality. Have we perhaps all neglected something when focussing on reverberation time in room acoustic design for concert halls? We indeed know that sufficient loudness and impact (the first aspect in WC Sabine’s list) is a pre-requisite for joyful listening in concert halls. Creating loudness and impact requires sending energy and reflections deliberately to certain audience zones. Rather than using computer models only to check standard parameters once the design is already relatively well-advanced, the author is in favour of extensive use of 3D-digital models and parametric design tools to optimise the acoustic response of spaces under design or renovation. With the advent of modern computers and adapted design tools it is now possible to literally “sculpt” the room, or rather the auditory room response of a concert hall or performance hall, leading to exciting aural and musical experiences in the built spaces and a truly collaborative design process with the architects.

Noise spectra for railborne noise sources when calculating sound insulation of façade elements

Mr. Tore Fodnes Killengreen[1], Mr Sigmund Olafsen[1]
[1]*Brekke & Strand, Oslo, Norway*

Biography:
Senior advisor for Brekke & Strand. 15 years of experience with environmental noise.

When calculating the airborne sound insulation of façade elements, a spectrum adaptation term is used to evaluate how different sound sources are transmitted through the façade elements. Based on measurements, spectrums for noise sources can be defined. SINTEF Byggforsk Handbook 47 (HB47) define spectrums for road and rail. This paper will focus on rail. The rail spectrums in HB47 originate from calculations with exception of the C5 spectrum for metro. The paper evaluates if the spectra given in H47 are valid for the train types MX3000, NSB BM 74/75 and NSB BM 71/73 that are in use in Norway today. New spectrums for use in calculations are proposed based on the comparison between the spectra in HB47, and the measured spectra for the train types MX3000, NSB BM 74/75 and NSB BM 71/73.

Impact sound pressure values - Field measurements for different configurations of concrete slabs on the ground

Senior Acoustical Engineer Bernt Mikal Larsen[1]
[1]*Multiconsult Norway, Kristiansand, Norway*

Biography:
The author is educated as civil engineer within physics and mathematics by NTNU in Norway. In total the author has 18 years of wide experience within acoustics, working with both sound in buildings and noise maps. The author is today member of working group 28 and 64 in the work with revision of ISO standards.

The presentation will summarize and discuss values of field measured normalized impact sound pressure level L'n,w measured sideways with different configurations of concrete slabs on ground within buildings. All results are adjusted to receiving room volume of 100 m3 and with thickness of concrete slab 80-100 mm. Measurement on continuous concrete slab on expanded polystyrene gives L'n,w between adjoining rooms of 74 dB. Different principles of splitting have been investigated to evaluate the effect on L'n,w. The configuration where only the concrete slab is split (and with a plastic film between the concrete base and the upper layer of expanded polystyrene), gives L'n,w of approximately 66 dB which is 8 dB lower than for a continuous bare concrete slab. When both the concrete slab and the upper layer of expanded polystyrene are split, measurements show L'n,w of 58-61 dB for the case of no flooring, which is 13-16 dB lower than for a continuous concrete slab (no split). When both concrete slab and all layers of polystyrene split down to continuous foundation measurement shows L'n,w of 55 dB. The situation with concrete slab and all layers of polystyrene split and with no foundation beneath gives L'n,w of 46 dB. For all configurations we have to consider what kind of flooring that will meet the requirements in Norwegian regulations (NS 8175:2012). Consequences for airborne sound and R'w will be discussed as well for the above mentioned configurations.

Swedish input data for road traffic noise in CNOSSOS-EU

Krister Larsson[1]
[1]RISE Research Institutes Of Sweden, Borås, Sweden

Biography:
Krister Larsson is senior researcher in acoustics at RISE Research Institutes of Sweden. At the same time, he is affiliated to Chalmers University of Technology. He has a broad experience in acoustics from building acoustics, environmental noise and machinery acoustics. He received his Ph.D. in 2002 on tyre road noise. 2004 -2007 he was head of research and 2007-2013 head of the acoustics laboratory at SP Technical Research Institute of Sweden. Since then he has worked as senior researcher. He is also involved in standardisation and was chairman of the Swedish standardisation committee on building acoustics 2009-2019.

According to the Environmental Noise Directive 2002/49/EC (END) the EU member states should map environmental noise in the major cities and report the number of exposed people each 5th year. The noise mapping for the next reporting period shall be done according to a harmonised noise prediction method, CNOSSOS-EU, which is specified in detail in the directive. However, the original document contained some errors and the method has recently been appended with corrections published in RIVM Letter report 2019-0023. One of the corrections is the default input data for road traffic noise, where the source strengths and speed dependence coefficients of road vehicles have been adjusted to fit the source model and radiation conditions used in CNOSSOS-EU. The prediction model can be adapted to national or regional conditions that differ from the default reference conditions by correction coefficients for the specific national road surfaces. Coefficients for typical Swedish roads for CNOSSOS-EU was reported in 2016, but these were based on the incorrect default source data used in the directive. This paper presents updated road surface corrections for the most common Swedish road surfaces fitted to the recently published adjusted CNOSSOS-EU default road traffic source data. The data could serve as an important input for the next round of noise mapping in Sweden and for similar Nordic countries.

