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## 2004 Annual Conference of the Australian Acoustical Society

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# Rail System Noise and Vibration Control

AUTHOR:
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ABSTRACT:
Control of noise and vibration emitted by steel wheel and rail transportation systems has a long history of designs and techniques, some of which were dismal failures and some which worked very well. Many of the early efforts had a valid technical base for the design, however, there were also many based on intuition or ideas with great expectations, but which had no real technical basis. In the last four decades the technology and materials used for rail noise and vibration control, particularly for the control of groundborne vibration from rail systems, has developed and benefited from thoughtful technical analyses and application of simple engineering principles. These also were not always successful in all respects but provided for a continuing development of the technology with ever-improving success and performance. Included in this presentation are a review of the development of rail noise and vibration control systems, including the lightweight, undamped concrete floating slab track for reduction of groundborne noise and vibration, and of the development of structurally integrated sound barriers with absorption materials for control of airborne sound. The presentation includes anecdotes and discussion of some of the unexpected results from new design installations, an outline of design progress and application extensions, and review of the concepts and designs which are successful and currently in use by rail systems located in many different parts of the world.

# Wear-Type Rail Corrugation Prediction: Passage Time Delay Effects

AUTHORS:
P.A. Meehan, W.J.T. Daniel
PAGE 11-16

ABSTRACT:
The growth behaviour of the vibrational wear phenomenon known as rail corrugation is investigated using analytical and numerical models. A feedback model for wear-type rail corrugation that includes a wheel pass time delay is investigated with an aim to determine what effects the time between successive wheel passages has on the growth of the amplitude of corrugations. The feedback model is simplified to encapsulate the most critical interactions occurring between the wheel/rail structural dynamics, rolling contact mechanics and rail wear. A stability analysis on the system yields the growth of wear-type rail corrugations over multiple wheelset passages as a function of the passage time delay magnitude. Based on these results, numerical and analytical investigations are performed to identify conditions under which the passage time delay has a significant effect on the growth of corrugations.

# Testing the Dynamic Properties of Resilient Track Components at Frequencies Critical to Noise and Vibration Performance

AUTHORS:
S. Shimada, Dave Anderson
PAGE 17-22

ABSTRACT:
Resilient track components play an important role in operational railway vibration control. They are often used for controlling railway noise and vibration at frequencies from 5 Hz to 500 Hz.

In-track vibration control is largely determined by the dynamic stiffness and damping characteristics of resilient components. Elastomeric materials, which are used extensively in rail applications, are known to exhibit a variety of frequency-, amplitude- and preload-dependent stiffness properties.

Procurement requirements for resilient track components generally refer to laboratory-tested static stiffness and also to dynamic stiffness values at up to 20 Hz, but neglect component performance at higher frequencies. This paper reviews the potential impact of this limitation, and discusses options for future testing methodologies at higher frequencies. These include an impact test, and a combination of small-scale material testing with Finite Element Analysis.

The conclusions of the study are that:

- Current specifications, standards and testing methodologies fail to encompass dynamic performance at important frequencies above around 25 Hz.
- As a result, complying track fasteners could result in vibration performance variations of up to 10dB.
- An impact test method may provide a practical way to address this limitation. Further research is recommended to confirm and refine this method.

# Field Measurements of Slab Track Vibration to Demonstrate the Insertion Loss of Low Stiffness Rail Fasteners

AUTHOR:
Steven C. Barlow
PAGE 23-30

ABSTRACT:
Structural vibration from railways in the range 10Hz to 400Hz can cause considerable disturbance in adjacent structures. The primary method of reducing the transmission of vibration from rail traffic is by means of adding mass and/or reducing the dynamic stiffness of the track support. An example of reduced stiffness support is the Pandrol Vanguard system, which uses the principle of rubber in shear to support the running rail by the web and the underside of the railhead, rather than using rubber in compression under the rail foot. The Vanguard system has been installed on concrete slab track in a number of metro systems throughout the world and under varying local traffic conditions. In each case slab vibration has been monitored in broadly similar ways, data being obtained before and after installation of the low stiffness trackform. The degree of insertion loss is shown to be largely dependent on the degree of stiffness change between the original and replacement fastener. Methods of fastener installation, vibration measurements and data from several locations are shown and the results discussed.

# Road Traffic Noise: Losing the Fight?

AUTHOR:
A.L. Brown
PAGE 31-40

ABSTRACT:
In 1986, the OECD produced “Fighting Noise: Strengthening Noise Abatement Policies” [1] and, less than a decade later, “Fighting Noise in the 1990s” [2]. More recently, the Australian Academy of Sciences used a similar title [3] — all dealing with the management of environmental noise. These titles clearly signaled resolve to tackle the issues of environmental noise, including the focus of this paper, road traffic noise, and one would have hoped that, now a decade or two down the track, we could report good progress. But, even in Australia, where we have had environmental noise legislation for over 30 years; Environmental Protection Agencies or equivalent in each state; a highly competent skill and knowledge base with respect to road traffic noise; noise control as an integral component of new roadway design — we are losing the fight against road traffic noise. This paper demonstrates that we have a major problem in Australian cities of exposure to high levels of road traffic, and that this situation will continue into the future, if not deteriorate. The paper examines why this is so, and speculates that significant change at policy level will be required to address this problem. This will require recognising that engineering *noise control* approaches to road traffic noise have failed to reduce overall urban exposure and cannot be relied upon to do so in the future. New concepts such as *soundscapes*, where several professional areas work together to define and implement desirable acoustic environments, warrant experimentation.

# Future for Noise Control in Australia?

AUTHOR:
Marion A. Burgess

PAGE 41-44

ABSTRACT:
The Australian Acoustical Society is a professional society with membership from all aspects of acoustics including vibration. As part of its response to the needs of the membership, a listing of the top ten issues of concern was developed. One important concern was the future for acoustics in Australia in respect to all the aspects of noise control — and in particular for transportation and in buildings. This was investigated to identify the factors leading to this concern. One important finding was that changes in the approach of the government have led to a reduction in the technical skill base in government and semi government agencies and in independent research establishments. The current trend is to rely on the voluntary support from the professional community to provide technical support or to contract out focused studies. This is a reactive approach to development of government policy. This paper summarises the investigation thus far and comments on the future of noise control in Australia.

# Wind Turbine Generator Noise Prediction — Comparison of Computer Models

AUTHORS:
C.E. Tickell, J.T. Ellis, M. Bastasch

PAGE 45-50

ABSTRACT:
The development of wind turbine generators as alternative sources of energy supply is a growing fact both in Australia and worldwide. One of the many aspects of the environmental impact assessment process for new wind farms is the prediction of their noise impacts (immissions). As well as the assessment of objective sound levels for environmental noise, the other main activity in assessing their noise impact is the prediction of receiver sound levels caused by emissions of noise from the wind turbine generators (WTG's). There are a number of computer noise models available for the prediction of environmental noise, as well as some specifically designed for noise emissions from WTG's. This paper presents the results of modeling for a typical wind turbine generator using three different prediction models. There is a significant difference between the predicted results using a noise model designed for static industrial sources, compared to algorithms or models designed specifically for WTG's. The main difference appears to be the method in which elevated sources are computed. A significant contributor to WTG noise is aerodynamic noise from each blade tip. These blades can vary in height by as much as 80m per revolution and have an axis 60 to 80m above ground. Wind farm noise emissions also increase with wind speed (typically from 4 to 12m/s), as does associated background noise. This makes the monitoring of background sound levels over the range of operating wind conditions also important. Selection of accurate prediction models for WTG's will enable a better assessment of the noise impacts from wind farms to be made.

# Prediction Results and Validation of Long Range Noise Propagation from Blast Events

AUTHORS:
Rachel Foster, Peter Teague
PAGE 51-56

ABSTRACT:
The UNAPS Long Range Noise Prediction model, developed by the US military, has been selected to obtain sufficiently accurate predictions of the resultant peak overpressure levels of loud blast events at large distances from the blast site — within approximately 5dB up to 100km from the blast site. The outputs from the model have been compared against the extensive noise monitoring of blasting carried out in 2001 and 2002. The model has been modified to specifically suit an Australian site and its requirements. Additional noise monitoring has also been carried out in 2004 to collect the base data in order to add a commonly tested blast source type into the model.

# Converting Bureau of Meteorology Wind Speed Data to Local Wind Speeds at 1.5m Above Ground Level

AUTHORS:
Tracy Gowen, Peter Karantonis, Tony Rofail
PAGE 57-62

ABSTRACT:
Long-term (unattended) noise monitoring is best undertaken with an understanding of the environment and meteorological conditions during the period of noise monitoring. Weather, in particular rainfall or significant wind (> 5m/s or 18km/h) can cause extraneous results and measurement errors, therefore data acquired during such periods are best discarded from further analyses. For smaller noise assessments of a low-risk nature, noise monitoring with concurrent weather monitoring on site is often impractical and not feasible. In these cases, data measured at a height of 10m above ground level supplied from the Bureau of Meteorology (BOM) are often relied upon. This paper presents a calculation method for converting wind speed data acquired from BOM meteorological stations at 10m above ground level to equivalent wind speeds at 1.5m above ground level. This technique can be useful for small projects and noise assessments of potential low-risk noise impact.

# Bio-Duck Activity in the Perth Canyon. An Automatic Detection Algorithm

AUTHORS:
David Matthews, Rod Macleod, Robert D. McCauley

PAGE 63-66

ABSTRACT:
Recently analysed data from Curtin University has revealed a significant amount of “bio-duck” activity in the Perth Canyon during December 2002. The name “bio-duck” originates from sonar operators on board the old Oberon class submarines who thought that the sound resembled that of a duck. Surprisingly this is not the case for the Curtin data. The difference however may be due to onboard audio processing prior to the operators hearing the sound that was absent in the Curtin data. It should also be noted that for both data sets the origin of the sound is unknown.

For the recent data there exists two distinct types of call. One long period (T~3.1 sec) and one short period (T~1.6 sec) covering the frequency range 60 Hz < f < 1000 Hz. This could have major implications on the operations of some of the sonar on-board the Collins class submarines. Consequently an algorithm was written to automatically detect the presence of bio-duck. In order to eliminate the effect of amplitude variations between data files a signal-time ratio method was used for a third octave band centred around 125 Hz. The reliability of this algorithm was estimated by comparing it’s output with that of the manual analysis of 2240 data files (23 days). It was found to have a 93% success rate in detecting the bio-duck. This will allow quick analysis of large amounts of data to investigate annual variations and also give a method for automatic detection on board the submarines. The results will be discussed.

# An Approach to Adaptive Transient Detection

AUTHOR:
Dragana D. Carevic
PAGE 67-72

ABSTRACT:
This paper describes a detection method that adapts to unknown characteristics of the underlying transient signal, such as location, length, and time-frequency content. It applies a set of embedded detectors tuned to a number of signal partitions. The detectors are based on the general wavelet theory whereby two different techniques are examined, (1) the local Fourier transform (LFT) and (2) the discrete wavelet transform (DWT). The detection statistics are computed so as to enable prewhitening of unknown coloured noise and to allow for a constant false-alarm rate (CFAR) detection. An adapted segmentation of the signal is next obtained with a goal of finding the largest detection statistics within each segment of the partition. The detectors are tested using several underwater acoustic transient signals buried in ambient sea noise.

# On Waveform Selection in a Time Varying Sonar Environment

AUTHORS:
Ashley I. Larsson, Chris Gillard
PAGE 73-78

ABSTRACT:
The best waveform to use in different scenarios has always been an issue for the Navy. Waveform choice is often based on minimising the effects of reverberation or searching for a feature of the target such as Doppler. A recent paper on environmental acoustics [1] showed that in a time varying environment, the probability distribution of received signal energy changes with the type of waveform used. In this paper we consider a similar acoustic environment with time variation and look at the effect of different waveforms on the probability of detection in an ambient noise limited environment.

# Statistics and the Two Microphone Method for the Measurement of Sound Absorption Coefficient

AUTHORS:
Rick C. Morgans, Xun Li, Anthony C. Zander, Colin H. Hansen

PAGE 79-82

ABSTRACT:
When calculating the normal incidence absorption coefficient using the two microphone method (ASTM E 1050 – 98) a number of different approaches can be taken to estimate the statistical variation of different samples of the same material. The most obvious approach can sometimes produce results that violate physical principles, especially for highly absorbent or highly reflective materials. This paper describes a method to estimate the statistical reliability of the procedure, which is both simple and based on sound physical principles, giving the range of absorption coefficients that would be expected to be measured 95% of the time. It is suggested that this method is adopted for future two microphone measurements when the statistical uncertainty of the measurements is to be reported.

# Sound Absorption of Porous Material in Combination with Perforated Facings

AUTHORS:
Michael J. Kingan, John R. Pearse

PAGE 83-88

ABSTRACT:
The absorption characteristics of porous absorbers in combination with perforated facings was investigated. The effect of the hole size, hole pattern and open area ratio were examined. The absorption coefficients for an absorber of uniform cross-section were compared to those for an absorber with a tapered cross-section for various volumes of absorbent and different perforated facings.

# Small Chamber Reverberant Absorption Measurement

AUTHORS:
Emma J. Carlisle, Robert J. Hooker
PAGE 89-92

ABSTRACT:
The objective of the Small Chamber Reverberant Absorption Measurement Project was to investigate the feasibility of performing absorption measurements in a small specially built chamber. Absorption coefficients calculated from the small chamber measurements were compared to those taken in a full size reverberation room and an impedance tube. The SCRAM method was shown to give absorption coefficients close to those obtained from either the reverberation room testing or impedance tube tests over the frequency range of 200–4000Hz.

