The Acoustical Society of NZ

Conference 2018

Auckland

Making the Building Boom Quiet!

The Maritime Room — Princes Wharf — 12 to 14 November 2018

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Venue Information

THE MARITIME ROOM

PRINCES WHARF

Viaduct Harbour,
Auckland,
New Zealand

09 302 3496

www.maritimeroom.co.nz

Program

Monday, 12/11/2018

Start Time	Session	ID	Activity
8:30 AM	Registration and receiving of conference packs		
9:00 AM	Introduction and housekeeping		
9:10 AM	**Planning & Legislation**	**K1**	**Keynote speaker 1: Chris Scrafton - BECA Planning**
10:00 AM	Morning tea		
10:30 AM	Planning & Legislation	P1	J. Cawley - A review of the provisions of the Auckland Unitary Plan – Operative in part for the control of noise from activities in business zones and the protection of amenity and sleep protection.
10:50 AM		P2	R. Finley - Drafting cost-effective and appropriate noise legislation for living environments in urban areas
11:10 AM		P3	J. Trevathan, W. Reeve - How acoustics can influence the construction of a new city: A Christchurch case study
11:30 AM	Site Visit	-	C. Fitzgerald, J. Whitlock - Construction Noise and Vibration in the Auckland CBD - an 'Actual Reality' experience.
12:30 PM	Catered lunch		
1:30 PM	Planning & Legislation	P4	M. Dunn, T. Phillips - G6 interpretation – Facilitating a consistent approach
1:50 PM	Theory & Technology	P5	Y. Yanamandra, B. Parr, M. Kainuku, M. Legg - Microphone Array 3D Acoustic Imaging
2:10 PM		P6	R. McKay, M. Kingan - Multi-rotor unmanned aerial system noise: Quantifying the motor's contribution
2:30 PM		P7	M. Kingan, R. McKay - Noise from shrouded UAV propellers
3:00 PM	Afternoon tea		
3:30 PM	Theory & Technology	P8	V. Sorokin - On wave propagation in quasi-periodic structures
3:50 PM		P9	B. Lawrence - dBWav: A software tool for analysing and viewing long-duration hydrophone measurements
4:10 PM		P10	M. Davoigniot, A. Hall, H. C. Chang, D. Hay, G. Dodd - Multimaterial reed printing
4:30 PM	ASNZ AGM - Attendance requested from all ASNZ members		

Tuesday, 13/11/2018

Start Time	Session	ID	Activity
9:00 AM	**Building Acoustics**	**K2**	**Keynote speaker 2: Richard Hunt (GIB) - Close Living Quarters - Challenges & Choices**
10:00 AM	Morning tea		
10:30 AM	Building Acoustics	P11	T. Hulland, A. Su, M. Kingan - Noise in an inpatient hospital ward in New Zealand
10:50 AM		P12	G. van Hout, T. Halliker - The burning issue of acoustics in fire stations
11:10 AM		P13	G. Dodd - Rating structure borne sound insulation of floors - and possibly walls - based on their Sound Reduction Index
11:30 AM		P14	G. Schmid, M. Kingan - Can we measure rainfall noise insulation on roofs without using rain?
12:00 PM	Catered lunch		
1:00 PM	Building Acoustics	P15	T. Beresford, J. Chen - The effects of acoustic flanking degradation on apartment floors with exposed cross laminated timber walls
1:20 PM		P16	W. Byrick, H. Myles - Laboratory data examining impact and airborne sound attenuation in cross-laminated timber panel construction
1:40 PM		P17	M. Kingan, Y. Yang, B. Mace - Analysis of cross-laminated timber panels using a wave and finite element method
2:00 PM		P18	A. Healey - Sound absorption comparison of suspended ceiling tiles
2:30 PM	Afternoon tea		
3:00 PM	Building Acoustics	P19	A. Hall, G. Dodd, G. Schmid, P. D'Souza, J. Wong - Helmholtz resonators as a tool for suppressing the mass-air-mass resonance in cavity walls
3:20 PM	Spatial Acoustics	P20	M. Poletti - An implementation of the Boundary Element Method for the calculation of acoustic scattering around objects of arbitrary shape
3:40 PM		P21	D. Protheroe - 3D impulse response measurements in ordinary rooms
4:00 PM		P22	M. Dunn, J. Sanz, S. King, D. Protheroe - Auralisation case study
Free time			
6:00 PM	Conference dinner starts (at The Maritime Room)		
8:30 PM	After dinner entertainment: Open mic band/jam		
10:00 PM	Conference dinner end		