Consequences of revised sound insulation requirements between dwellings in Norway

Dr. Anders Løvstad[1], Mr Per Kåre Limmesand[1]
[1]*Brekke & Strand Akustikk AS, Oslo, Norge*

Biography:
Løvstad finished his M.Sc. in 2003 and Ph.d. in 2012. He has worked in acoustic consultancy since 2003, and presently works in Brekke & Strand Akustikk, and was member of the comittee revising NS 8175.

The Norwegian standard NS 8175 which gives requirements for sound insulation in various buildings types, amongst them dwellings, was revised in 2019. One major change in the revision was to include frequencies down to 50 Hz in the sound insulation requirements for dwellings. This paper briefly discusses the revised requirements in comparison with the corresponding requirements in the other Nordic countries. Then practical consequences in how constructions separating dwellings vertically and horisontally must be built to meet the new requirements are investigated. Specific challenging situations are highlighted and exemplified with measurement results. Possible measures are discussed. This is done for slabs and walls made of concrete, cross-laminated timber and light-weight wooden constructions.

Features of reverberation time criteria application for sound classification in Lithuania

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[1]*Vilnius Gediminas Technical University, , Lithuania*

Biography:
Civil Engineer,
PhD of Technology science,
Associated Professor at Vilnius Tech (VGTU, Lithuania),
President of Lithuanian Acoustical Society (LAS).

Lithuanian sound classification scheme contains five sound classes and describes different acoustic quality of new, old and renovated buildings. Reverberation time is among descriptors used to express acoustic properties of different purpose building areas and building elements.
In order to mitigate noise level in the rooms, the maximum permissible reverberation time values were set in octave bands at least in the frequency range 500–2000 Hz. The mandatory requirement was indicated for residential and some non-residential purpose buildings. Additionally expanded frequency range of estimation indicates more strict requirements and was dedicated for increasing clarity of speech and lowering tiredness in educational rooms. In case of teaching purpose rooms the lower limit of required reverberation starts from the 250 Hz octave band and in case of musical purpose rooms – from the 125 Hz.
The experience obtained during more than 10 Years' of practical labeling conformity with the corresponding acoustic class requirements for new and renovated buildings shows necessity to take into consideration the application of the sound absorbing treatments already in early design stage. Few typical cases of conducted reverberation time measurements in different purpose rooms are presented.

Sound absorption of slat structures for practical applications

Henrik Möller[1], Janne Rionheimo[1,2], Nella Näveri[1], Tapio Lokki[2]
[1]Akukon Ltd, Helsinki, Finland, [2]Aalto University, Espoo, Finland

Biography:
Leading Consultant

This paper presents a study of sound absorption of slat structures. The paper stems from a need for a tool to predict the absorption coefficient for slat structures used in spaces for critical listening. For an acoustic designer, the accurate knowledge of absorption coefficient is vital in successful planning and predicting the behaviour of sound in, say a sound studio or instrument rehearsal room.

Theoretical models can be used to predict the absorption of slat structures, but in our experience, only with regular structures and moderate thicknesses. Even in these cases, the results leave much room for experience-based approximation. For thicker absorbers and irregular slat sequences measurements are needed. However, not many published measurement results can be found.

A study, with measurements of sound absorption in a reverberation room was concluded, to provide acoustic designers with more reliable and comprehensive understanding about the behaviour of slat absorbers. Four different slat sequences were used in the measurements, with complementary additions to provide different slot percentages. Each sequence was measured with multiple absorber thicknesses, varying from 600 mm to 100 mm. The results are presented at one-third-octave bands from 63 Hz to 8000 Hz. The room modes were not addressed in the measurements, and therefore it seems, that the results are only applicable from 200 Hz upwards.

A review of STI measurements

Henrik Möller[1]
[1]Akukon Ltd, , Finland

Biography:
Leading Consultant Akukon Oy

Since the STI concept was introduced by Houtgaard and Steeneken in 1973[1], the different derivations of the STI has been the principle parameter for evaluation of speech intelligibility, both in sound reinforcement systems as well as in room acoustics. The basic parameter is defined in IEC 60268-16. In the standard, the parameter is defined for sound reinforcement system, however not described as a room acoustic parameter. In the standard ISO 3382-3:2012, the inverse STI is used as measure of speech privacy. The standard requires that the measurement must be done with an omnidirectional loudspeaker.
In current software implementations, at least 5 different variations of the basic STI parameter. STI is described as a requirement (as a measured parameter) in several international standards. However there seems to be some differences in how the parameter is measured and calculated.
In this paper, a review of some of the measurement techniques and calculation methods will be presented and a variation of the STI parameter, based only on omnidirectional sources and impulse response measurements will be presented.

Noise from 90-tonnes vehicles, measurements and input to the prediction method

Acoustician Henrik Naglitsch[1], Mrs Linda Grenvall[1]
[1]*Sweco Environment AB, Uppsala/Umeå, Sweden*

Biography:
Henrik Naglitsch is an acoustician and consultant with over 20 years of experience within the field of urban noise and building acoustics, specializing on building façades. He is a senior advisor at Sweco and is currently working with development of processes within in the field of acoustics internally at Sweco and the Swedish Transport Administration.