# Propagation of Vibration from Rail Tunnels: Comparison Results for Two Ground Types

AUTHOR:
Robert Bullen

PAGE 93-98

ABSTRACT:
Detailed measurements of vibration transmission from an underground rail line in Sydney and a line in a deep cutting in Perth have recently been conducted. The propagation characteristics of these two ground types are very different, and neither fits comfortably with standard theoretical models of vibration transmission through a uniform ground. In Sydney, the results can generally be modelled as a vibration source slightly larger than the tunnel floor, propagating into a uniform medium, but with an attenuation rate which is much higher than expected for sandstone or similar rock. The additional attenuation may well be due to scattering from inhomogeneities in the rock, and hence may differ significantly between locations. In Perth, the only successful model is of two-dimensional propagation in a medium with almost no attenuation at low frequencies. These results emphasise the importance of on-site measurements in predicting vibration and structure-borne noise levels from rail tunnels.

# Vibration Control Systems for Trackbeds and Buildings Using Coil Steel Springs

AUTHOR:
Hans-Georg Wagner

PAGE 99-104

ABSTRACT:
In congested cities the number of railway lines has rapidly increased. The close vicinity of rail tracks to buildings often gives rise to conflict in respect of the transmission of noise and vibration to people or sensitive equipment. Vibration attenuation can be safely achieved by well designed vibration control systems applied preferably to the source but also to the receiver. In both cases, the installation of an elastic interface effectively reduces the transmission of vibration. Here, the support of either the rail track or the building on coil steel springs has proved to be a highly-effective and reliable measure. The paper deals, at the beginning, with the description of some floating slab variants based on different steel spring elements. Then some examples of elastically supported buildings are shown. The paper refers to layout and design as well as to installation and construction features and considers the efficiency achievable by these measures.

# Effect of Rail Grinding on Rail Vibration & Groundborne Noise: Results from Controlled Measurements

AUTHOR:
Ben Lawrence

PAGE 105-110

ABSTRACT:
The Sydney Conservatorium of Music is located close to the City Circle underground rail line, and significant work has been done to reduce groundborne rail noise within the performance and rehearsal areas. This paper reports the results of measurements of groundborne noise within a number of spaces, conducted before and after a regular rail grinding treatment. Rail track vibration levels were also measured within the tunnel by Richard Heggie Associates and RailCorp, and these results are also reported. Rail grinding is found to have a significant impact on vibration and noise levels, for both curved and tangent track. The implications for the control of groundborne noise are discussed. In particular, to reduce the maximum expected noise level it will often be more cost-effective to improve the control of rail roughness rather than to incorporate direct mitigation measures in the form of track or building modifications.

# Isolation of Performance Halls from Ground Vibration

AUTHOR:
George Paul Wilson

PAGE 111-116

ABSTRACT:
One of the inherent characteristics of transportation systems, especially steel wheel and rail systems, is that vehicles running on the roadway or trackway generate vibration which transmits through the ground into nearby buildings. As our urban areas build up or are redeveloped, it is frequently desired for a variety of reasons to place a concert hall or theater in a location which is in close proximity to or over a rail system or roadway. In such cases, the application of building isolation design, either to the performance hall within a building or to an entire building, can be used to allow placement in a location which would otherwise be unacceptable because of the noise, and possibly vibration, generated within the building due to the nearby transportation facility. Recently there have been several instances where the desired location in a central city area, or in proximity to other arts facilities, resulted in major concert halls being located near rail system subway tunnels. Structural design configurations were developed to accomplish noise and vibration isolation of the performance hall box within the building to eliminate the groundborne noise and vibration as a potential intrusion within the performance halls. In most cases the design criterion was that the noise from outside sources should not exceed the threshold of hearing. Design procedures, configurations and materials to successfully achieve this criterion are presented.

# Acoustic Characterization of an Engine Exhaust Source — A Review

AUTHOR:
M.L. Munjal

PAGE 117-122

ABSTRACT:
For an engine running at a constant speed (RPM), the exhaust process and intake process are periodic. This enables use of the frequency-domain analysis of the essentially linear exhaust system consisting of the exhaust runners, manifold, exhaust pipe, the muffler proper and the tail pipe. Over the last forty years, transfer matrices have been derived for use with aeroacoustic state variables as well as the classical state variables of acoustic pressure and acoustic volume/mass velocity. This frequency-domain analysis, however, requires prior knowledge of the load-independent source characteristics $p_s$ and $Z_s$, corresponding to the open-circuit voltage and internal impedance in an analogous electrical system (as per Thevenin theorem). Several methods have been suggested for prediction or measurement of the source characteristics over the years, but with little success.

Alternatively, time-domain analysis of the exhaust system, making use of the method of characteristics, does not require prior knowledge of the source characteristics. On the other hand, it can, and indeed has been harnessed to evaluate the source characteristics for use with linear frequency-domain analysis. Unfortunately, the source characteristics so obtained are not load-independent because of the inherent non-linearity and time dependence of the piston motion, exhaust valve/port opening and high blow-down pressure in the cylinder. Besides, the time-domain analysis of complex muffler elements is very cumbersome and error-prone. Therefore, hybrid approach has been mooted where the time-domain analysis of the exhaust source is combined with the frequency-domain analysis of the exhaust muffler making use of the discrete Fourier transform pair. Here again, there are several difficulties and challenges.

This paper reviews all these developments and presents the state of the art for estimating unmuffled exhaust noise and insertion loss of commercial mufflers.

# Computational Fluid Dynamics Analysis of the Acoustic Performance of Various Simple Expansion Chamber Mufflers

AUTHORS:
J.M. Middelberg, T.J. Barber, S.S. Leong, K.P. Byrne, E. Leonardi
PAGE 123-128

ABSTRACT:
Different configurations of simple expansion chamber mufflers, including extended inlet/outlet pipes and baffles, have been modelled numerically using Computational Fluid Dynamics (CFD) in order to determine their acoustic response. The CFD results are compared with published experimental results. The CFD model consists of an axisymmetric grid with a single period sinusoid of suitable amplitude and duration imposed at the inlet boundary. The time history of the acoustic pressure and particle velocity is recorded at two points, one point in the inlet pipe and one point in the outlet pipe. These time histories are Fourier Transformed and the transmission loss of the muffler is calculated. Calculated results show excellent agreement with the published data. The mean flow performance has also been considered. The mean flow model of the muffler uses the same geometry, but has a finer mesh and has a suitable inlet velocity applied at the inlet boundary and the pressure drop across the muffler is found.

# Vibro-Acoustic Studies of Brake Squeal

AUTHORS:
Antti T. Papinniemi, Joseph C.S. Lai, Jiye Zhao
PAGE 129-134

ABSTRACT:
In recent years, brake squeal has become an increasing source of customer dissatisfaction and of warranty cost. During squeal, the brake system is operating in a resonant and unstable vibration mode. Research undertaken at UNSW@ADFA to predict brake squeal propensity will be summarised. Experimental modal testing of a sample brake system was firstly used to develop and validate a numerical model based on the finite element technique. The unstable modes were then predicted by applying complex eigenvalue analysis to the finite element model. The frequencies of these unstable modes compare favourably with recorded audio signals of brake squeal. Three methods for assessing which brake components need to be modified in order to reduce brake squeal propensity are described. They are: strain energy, feed-in energy and modal participation. A practical example is given to illustrate how all these methods can be used to predict and reduce brake squeal propensity.

# The Role of Modular Bridge Expansion Joint Vibration in Environmental Noise Emissions and Joint Fatigue Failure

AUTHORS:
Eric J. Ancich, S.C. Brown, Gordon J. Chirgwin
PAGE 135-140

ABSTRACT:
Modular bridge expansion joints (MBEJ's) are widely used throughout the world for the provision of controlled pavement continuity during seismic, thermal expansion, contraction and long-term creep and shrinkage movements of bridge superstructures. Modular Bridge Joint Systems (MBJS) are considered to be the most modern design of waterproof bridge expansion joint currently available. It was generally known that an environmental noise nuisance occurred as motor vehicle wheels passed over the joint but the mechanism for the generation of the noise nuisance has only recently been described [1].

Observation suggested that the noise generation mechanism involved possibly both parts of the bridge structure and the joint itself as it was unlikely that there was sufficient acoustic power in the simple tyre impact to explain the persistence of the noise in the surrounding environment. Engineering measurements were undertaken at Anzac and Georges River (Tom Ugly's ) Bridges and the analysis of these measurements indicated that an environmental noise nuisance resulted from modal vibration frequencies of the MBEJ coupling with acoustic resonances in the chamber cast into the bridge abutment below the MBEJ. This initial acoustic investigation was soon overtaken by observations of fatigue induced cracking in structural beams transverse to the direction of traffic. A literature search revealed little to describe the structural dynamics behaviour of MBEJ's but showed that there was an accepted belief amongst academic researchers dating from around 1973 that a significant part of the load history was dynamic. In spite of this knowledge it would appear that almost all designers use a static or quasi-static design with little consideration of the dynamic behaviour, either in the analysis or the detailing.

Principally, this paper identifies the role of vibration in the generation of environmental noise complaints and links this vibration to the now endemic occurrence of structural fatigue failures of MBEJ's throughout the world.

# The BCA 2004 — A Plan for the Future

AUTHOR:
Renzo Tonin
PAGE 141-150

ABSTRACT:
The Building Code of Australia 2004 (the "BCA 2004") came into effect on the 1$^{st}$ of May 2004. The new code was developed by the Australian Building Codes Board (the ABCB) in response to wide community complaints regarding the poor quality of noise control in new buildings, particularly multi-storey apartment buildings. Initial complaints received from new apartment owners about "noisy buildings" were variously attributed to poor construction and poor design. However, whilst this was true in a number of situations, it also became clear that the acoustic standards contained in the old code (the "BCA 1996") were simply not good enough even for low cost accommodation. The community expected the old code to protect them from poor quality buildings which regrettably it failed to do. There was also a misunderstanding in the community that the old code would provide good quality acoustics in the high end of the market. The changes in the BCA 2004 reflect an improvement in the minimum standards, however, to what extent these changes "fix the problem" is debatable. This paper examines how the BCA 2004 addresses the problem of poor quality noise control in buildings, recommends a methodology of implementation to ensure the intended end result is achieved and proposes a plan for future action where the code is found deficient or inconsistent.

# 2004 Changes to the BCA — Are They a Step Forward?

AUTHORS:
Robert J. Fitzell, Fergus R. Fricke
PAGE 151-158

ABSTRACT:
The regulatory requirements affecting the acoustical quality of multiple occupancy buildings in Australia will change from mid 2004. This represents the first significant change to the acoustical requirements of the Building Code of Australia in eight years and, in fact, is the first change to technical performance standards imposed by the BCA since its commencement. The BCA was originally compiled as a redraft of regulatory standards existing at the time, such as Ordinance 70 in NSW. The new requirements are, therefore, the first substantial upgrade to regulatory building acoustic standards in Australia in over 30 years. This paper reviews the new BCA requirements in the context of other international building regulations and building design standards. The relevance of spectrum adaptation terms included in airborne and impact performance requirements is examined, as are the implications of those terms to common building construction materials. The priorities implied by the Code are compared with those expressed by apartment owner-occupiers. This examination aims to highlight the difficulties in some aspects of the new code with the intent that this may assist planners and other building regulators in the preparation of Local Environmental Plans and Development Control Plans.

# The Tortuous Path for Upgrading Acoustic Regulations

AUTHOR:
Peter Knowland

PAGE 159-164

ABSTRACT:
The acoustic regulations prior to May 2004 contained within the Building Code of Australia trace back to Ordinance 70 of the NSW Government for the year 1969. Even when Ordinance 70 was promulgated, the acoustic performance standards were the lowest in the developed world. Providing appropriate acoustic standards in terms of sound insulation within dwellings in line with community expectations has been a long and difficult process. There are many stakeholders and lobby groups that may resist acoustic change due to the impact that it may have on their industry.

This paper looks at the process that has been involved and explains a number of key issues of the acoustic provisions of BCA2004.

# Recent Changes to the Sound Insulation Provisions of the Building Code of Australia

AUTHOR:
Matthew J. Patterson

PAGE 165-170

ABSTRACT:
This paper discusses the recent changes to the Building Code of Australia (BCA) sound insulation requirements. It outlines the main drivers for the changes and looks at the process used by the Australian Building Codes Board to develop the measures. It also outlines the extent of the changes and the different options for demonstrating compliance with the BCA.

# Modeling Bistatic Surface Scattering Strength Including a Forward Scattering Lobe with Shadowing Effects

AUTHOR:
Zhi Yong Zhang

PAGE 171-174

ABSTRACT:
Both the rough air-sea interface and entrapped air bubbles due to wave breaking scatter sound in all directions and contribute to so-called reverberation in active sonar. There are monostatic sonar systems where the source and receiver are at the same position, bistatic sonar systems where the source and receiver are separated, and multistatic sonar systems involving multiple sources and receivers at different positions. In monostatic situation, reverberation is mainly due to backscattering. In bistatic and multistatic situation, forward and out-of-plane scattering are significant contributors. The empirical Chapman-Harris formula is often used to predict surface backscattering strength in monostatic sonar. To better predict reverberation due to the sea surface in bistatic or multistatic sonar, a three-dimensional scattering formula that includes a forward scattering lobe will be desirable. Following the approach of earlier work, in this paper the separable form of backscattering models are extended by including an expression of forward scattering lobe obtained under the Kirchhoff approximation, taking into account shadowing effects. Comparison with another more sophisticated model shows that shadowing corrections are important at low grazing angles. The formula obtained here is simple and includes scattering effects from both the roughness of the sea surfaces and the sub-surface bubbles. It may be useful for modelling multistatic surface reverberations.