Wednesday, 14/11/2018

Combined Session with NZ Planners Institute

Start Time	Session	ID	Activity
9:00 AM	Planners' Session	-	Panel discussion: Acoustics from the planner's perspective
10:00 AM	Morning tea		
10:45 AM to 12:00 PM	Planners' Session	-	Panel discussion: Planning from the acoustician's perspective

Conference Activities

Conference Dinner Entertainment: Open mic / jam

Entertainment during the latter part of the conference dinner will be provided by yourselves!

Feel free to jump up on the provided equipment (mic, guitar, bass, drums, keyboard) or bring your own instruments if you play something unusual.

Warming up the stage will be the ASNZ All Stars. Anyone is invited to join them and jam along.

Members of the ASNZ All Stars performing at Construction Rocks 2016

Site visit - Monday 11:30am

James Whitlock and Craig Fitzgerald will be conducting a walking tour of some of the interesting construction sites in the local vicinity of the conference venue.

Acoustical Society of New Zealand Annual General Meeting

The ASNZ AGM will be held after the last paper presentation on Monday afternoon. All ASNZ affiliates and members are requested to attend. ASNZ Council nominations will be considered.

Food

Morning & Afternoon Tea

Coffee, tea, orange juice, water
A selection of savoury and sweet snacks

Lunch Buffet

Monday: Breads, Mediterranean salad, Chickpea salad, Sushi, Chipotle chicken breast, Moroccan lamb, Fresh fruit platter, Beverages
Tuesday: Breads, Ceasar salad, Purple cabbage slaw, Southern fried chicken, Teriyaki meatballs, Fresh fruit platter, Beverages

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Conference Dinner - Alternating Plate Set Menu

Entrée

Almond Milk Chicken: Poached chicken breast, snow peas, baby cos, watercress, sprouts, lime, basil (GF, DF)
Arancini Trio: Mushroom & bocconcini, Thyme & picante provolone, Pumpkin & shaved almond crust (V)

Main

Crisp Skin Snapper Filet: Pomme du puree, green peas & saffron butter sauce (GF)
Roast Rack of Lamb: Mustard crust lamb, minted pea mash, bacon lardons, braised baby onions, pan jus

Dessert

Chocolate Marquise: Raspberry coulis, dark chocolate shavings, caramel cream
Boysenberry crumble: Poached apple and berries, vanilla cream, brady wafer

Drinks: Beer, cider, wine, sparkling wine & non-alcoholic

Paper Abstracts

K1 - Chris Scrafton - Technical Director - Planning at Beca

Chris is a Principal Planner with more than 15 years town planning experience both within the UK and New Zealand. He has worked for central government, local government and private sector clients in both policy and consenting. He is an accredited hearings commissioner.

Chris has prepared and reviewed a number of structure plans and developed plan changes and other methods of implementation to give effect to the structure plan vision both in the UK and in New Zealand. He has undertaken several district plan review processes, including the management, development and implementation of the research and analysis basis to support plan changes for contentious topics. He has experience in preparing Section 32 analysis summary reports providing detailed analysis of the decision making process that underpins a Plan Change or Plan review process.

Chris also has a broad range of resource consenting experience from both an applicant and processing perspective. He has worked for private sector applicants applying for subdivision, landuse and regional consents and have worked for district councils and Council Controlled Organisations applying for (amongst other things) regional consents for global wastewater and stormwater discharges and for municipal water takes.