Linda Grenvall is an acoustician and consultant with 10 years of experience within the field of urban noise and building acoustics, specializing on road traffic noise.

In Road traffic Noise – Nordic prediction Method [TemaNord 1996:525] the definition of heavy vehicles is "all vehicles with a mass exceeding 3,5 tonnes". In the Nordic countries the maximum weight of a road vehicle was 60 tonnes when the prediction method was developed. Today on some roads in Sweden vehicles of 90 tonnes are being allowed. This is a problem when an EIA is being prepared and our prediction method is not suited for these traffic conditions. In this paper we present the results from measurements being carried out on 90-tonne vehicles, loaded with iron ore, driving at speeds ranging from 30 to 80 km/h. The measured sound pressure levels have been compared to calculated levels from the Nordic prediction Method. The measured spectrums, in one-third-octave bands, have also been compared to established spectrums for traffic noise, Ctr, according to ISO 717-1:2013. The results show that the emitted sound levels from the 90-tonne vehicles are significantly higher than those from "heavy vehicles" in the Nordic prediction Method, at speeds of 50 km/h and higher, both for maximum and equivalent levels. At 30 and 40 km/h the measured levels are lower than the calculated levels. At 30, 40 and 50 km/h the sound level from the vehicle's startup is higher than the sound levels from a pass-by at a steady speed. Finally, the paper presents a method on how to tweak the input parameters in the Nordic prediction Method to more accurately calculate sound levels according to the measurements.

Comparison of different computational methods for acoustic wave propagation.

Technology Manager Bertil Nistad[2], Dr Bertil Nistad[1]
[1]*COMSOL AS, Trondheim, Norway,* [2]*COMSOL A/S, Lyngby, Denmark*

Biography:
Bertil Nistad is working as Technology Manager in the Norwegian branch of COMSOL. He is involved in a wide variety of projects among different products related to COMSOL Multiphysics. Before starting in COMSOL in 2007, he was at NTNU in Trondheim working on his PhD in electromagnetic wave propagation for metamaterials and optical fibers.

In this paper we discuss the application of different methods for calculation of acoustic wave propagation that are available in COMSOL Multiphysics®. In particular we present; wave based implicit methods for frequency domain simulations with modern iterative solvers, a dG-FEM (discontinuous galerkin) time explicit, higher order method, for transient simulations, and also a ray tracing method with a hybrid FEM approach where the source and its vicinity is modeled in detail. These methods are highlighted and compared with regards to accuracy and performance. The feasibility for different applications with pros and cons of these methods are discussed with examples taken from room acoustics applications

Using Digital Tools to Analyse and Validate Sound Measurements

Fredrik Norell[1]
[1]Gärdhagen Akustik AB, Göteborg, Sverige

Biography:
Acoustician working with project planning, problem solving, measurements and calculations regarding building acoustics.

Sound measurements are a key part of many acousticians daily work. Whether the purpose is to verify sound insulation in a new building, to investigate the source of annoying residential noise, or to provide input to a legal dispute, it is of great importance that the results can be trusted. However, there are a number of things that can go wrong when making measurements in the field. This article discusses common sources of error, both in measurement and evaluation, and gives examples how various digital tools can help us make sure these are caught before leading to wrong decisions. The suggested methods include logging third-octave band levels for each time step, recording audio for listening, and analysing spectrograms to identify disturbances even when third-octave band levels of sound source and disturbance overlap. The article also illustrates how a customised evaluation of reverberation time can improve transparency and reduce uncertainties, and at the same time allowing more flexibility in the measurement procedure. Finally, it is suggested how an automated handling of measurement data can reduce the risk of human errors and improve traceability, while also enabling the engineer to be solely responsible for fulfilling calculation standards instead of being dependent on third-party software. The latter can be of strategic importance, both to retain understanding of the standardised methods in the company, but also to react more quickly to changes in measurement or calculation standards.

The correlation between outdoor and indoor vibrations from metro trains in Oslo

Senior Researcher Sigmund Olafsen[1]
[1]*Brekke & Strand Akustikk As, Oslo, Norway*

Biography:
Siv. ing. Trondheim 1982, Ph. D. Lund 2016. Consultant and researcher within noise and acoustics since 1986

The increasing population of Oslo has led to an increasing demand for metro traffic. It is important to avoid annoyance due to vibrations from these metro trains. Thus it is crucial to determine the level of vibrations transmitted into residences near the track. Correct prediction of transmission of vibrations from a metro track into a house close to the line is a very difficult challenge. A simple way of reliably predicting vibrations inside a house based on measurements of the vibrations on the ground outside the house would be very desirable. This paper will present results of measurements outside and inside houses. Many of the measurements were made during systematic control measurements along the recently rehabilitated metro lines Østensjøbanen and Kolsåsbanen in Oslo and neighbouring Bærum. Measurements have been made outside the house on the ground and usually at each level in the house, often in the basement, at ground level and on the first floor. This paper will present results based on vw,95 in three dimensions. It would seem that indoor vibrations from metro trains are usually lower than those measured on the ground outside the house.