# Simulation of Scattering Effects of Marine Organisms on Active Sonar Returns

AUTHORS:
Sergey Simakov, Zhi Yong Zhang
PAGE 175-180

ABSTRACT:
Marine organisms with gas inclusions, such as fish with swim bladders and bubble-carrying plankton, can scatter sound strongly thus contributing to volume reverberation of an active sonar and possibly introducing distortion to its pulses. Numerical evaluation of scattering effects from these objects is often based on reduction of their shapes to simple geometries, such as spheres or cylinders. In this work we use a viscous compressible spherical shell model with a gas inclusion to obtain a parameterisation of the frequency dependence of the scattering cross section of individual scatterers in terms of their effective size and material properties. We consider the range of sonar frequencies and scatterer sizes for which the contribution of non-monopole spherical modes becomes significant. Graphical interfacing of access to model parameters is discussed and an assessment of the characteristics of the echo returns from an ensemble of scatterers in frequency and time domains is given.

# Identification of Seafloor Habitats in Coastal Shelf Waters Using a Multibeam Echosounder

AUTHORS:
I.M. Parnum, Paulus J.W. Siwabessy, Alexander N. Gavrilov

PAGE 181-186

ABSTRACT:
Modern, high-resolution multibeam sonar systems are capable of mapping acoustic backscattering strength coinciding with fine bathymetry, which improves substantially the capability of sonars to discriminate different types of seafloor habitats. As part of the Coastal Water Habitat Mapping project of the CRC for Coastal Zone, Estuary and Waterway Management, a set of bathymetry and acoustic backscattering data has been collected in different regions of the Australian coastal shelf in 2003–2004, using a state-of-the-art, 450-kHz RESON SeaBat 8125 multibeam echosounder. The surveyed sites included a sediment dominant area of Sydney harbour and regions of seagrass and sand found in the Recherche Archipelago. The analysis results show that the seafloor can be characterized by specific angular dependence of acoustic backscattering and statistical distribution of the backscattering energy, however, caution is needed when using these methods for habitat mapping. Preliminary conclusions are made in the paper with regard to the efficiency and adequacy of seafloor habitat mapping using high-resolution multibeam sonar systems.

# Seabed Habitat Mapping in Coastal Waters Using a Normal Incident Acoustic Technique

AUTHORS:
Paulus J.W. Siwabessy, Yao-Ting Tseng, Alexander N. Gavrilov
PAGE 187-192

ABSTRACT:
As part of the Coastal Water Habitat Mapping (CWHM) project of the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC), a set of bathymetry and acoustic backscattering data was collected in Cockburn Sound, Western Australia in March 2004 in order to develop acoustic methods for seabed classification. The acoustic recordings were made over seabed areas of different habitat types using a SIMRAD EQ60 echosounder operating at two frequencies of 38 and 200 kHz. A drop video camera was also used to provide groundtruthing for the acoustic results at selected stations. A RoxAnn-like technique was adopted for acoustic classification of the seabed habitat types. An analysis of the backscattered signals was also made to determine the backscatter characteristics which were more robust with respect to discrimination of seagrass on the seabed. Five different seabed habitats were derived from the RoxAnn-like technique, which agreed well with the video recordings. From the backscatter analysis, it was found that the effective pulse width of backscattered signals and the surface backscatter coefficient were the most suitable characteristics for distinguishing seagrass meadows from the other, seagrass-free bottom types.

# Test Subject Numbers and the Performance of Hearing Protectors

AUTHORS:
Warwick Williams, G. Colin-Thome

PAGE 193-196

ABSTRACT:
Current Australian requirements for the attenuation testing of hearing protectors call for a minimum of sixteen test subjects for ear muffs and twenty for earplugs. However, sometimes because of the nature of the device under test the variance of the test results can be quite large. In fact, at some frequencies the standard deviation of the test result can be larger than the mean attenuation. Since the parameter used for the calculation of the overall performance of a hearing protector is a direct function of the mean attenuation minus the standard deviation, ($\bar{a}$ – SD), a large standard deviation can have a significant negative impact on the final performance indicator. It can result in an apparent 'amplification' of the test sound. While the suppliers of hearing protectors wish to minimise test costs by using a minimum number of test subjects, it may be of benefit to increase the number of test subjects in order to determine the "true" attenuation performance.

# Impulse Noise Attenuation: Hearing Protection and Communication in a Military Environment

AUTHORS:
Andrew Barrett, Warwick Williams

PAGE 197-202

ABSTRACT:
Military training creates unique noise hazards including high impulse noise content. The need for hearing protection needs to be considered alongside the need for effective voice communication. This requires a hearing protector with high impulse protection that minimally impedes low intensity voice communication. These level dependant devices are called non-linear hearing protectors. A range of commercial plugs both linear and non-linear and one home made non-linear plug (a modified commercial plug) were tested to determine the suitability of each against the criteria stated above. Two commercial plugs were identified as possibly suitable and interestingly the home made plug performed comparably to these plugs. This study provides direction for future research to determine the best hearing protector for military situations taking into consideration level of protection, need for communication, operational suitability and cost.

# Communications in Very High Noise Environments

AUTHORS:
Paul Ebbeck, Carl Holden, Warwick Williams

PAGE 203-206

ABSTRACT:
Sometimes while working in a very high, continuous noise environment regular voice communication may be necessary. One example of such an environment is the run-up area used to test recently serviced, jet aircraft engines before the aircraft is returned to active service. It is typical for the continuous noise in the immediate work area surrounding the aircraft to exceed an A-weighted, continuous sound pressure level, $L_{Aeq}$, of around 132 dB. Voice communication is unrealistic if not impossible and normal radio communication is limited and difficult. This project addressed this issue with successful results.

# Application of Signal Detection Theory to Alarm Audibility in a Locomotive Cabin Environment

AUTHORS:
Michael Caley, Peter Georgiou
PAGE 207-212

ABSTRACT:
The diversity of design criteria for the audibility of safety-critical alarms is illustrated through a review of design standards across a range of industry applications. Several of these design criteria have been tested on sound pressure level samples of audible alarms in locomotive cabins in a recent study commissioned by Queensland Rail. Noise sampling was conducted under a wide range of locomotive operating conditions and for a wide range of alarm types. All-pass frequency and single-band types of design criteria were in some situations found to give unreliable predictions of audibility. The Queensland Rail study suggested that all-pass type criteria have the potential to lead to excessively loud alarm designs. An alternative audibility index based on the band-width adjusted root-sum-of-squared band signal/noise ratios has been found to give consistent predictions of audibility. This Detectability Index, $d'$, offers a metric that can be readily calibrated through field testing. The index is able to achieve a consistent approach to audibility across diverse background noise conditions without leading to excessive alarm levels that may compromise function by inducing startle reactions or by generating unnecessary annoyance.

# Global Monitoring of the Earth, Ocean and Atmosphere for the CTBT

AUTHOR:
Martin W. Lawrence
PAGE 213-220

ABSTRACT:
The Comprehensive Nuclear-Test-Ban Treaty (CTBT) provides for monitoring of the whole globe by a network of stations, using various technologies, in order to verify the absence of nuclear explosion tests. For this purpose, vibrational energy is monitored in earth, ocean and atmosphere, with nearly uniform global coverage. Of the 321 stations that comprise the full network of the CTBT, 241 stations monitor vibrations. The sensors used are seismometers (in the ground), hydrophones (in the water) and microbarometers (in the atmosphere) detecting seismic, hydroacoustic and infrasound energy respectively. This International Monitoring System (IMS) has been under construction since 1997 and currently is over 50% complete. This first ever fully global vibration monitoring system includes stations in very remote locations (such as Robinson Crusoe Island and the South Pole). Waveform data from these stations are transmitted continuously in real-time to the CTBT's International Data Centre in Vienna, Austria. There the data are analyzed to detect and locate impulsive events occurring anywhere in the world at any time. These events have many different causes in addition to nuclear explosions, such as earthquakes, volcanoes, meteors, whale vocalizations, mining explosions. The impulsive events detected by this global observatory are analyzed to ensure that a clandestine nuclear explosion does not go undetected.

# An Acoustician's Guide to Railway Terminology and Common Pitfalls with Acoustic Terminology When Applied to Rail

AUTHOR:
Dave Anderson
PAGE 221-226

ABSTRACT:
This paper provides an explanation of key railway terms that may not be familiar to acoustic engineers and also suggests some standardisation of acoustic terms used in rail noise and vibration projects. It highlights some aspects of railway noise and vibration that are challenging, either because of the constraints imposed by the rail environment or because of the complexity of the issues involved. The aim of the paper is to prompt debate on these issues rather than to provide definitive answers.

# A Closed Form Analytical Solution for a Simplified Wear-Type Rail Corrugation Model

AUTHORS:
N. Song, P.A. Meehan
PAGE 227-232

ABSTRACT:
Wear-type rail corrugation, a longitudinal surface profile irregularity, is predicted as a closed form analytical solution for wear variations about constant nominal wear. This prediction is based on a two-mode model and a wear-type rail corrugation growth analysis of [7]. The wear profile is comprised of a superposition of wear variation for each vibration mode of interest. The solution can be presented either as a first order approximation with reasonably good accuracy, or as a full series expression. The solution is tested and compared with numerical simulations under various parameter conditions. Good agreement between analytical and numerical results has been found. After the wear profile prediction is obtained, the growth rate is derived in the time and frequency domains. The effect of an initial impulse, representing a rail surface irregularity, on the growth rate measurements is investigated and found to be significant. The closed form analytical growth rate results are shown to agree with numerical simulations of the two-mode model and the simplified growth rate expression derived previously.

# Wheel Squeal Measurement, Management and Mitigation on the New South Wales Rail Network

AUTHOR:
Dave Anderson
PAGE 233-238

ABSTRACT:
This paper provides an update of RailCorp's recent progress with the measurement, management and mitigation of wheel squeal on the New South Wales rail network. Recent mitigation measures have focussed on the application of a friction modifier to the head of the rail. This has been very successful at some sites, but it is now clear that it is only partially effective at others. The paper discusses the results of wheel squeal noise monitoring during a number of recent tests and mitigation trials and explains the emerging focus on freight rolling stock for management of the issue in the future.

# Rail Wheel Squeal — Some Causes and a Case Study of Freight-Car Wheel Squeal Reduction

AUTHORS:
C.E. Tickell, P. Downing, C.J. Jacobsen
PAGE 239-244

ABSTRACT:
Rail wheel squeal on curves in rail track is a source of potential noise annoyance to residents adjacent to rail lines. For one private rail freight operator, wheel squeal was causing repeated complaints from neighbours. Wheel squeal can be caused by the wheel-tyre to rail-top interaction and the wheel flange interaction with the gauge face of the rail (more like a screech). This paper describes some of the main causes of wheel squeal and the alternative approaches taken by various rail operators to reduce the generation of wheel squeal. The approaches taken by the operator in one study to successfully reduce wheel squeal are described. The source of wheel squeal in that case was identified as being related to the steering and suspension of the bogies on the rail car. Different bogies have different suspension systems and the methods to reduce wheel squeal may differ for bogie types. Rail vehicle maintenance regimes may also need to consider wheel squeal issues to reduce the potential for noise annoyance.

# Application of the NSW EPA Road Traffic Noise Criteria to Heavy Vehicle Traffic Associated with Rural Industry in Tasmania

AUTHOR:
C.P. Huybregts
PAGE 245-250

ABSTRACT:
As a trial, the Tasmanian Department of Infrastructure, Energy and Resources (DIER) chose to apply the New South Wales Environment Protection Agency (NSW EPA) traffic noise criteria to a proposed road upgrade associated with heavy vehicle traffic servicing a proposed timber processing plant in southern Tasmania. The NSW EPA policy is unique in that it (somewhat tentatively) provides criteria specifically for controlling noise impacts due to increased truck traffic associated with rural industry. The proposed works consisted mainly of an upgrade, together with a short new deviation in Ranelagh, one of the affected townships. The NSW criteria were found to be complex to apply. There are separate daytime and night-time criteria, and in each case, it must be established whether the absolute criteria (60 dB(A) $L_{Aeq,1hr}$ daytime or 55 dB(A) $L_{Aeq,1hr}$ night-time) or the "existing + 2" criteria are applicable. The absolute criteria applied to the busiest time of day and the "existing + 2" criteria applied during the quietest time of day, so traffic volume estimates were required for particular times of day. Nevertheless, use of the NSW criteria resulted in recommendations for noise mitigation measures that would provide useful noise reductions, namely the use of low-noise trucks and an extension of the 80km/hr speed zones near Judbury. In addition, the need for consideration of other potentially "reasonable and feasible" noise mitigation measures was indicated.