K2 - Richard Hunt (GIB Winstone Wallboards) - Close Living Quarters - Challenges & Choices

With an increasing trend towards multi-unit homes the quarter acres dream is fast becoming a distance reality. When we examine the stats the trends are clear. We are faced with changing market requirements, driven by customer demands for new types of living environments coupled with larger issues at force such as increasing land prices, infrastructure challenges, population growth resulting in higher density living in the major urban centres, and housing affordability.

With numerous construction options to consider, along with increase technical demand to meet multi performance requirements the market needs better information and systems to support this growing segment.

Winstone Wallboards is New Zealand's only manufacturer and largest marketer of gypsum plasterboard, drywall systems, associated products and services. The company has been operating since 1927 and manufactures plasterboard systems under the GIB® brand. Winstone Wallboards has facilities in Auckland, Wellington and Christchurch, and is part of the Building Products Division of Fletcher Building - a New Zealand-based international company.

P1 - J. Cawley - A review of the provisions of the Auckland Unitary Plan – Operative in part for the control of noise from activities in business zones and the protection of amenity and sleep protection.

The Auckland Unitary Plan – Operative in part establishes noise limits for activities in business zones and also prescribes internal noise criteria for spaces within the business zones occupied by activities sensitive to noise. The façade attenuation required to achieve the internal criteria based on the permitted external noise levels, particularly for the control of low frequency noise in bedrooms, places constraints on the selection of building materials. This paper considers the issues associated with providing for the development of accommodation for activities sensitive to noise, within and on the peripheries of the business zones, against the operational needs of activities generating high levels of noise, principally amplified music with a significant bass beat. Examples of the constraints on building materials that can be used to achieve the required attenuation are presented; the needs and responsibilities of receivers and generators of noise are considered; and options for the management of future development that could improve the balance between providing, in particular, for sleep protection and enabling a vibrant city night-life are offered.

P2 - R. Finley - Drafting cost-effective and appropriate noise legislation for living environments in urban areas

The cost-effective control of urban noise intrusion into apartments requires a holistic understanding of the environment that produces the noise, the manner in which noise breaks though the various parts of the building envelope and the way in which humans perceive noise to be intrusive. Setting any form of urban noise criteria without due regard to these three aspects can leads to some or all of the problems of overly costly designs, post construction compliance issues or unsatisfactory amenity levels. The particular focus of this paper is noise received at inner city residencies from road traffic, neighbouring properties and entertainment sources. Four typical methods from NZ and overseas for setting external and internal noise criteria in an urban setting are investigated and the following are identified:

1. Advantages and disadvantages are identified for the four approaches and recommendations are made on how these approaches could provide more cost-effective outcomes.
2. The practical limitations of façade systems found in the New Zealand construction industry are reviewed with guidance on realistic insulation ratings that can be achieved on site offered.
3. The cost differences in various glazing systems are reviewed with $ /m2 presented for a range of systems.
4. Steps to follow for those involved in drafting noise legislation to ensure better outcomes are suggested.

P3 - J. Trevathan, W. Reeve - How acoustics can influence the construction of a new city: A Christchurch case study

The devastation to built infrastructure in the centre of Christchurch resulting from the 2010 / 2011 earthquake sequence has been widely publicised. In a paper entitled Entertainment Noise Rules in a Vibrant City presented at the 22nd Biennial Conference of the Acoustic Society of New Zealand in 2014, Camp discussed the challenges and opportunities that this presented with respect to noise and the hospitality industry. Another four years on, the construction and establishment of new hospitality, commercial, civic and accommodation facilities within the central city is now well progressed.