Spectrum shape of road traffic noise at 50 km/h

Senior Researcher Sigmund Olafsen[1], Mr. Tore F. Killengreen[1]
[1]*Brekke & Strand Akustikk As, Oslo, Norway*

Biography:
Siv. ing. Trondeheim 1982, Ph. D. Lund 2016. Worked as consultant and researcher within noise and acoustics since 1986

The spectrum shape of road traffic noise in towns and cities is of critical importance in proper prediction and measurement of indoor noise. It is also of paramount importance in designing optimal walls and windows for noise sensitive buildings.

There are two very different spectra available in Norway. The paper will show that the two spectra represent extreme cases of what can be expected. The basis for the current paper is 250 measurements of outdoor road traffic noise spectra performed through more than 20 years. The study is limited to cases where the speed limit is 50 km/h. It would seem that the average spectrum shape is somewhere midway between the two spectra currently in use.

The measurements strongly indicate that a measurement of local spectrum shape will improve the accuracy of prediction or indirect measurement of indoor noise significantly.

Measurements of the spectrum shape of the local road traffic noise is a wise precaution for projects where indoor noise is critical.

Annoyance due to vibrations caused by metro trains in Oslo

Senior Researcher Sigmund Olafsen[1]
[1]Brekke & Strand Akustikk As, Oslo, Norway

Biography:
Siv. ing. Trondheim 1982, Ph. D. Lund 2016. Consultant and researcher in noise and acoustics since 1986.

The annoyance caused by vibrations from metro trains in Oslo has been investigated by means of a questionnaire sent to persons living along the metro lines in Oslo. The questionnaire has been sent to households where vibration measurements had been made. The paper will present the correlation between degree of annoyance and measured vibration level. The novelty of the paper is the level of detail in determining the physical vibration level. Vibration measurements were made using 3 to 6 vibration transducers, in most cases 5 triaxial transducers (geophones or accelerometers) were used. The measured vibration level has been defined as the vw,95 level measured in the direction with the highest level in the room with the highest level. Normally the vw,95 level is based on measurements during 20 metro train passages. The annoyance is graded from 0 (“do not notice”) to 4 (“highly annoyed”). A SurveyMonkey questionnaire has been distributed to the households where measurements had been made. 55 respondents have completed the form so far. The results indicate that the threshold of annoyance for vibrations from metro traffic may be lower than previously assumed.

Acoustics in rooms for music rehearsal and performance – the Norwegian experience

Ceo Jon G. Olsen[1]
[1]*Council For Music Organizations In Akershus, Norway., Lillestrøm, Norway*

Biography:
Jon G. Olsen is CEO for the Council for Music Organizations in Akershus, Norway. He is the convenor of the ISO/TC 43/SC 2/Work Group 33 "Acoustic quality criteria for music rehearsal rooms and spaces". He is the chair of the CMON Committee for music rehearsal and concert rooms. He has been working with room acoustics and acousticians for more than 30 years, mainly representing the users, the musicians. He has initiated the acoustic measuring program for the CMON and works also with administrators and politicians to improve the room situation for music groups, musicians and the music life in Norway.

Each week local music groups in Norway use more than 10.000 rooms for rehearsal and concert, many of the rooms are in schools. The size of the rooms vary from under 100 m3 to over 10.000 m3. The users cover a broad variety of music ensembles, mostly wind bands, choirs and other amateur ensembles. Since 2009 the Norwegian Council for Music Organizations («Norsk musikkråd») has completed more than 600 room acoustical measurement reports on rooms used for rehearsal and concert. The measurements include reverberation time, the strength parameter G and background noise. All the reports are made available online in a Google Map. The analysis shows that 85% of the rooms do not comply with the Norwegian Standard NS 8178:2014 and are evaluated more or less unsuitable for the purpose for acoustical reasons. The important criteria are volume, room form and dimensions, reverberation, acoustic treatment of surfaces, and background noise. In particular, the importance of volume is clearly documented. Analysis of room strength indicates that this also is an essential factor for this type of rooms. The systematic collection of acoustic reports gives important background for recommendations on how to build or refurbish rooms for music in schools and cultural buildings.
This work, combined with experience from 5 years using the Norwegian Standard NS 8178 is also used in the ongoing process in the ISO Work group ISO TC 43/SC 2 WG 33 developing a new ISO standard "Acoustic criteria for rooms and spaces for music rehearsal".
The Norwegian experience also clearly shows the importance of close relationship between the owners (municipalities, government etc), the users (choirs, bands, music schools, musicians) and the acousticians – "the golden triangle".
Examples of typical rooms will be presented together with comments from the users.

ACOUSTIC REGULATIONS AND DESIGN OF THE MULTIPURPOSE HALL AND EXHIBITION HALLS OF THE NEW MUNCH MUSEUM IN OSLO

Siv. Ing./M. Phil. Jannicke Olshausen[1]
[1]Multiconsult Norge As, Oslo, Norway

Biography:
Jannicke Olshausen works as an acoustic engineer in Multiconsult Norway, and has done so for the last 20 years. She was in charge of the acoustical engineering at the Munch museum and is a member of the acoustic committee in Standards Norway.