# Evaluation of Noise Amelioration Treatments Within and Outside the Road Reserve

AUTHORS:
L. Chen, P. Douglas, S. de Silva, Julie K. Peters

PAGE 251-256

ABSTRACT:
In urban environments road traffic volumes are increasing and the density of living is becoming higher. As a consequence the urban community is being exposed to increasing levels of road traffic noise. It is also evident that the noise reduction potential of within-the-road-reserve treatments such as noise barriers, mounding and pavement surfacing has been exhausted. This paper presents a strategy that involves the comparison of noise ameliorative treatments both within and outside the road reserve. The noise reduction resulting from the within-the-road-reserve component of treatments has been evaluated using a leading application of the CoRTN Model, developed by the UK Department of Transport 1988 [1], and the outside road reserve treatment has been evaluated in accordance with the Australian Standard 3671, Acoustics — Road traffic noise intrusion — Building sitting and construction [5]. The evaluation of noise treatments has been undertaken using a decision support tool (DST) currently being developed under the research program conducted at RMIT University and Department of Main Roads, Queensland. The case study has been based on data from a real project in Queensland, Australia. The research described here was carried out by the Australian Cooperative Research Centre for Construction Innovation [9], in collaboration with Department of Main Roads, Queensland, Department of Public Works, Queensland, Arup Pty. Ltd., Queensland University of technology and RMIT University.

# “Gardens on Lindfield” Retirement Community - Traffic Noise Impact Assessment — Case Study

AUTHOR:
Sasho Temelkoski

PAGE 257-262

ABSTRACT:
Gold Coast, the fastest growing city in Australia, is experiencing an unprecedented development boom. A major growth corridor is established along the recently completed Pacific Motorway (M1). Currently, M1 carries as much as 100,000 vehicles per day (Annual Average Daily Traffic – AADT). Within a planning horizon of 10 years (year 2014), the AADT is expected to be close to 180,000 vehicles. Major noise amelioration measures are becoming a necessity for establishment of noise sensitive developments along M1. Recently, a major earthmound along the M1 at Helensvale has been designed to protect the noise amenity of a newly established retirement community — “Gardens on Lindfield”. The recommended noise amelioration measures are presented. The earthmound was designed to bridge a gully along M1 that was a major conveyor of traffic noise. The results showed high efficiency in noise attenuation, ensuring compliance with the relevant road traffic noise criterion of 63dB(A) $L_{10(18Hour)}$ within a 10 year planning horizon.

# A Case Study on Cost/Benefit Assessment of Road Traffic Noise Amelioration Within and Outside the Road Reserve

AUTHORS:
P. Douglas, S. de Silva, L. Chen, Julie K. Peters

PAGE 263-268

ABSTRACT:
Whilst the road network is essential for the community's environmental, social and economic well being, there is a growing concern for the adverse effects of its operation and use, including the levels of exposure to road traffic noise. In addition it is evident that in urban centres where the problem is relatively critical, all treatment options within the road reserve have been exhausted. The consideration of possible treatment options currently is largely based on the experience and knowledge of the decision maker and not necessarily on the costs and benefits associated with each treatment option and its value to the community. A research program that aims to develop a framework for conducting a cost/benefit evaluation of the alternative road traffic noise amelioration treatments is currently underway. The project aims to foster methods for the management of road traffic noise by control at the noise source, along the transmission path and at the receiver (architectural treatment to the building envelope). The benefit of such a study would adequately equip a decision maker to mitigate the problem where it is most effective with the potential to defuse traditional "authority" boundaries and produce the optimum outcome. The research described here was carried out by the Australian Cooperative Research Centre for Construction Innovation [1], in collaboration with the Queensland Department of Main Roads, Queensland Department of Public Works, Arup Pty. Ltd., and QUT. This paper presents a case study based cost/benefit assessment, comparing the road traffic noise amelioration alternatives within and outside the road reserve using a real project in Queensland, Australia. The cost/benefit assessment of the alternative treatments has been based on the existing pre-treatment data, the size, number and type of affected residences as well as estimates of outside the road reserve treatment costs. The assessment has been undertaken using the decision support tool currently being developed under the research program conducted at RMIT University.

# Conveyor Noise Specification and Control

AUTHOR:
S.C. Brown

PAGE 269-276

ABSTRACT:
Large, outdoor Belt Conveyor Systems for bulk materials are major sources of industrial noise and frequently become an environmental emissions issue for many existing and proposed plants. Deficiencies in the industry's understanding of the complex, underlying conveyor noise generating mechanisms has meant there are relatively few practical and cost-effective noise management strategies. On the other hand, pressure from regulators and the community generally has frequently led to unachievable conveyor noise specifications. This paper presents the results of an innovative programme of research and testing of conveyors and conveyor components. Conveyor noise is shown to be a composite of noise generating mechanisms, the most dominant of which is the dynamic interaction at the belt/idler roll interface. The Idler Roll surface profile is shown to be a major input to excitation of vibration and noise radiation for most conveyors. An idler roll surface profile measurement parameter is proposed – the Maximum Instantaneous Slope, (MIS) – which can be used to evaluate and assess the operating condition and noise generation potential of existing equipment, as well as to provide a practical basis for specification of new conveyor systems.

# Control of Ore Transfer Station Noise at a Mining Site

AUTHORS:
Jingnan Guo, Jie Pan
PAGE 277-282

ABSTRACT:
A large ore transfer station at a mining site in Western Australia caused a noise problem to a large nearby area. The noise was mostly from the impact of the falling ore on the chute of the transfer station, which was random and low frequency in nature. A noise measurement conducted at a residence about 2.5km away from the transfer station indicated that noise level, though dependent upon the wind directions, was about 38 dB(A), which is above the environmental noise limit assigned to the area at night. The impact noise inside the station was as high as 100 dB(A), very likely to cause the noise exposure level of workers working in and around the station to exceed the occupational daily noise exposure limit of 85 dB(A). The impact of the falling ore on the chute was so strong that the vibrations of the chute, as well as of the whole structure of the station, were measured at very high levels. The reduction of low-frequency structure-borne noise from the vibration was one of the major priorities in the noise control project. A noise control system involving various technologies of noise absorption, wave trapping, noise barrier, vibration isolation and reduction has been successfully installed. The noise level on the top floor of the station has been significantly reduced by more than 10 dB(A). The vibration-borne noise has been dramatically decreased, as the vibration levels on the noise panels are now over 10 dB lower. The noise radiated to the environment from the station has been significantly attenuated. At the locations from 3 m to 48 m away from the station, the noise levels have been reduced by about 7 – 12 dB(A).

# Wave Trapping Barriers

AUTHORS:
Jie Pan, Ruisen Ming, Jingnan Guo
PAGE 283-288

ABSTRACT:
A noise barrier is an effective noise control device with many applications. However when installed in front of a noise source with a large reflective surface, its performance deteriorates. Multiple reflections of noise between the barrier and the source significantly reduce the insertion loss of the barrier. For instance, 15 dB insertion loss of a single noise barrier can be decreased to about 5 dB when multiple reflections occur. Absorptive treatment of the noise barrier can reduce the multiple reflections, but it is often not practical when used in an outdoor environment, especially for low-frequency noise. A wave-trapping barrier has been developed to solve the multiple-reflection problem. The surface of the wave trapping barrier facing the noise source is designed to effectively absorb low frequency noise and to control the direction of the multiple reflections. The internal surface of the barrier is made of perforated panel. When combined with the back cavity and absorptive lining in the cavity, the surface/cavity system behaves as a distributed Helmholtz absorber, which can be tuned to the frequency range of interest. The profile of the surface is designed such that the residue (reflected) noise is trapped between the barrier and noise source, so that the noise escape from the barrier top due to multiple reflections is minimized. This wave-trapping noise barrier has been designed and installed at a WA mining site. Its advantage over traditional noise barriers is demonstrated experimentally. A significant reduction of the noise from several large gear-boxes, especially for the low-frequency tonal components, is achieved.

# Great Whale Vocalisations Along the Western Australian Coast — Their Use in Biological Studies

AUTHORS:
Robert D. McCauley, C. Salgado Kent, Douglas H. Cato, C. Jenner, M.-N. Jenner, J.L. Bannister, C.L.K. Burton

PAGE 289-290

ABSTRACT:
The CMST had been conducting passive acoustic studies along the WA coast since 1996. We have recently developed a flexible, high storage capacity, low-power, low-noise logger designed for sea noise, which has greatly expanded our capability. Low frequency signals produced by great whales are a dominant component of ambient sea noise from all offshore locations. These signals may travel hundreds of km along the shelf edge or in deep water. In some instances, such as pygmy blue or humpback whales, calling may be so prodigious as to raise noise levels continuously over the calling bandwidth for months. Several studies have focused on key regions used by whales, such as the Perth Canyon for blue whales. In this location pygmy blue whales visit to feed on small krill over November to June with maximum whale numbers found in February-March. A multifaceted program has studied this phenomenon through oceanography, productivity, krill and whale biology. Passive acoustic studies run year round at this site have revealed a range of great whale species that use or transit the Canyon. We deploy grids of hydrophones in the Canyon in five km triangles to enable tracking of whales, although the analysis of this is complicated by clock drift of the independent loggers and relies on external synchronisation signals. Tracking grids allow us to determine travel movements, and so migratory routes, and to study local whale behaviour. Combining all data sets available along the coast and strategically locating other loggers will allow us to map the movement patterns of whales along large stretches of the WA coast and to estimate whale abundance and behavioural patterns, which for offshore species is currently poorly known. This presentation will focus on great whale acoustics and biology from the Perth Canyon and then consider passive acoustic information available along the WA coast.

# Development of Passive Acoustic Tracking Systems to Investigate Toothed Whale Interactions with Fishing Gear

AUTHORS:
Geoffrey R. McPherson, Chris Clague, Phillip Turner, Craig R. McPherson, Andrew Madry, Ian Bedwell, Douglas H. Cato

PAGE 291-296

ABSTRACT:
Depredation (=stealing) by toothed whale species of Coral Sea tuna longline catches threatens the viability of the fishery through direct removal of bait and hooked fish and behavioural modification of the target fish species. The false killer whales and short-finned pilot whales responsible for depredation on longline catches generate frequency modulated communication whistles, time constant broadband burst-pulses with a possible emotional context, and time variable broadband echolocation trains used in hunting. All vocalisations offer potential for passive acoustic tracking. A range of methods is being developed to mitigate depredation including acoustic, mechanical and chemical approaches. To assess the effectiveness of these methods, an integrated passive acoustic tracking system to determine movement trajectories of toothed whales relative to longline gear is under development for use in oceanic situations. A real-time tracking system for broadband clicks using a small aperture Mills Cross array to obtain an initial azimuth to source, is being integrated with a post-processing, wide aperture sonobuoy system for all vocalisations to obtain localisation in three dimensions. Data obtained from the small aperture array showed that comparable azimuth estimates were obtained for inshore toothed whales using both tracking systems. Trials over wide areas in oceanic conditions with larger arrays (1.5–1,000 m) to determine 3 dimensional trajectories, are yet to commence.

# Eavesdropping on Antarctic Pack Ice Seals — Appropriateness Acoustic and Visual Surveys?

Authors:
Tracey L. Rogers, Douglas H. Cato, Colin Southwell, M. Chambers, K. Anderson
Page 297-300

Abstract:
The pack ice seals, the crabeater, Weddell, leopard, and Ross, seals, are an important group of animals within the Antarctic ecosystem. As large bodied, top order predators, their population levels are thought to react to large-scale climate changes. Visual surveys are conducted from both ship-based and air-based survey platforms. However seals are available for survey only when hauled out on the ice. This study aimed to investigate whether information from acoustic surveys augmented the visual surveys by effectively including animals underwater during the survey period. Three acoustic surveys were conducted from the icebreaker, Aurora Australis, during October 1996 and 1997 and between December 1997 and January 1998. Visual surveys were conducted coincident with the acoustic surveys. Although there were numerous sighting of crabeater seals, no crabeater seal vocalisations were heard. Weddell seals were neither sighted nor heard in the pack ice but were recorded at the fast ice. Ross and leopard seals, although rarely sighted, were highly vociferous in December but not in October. The December surveys coincide with their breeding seasons. At this time only a few seals were identified hauled out on the ice. This study suggests that the best time to conduct bi-modal (both visual and acoustic) surveys for pack ice seals are in December where crabeater seals are observed in visual surveys and Ross and leopard seals in acoustic surveys.

# An Introduction to the Users Guide to the Building Code of Australia

AUTHOR:
Martti K. Warpenius

PAGE 301-306

ABSTRACT:
This paper introduces the Users Guide to the BCA. It presents a summary of the acoustical provisions of the May 2004 Building Code of Australia. The objectives are to provide guidance on the BCA compliance process, the acoustical design process and to provide guidance on detailing and other issues which need to be considered during the design and construction process. Examples and scenarios are presented to identify areas where acoustical standards have had to be raised to enable conflicting building occupancies to coexist. Inconsistencies and potential discrepancies in the May 2004 Building Code of Australia are also highlighted and discussed.