This paper discusses how acoustics have influenced reconstruction activity, and examines whether a better outcome has been achieved compared to the situation which existed before the earthquakes. Founded in the 1850's, the central city had been shaped by ad hoc development, the state of scientific knowledge, availability of materials, practical limitations in construction and various financial and societal factors. Starting again with close to a 'blank slate', the rebuild was well placed to benefit from modern approaches to land use planning, noise management, acoustic design and building design.
However, the process has revealed a number of issues, including the tension between land use planning ideals and commercial reality, and new challenges presented by modern building techniques. The situation has also provided a unique insight into the role of user expectations and the importance society actually places on good acoustic outcomes when faced with other constraints. This paper also considers how these experiences may allow the acoustics community to better communicate the benefits of high quality acoustic outcomes, when competing with other more readily relatable considerations such as cost, safety, aesthetics and buildability.

P4 - M. Dunn, T. Phillips - G6 interpretation – Facilitating a consistent approach

As part of their wider medium-density housing (MDH) research program, BRANZ undertook a research project to better understand what can be done to help the NZ building industry address noise issues in multi-unit dwellings. A summary of the research was published in Volume 31 of the ASNZ Journal.
One of the issues that was raised in industry consultations as part of the BRANZ research was the inconsistencies in the way in which the NZ Building Code Clause G6 requirements are handled across the country. This brief paper highlights the concerns raised and discusses ways in which the Acoustical Society of New Zealand may be able to play a role in promoting a consistent approach. It is intended that the paper provide an introduction the issue and facilitate discussion amongst ASNZ members. The discussion will focus on G6 compliance and interpretation but could include a preliminary discussion on the development of best practice guidelines.

P5 - Y. Yanamandra, B. Parr, M. Kainuku, M. Legg - Microphone array 3D acoustic imaging

Microphone phased arrays, commonly known as acoustic cameras, are used by industries such as the aeronautical, automobile and construction industries to measure the magnitude and location of noise sources. These acoustic images are commonly obtained using beamforming and deconvolution algorithms. Traditionally, these acoustic images use 2D imaging planes. However, this can lead to errors in the nearfield for 3D objects due to incorrect beamform focusing. This paper outlines the development of a 3D scanning microphone array that automatically corrects for 3D objects and provides the correct acoustic imaging focus. New techniques for processing these 3D images are also described.

P6 - R. McKay, M. Kingan - Multi-rotor unmanned aerial system noise: Quantifying the motor's contribution

Unmanned Aerial Systems (UASs, also known as UAVs or colloquially as drones) are a rapidly developing technology with an increasing number of everyday applications. One of the concerns with the proliferation of UAS is their noise pollution. The two main noise sources of an UAS are the motors and propellers. It is often assumed in literature that the propellers are the dominant noise source; however, the contribution from the motor has not been conclusively demonstrated. This presentation will discuss a test rig that enclosed a motor and enabled a propeller's noise to be measured with minimal contribution from the motor. Acoustic measurements of an enclosed and unenclosed motor performed in the University of Auckland's anechoic chamber will be presented. The noise emitted from the enclosure has been quantified using laser Doppler vibrometry and the boundary element method which will also be presented. The test rig has shown that propeller noise is typically the dominant noise source. However, if a motor is operated at high torques, then the motor noise can have a significant contribution to the UAS's overall noise. This tends to occur when the motor is underpowered for a particular propeller; hence, the noise from an UAS can be minimised with careful motor selection.

P7 - M. Kingan, R. McKay - Noise from shrouded UAV propellers

This paper describes a preliminary investigation into the acoustic effect of a UAV propeller shroud. A method for projecting near-field acoustic data, measured using a traversing probe microphone, to the far-field is presented. Far-field measurements of a shrouded and unshrouded propeller are also presented. The instantaneous pressure on the inner surface of the shroud was also measured using a probe microphone technique.