The presentation will deal with room acoustical challenges that comes up with a multipurpose hall and high ceiling exhibition halls for monumental works by Edvard Munch. The new museum for the Norwegian painter Edvard Munch drawn by estudio Herreros architects will open next year in 2021. The building is located close to the Oslo opera house (opened 2008).

Prediction of railway traffic ground-borne vibrations for Copenhagen Metro

Simon Rex[1], Mr Jacob Egede Andersen[1], Mr Simon Rex[1]
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The need for increased rail infrastructure in densely populated urban areas has extended the use of railway traffic. This often turns into conflict with environmental regulations for ground-borne vibrations in neighboring buildings along the alignment. When designing new railways, the design challenge is to determine the minimum damping solutions ensuring all environmental regulations are met, as damping measures are expensive to install. The process of how COWI A/S has developed a cost efficient vibration and control plan for design and execution of Cityringen, Copenhagen Metro, Denmark, is presented. The design was based on a developed prediction model build on the experience from working with metros in Oslo, urban rail tunnels in Malmö and London as well as high speed rail tunnels in lower Inn valley, Austria. A general model for predicting ground-borne vibrations and structure-borne noise in buildings near railways in relation to passing trains is introduced. The prediction model for vibrations and structure-borne noise is based on transfer functions. The model relies on the statistical analysis of a large set of measurements, which enable to estimate the acceleration at a particular building floor, the structure-borne noise level and an estimate of the associated error. The transfer functions used in the model are derived from measurements of several geographical locations and several buildings along the alignment. As tunnel works progressed new transfer functions have been measured from tunnel to selected buildings within a distance of approximately 100m. This final model update based upon measurements has formed decision basis for final track design meeting site specific noise and vibration requirements as it was the case for Cityringen, Copenhagen Metro. The approach has also shown very efficient for mitigating neighbor concerns and press interest. However, the method is general and is also applicable for high speed lines, trams and light rail trains.

Searching the musical rehearsal room

Dr. Jens Holger Rindel
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Biography:
Jens Holger Rindel, M.Sc. 1971, Ph.D. 1977, both from the Technical University of Denmark. Broad experience in architectural acoustics, project work as well as research and teaching. Until 2008 professor in acoustics at the Technical University of Denmark. Senior researcher at the Norwegian Building Research Institute (1998-99). Visiting professor at universities and research centres in Australia (1991), Germany (1993), Japan (2001), and New Zealand (2002). Initiated the development of the ODEON room acoustics software in 1984. Coordinator of European research projects. Convenor of working groups within standardization. Since 2008 working part time in Odeon A/S, Denmark and in Multiconsult, Norway.

The room dimensions are important for the frequency distribution of the normal modes of the room. The influence of the dimension ratio is analysed in box-shaped rooms with volume between 25 m3 and 300 m3. Three different criteria have been applied to evaluate whether the frequency distribution is favourable; a smooth frequency response, the variance of the interval between modal frequencies, or the number of tones in the musical scale, supported by at least one of the room modes. The analysis shows clearly that a square room or a cubic room is unfavourable and should be avoided as a music room. The results of all the applied methods agree that there are three usable optimum dimension ratios, which have also been reported previously in the literature. The optimum ratios of height (H) to width (W) to length (L) are (1:1.2:1.45), (1:1.4:1.89), and (1:1.48:2.12). However, nearly optimum dimension ratios are found close to a line that establishes a relation between L/H and W/H. Using this relation for the room design gives more freedom than using only fixed optimum dimension ratios. It is concluded that the L/W ratio should be in the range from 1.15 to 1.45, while the W/H ratio can be chosen more freely.

Acoustical aspects of the transverse flute from 1700 to present

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Biography:
Jens Holger Rindel, M.Sc. 1971, Ph.D. 1977, both from the Technical University of Denmark. Broad experience in architectural acoustics, project work as well as research and teaching. Until 2008 professor in acoustics at the Technical University of Denmark. Senior researcher at the Norwegian Building Research Institute (1998-99). Visiting professor at universities and research centres in Australia (1991), Germany (1993), Japan (2001), and New Zealand (2002). Initiated the development of the ODEON room acoustics software in 1984. Coordinator of European research projects. Convenor of working groups within standardization. Since 2008 working part time in Odeon A/S, Denmark and in Multiconsult, Norway.

The transverse flute is one of the oldest musical instruments and in principle, the acoustics is very simple, being a tube that is open in both ends. However, the modern flute is a very sophisticated instrument, and the acoustics is not at all simple. In medieval Europe, a cylindrical flute with six or seven tone holes was used in folk music and in the military (the fife), but the range of usable musical tones was rather limited, and the harmonics of the tones were in general out of tune. Around 1700, instrument makers in France managed to solve these acoustical problems with the so-called Hotteterre flute, which had a cylindrical head joint combined with a conical body with seven tone holes, narrowing towards the end. This flute had a pleasant soft tone suitable for indoor playing. However, there were still musical limitations, because some tones were quite weak, and the flute could not play all chromatic pitches equally well. Thus, the flute continued to develop gradually until 1847, when Theobald Boehm presented a quite revolutionary new design of the flute, which solved the technical problems, but also changed the sound to be stronger and brighter than before. Boehm also introduced a change of material from wood to silver. The evolution of the flute is illustrated with instruments from the author's flute collection and measured spectrograms from some of the flutes.