# Peak Noise Events Occurring in Road Traffic Noise

AUTHORS:
Stephen E. Samuels, Jeffrey Parnell
PAGE 307-312

ABSTRACT:
The $L_{eq}$ descriptor measured over various day and night periods is being favoured domestically and internationally for establishment of road traffic noise criteria. These criteria are generally based on annoyance levels for a proportion of the affected community. A number of studies have, however, concluded that the use of the $L_{eq}$ descriptor does not provide an adequate measure of sleep disturbance, therefore, road and traffic agencies are finding it increasingly important to assess the impacts of peak noise level events that may occur because of a proposed road or traffic facility. Quantification of $L_{max}$ events is far from simple because there is always just one $L_{max}$ event for each time interval measured and it is difficult to confirm that the cause of an identified $L_{max}$ result was a road traffic incident, rather than say a dog barking. The present paper deals with a study of the peak noise level events that were observed in road traffic in the NSW cities of Newcastle and Wollongong, particularly during the night time. Over all days of the study it was found that road traffic noise was the dominant noise source at selected noise sensitive sites for 55% of the time. For the remaining periods, sources other than road traffic represented the dominant influences on the noise climate at each of the sites. Aggregated over all sites in both cities it was concluded that the $L_{max}$ exceeded the $L_{eq}$ by 15 dB(A) or more for 35% of the time between 10 pm and 6 am as a direct result of road traffic.

# Development of an Individual Vehicle Noise Model

AUTHOR:
Frits Kamst

PAGE 313-318

ABSTRACT:
An individual vehicle noise model (IVNM) able to predict a time history of noise levels due to passing vehicles at locations alongside a road has been developed. Resultant vehicle noise levels for the various vehicle types are derived from the TNM model. The model has been developed to assist research into sleep disturbance due to road traffic noise. The output of the model allows one to investigate the noise parameters which are important with respect to sleep disturbance and determine whether these parameters are correlated with commonly used noise parameters such as Leq and L10.

# An Assessment of the Relationship Between the $L_{10(18hour)}$ Noise Level Parameter and Other Road Traffic Noise Level Parameters

AUTHOR:
Russell Brown

PAGE 319-322

ABSTRACT:
Historically, the extent of intrusion of road traffic noise at residential locations has been quantified by the $L_{10(18hour)}$ noise level parameter. Well-researched prediction algorithms exist for this parameter. In recent times, various regulatory authorities have attempted to set standards for acceptable levels of road traffic noise emission in terms of many other noise level parameters (eg. $L_{Aeq,1hr\ night}$). At present, there are few if any validated prediction algorithms for any of these other noise level variables. Rather, the most practical means of making accurate predictions is to condense all of the alternative parameters to equivalent $L_{10(18hour)}$ values and use the lowest $L_{10(18hour)}$ value to set the acceptance standard. This paper examines the results of continuous noise level monitoring at 35 sites with the objective of determining the typical relationships between the alternative parameters and the $L_{10(18hour)}$ parameter. The practitioner, when confronted with the requirement to make predictions of the extent of road traffic noise intrusion in terms of parameters other than $L_{10(18hour)}$, may then make use of these results to establish a first order assessment of the likely equivalent predicable $L_{10(18hour)}$ value which may be used instead of the non-predictable alternative variables.

# Sources of Uncertainty and Error in the Measurement and Prediction of Transportation Noise

AUTHOR:
James Heddle

PAGE 323-324

ABSTRACT:
This paper will present an overview of acoustic issues in the assessment and prediction of noise generated by road and rail traffic and aircraft. Significant recent progress has been made in the understanding of sound propagation from transportation sources, their sound generation characteristics and the limitations of current prediction models and measurement techniques. These recent findings point to ways to improve existing prediction algorithms, highlight areas of prediction difficulty and possible approaches to improve measurement accuracy and mitigation measures. Sound propagation modelling will be discussed in general together with specific discussion of road, rail and aircraft noise with case studies.

# The Colors of Urban Noise — A New Concept of Monitoring

AUTHORS:
Patrice Pischedda, Stephane Bloquet
PAGE 325-328

ABSTRACT:
The new European directive puts pressure on noise policies in cities. Measuring urban noise is not an easy task. The paper describes a new approach to the problem. It is based on a dense network of simple and independent measuring stations. Each station is connected to an area server via a Hertzian link. The area servers sort and transfer data to a processing system (database archiving, web sites, particular calculations…). The stations pre-process the signal and only relevant and pertinent information is transferred. For example, neural network based algorithms are implemented in the stations to automatically identify noise sources. The low price of the system (a small fraction of the current market price) makes possible a mesh density compatible with the complexity of sound propagation and problems to solve. An actual urban implementation is shown in real time. Applications and development options are discussed.

# Environmental Noise Update at an Aluminium Smelter

AUTHORS:
J.F. Rivory, P.J. Black, P. Johnson
PAGE 329-334

ABSTRACT:
A progressive noise mitigation programme has been implemented at Boyne Smelters Limited (BSL) over the last three years. Sixteen (16) new impellers were designed and retrofitted into the existing Gas Treatment Centre (GTC) fan casings. This retrofit was a challenge in its own right as the smelter is unable to be shut down and the retrofit had to occur with the plant running. Additionally, eight (8) new rectiformers, specified to be quieter than existing units, were purchased and installed to replace existing rectiformers on Reduction Lines 1 and 2 (L1 & L2). The latest works include the installation of trial noise mitigation schemes on the five (5) Reduction Line 3 (L3) rectiformers including a sound wall on one unit. The paper will outline the possible future paths that may be required to ensure that BSL continues to meet community expectations regarding noise emissions.

# Potential of Airblast Overpressure and Ground Vibration from Quarry Blasting to Increase the Frequency of Rockfalls on Mt. Coonowrin

AUTHOR:
Cedric Roberts
PAGE 335-340

ABSTRACT:
Mount Coonowrin located in the Sunshine Coast hinterland north of Brisbane, is one of a scattered group of peaks and hills that constitute the Glasshouse Mountains and which is protected within the Glasshouse Mountains National Park. Concern about visitor safety in relation to rockfalls on the mountain were supported by the results of two geotechnical studies and led to the closure of this section of the National Park. The rockfall problem has become the focus of renewed community concern since 1998, and some sections of the local community believe that blasting from a nearby quarry is causing an increase in the incidence of rockfalls. A joint study was carried out by the Environmental Protection Agency and the Department of Natural Resources, Mines and Energy to investigate whether the quarrying activities were having an impact on the stability of the mountain.

The report [1] describes the primary investigation which included the monitoring of a series of blasts at four locations on three days and modelling of the results to quantify the ground vibration and airblast overpressure currently occurring at the base of the mountain and at more remote locations. This paper describes the model (in terms of site laws) subsequently used to predict future ground vibration and airblast levels at the mountain as quarrying progressively approaches the National Park. The site laws will be used to optimise blast design, maximising blast efficiency while ensuring that vibration and airblast limits are not exceeded. An extensive literature search of Australian and overseas standards and guidelines has shed no light on 'acceptable' ground vibration and airblast overpressure criteria to avoid triggering rockfalls from potentially unstable natural rock faces.

# Brisbane Community Noise Survey 1998

AUTHORS:
Frank D. Henry, W.L. Huson
PAGE 341-346

ABSTRACT:
The following is the full-length version of a summary paper presented at ICBEN 2003, the $8^{th}$ International Congress on Noise as a Public Health Problem, in July 2003 [1]. Although the Brisbane Community Noise Survey was conducted in 1998, the details of the survey were not published until this time. This paper presents the background, methodology and results of the Survey and may assist others conducting community response to noise research. Huson and Associates were commissioned by Brisbane City Council to undertake a Community Noise Survey for Brisbane in 1998. The study was commissioned to address information gaps to assist Brisbane City Council develop a strategy to manage the impacts of environmental noise on the community. The survey was delivered under controlled conditions via telephone with 450 respondents being interviewed. The results of the survey indicate that the impact of community noise is a significant issue in Brisbane and is at the top of residents' pollution concerns in their local neighbourhood. Forty- seven percent (47%) of respondents indicated that they had been bothered or annoyed by noise in the 12 months preceding the survey. Road and air traffic were the dominant noise sources causing annoyance to respondents, while the greatest effect on lifestyle is sleep disturbance. Perhaps the most important effect of concern is that for those seriously annoyed by environmental noise, 9% of the responses describing its effect report that it results in aggressive behaviour. The majority of people reporting to be seriously affected by noise did not complain. The major reason for not complaining was that they considered there was nothing that could or would be done about the noise.

# About the Noise Guide for Local Government

AUTHORS:
Christopher K. Schulten, Geoff Mellor, Roger Treagus
PAGE 347-352

ABSTRACT:
We live in communities where noise levels tend to be increasing and which can affect both our working and home lives. Local government plays the leading role in managing noise impacts in the community. This paper presents a discussion on the Noise Guide for Local Government that has been developed by the Department of Environment and Conservation (DEC) to aid council officers in their day to day role of addressing residents' noise complaints by finding solutions to community noise problems, informing the community about quieter noise practices, explaining the noise laws and generally raising awareness. The Noise Guide has a multi-disciplinary approach and can be used proactively by strategic planners so that noise can be considered in future land use planning decisions as well as reactively to current problems. The Noise Guide represents a significant contribution to better management of neighbourhood noise.

# Acoustic Tracking of Humpback Whales: Measuring Interactions with the Acoustic Environment

AUTHORS:
Michael J. Noad, Douglas H. Cato, M. Dale Stokes
PAGE 353-358

ABSTRACT:
Although there is some knowledge of the characteristics of sounds produced by baleen whales, little is known about the function of these sounds or how these whales interact with their acoustic environment in general. The Humpback whale Acoustic Research Collaboration, or HARC, is a large project that is undertaking a rigorous study of the effects of ambient noise (including conspecific vocalisations) on the behaviour of humpback whales, in the presence and absence of anthropogenic sound sources, off the east coast of Australia. HARC includes participants from Scripps Institution of Oceanography, the Defence Science and Technology Organisation, the University of Queensland, and Woods Hole Oceanographic Institution. A suite of techniques is being used to examine the whales as they migrate through a study area that is being accurately characterised physically and acoustically. One technique involves the passive acoustic tracking of vocalizing whales and whales involved in energetic surface displays so that reactions to the sounds of conspecifics can be measured. This is beginning to reveal how whales react to acoustic signals from other whales, and that the response may vary depending on the reproductive status of the signaller and listener.

# Matched-Field Processing of Humpback Whale Song Off Eastern Australia

AUTHORS:
A.M. Thode, P. Gerstoft, M. Guerra, Michael J. Noad, M. Dale Stokes, Douglas H. Cato
PAGE 359-362

ABSTRACT:
Matched-field processing (MFP) is a technique for tracking an acoustic source in range and depth by comparing the output of an ocean acoustic propagation model with measured acoustic data collected across multiple hydrophones. In October 2003 a MFP experiment was conducted using humpback whale sounds recorded during the spring migration off the Sunshine Coast in Queensland, in conjunction with a larger experiment conducted by the Humpback Acoustic Research Collaboration (HARC). Humpback whale sounds with frequency content between 50 Hz to 1 kHz were recorded on a five-hydrophone vertical array deployed in 24 m deep water near Noosa, Queensland. The vertical array consisted of a set of flash-memory autonomous recorders attached to rope with an anchor at one end, and a subsurface float at the other. Acoustic data were simultaneously collected and monitored on five sonobuoys deployed over approximately 2 km range. The azimuth and range of the whale could be estimated via relative time-of-arrival measurements on the buoys. Using the range estimates as bounds on the matched-field processing, a inversion using the calls was performed on the vertical array data using a genetic algorithm. Inversion parameters included animal range, depth, and array geometry. Preliminary results of the inversion and resultant 3-D position fixes are presented.

# Acoustic Alarms to Reduce Marine Mammal Bycatch from Gillnets in Queensland Waters: Optimising the Alarm Type and Spacing

AUTHORS:
Geoffrey R. McPherson, Denis Ballam, Jason Stapley, Stirling Peverell, Douglas H. Cato, Neil Gribble, Chris Clague, Jon Lien

PAGE 363-368

ABSTRACT:
To reduce bycatch of marine mammals in Queensland commercial gillnet fisheries, acoustic alarms to warn mammals of the nets to which they are attached, were trialed. Alarms with fundamental frequencies of 2.9 and 10 kHz in 300 msec tone bursts at 130–140 dB re 1 $\mu$Pa at 1 m were deployed on commercial gillnets in northern Australian waters. Due care must be taken to ensure that the mammals should detect alarms with sufficient time to permit acknowledgement, avoidance, or cautious investigative action in order to prevent net entanglement. A model to relate environmental and propagation parameters with known or inferred animal acoustic abilities was used to assess performance of two acoustic alarms in different gillnet fishery environments. Fishery Observers and industry volunteer observations indicate mammal reactions to 2.9 and 10 kHz fundamental frequency alarms differ between species. Data were insufficient to suggest alarms reduced entanglement, however clear behavioural reactions were observed for dugongs and delphinid species to alarms under specific circumstances. Aggressive behaviour of delphinids toward the 10 kHz alarms were associated by industry with dolphin entanglements in nets within 1 m of 10 kHz alarms, with industry terminating the trials. Departmental ethical policy dictated that the experiment was terminated as a precautionary measure. The 10 kHz alarm tested may not be suited to commercial fisheries.

# Potential Effects of Noise from Human Activities on Marine Animals

AUTHORS:
Douglas H. Cato, Robert D. McCauley, Michael J. Noad
PAGE 369-374

ABSTRACT:
There is considerable interest in the effects of noise from human activities on marine animals but our knowledge is limited. This makes it difficult to demonstrate compliance with environmental protection requirements in the conduct of ocean activities. Consequently, a significant amount of research is being conducted in Australia and world wide. This paper discusses the areas of potential impact and what is known. Potential levels of impact include disturbance, masking of sounds of interest and hearing damage. Studies of behavioural reactions to noise exposure have demonstrated that disturbance does occur, but it is more difficult to determine the consequence of the disturbance. The potential for masking and hearing loss can be inferred from what is known about effects on humans and terrestrial animals and the limited data available for marine animals, but depends on the validity of modelling the differences in animal hearing mechanisms in air and water.