P8 - V. Sorokin - On wave propagation in quasi-periodic structures

Analysis of wave propagation in periodic structures is a popular research topic. Such structures are used for vibration mitigation purposes, e.g. to secure certain parts of technological devices or constructions from vibrations. Frequency pass and stop bands, wave speeds, attenuation levels, etc., are dynamic properties that govern responses of these structures to time-dependent excitations. For vibration isolation purposes, frequency stop bands (or bandgaps) are of particular importance since these are frequency ranges in which traveling waves attenuate in the structures. Tailoring these dynamic properties allows mitigating sound and vibration in pre-defined frequency ranges.
The question is, what are the characteristics of the dynamic behavior of structures that are not periodic, but quasi-periodic, i.e. involve combined variations of parameters with incommensurate spatial periods? Application of the conventional analytical methods, including those based on Floquet theory, to study dynamics of such structures is impossible or cumbersome. In the present paper, the method of varying amplitudes is adapted and used for the analysis of wave propagation in quasi-periodic structures. Applying the method, widths and locations of frequency bandgaps featured by a model quasi-periodic waveguide are determined. It is demonstrated that introducing additional spatial modulations to a pure periodic structure can enhance its dynamic properties. Specifically, a relatively low frequency bandgap can be induced.

P9 - B. Lawrence - dBWav: A software tool for analysing and viewing long-duration hydrophone measurements

Ambient underwater noise surveys typically involve deploying one or more hydrophones to measure underwater noise levels over periods ranging from several days to multiple weeks. The audio data obtained can often be several terabytes in size, particularly if the measurements contain high-frequency content. A common challenge is analysing and viewing this data quickly and efficiently. To address this issue, a software tool called dBWav has been developed which pre-processes the raw audio and stores the key information in a much smaller data file, which can then be displayed and analysed in a simple interface. This software is intended to be a screening tool, allowing the user to locate periods/events of interest and export the necessary information in full resolution for reporting or further processing with other software tools.

P10 - M. Davoigniot, A. Hall, H. C. Chang, D. Hay, G. Dodd - Multimaterial reed printing

Can cane reeds for single reed musical instruments be replaced by additively manufactured (3D printed) "plastic" reeds?

This project was initiated in the Acoustic Research Centre by members of the centre who are saxophone and clarinet players. Their interest was to see if the traditional cane reeds could be replaced by ones produced by 3D printing using the current level of technology of desk-top 3D printers.
The aim is to provide "plastic" reeds which have the same subjective acceptability (both for players and listener) as cane-based reeds and which can be consistently and reliably reproduced. This offers the following potential advantages -

1. Reeds which are guaranteed to work (30% of a box of cane reeds are typically unusable)
2. Less expensive reeds
3. Reeds which have a longer lifespan
4. Reeds which are more or less instantly available via a personal/home-based printer

5. Reeds which can be finely "tuned" to a particular player's needs
6. Reeds going beyond the creative capabilities of traditional cane

This presentation will describe the work so far which includes an investigation of the mechanical properties of cane reeds and why reeds deteriorate with playing time, how the different properties of reeds correlate with the playing quality of the reeds (by subjective comparisons) and the challenges of replicating these properties in a PRUSA i3 Mk 2 printer (a popular hobbyist's printer) using a multi-material print head.

P11 - T. Hulland, A. Su, M. Kingan - Noise in an inpatient hospital ward in New Zealand

This paper describes an investigation into the noise levels which patients are exposed to on a general inpatient hospital ward in New Zealand. Three noise surveys were undertaken between 4:30 am and 7:00 am on a typical weekday using a microphone placed inside a shared bedroom. During the noise survey an observer located discreetly outside the bedroom identified the noise sources and locations of these sources for each significant noise event. A significant noise event was defined as one where the measured LAf,max exceeded 45 dB, which was taken to be the level at which sleep would be disturbed. Noise sources were then categorised into three main groups based on the character of the source (machines, staff or patient) and then more detailed sub-groups. Noise events were also classified by whether the noise source could be either eliminated or mitigated by a reasonable change e.g. moving the noise source to a different location. Staff noise was found to account for 64% of the total significant noise events which occurred during the observation compared with 28% of patients and 16% from machines. It was found that 94% of staff noise could be mitigated compared with 33% of machine noise. Patient noise was assumed as unable to be mitigated and varied greatly between observations. Numerical simulations using the acoustic diffusion equation were used to assess the likely reduction in the noise level which the patient was exposed to due to moving the noise source to a different location. These results were used to make recommendations to reduce the number and level of noise events which patients are exposed to.