Effects of Intermittent Noise on Real Ear Measurements in Hearing Aid Fitting

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[1]*Aalborg University, Aalborg, Denmark*

Biography:

Palle Rye graduated as M.Sc.E.E. from Aalborg University in 1998. For 10 years, he worked as an Acoustics Engineer in the telecom industry. Until 2018 he taught Physics, Technology and Electronics at Tech College. He is currently employed as a PhD fellow in the Better hEAring Rehabilitation (BEAR) project, primarily working on patient-driven diagnostics and fitting.

When fitting a hearing aid, real ear measurements (REM) can prove a valuable tool for adjusting the gain of the hearing aid. In REM a probe microphone is inserted into the ear canal carefully placing the probe microphone tip a few millimeters from the tympanic membrane. Typically a reference microphone is present outside the ear canal near the pinna. Proper calibration before the REM measurement ensures a flat response of the probe microphone when placing the tip at the same positions as the reference microphone. The real ear unaided gain (REUG) is measured as the level difference between the reference microphone and the probe microphone placed near the tympanic membrane. Inserting the hearing aid the real ear aided gain (REAG) can be measured similarly and the real ear insertion gain (REIG) is calculated as the difference between the REAG and the REUG. Fitting a hearing aid typically involves matching the hearing aid gain to match a REIG prescription target derived by the patients audiogram and occasionally other diagnostic data. To ensure matching the REIG to the prescription target care must be taken to ensure accuracy in the REM measurements.

Inspecting a database of thousands of clinically recorded REM a handful of anomalies were detected and the present study seek to reproduce the observed effects under controlled laboratory conditions. The study involves measuring REM using manikins as well as human subjects. A semi-automated test setup was developed to synchronise the measurement equipment and the noise disturbance in order to investigate the effects of different types of intermittent noise on REM.

Preliminary results indicate that intermittent noise burst even shorter than 1s in duration can cause detrimental effects on the real ear measurement.

Uncertainty in industrial noise calculations with General Prediction Method

Arne Scheck[1]
[1]*Cowi AS, OSLO, Norway*

Biography:
Arne Scheck studied in Ilmenau, Germany, where he finished as Dipl.-Ing.in 2008. Since then, he's worked with and led projects in room- and building acoustics and environmental noise. He's currently employed as an acoustical engineer at COWI AS in Oslo. Before that, he was responsible for technical trainings at DataKustik GmbH.

In noise calculation projects, the uncertainty of both the emission levels and of sound propagation must be taken into account. Calculation standards such as General Prediction Method (GPM) are mostly conservative, based on light downwind or inverse temperature conditions, reducing the risk of underestimating results. However, severe calculation errors can nonetheless occur due to general uncertainty and the limitations of the method. Uncertainty of emission levels and propagation can be quantified to a certain degree and combined to an overall uncertainty. Based on 4 existing industrial projects with several statistically independent noise sources, uncertainty when using GPM for industrial noise purposes was examined and set into relation to the implicitly used conservative conditions. Standard deviations for noise sources and propagation were visualized on a map. The results were used for identifying sources which contribute most to overall uncertainty at receiver positions, in order to focus on the correctness of these sources.

Can our standard digital tools predict the real performance of wooden buildings ? - A systematic comparison with field measurements made in new buildings with a variety of floor constructions

Ph.d Christian Simmons[1]
[1]Simmons Akustik & Utveckling, Gothenburg, Sweden, [2]Luleå university of technology, Luleå, Sweden

Biography:
The author has been an acoustician for more than 30 years, active both as an consultant to the building industry and as a researcher (at SP/RISE, WSP and Luleå univ of tech.). In 2009, a doctoral thesis summarized a long term study on uncertainty in calculation and measurement methods widely used in building acoustics, ref www.dissertations.se.
At the web site www.simmons.se, further info is given.

Within the research projects AkuLite, Aku20 and the current AkuTimber, about 30 wooden buildings have been examined by means of detailed field measurements of sound insulations and vibration transmissions. In addition, questionnaire surveys have been made which gives us an opportunity to study buildings more in detail, where the residents are disturbed by poor sound insulation to some extent. The main focus of those research projects is to determine a new criterion for impact sound that takes very low frequencies into account. But the field results were also used to look into another question: - When acoustic consultants apply the most commonly used calculation softwares as well as some own experience of building acoustics, how close to the real performance is reasonable to assume they will get, on the average? To find out, some building cases examined in the research projects have been studied. The first estimates were made from drawings only, but the second estimates were supported by vibration transmission measurements to refine the models of the junctions. Several types of constructions have been used in 2-3 buildings, which helps reduce uncertainty in the study. The result are presented as an average (systematic) error and standard deviations, combined to a provisional safety margin. If there are particular concerns that should be observed, e.g. on the apparent vibration reduction at the junctions between walls and floors, this will be highlighted as well.

Live concert or headphone listening? The binaural signal and the musical experience.