# Design and Implementation of Spatial Feedback Control on a Flexible Plate

AUTHORS:
Y.K. Lee, D. Halim, L. Chen, B. Cazzolato

PAGE 375-380

ABSTRACT:
This paper describes the design and experimental evaluation of an optimal feedback control strategy to suppress global broadband structural vibration of a flexible plate. The feedback controller was designed to minimize the spatial H2 norm of the transfer function from the disturbance signal to the structural response, at every point over the plate. This approach ensures the vibration contributed by all the in-bandwidth (0–500Hz) vibration modes is minimized, and hence is capable of minimizing vibration throughout the entire plate. The controller was implemented on a simply supported plate to show the effectiveness of the proposed controller in cancelling global structural vibration and noise radiation. The effectiveness of the spatial collocated feedback controller was then compared experimentally with that of a standard point-wise controller. Surface-bonded piezoceramic transducers were used as the disturbance generator, control source, and feedback sensor. Experimental results demonstrated that the spatial collocated feedback controller is able to reduce the energy transfer from the disturbance to the structural output across the structure.

# A Hybrid Control System for Distributed Active Vibration and Shock Absorbers

AUTHORS:
Lei Chen, Colin H. Hansen

PAGE 381-386

ABSTRACT:
The control methods used for shock or free vibration are usually different from those for forced vibration, because shock vibration can be regarded as a type of transient vibration that is different from steady-state forced vibration. In reality, however, both steady-state and transient excitations may occur in transport vehicles, thus there is a need to control both types of vibration. To show the integration of different vibration control strategies, a hybrid control system including a distributed resonant absorber and a distributed shock absorber is proposed. The hybrid system is governed by a control arbitrator that switches a set of sensors and actuators between the two active vibration absorbers according to various external excitation conditions. The effectiveness of the integrated system is shown through simulations and experiments.

# Fast Boundary Element Models for Far Field Pressure Prediction

AUTHORS:
Rick C. Morgans, Anthony C. Zander, Colin H. Hansen, David J. Murphy

PAGE 387-392

ABSTRACT:
The prediction of the pressure field at a distance from an arbitrary structure is often of interest in the acoustic design of products, or for the prediction of the sound field scattered by an incoming plane wave. Analytical techniques are restricted to structures that conform to separable coordinate systems and alternative approaches such as finite or boundary element methods are often used to overcome this limitation. This paper compares results obtained from the analytical solution of a vibrating cap mounted on the surface of a sphere with two alternative boundary element based techniques, a traditional direct boundary element method and a new source superposition technique. The accuracy of the far field pressure solution for both techniques is examined. It has been found that accurate solutions for beamwidth can be obtained when the mesh density is reduced below 6 elements per wavelength.

# The Application of Spectral Kurtosis to Bearing Diagnostics

AUTHORS:
Nader Sawalhi, Robert B. Randall

PAGE 393-398

ABSTRACT:
The choice of demodulation band for envelope analysis of faulty bearings is often made by spectrum comparison with a healthy bearing, to choose resonance frequencies where the largest change occurred as a result of the fault. It has recently been established that the so-called “spectral kurtosis” gives a very similar indication of the band to be demodulated without requiring historical data. The kurtosis is a statistical parameter based on the fourth moment of a signal, which is close to zero for gaussian noise and other stationary signals, but large for impulsive signals containing series of short transients, such as a bearing fault signal. The spectral kurtosis (SK) is obtained by calculating the kurtosis for each frequency line in a time-frequency diagram. It has also been found that the spectral kurtosis can be used to form a filter to select out that part of the signal that is most impulsive, considerably reducing the background noise and improving the diagnostic capability. The initial definition of the SK used the short time Fourier transform (STFT) for the time-frequency analysis, but this does give some artifacts and anomalies in the results, and the paper discusses the potential use of other time/frequency analyses such as Wigner-Ville and wavelets. The paper illustrates the use of the SK for bearing diagnostics, including a number of extensions and improvements in the basic technique and the choice of optimum analysis parameters. The results are illustrated using simulated and actual bearing fault signals.

# Bridgeclimb Sydney — Reducing Tonal Noise from Safety Latches

AUTHOR:
Conrad M. Weber
PAGE 399-404

ABSTRACT:
Each year, thousands of Sydneysiders and visitors climb Sydney's most prominent icon, the Sydney Harbour Bridge. To ensure a safe journey, each Climber is required to wear a safety harness, which attaches to a static line on the bridge. When the first Climbs commenced in October 1998, the latches, which form part of the safety harness, emitted a bell-like noise at every static line connection point. These tonal emissions were audible in a nearby residential area. Over a period of 4 years, various engineering noise control measures were implemented on the latches and static line connection points to significantly reduce the tonal characteristics and overall noise emissions. As a result, BridgeClimb is now able to offer Climbs during night-time periods without creating excessive noise. This paper describes some of the noise controls that have been implemented and the resulting noise reductions.

# Automotive Noise — The Indian Scene in 2004

AUTHOR:
M.L. Munjal

PAGE 405-414

ABSTRACT:
Automobiles and two wheelers have been manufactured in India since sixties, but the real thrust in the indigenous effort came in 1990 when the process of liberalization and reforms started earnestly. The story of the automotive noise control is similar. Research and development work in acoustics of ducts and mufflers has been going on at the Indian Institute of Science since late sixties. However, public consciousness of noise pollution in general, and automobile noise in particular, developed during the last decade. This came about primarily because of global competition. National Committee for Noise Pollution Control was set up in 1997 to advise the Central Pollution Control Board, executive wing of the Ministry of Environment and Forests. Advice of the committee has resulted in several gazette notifications limiting the pass-by noise of two wheelers, three wheelers, passenger cars, multi-utility vehicles, buses and trucks/lorries. Type testing and the conformance of production testing is carried out by the Automotive Research Association of India, among others. Research and development work is carried out at the Indian Institute of Science, several Indian Institutes of Technology, etc. Several of the major automobile manufactures have their in-house design and development departments. Department of Science and Technology of the Government of India has set up a Facility for Research in Technical Acoustics (FRITA) at I.I.Sc. in order to offer consultancy in noise control as well as on designing for quietness to industry, apart from carrying out post-graduate teaching and research. This keynote or plenary paper gives an overview of the current automotive noise scene in India.

# Interior Noise of a Korean High-Speed Train in Tunnels

AUTHORS:
Sunghoon Choi, Chan-Woo Lee, Jae-Chul Kim, Joon-Ho Cho
PAGE 415-420

ABSTRACT:
High-speed trains with the maximum speed of 300 km/h, named as Korea Train Express (KTX), have started revenue services since April 2004. Because of the geomorphologic conditions of Korea a large portion of the 'Kyung-Bu' line is comprised of tunnels or bridges, which may cause excessive noise in a vehicle. The vibration generated by the trains propagates into the tunnel and the vehicle structure and it can be radiated as noise inside the vehicle interior. This noise can usually be heard as low frequency structure-borne noise. Measurement of the noise and vibration inside the KTX vehicle confirmed that the noise comprises of frequencies below 250 Hz with a couple of broad peaks. In this study the analysis has been presented to reveal the cause of the excessive noise level and the correlation between the vehicle interior noise and the vibration of the tunnel structure.

# Development of a Line Based Rail Noise Pollution Reduction Programme

AUTHORS:
Andrew J. Wearne, Conrad M. Weber
PAGE 421-426

ABSTRACT:
RailCorp is currently implementing a programme of noise reduction initiatives in the Sydney metropolitan area, which involves some 38 specific projects. In order to develop the programme, Rail Access Corporation (RAC now RailCorp) initiated an extensive study, evaluating the noise emissions, mitigation options and the cost-benefit of these options. The study focused on five “priority” lines that had been qualitatively identified as having the highest noise impact. Computer noise modelling was undertaken over a total of 130 corridor km, including many thousands of buildings located within 100 m of the five lines. The modelled noise levels were used in conjunction with the number of sensitive receivers to determine a rating of the community noise burden along each line. Specific mitigation options were identified and the task of prioritising these options was undertaken on the basis of the potential reductions in Community Noise Burden and the overall cost-benefit. The final programme of actions was confirmed by RAC following consultation with the rail stakeholders and EPA (now DEC). This paper describes the development of the Noise Pollution Reduction Programme, the noise mitigation measures identified and the process of prioritising the measures to obtain a cost effective outcome.

# Using Insertion Gains to Evaluate Railway Vibration Isolation Systems

AUTHORS:
Kym A. Burgemeister, Richard J. Greer
PAGE 427-432

ABSTRACT:
The insertion gain describes, all other parameters remaining equal, the vibro-acoustic performance of a particular railway system measured relative to a reference trackform. The insertion gain of a track-system is dependent on the physical *dynamic* parameters of both the train and trackform (including the sub-base), and is therefore highly system dependent. Measured and predicted insertion gains of various railway isolation systems can be used to evaluate the expected reduction (or increase) in wayside groundborne noise and vibration that the isolation system will provide. However, accurately measuring actual insertion gains achieved on site is notoriously difficult, since it is generally impractical to separate the many system or location-dependent effects from the results. Using inappropriate insertion gains based on measurements of 'similar' systems can result in significant inaccuracies in the predicted vibration and groundborne noise levels. For the designer, this can result in unnecessary over- or under-design of the vibration mitigation requirements. Several methods of dynamic analysis are reviewed which allow the prediction of track system insertion gains. This allows more accurate prediction of overall groundborne noise and vibration and therefore better comparison of the benefits of various track isolation systems.

# A Method to Incorporate Meteorological Effects Within a Road Traffic Model

AUTHOR:
Mark A. Simpson

PAGE 433-442

ABSTRACT:
CoRTN (Calculation of Road Traffic Noise) by the UK Department of Transportation, Welsh Office has been extensively used to model road traffic noise in Australia for many years. The CoRTN model is relatively simple to use manually and, with the use of a computer, to use in complicated road layouts and terrain. This paper proposes a method to incorporate meteorological effects within the framework of the CoRTN model approach. The paper details how to calculate and apply the curved noise path resulting from the local meteorology. The method has been designed to permit hand calculation and relies on existing excess attenuation factors within the CoRTN model. The results of the application of the curved path to CoRTN algorithms are expected to improve predictive accuracy of noise models.

# Uncertainties in Environmental Noise Modeling

AUTHOR:
Arne Berndt

PAGE 443-446

ABSTRACT:
With sound level meters the measurement uncertainty is fixed and transparent, depending on the class of the instrument. The counterpart of the measurement, the noise simulation, has many more uncertainties. The uncertainties stem from the calculation standard used, the application of the model's theoretical basis in a computer program and the construction of the data model. The uncertainty of the simulated results is the sum of the uncertainties of the applied standard, the computer program and the physical representation of the reality in a computer model. The end user only has influence upon the creation of the data model and most likely is not aware of the other uncertainties. The assessment of the sources sound power is also an uncertainty but will not be discussed in this paper. This paper is concentrating on the use of popular standards and their built in systematic errors and shortcuts in the evaluation of propagation parameters. Special focus is given to the evaluation of the ground effect. Discussed standards include CoRTN, CoRRN, CONCAWE, ISO9613, GPM (Nordic) and Nord 2000. Testing routines and procedures both listed in the standard and external are to be shown and comments made. Other sources of uncertainty are the transition from area and line sources to the evaluated point sources and the acceleration techniques in the modeling software. In the near future one can hope that the shortcomings in today's standards are avoided with the next generation of noise models conceived at the moment in Europe.

# Insulating Buildings Against Transportation Noise

AUTHOR:
John L. Davy
PAGE 447-454

ABSTRACT:
Transportation noise contains significant low frequency components. It is difficult to sound insulate buildings against transportation noise because wall cavities are only effective in increasing sound insulation above the mass-air-mass resonance frequency. Stud walls can also have a significant structural resonance in this low frequency range, although it is not yet clear if this is significant in the field. This paper gives typical diesel electric locomotive traffic noise, road traffic noise, aircraft traffic noise and other rail traffic noise spectra. The paper examines the sound insulation of measured wall sound insulation spectra against these typical transportation noise spectra using A-weighted sound level reduction. This will be compared to the $R_w + C_{tr}$ and $R_w$ values of the walls. Another problem with low frequency sound insulation is the large uncertainty in both laboratory and field measurements. The adoption of $R_w + C_{tr}$ in the Building Code of Australia will make the common single number rating more appropriate for transportation noise.

# Acoustic Monitoring of the Global Ocean for the CTBT

AUTHOR:
Martin W. Lawrence

PAGE 455-460

ABSTRACT:
The Comprehensive Nuclear-Test-Ban Treaty (CTBT) provides for monitoring of the whole globe by a network of stations, using various technologies, in order to verify absence of nuclear explosion tests. The hydroacoustic component of this network, which monitors the major world oceans, is currently under construction. When complete it will consist of eleven stations located with an emphasis on the vast ocean areas of the Southern Hemisphere. At mid 2004, eight stations were transmitting data and construction is well advanced on all but one of the remaining stations. The stations transmit real-time continuous data to the CTBT Organization headquarters in Vienna, Austria. The hydroacoustic network uses two different types of stations. One type is based on hydrophones floated from the sea floor to the SOFAR axis depth, arranged horizontally in a triplet configuration. The other type is based on use of seismometers located on small islands to detect hydroacoustic signals after conversion to seismic signals at the flanks of the island. During the time since completing the first stations, many interesting acoustical phenomena have been observed in the data, including earthquakes, volcanoes, oil exploration, whale vocalizations, Antarctic ice bergs. Also, many interesting physical phenomena have been observed, such as reflections of hydroacoustic energy from the sides of continents. Hydroacoustic path lengths of in excess of ten thousand kilometres are routinely observed.