P12 - G. van Hout, T. Halliker - The burning issue of acoustics in fire stations

In Christchurch, several Fire Stations were significantly damaged in the 2010 and 2011 Canterbury Earthquakes. An ambitious $50 million post-earthquake rebuild programme was announced in 2013, which provided a unique opportunity to build a future-proofed network of Fire Stations in Christchurch. In 2015 the New Zealand Fire Service (now Fire Emergency New Zealand, or FENZ) produced a guidance document outlining design considerations for new manned Fire Stations within New Zealand. The Ministry of Business Innovation and Employment (MBIE) complemented this guidance in 2016 with a document intended to assist the designers of Fire Stations with regard to the application of the New Zealand Building Code. Neither of these documents mention acoustics.

The authors were approached in 2016 by FENZ while they were commencing the design process for their new Christchurch facilities. They reported feedback they had received from staff, who were dissatisfied with the clarity of messages which are broadcast within Fire Stations, especially as they transit to deploy to an emergency call-out. These issues were evident within a number of existing and temporary Fire Stations in the Canterbury area, and FENZ were interested in measures that could be adopted to ensure that these issues were not repeated in any new facilities.

Following discussions with key stakeholders at FENZ, various acoustic design targets were established with the aim of improving the speech intelligibility of emergency messages from the Fire Communications Centre when received within Fire Stations. This included consideration of Reverberation Time, airborne and impact noise, external noise break-in and internal noise levels. Based on relevant national and international guidance, a target Speech Transmission Index (STI) of 0.6 was recommended to FENZ. During the design phases for each Fire Station, the authors undertook evaluation and assessment including computational modelling of the proposed fire station design (including speaker placement, type and coverage) to ensure that the speech intelligibility target would be achieved. The distributed loudspeaker system was commissioned following construction of the new Fire

Stations to correct any installation, noise level or hardware issues, and to confirm the STI 0.6 criteria was achieved. A number of the new Fire Stations have been operational now for several months. The feedback on the acoustic design received from occupants has been favourable, with a noticeable improvement in the comprehensibility of emergency messages announced via the distributed loudspeaker system compared to previous operating situations.

P13 - G. Dodd - Rating structure borne sound insulation of floors - and possibly walls - based on their Sound Reduction Index

At a previous ASNZ conference we reported on our investigations towards replacing standard tapping-machine testing of floor-ceiling structures by a combination of a measurement of the force spectrum applied by impact hammers and a simple airborne sound insulation measurement. In this presentation we will report on continuing work towards verifying the technique's applicability to all types of flooring structures and surface coverings, and introduce the idea of applying it to walls for quantifying their "impact" sound insulation. This raises the possibility of including in building codes a means of setting a minimum rating for the performance of inter-tenancy walls against the sounds initiated by doors, kitchen furnishings etc where they are supported by connecting walls.

P14 - G. Schmid, M. Kingan - Can we measure rainfall noise insulation on roofs without using rain?

A recently introduced part of ISO 10140 proposes a method for measuring rainfall noise insulation of roofing structures by a technique involving water tanks with holes to generate artificial rain dropping onto structures built in a standard reverberation chamber. This method has been used in the Acoustics Research Centre of the University of Auckland but has proved labour intensive and inconvenient to fit within a busy programme of other acoustical "dry" testing.
The experience has prompted a research programme investigating the possibility of replacing actual rain impacts for exciting roofs by a simple

airborne sound insulation test. The idea is to use knowledge of the impact force of different rain intensities and knowledge of a roofs point impedance to infer the impact sound that would be radiated by the roof. This approach was suggested by work half a century ago showing that the impact sound pressure levels radiated by floors excited by the standard tapping machine can be satisfactorily predicted if we know the airborne sound insulation of the floor and the impact force delivered by the tapping machine. So far the research has involved constructing a rig to measure the rainfall noise insulation according to the ISO Standard and then developing a system to measure the impact forces from raindrops/water droplets of relevant sizes. A surprise finding from our measurements using the rig specified in international standard (ISO 10140) suggests that it does not produce the results it claims. The reason for this difference is still under investigation. Our work towards measuring the impact forces of water droplets will be described in the presentation.