Magne Skålevik[1]
[1]Brekke & Strand, , Norway

Biography:
The author, first an educated and practicing music teacher for several years, continuing with studies in acoustics at NTNU, Trondheim, since 1997 an acoustical consultant, for 30 years researching in acoustics related to music, founder and editor of www.akutek.info, currently a member of the ISO work group for a new standard for music rehearsal rooms, is a senior room acoustic consultant in Brekke & Strand, Oslo, Norway.

Localization, Source Broadening and Envelopment are among the listening aspects necessary to achieve excitement and engagement when listening to a live classical music performance. A playback of a binaural recording in headphones can quite accurately reproduce the sonic impression from the concert. In contrast, common stereo recordings techniques are very different from those used for binaural recordings. Newer generations seem to enjoy all kinds of recorded and streamed music in headphones. Can a good recording provide binaural signal qualities equivalent to those of a good live event? For newer recordings the answer seems to be no. Older recordings seems to be more similar to live, as far as the IACC-comparisons in this investigation can tell. However, a full similarity test would need more detailed investigation. Considering the nature of common practical recording techniques, similarity with live listening is not possible.

Experience from a large-scale railway project- handling multiple environmental noise sources in populated areas

M.sc. Acoustics Adam Suleiman[1], Mrs Nelly-Ann Molland[1]
[1]*Norconsult As, Oslo, Norway*

Biography:
Nelly-Ann Molland and Adam Suleiman are both siv.ing / M.Sc Acoustics in Norconsult AS. They have been working with a wide variety of complex environmental-noise projects through calculations and measurements

In Norway there is a great amount of major railway projects planned, called The InterCity initiative. This development has its focus in the south eastern part of Norway, and includes 25 stations and 270 km of new double track, which will give 1.5 million residents and commuters faster journeys and an increased amount of departures.

The Intercity-project Drammen – Kobbervikdalen has a starting location in a densely populated city-area and will have noise impact on approximately 700 residential buildings. These residents will be exposed to permanent noise from trains, in addition to noise from a temporary depositing terminal. Besides, noise from the associated construction work which will last for 5-years, needs to be considered.
With several different noise sources in the same residential areas, complex noise evaluations need to be carried out to ensure that the current domestic requirements will be satisfied with a minimal annoyance and via ensuring good communication with the residents.
The question is, are the noise requirements suited for this complexity? With respect to the different sources, how should the outdoor noise calculations be performed to assess whether the current noise limits are satisfied at nearby housings?
With so many different sound sources, how do we design acoustic measures that consider the complexity of the low frequencies from one source and the high frequencies from the other?
With the upcoming replacement of today’s trains to newer “low noise” trains, a challenging key factor to consider, while predicting permanent noise levels, is how to implement future noise sources as the associated levels are yet unknown. Regarding the construction work it is often challenging to predict the noise levels at given periods, because off the deviations and uncertainties in the planning and timetables.
To illustrate this approach in practice, we will present specific examples of the ongoing project.

Possibilities and limitations for computerized prediction in room acoustics

Peter Svensson

Biography:
Professor Svenssin has had research stays at University of Waterloo, Kobe University, Rensselaer Polytech Institute, University of Reading and University College London. In the past he has been a board member of the Swedish Acoustical Society, president of the Norwegian Acoustical Society and vice president of the European Acoustics Association (EAA). Currently, he represents EAA in the Initiative for Science in Europe.

His current research interests focus on computational room acoustics, 3D audio techniques, and measurement techniques.

The era of computerized prediction of room acoustical conditions arguably started with the paper by Krokstad et al in 1968 on the ray tracing method. The techniques and tools have evolved slowly but steadily, with a few methods and softwares dominating the toolbox. This presentation will give an overview of the methods that have been developed over time, leading to the development of the auralization technique, showing their progress from research labs to commercial tools. Computerized prediction is challenging because of the complexity of the input data, and therefore, the evaluation of the results is of great importance. Published evaluation studies will be reviewed, identifying the state of the art today.

Assignment list for acoustic design in Finnish building construction projects

Pekka Taina[1], Mr Matias Remes[1]
[1]*Sitowise Oy (Helimaki Acoustics), Espoo, Finland*

Biography:
Mr Pekka Taina has 14 years of experience in building acoustics and environmental noise and vibration assessments. He has worked in Helimaki Acoustics with projects such as Helsinki new central Library "Oodi" and Raide-Jokeri light rail. After company merger Helimaki Acoustics is now a building acoustics unit in Sitowise since July 2020. Mr Pekka Taina works as the director of the unit.

In Finland acoustic design is recognized as an independent field in building construction projects. In 2015 an assignment list for acousticians, AKU12, was published. It included a list of acoustic design tasks and their outcomes in a building construction project. The list was published by the Finnish Building Information Group and it was a part of a RAKLI ry (The Finnish Association of Property Owners and Construction Clients) project, where many other assignment lists (architectural design, structural engineering, etc.) were updated. The general structure of the AKU12 assignment list was similar to the lists of other design fields.