# A Descriptive Study of the Contribution of Scattering by Seafloor Features to Long-Range Sound Propagation in the Deep Ocean at 16 Hz

AUTHOR:
Marshall V. Hall

PAGE 461-466

ABSTRACT:
The long-range signal from a loud underwater impulse contains multiple echoes due to scattering by prominent seafloor features such as islands, seamounts and banks. Intensities of such echoes (relative to the intensity of the direct pulse) will vary with the size of the feature, and the horizontal angle by which the feature deflects the path. Signals recorded at New Zealand from two nuclear shots in Fangataufa, French Polynesia contained six echoes whose intensities could be noted. The relative intensities (RI) at 16 Hz ranged between -44 and -25 dB, and the estimated deflection angle (DA) ranged between 20° and 56°. Neglecting the size of the features, the logarithmic regression between RI and DA was found to be RI = –6 - 18 log |DA|, ± 4 dB. Signals from an earthquake in North-west India have been recorded by CTBTO's "H08" North and South hydrophones in the northern Indian Ocean. The effective source of waterborne sound is localized to where the measured reverse azimuth from H08 North (355°) intersects the continental shelf edge, near the earthquake. The signal at H08 South was scattered by a known seamount, located on the measured reverse azimuth from H08 South of 36°. The estimated deflection by the seamount is 45°, where the RI predicted by the Fangataufa regression is -36 dB, in agreement with the measured RI.

# Underwater Sound Received from Some Defence Activities in Shallow Ocean Regions

AUTHORS:
Adrian D. Jones, Paul A. Clarke

PAGE 467-474

ABSTRACT:
The Environmental Protection and Biodiversity Conservation (EPBC) Act 1999 became effective on 16 July 2000. This Act places requirements on the Department of Defence in regard to actions which are likely to have an impact on the environment anywhere in the world. As a consequence, it is essential for Defence to be aware of the environmental implications of its activities. In the area of Defence maritime operations, relevant issues include the radiation of acoustic energy, particularly in regard to sonar systems, and the acoustic signal levels which are expected to be incident upon marine fauna. This paper reviews some of the progress in relevant studies carried out by DSTO, with particular emphasis made on the signals received in shallow ocean areas as a result of detonations of small explosives known as “SUS” charges. Data displayed in this paper, for a particular shallow tropical water location north of Australia, suggest that received peak levels, in particular, may be substantially less than published weak shock theory suggests. Based on the circumstances of these measurements, reasons for the discrepancies between measured and predicted peak levels are suggested.

# Improving the Accuracy of Runway Allocation in Aircraft Noise Prediction

AUTHORS:
David G. Southgate, Jonathan P. Firth

PAGE 475-480

ABSTRACT:
The accuracy of predictions about aircraft noise exposure patterns in the vicinity of airports is highly dependent on the way aircraft movements are allocated to runways during the forecasting process. Conventionally the allocation of movements to runways has been based on the use of 'wind roses' which provide information on wind patterns on an average day. Experience has revealed a number of shortcomings with this approach and DOTARS is now developing a concept for allocating aircraft movements to runways which avoids wind averaging. Work to date indicates that the new approach provides robust runway allocation outcomes and can deliver these very quickly through an essentially automated process. This concept facilitates the carrying out of rapid 'what-if' and sensitivity analyses and enables noise exposure patterns to be reported using descriptors which go beyond the conventional 'annual average day'.

# Aircraft Noise Events — The Cornerstone of Monitoring

AUTHOR:
Keith Adams

PAGE 481-484

ABSTRACT:
Current procedures for monitoring aircraft noise impact make use of the concept of aircraft noise event. In spite of international agreements to base the impact on LAeq, or LAden, measured over a defined period, significant differences can occur, because of the different ways in which individual noise events are measured. Apart from the differences arising from the algorithmic procedures employed in different jurisdictions, the determination of the event threshold is a key factor in separating aircraft noise from other noise causes. In this paper we compare a number of alternative procedures, including fuzzy thresholds, loudness measures and recognition techniques in order to achieve a more rational noise impact measure. Recent data obtained on site at noise monitoring stations are used to illustrate these procedures. Since the impact measure should correlate closely with community annoyance, aircraft noise abatement services should be looking much more closely at loudness and its refinements, instead of sound pressure, as the basis for monitoring.

# One Can Control Airport Noise — The Tried and Proven Airnoise Boundary Concept

AUTHOR:
Philip J. Dickinson

PAGE 485-490

ABSTRACT:
In many countries, the air transport industry is given privileges that other, just as important, industries are denied. Whereas the large majority of industries have to meet strict noise emission standards, it would seem that, except in a very few countries, the air transport industry does not — irrespective of any public health concerns by local territorial authorities. Admittedly, just as a piece of industrial machinery may have to meet certain sound emission levels at source, so commercial aircraft have to meet noise certification levels. However, once a specially prepared single example of the aircraft is tested at certain all-up weights, rarely if ever are the production aircraft checked for compliance — and the certification levels themselves bear little relationship to the noise produced around an airport when the aircraft is in airline service. Added to these problems, it is common for governments to hide the noise immission of residential areas in the airport environs by using sound descriptors that no-one can measure, and by making themselves the sole suppliers of information. Yet there are very effective and transparent ways of controlling airport noise as proven in New Zealand over the last ten years. There, the local residents have a say in how much noise the airport is going to be allowed to make in their area, and hold the airport to it. The situation around some airports is an order of magnitude better than 10 years ago — indeed at Wellington International Airport in the summer months of 2003/2004, complaints about aircraft noise were zero.

# Noise and Flight Path Monitoring at Australian Airports

AUTHOR:
Leigh C. Kenna

PAGE 491-494

ABSTRACT:
The noise from aircraft operations can be a source of dissatisfaction for residents of communities surrounding airports. To provide information which may assist in reducing that dissatisfaction, Airservices Australia operates a noise and flight path monitoring system at several of Australia's major civil airports. The system is networked for operation from a single control centre in Canberra. In the surrounds of each airport is a number of noise monitoring terminals, continuously monitoring the noise to which they are exposed. The system also records flight track and aircraft operational information from the airport radar systems, and correlates the noise with the flight track data. The detailed numerical and pictorial analyses of the data which can be produced are invaluable in the environmental management of aircraft operations in the vicinity of the monitored airports. They also assist community understanding of the issues. The paper describes the system, the way it operates, the data it produces and the applications to which the data is put.

# Audibility of Transportation Noise

AUTHOR:
Bob Thorne

PAGE 495-500

ABSTRACT:
A lack of information as to why noise created by transportation may be “loud but acceptable” compared to “audible and annoying” to an individual is creating problems in resolving noise issues. For example, people complain about tire noise, but what is tire noise and why is it “noisy”? Traditionally, land-based transportation noise has been described using a range of dB(A) descriptors; many of them are variations on a theme (Leq, L10 and so on). By contrast, aircraft noise has more sophisticated perceived noise level criteria. Common dose-response data tends to describe noise that affects the community rather than individual sensitivity and annoyance. Developing a methodology to measure and assess audible intrusive noise and correlating to individual sensitivity and response is part of a continuing research program at Massey University, Wellington, NZ. The Paper presents a snap-shot of the aims and methodologies of the research, plus some of the problems found.

# A Vehicle Maximum Noise Level Study

AUTHORS:
Jim A. Campbell, Jeffrey Parnell
PAGE 501-506

ABSTRACT:
The RTA is currently embarking on a program of fixed speed camera (FSC) installation throughout NSW and has developed draft selection criteria for their installation. In response to community concern regarding perceived increases in noise levels and more particularly, the perceived increases in the number of noisy engine brakes, research has been undertaken to evaluate whether installation of FSC's and warning signs contribute to impacts, and whether site selection criteria should address noise issues. The assessment concentrates on evaluating the effects of FSC installation on changes in the application of audible engine brakes, 'A' weighted night-time $L_{eq(9hour)}$ traffic noise levels and $L_{max}$ vehicle noise events. It was found that the prototype "Mad Max" software package currently being developed by Wilkinson Murray P/L provided a credible definition and protocol for interpreting single vehicle noise events where multiple vehicle pass-bys are common. Research suggests that external noise events below 65 dB(A) are of reduced concern in terms of maximum noise level impacts but all events should be identified to ensure a normal distribution of data and therefore statistical validity. None of the road types investigated showed a significant increase in audible engine brake application or noise impact. However, some further research is needed to capture all road geometry scenarios. Where traffic is comprised of primarily light vehicles a significant benefit can be expected due to a reduction in vehicle speed.

# Reassessment of the Impact of Road Traffic Noise for the Pacific Motorway Upgrading (Logan Motorway to Nerang)

AUTHORS:
Stephen E. Samuels, Julie K. Peters, Arthur M. Hall

PAGE 507-512

ABSTRACT:
Members of the public residing beside the Pacific Motorway, in particular the Portland Cement Concrete (PCC) pavement sections, have expressed strong concerns with respect to the impact of the road traffic noise on their life style with the opening of the new eight-lane motorway. As such, Queensland Department of Main Roads engaged the services of independent consultants, Professor Lex Brown (Griffith University) and Dr Stephen Samuels (TEF Consulting), to undertake a review of the implementation of the impact management plan with respect to road traffic noise. An outcome of this review was to undertake an independent comprehensive post-construction noise measurement and modelling program. Richard Heggie and Associates (RHA) and ASK Consulting Engineers (ASK) were engaged to carry out the program. Established standard practices were used throughout the program. In addition, because of the significant length of road (42 km), the complex terrain and the eight-lane facility, in excess of 150 measurements were undertaken and high quality data were collected. A robust statistical analysis was performed as it became evident that, due to the complex nature of the project, an evaluation, calibration and validation of the CoRTN model was necessary for noise level predictions along the motorway. This resulted in project specific calibration factors being incorporated into the CoRTN model for calculating and predicting pre-construction, post-construction and future road traffic noise levels. As a result, the Queensland Government has allocated $7.5 million to deal with noise problems along the motorway where noise levels have exceeded the departmental criterion level and wherever possible, to manage noise impacts such that there will be no sustained increase in baseline ambient noise levels at sensitive receptors.

# Study of Traffic Noise Levels in Singapore

AUTHORS:
H.T. Chui, Raymond B.W. Heng, K.Y. Ng
PAGE 513-518

ABSTRACT:
Environmental noise generated by traffic is an area of environmental concern especially with the rising vehicle populations and the near proximity of housing to the roads. The study of traffic noise affecting public housing in Singapore is of great importance. This study seeks to obtain detailed noise measurements at the various locations chosen in order to ascertain the actual noise levels and characteristics and the degree of the problem faced. This paper intends to present the field measurements results which will eventually be used in a detailed comparison study where the measured values are compared against those calculated using commercially available predictive software to understand the causes for the variations between the two sets of results.

# Acoustic Mine Imaging (AMI) Project an Underwater Acoustic Camera for Use in Mine Warfare

AUTHORS:
Col Ellis, Ed Murphy
PAGE 519-522

ABSTRACT:
There have been significant advances in sonar processing, imaging and synthetic apertures processing being made in the Australian Defence Acquisition Project SEA 1432 Acoustic Mine Imaging (AMI). This paper will detail the Australian based development of the "AMI" an underwater acoustic camera for the detection, classification and characterisation of mines and other underwater objects in turbid water where optical imaging is ineffective. The paper will consider the phases of this project and detail the very high computational capability and sub-millimetre transducers in a 2D matrix array developed within the program. The paper will then present the recent trial results and discuss the ongoing development plans to enhance visualisation.

# Robust High Resolution Dominant Mode Rejection (DMR) Beam-Former for Passive Sonar

AUTHOR:
Chaoying Bao
PAGE 523-526

ABSTRACT:
Resolving the bearings of acoustic sources is one of the most important objectives of sonar arrays. In this paper, we present a robust high bearing resolution adaptive beamforming (ABF) algorithm. The algorithm is based on two existing ABF methods both being extensions of the well-known minimum variance distortionless response (MVDR) method. One is dominant mode rejection with eigenvector-beam association and excision (DMR/EBAE) beamforming that gives high bearing resolution. The other is robust Capon beamforming (RCB) that provides excellent robustness. Applying the algorithm to sonar data from sea trials shows that the proposed algorithm exhibits excellent robustness; it performs well even in the presence of failed sensors in the sonar array. It also provides improved performance in terms of interference rejection and signal separation compared to other existing ABF algorithms.