P15 - T. Beresford, J. Chen - The effects of acoustic flanking degradation on apartment floors with exposed cross laminated timber walls

Cross Laminated Timber (CLT) is a modern building material which is gaining increasing application in New Zealand and Australian apartment developments. It is used as a structural wall and/or floor element, with certain advantages over traditional concrete or steel structures, particularly relating to the speed with which it can be constructed on-site. The raw wood look of CLT is often considered attractive by designers, and it may be desired to leave it exposed as the finished wall, floor or ceiling material. Exposing the bare CLT on adjacent apartments, however, has the potential to degrade the sound and impact insulation of inter-tenancy walls or floors due to flanking transmission through semi-continuous or continuous CLT elements spanning between the apartments. Based on a series of onsite measurements within a CLT apartment building, this paper investigates the real-world flanking degradation of inter-tenancy floors which have varying degrees of exposed CLT on the walls above and below the floors. Airborne and impact sound insulation performance (FSTC, $D_{nT,w}$ + C_{tr}, FIIC and $L_{nT,w}$) of the floors has been determined and these results

compared to New Zealand and Australian Building Code criteria for apartment inter-tenancy floors. It was found that flanking via the exposed CLT produces only a small degradation in the floor airborne sound and impact performance.

P16 - W. Byrick, H. Myles - Laboratory data examining impact and airborne sound attenuation in cross-laminated timber panel construction

Cross laminated timber panels (CLT) are a relatively new method of constructing residential dwellings. The panels are composed of numerous layers of wood, each perpendicular to the adjacent layers. Wood is a renewable resource and producing the components of CLT panels consumes roughly half of the energy of concrete. 12-storey buildings are possible with cross-laminated timber. Given a general lack of data and in an effort to better understand how a CLT floor ceiling structure will perform in impact and airborne sound attenuation testing, we constructed a 175mm thick floor assembly in the laboratory and conducted numerous tests (STC-ASTM E90 and IIC-E492) with different floor toppings and with and without a ceiling assembly. Plywood installed over resilient underlayment of various thicknesses was tested in addition to finish floor installed directly over resilient underlayment. A resiliently mounted ceiling with insulation was also tested. The test data collected is compared to other labs including testing done by the National Research Council of Canada (NRC). As a result of the test program we can hope to design locally code compliant CLT assemblies, better understand lab variations with this type of structure and compare it to conventional concrete slabs of equivalent thickness.

P17 - M. Kingan, Y. Yang, B. Mace - Analysis of cross-laminated timber panels using a wave and finite element method

This paper describes an approach to the prediction of sound transmission and flanking transmission in structures. The focus is on complicated materials (laminates, CLT etc.) and constructions (joints

etc.), where it is necessary to capture the structural detail in order to make accurate predictions.
The method involves first finite element (FE) modelling of just a small part of the structure, followed by post-processing, which relies on the characteristics of wave propagation in the structure and/or in the air surrounding the structure. From this, the details of wave propagation can be determined. These results are then used to predict (airborne) sound transmission through a structure, or sound radiation produced by excitation on the structure. Numerical examples of sound transmission are presented, including laminates and CLT constructions.
For the prediction of flanking transmission, a detailed FE model of the joint or connection is assembled with the wave and finite element models of the structure (floors, walls etc.) connected at the joint. This enables the prediction of the transmission of waves, and hence vibrational energy, through the joint. Examples of the application of this method are presented.
The presentation includes numerical examples, together with a description of current and proposed work which centres on the prediction of noise transmission in cross-laminated timber (CLT) constructions.