In 2017 RAKLI started a project to update all the assignment lists. It had become evident that AKU12 also needed updating - the list had become partly outdated and had also been found to contain ambiguities and deficiencies, which needed correcting. The update project started in 2018 and the list was released in the spring 2020. The new list AKU18 aims to specify the acoustic design tasks more clearly and unambiguously than before and so that the tasks relevant to acoustics are dealt with in the right phase of the project. Hopefully the new assignment list AKU18 will further improve the understanding of the role and tasks of acoustic design in Finnish building construction projects as well as unify the practices among the companies and consultants working in the field.

Sound exposure at home and its health effects

Dr. Irene van Kamp

Biography:
Since 2000, Dr. van Kamp has been working as a senior researcher and project manager at the National Institute of Public Health and the Environment (Netherlands), with an assignment in the field of urban environmental quality and quality of life, and specific expertise in the field of environmental noise. She was co-author in the review on interventions in the framework of the WHO Environmental Noise Guidelines. Current projects include mapping the burden of disease from low frequency noise; advising the EU on the use of environmental health indicators in the Environmental Noise Directives; the perception of noise and vibration from rail traffic; and the health promoting role of positive aspects in the sound environment in their physical and social context. Irene van Kamp is (co) author of some 150 publications and five book chapters. In 2012 she was granted the Dutch Golden Decibel award for her scientific work in the noise domain.

It had been a while that the first WHO guidelines for health protection against environmental noise were published in 1999. Since then many new studies on the health effects of sound exposure at home have been performed and an update of the WHO environmental noise guideline saw the light in November 2019. The earlier guidelines were primarily focused on transportation noise. At the ministerial Conference at Parma in 2010 the need for guidelines for other sources such as devices, toys and wind turbines was emphasized. In order to achieve this, reviews were prepared on the main health outcomes including annoyance, sleep, cardiovascular disease, cognitive effects, birth effects, hearing impairment and the effectivity of noise interventions in terms of human response and health. These systematic literature reviews over the period between 1980 and 2014 were published in a special issue of IJERPH spread out over late 2017 and early 2018. This presentation will provide an overview of the evidence including an update since 2014 for some key endpoints and other sources. The implications of the findings for noise policy and management will be discussed. And finally, some trends and research needs in the field of sound and health will be presented.

EVALUATION OF THE EFFECT OF STRUCTURAL MEASURES ON ROAD TRAFFIC NOISE, GAZI BOULEVARD ANTALYA

Nazlı Yalçındağ[2], Mr Mehmet Kılıç[1]
[1]Süleyman Demirel University, Isparta, Turkey, [2]Antalya Metropolitan Municipality, Antalya, Turkey

Biography:
The author, who graduated from Akdeniz University Environmental Engineering in 2005, has been working on environmental noise in Antalya Metropolitan Municipality since 2009. She is about to finish her doctorate study, which she started about noise at Süleyman Demirel University in 2016.

Antalya has a surface area of approximately 21,000 km² located in the south-west of Turkey and there are more than 2 million inhabitants concentrated in coastal areas. Due to the settlement extending from the west to the east, transportation routes parallel to the sea are important. There are two important boulevards connecting the east-west line in the city center; 100th Avenue Boulevard and Gazi Boulevard. Gazi Boulevard has heavy weight and high traffic density especially for heavy vehicles and transit. Structural measures such as intersection arrangements and fly over junctions were taken on the mentioned boulevard to provide more efficient transit flow. In this study, it will be discussed how these structural interventions implemented changed the sound level values on the boulevard. The effects of express traffic and raised intersections on noise exposure will be tried to be revealed.

Analysis of technical noise measurement according to the ISO 16032

Consultant Mykhailo Yaroshenko[1]
[1]*Akukon Eesti OÜ, Tallinn, Estonia*

Biography:
M.Sc (Tech.) National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Acoustic consultant in Akukon Eesti OÜ.

Were performed measurements of technical noise in the rooms of each apartment of a new residential complex according to the ISO 16032. Main sources of noise were ventilation units that have been installed in each bathroom of the apartment.
According to regulation 42 in the Republic of Estonia, were measured and evaluated three parameters - LAeq, LASmax and LCeq. The number of rooms where noise levels were measured - 364, where 27% are bathrooms, 73% - living rooms, bedrooms, saunas etc.
Since a large number of measurements were made, it was decided to test the following hypotheses:
What the difference between measured and evaluated levels in the rooms where ventilation units were installed?
What the difference between measured and evaluated levels in the living/bedrooms?
As a result of measurements, it is established that:
For 90% of bathrooms, where ventilation unit was installed, the difference between measured and estimated levels was in the range 0-1.4 dB for LAeq, LASmax and LCeq. Correction by background noise levels changed the status of the room where measured levels exceeded the required levels to the room where noise levels fulfilled the requirements only for 5% of measurements in bathrooms.
For more than 85% of unfurnished rooms difference between measured and evaluated levels locates in the range 6-10 dB for parameters LAeq and LASmax. For LCeq, the difference between measured and evaluated noise levels greater than 6 dB only for 55% of the unfurnished rooms.
According to the ISO 16032, results of reverberation time measurements strongly affects on evaluated noise levels, but measurement of background noise does not affect on evaluated levels in most case