P18 - A. Healey - Sound absorption comparison of suspended ceiling tiles

The sound absorption of several commonly available suspended ceiling tiles were measured to accurately compare their sound absorption properties. The suspended ceiling tiles were tested in a reverberation room in accordance with ISO 354-2003. The results were plotted to identify any differences between published data and tested data. The effect of the mounting conditions of the ceiling tiles in the test room is also addressed.
Inconsistencies have been found between acoustic test data of several brands of imported and local products supplied into the New Zealand interior fit-out market. These inconsistencies are of a concern as the test data is frequently used for calculating the reverberation time of many different internal spaces such as learning environments, open plan offices, commercial fit outs etc.

P19 - A. Hall, G. Dodd, G. Schmid, P. D'Souza, J. Wong - Helmholtz resonators as a tool for suppressing the mass-air-mass resonance in cavity walls

In this exploratory research project we report on initial encouraging results of using HRs to reduce the loss of insulation in lightweight cavity walls in the region of the mass-air-mass resonance. This resonance results from the two wall leaves enclosing an air spring on which they can resonate. Often the wall insulation in this critical low frequency band is significantly poorer than if it were only a single leaf wall. Many light weight propriety wall systems are designed so that this region is sited just outside the range assessed by the single figure values (STC and Rw) used to set building code requirements. Such walls, although meeting code requirements, can be subjectively undesirable when insulating against sounds from low frequency loudspeakers which are a ubiquitous feature of modern living.
So far the work has comprised using 3D printed HRs tuned to the M-A-M and coupled into an experimental cavity to demonstrate proof of principle, and then moved to investigating designs which would fit into typical wall studs so as to minimise any disruption of standard wall construction processes.

P20 - M. Poletti - An implementation of the Boundary Element Method for the calculation of acoustic scattering around objects of arbitrary shape

Virtual reality (VR) is a technology in which 360-degree video and surround sound are combined to create convincing illusions of "being there". The capture of the 3D characteristics of sound fields is most easily done using spherical microphone arrays, but many VR recording devices use complex shapes to accommodate the cameras, and the sound recording is therefore compromised.
Microphone arrays of arbitrary shape can be used to record surround sound if the sound pressure at all microphones positions can be calculated at all frequencies and for all directions of arriving sound. This can be done by modelling the diffraction around the array.
This paper introduces a Boundary Element approach to calculating diffraction around arbitrary shapes. The method is based on the

equivalent sound reproduction problem, where a sound field generated by a monopole or dipole array also generates an exterior field which can be interpreted as the scattered field produced by a sound-soft or sound-hard scatterer, respectively, of the same shape as the loudspeaker array. The use of sound sources modeled as resilient disks allows the sound-hard diffraction relevant to solid baffles to be solved in a relatively simple manner.
The method is described and simulations of sound scattering around a cube are presented.

P21 - D. Protheroe - 3D impulse response measurements in ordinary rooms

3D impulse response measurements have become common practice for evaluating the acoustical characteristics of large performance spaces, especially among researchers, and to a lesser extent, consultants. In concert halls, for example, the direction of sound reflections is a key component of the subjective sound. However, these measurements have advantages over the traditional omnidirectional approach in other types of spaces too, such as schools, lecture theatres, offices and recording studios. The resulting visualisations make it possible to relate the reverberant sound to the physical form of the room, and quickly diagnose any potential anomalies on site. This paper presents several examples of 3D impulse response measurements conducted in a variety of 'ordinary rooms' as part of consulting work, and how this technique provides significantly more useful information than traditional approaches.

P22 - M. Dunn, J. Sanz, S. King, D. Protheroe - Auralisation case study

Auralisation is the process of simulating the acoustic performance of real or virtual rooms in another environment. Modern spatial sound techniques along with high quality (VR) virtual reality visual models enable a very immersive and realistic environment to be created. This paper outlines the process undertaken to create an auralisation of a 900 seat multi-purpose venue. The auralisation process proved very successful in testing design concepts and communicating these to the client and project team.