# Creating an Incoherent Synthetic Aperture Using an Autonomous Profiling Vehicle

AUTHORS:
Parijat D. Deshpande, Venugopalan Pallayil, Boon Siong Wee, Paul J. Seekings, John R. Potter

PAGE 527-532

ABSTRACT:
Acoustic synthetic apertures are usually generated by coherent summing of signals, correcting for phase shifts due to the lapse in time as a receiver array moves to create the aperture. This approach suffers from phase estimation errors arising from both positioning errors of the moving receivers and from phase instabilities in the signal. An incoherent synthetic aperture can be created if compact broadband signals are used, avoiding phase error problems. Furthermore, since no overlapping sensors are required for phase estimation, a synthetic aperture can in principle be created from a single moving receiver. This paper investigates the feasibility and expected performance of an incoherent synthetic aperture constructed by moving a single acoustic receiver in the vertical plane. The application discussed in this paper is to evaluate the focal region of an Acoustic Time Reversal Mirror (TRM) where the receiver platform is an Autonomous-Profiling Vehicle (APV). The APV is a modified commercial product from Ocean Sensors in San Diego, USA, and carries an acoustic data acquisition payload designed by the Acoustic Research Laboratory. The APV has the ability to profile in the vertical plane, guided by a taut vertical mooring line, or to zigzag in a series of progressively displaced vertical profiles as it drifts freely with currents. The APV also monitors conductivity, temperature and depth, so that the sound speed profile and the depth of the receiver at each pulse reception can be reconstructed. Numerical propagation models are used to simulate the performance of such an incoherent synthetic aperture array during shallow water TRM experiment to validate the overall performance prior to conducting sea-trials. Both Fast Field (SPARC) and Normal Mode (Kraken C) models are applied. The temporal-spatial ambiguity problem is considered with respect to the time it takes to form the aperture compared to the coherence time of the TRM focussing, limited by the coherence time of the shallow-water waveguide. We also present some CTD and acoustic data taken by the modified APV.

# Using a Towed Array to Localise and Quantify Underwater Sound Radiated by the Tow-Vessel

AUTHORS:
Alec J. Duncan, Darryl R. McMahon
PAGE 533-538

ABSTRACT:
This paper presents the results of a study aimed at determining the feasibility of using a towed array of hydrophones to localise and quantify sound sources on the tow-vessel. The method requires the tow-vessel to execute a manoeuvre in order to bring the array into a suitable geometry to allow it to image the tow-vessel. Previous work has focussed on a scenario where the tow-vessel executes a U-turn manoeuvre, resulting in rapid relative motion between the tow-vessel and hydrophones. In this paper a simulation is used to compare the performance of different beamforming algorithms in a scenario where the tow-vessel executes a constant radius turn. This scenario has the advantage of allowing longer integration times than the U-turn manoeuvre.

# The Noise Gap Index: A New Way to Describe and Assess Aircraft Noise Impacts on the Community

AUTHORS:
Tharit Issarayangyun, Stephen E. Samuels, John Black

PAGE 539-544

ABSTRACT:
It is well known that aircraft noise potentially disturbs (or annoys) the daily activities (such as communication, study, sleep, rest and relaxation) of residents living in the vicinity of airports. This particular type of annoyance can be a cause of stress and evidence is emerging that appears to associate some forms of health risk with this stress. Current research being undertaken by the authors is aimed at developing a better understanding of the impacts of aircraft noise on community health and well-being. The present paper is concerned with a major component of the research which involves the development of a new index for describing and assessing aircraft noise. Subsequently it is planned to apply this index in exploring the correlations that might exist between community health and well being and aircraft noise. The index, which has been termed the Noise Gap Index (NGI) has been developed on the assumption that people living in areas of different background noise may have different reactions to the same aircraft noise level. Parameters involved in the NGI are the LAeq of the background noise level and the LAeq of the aircraft noise, along with a Number-Above-Index (NA) and a Time-Above-Index (TA). An extensive noise monitoring program has been implemented in a number of suburbs around Sydney (Kingsford Smith) Airport and the resulting data applied in developing the NGI. The paper summarises these noise data, describes their analyses and finally presents the NGI. This paper reports work in progress.

# Adelaide Airport Noise Insulation Program — Public Buildings

AUTHORS:
Ivailo Dimitrov, Neil C. MacKenzie
PAGE 545-548

ABSTRACT:
The Department of Transport and Regional Services is overseeing a $63 million federally funded sound insulation program for residential and public buildings surrounding the Adelaide Airport. VIPAC was engaged by the project manager (Clifton Coney Group) as the acoustic consultant to design the treatments for the buildings, to oversee the installation of the treatment and to verify its performance.

This paper presents a review of the different types of public buildings included in the noise insulation program and the noise control treatments utilised. An analysis of the noise reduction gained so far in the program (based on pre- and post-construction measurements). These results are compared to the noise reduction achieved during the residential part of the Adelaide Airport Noise Insulation Program is presented.

# The Long Term Road Traffic Noise Attributes of Some Pavement Surfaces in Townsville

AUTHOR:
Stephen E. Samuels

PAGE 549-554

ABSTRACT:
This paper documents the conduct and outcomes of an extensive study of the noise attributes of several pavement surfaces currently in service in and around Townsville. A specific objective of this study was to examine the acoustic performance of the set of pavement surfaces over time. To do this the study involved two extensive data collection exercises which were separated by one year in time. Analyses of the data produced values of a parameter known as the Statistical Passby Index which was applied to quantifying the acoustic performance of the pavement surfaces over time. It was found that most of the pavement surfaces maintained their acoustic performance over the year. However one which was about the quietest initially exhibited an increase in noise over the year. Some possible reasons for this drop in acoustic performance were also investigated and are reported in the paper.

# The Radiation Efficiency of Finite Size Flat Panels

AUTHOR:
John L. Davy

PAGE 555-560

ABSTRACT:
The radiation efficiency of an infinite flat panel which is radiating an infinite plane wave into an infinite half space can be shown to be equal to the inverse of the cosine of the angle between the direction of propagation of the plane wave and the normal to the panel. The fact that this radiation efficiency tends to infinity as the angle tends to 90° causes problems with simple theories of sound insulation. Sato has calculated numerical values of radiation efficiency for a finite size rectangular panel. This paper presents a simple analytic strip theory which agrees reasonably well with Sato's numerical calculations for a rectangular panel. This leads to the conclusion that it is mainly the length of the panel in the direction of radiation, rather than its width that is important in determining its radiation efficiency.

# The Potential for High Acoustic Performance by the Use of Glasswool Insulation in Double Stud Plasterboard Partitions

AUTHORS:
Peter Knowland, Clayton Roberts, Ray Thompson
PAGE 561-562

ABSTRACT:
This paper documents acoustic research carried out on behalf of CSR Bradford Insulation. The program investigated the performance of various insulation products in the cavity of a double steel stud plasterboard wall. Comparisons are made between glasswool, rockwool and a number of polyester insulation products. The results from the tests indicate clear differences in the relative performances, with the best results being for the glasswool insulation. A full set of the results will be presented.

# Noise and Teacher and Student Stress: A Flawed Inclusive Approach in Inappropriate Facilities?

AUTHORS:
Stephen Winn, Ian Hay
PAGE 563-564

ABSTRACT:
This research has identified that the physical environment has an impact on teacher stress levels and student learning. This qualitative and quantitative study investigated the impact that excessive noise in the teaching and learning environment has on special education teacher stress levels. The study was conducted in a high school where school students with Asperger's Syndrome were included. The main concerns identified were the impact that noise had on students' behaviour and subsequent teacher stress levels. Using the Travers and Cooper (1996) *Stress in the Teacher Profession Questionnaire* [1], developed in the UK and based on Cooper's model of occupational concerns, teachers indicated that the facilities were a major contributor to their stress as well as to inappropriate student behaviour. In consultation with key stake holders, an assessment was conducted of some of the teaching and learning environments was undertaken. The assessment included provision of a scope of works for refurbishments (limited to $40,000). Subsequent to building modification works, a post modification assessment (at nine months after the alterations) using the same instrument, showed significant changes in teacher stress levels as well as significant changes in student behaviour.

# An Approach to Soundscape Planning

AUTHOR:
A.L. Brown

PAGE 565-570

ABSTRACT:
This paper focuses on *soundscape planning*, or *acoustic design*, in the planning and management of open space in both urban and non-urban areas. It is based on notions, promoted over several decades, that the acoustic aspects of open space can, and should be, subject to design in the same way as are the visual dimensions. The current paradigm for the management of the outdoor acoustic environment is *noise control* and *soundscape planning* needs to adopt quite different practices from noise control with respect to acoustic criteria and measurement. The paper explores the specification of *acoustic objectives* for outdoor soundscapes and the translation of these objectives into acoustic criteria that are amenable to measurement and prediction as part of the design process. Such objectives, termed *Proposed Acoustic Environments*, focus on the *information content* in sounds in a particular space and, only indirectly, on characteristics such as level or loudness. Outdoor acoustic design is mostly concerned with avoiding, or achieving, the *masking* of one set of information in the acoustic signal with other sets of information in the same signal. These are critical methodological issues if soundscape planning is to move from being a good idea to common practice.

# Water Injection for Bubble Noise Reduction

AUTHORS:
Chris Norwood, Li Chen

PAGE 571-576

ABSTRACT:
Underwater exhaust noise is potentially a significant contributor to the acoustic signature of a conventional diesel electric submarine. The design of an underwater exhaust outlet has an impact on the radiated noise levels, particularly the flow noise generated at the exit. This paper details the results of an experimental study of the acoustic performance of air-water mixture through a simple exhaust outlet. The acoustic emission of the exhaust jet at airflow rates from 0.32 l/s to 1.72 l/s and water injection rates between 0 l/s to 0.08 l/s was investigated. It was found that noise reductions of approximately 10 dB could be obtained by injecting approximately 10% water, by volume, uniformly into the discharging air. It is also important to ensure good mixing between the water and gas phases in order to achieve optimum noise reductions.

# Characteristics of Merchant Ship Acoustic Signatures During Port Entry/Exit

AUTHOR:
Mark A. Hallett
PAGE 577-580

ABSTRACT:
Results are presented of underwater acoustic radiated noise measurements of 10 merchant ships during port entry or exit. The speed of the vessels ranged from 7–15 knots and the displacement of the vessels between 3500–200000 deadweight tonnes. All measurements were taken in very shallow water (~20 m) and at very close range (~100 m) while the ships were transiting narrow shipping channels. The source level dependence on ship length and ship displacement is examined and compared with an empirical model developed by Ross (1976). Results from this limited dataset suggest that for port entry/exit, the acoustic source level is not dependent on ship speed or displacement. Using this observation, an average spectrum level is calculated that can be taken to be representative of a wide variety of merchant ships during port entry and exit.

# Silencing High Velocity HVAC Ducts in Ocean Going Fast Ferries

AUTHORS:
J.R. Neale, J.M. Middelberg, S.S. Leong, T.J. Barber, K.P. Byrne, E. Leonardi
PAGE 581-586

ABSTRACT:
Preliminary acoustic testing of conical diffusers has been completed for use in a proposed high velocity HVAC duct system for large ocean going fast ferries. The flow-induced noise from such a system was identified as a critical limit on the maximum air distribution velocity. The design of the diffuser outlet was found to have a pronounced effect on the noise spectrum radiating from the duct outlet. Upstream system noise can be treated with inline silencers and controlling the expansion of the exiting air can effectively treat the flow-induced noise created. The noise level from a straight jet of air exiting a 50 mm diameter pipe was measured and compared with the same pipe fitted with a 7° diffuser with an outlet diameter of 150 mm. The length of pipe fitted to the end of the diffuser was varied to identify the optimum outlet design. The addition of a 90° elbow and a 135° Y outlet duct configuration were also investigated. Noise levels have been recorded based on a mean duct velocity ranging from 15 to 60 $ms^{-1}$. Corresponding numerical (CFD) models have also been used to predict noise levels for new diffuser designs.

# A Hybrid Approach to Predict the Vibration Transmission in Ship Structures Using a Waveguide Method and Statistical Energy Analysis

AUTHORS:
Nicole J. Kessissoglou, John Keir

PAGE 587-592

ABSTRACT:
Prediction of vibration transmission in ship structures is important, to design maritime vessels with greater power and reduced weight, without increasing noise levels. As the frequency increases, and hence the number of modes increases, it is more practical to consider average responses and their distribution over the structure, using a technique such as Statistical Energy Analysis (SEA). Numerical results from an exact, analytical waveguide model are compared with those of conventional SEA models. These results include both response predictions and the SEA parameters. The theoretical estimation of the SEA parameters, namely the coupling loss factors, form the basis for the hybrid approach between the waveguide method and SEA technique. Results are presented for plate structures in an L, T and X-shaped configuration, and a complex built-up structure.

# Effect of Noise on Facial EMG

AUTHORS:
Sanjay Kumar, Dinesh Kant Kumar, Melaku Alemu, Mark Burry

PAGE 593-598

ABSTRACT:
Noise is the single biggest source of complaints in large cities around the world and is a cause of stress and reduced human efficiency. In the past, questionaires have been widely used in order to assess the effects of noise on human. The difficulty with this technique is the lack of objectivity leaving a room for doubt. This paper presents a result of a preliminary investigative work in which facial electromyography (EMG) is monitored while experimental subjects are exposed to noise. Sound or noise stimuli with varying properties at different level have been used and facial EMG observed. Facial EMG activities in facial muscles (M. *frontalis laterali*, M. *orbicularis oculi*, and M. *zygomaticus major*) have been recorded and investigated. The preliminary experimental outcomes indicate that there is an increase in the activity of the facial EMG as the level of the noise increases. It has been also observed that in order to draw a pattern between the emotional state of humans and the level of a given noise or sound, more enhanced analysis techniques as well as a larger number of subjects are required.

# Detection of the Human Stress Response to Auditory Noise

AUTHORS:
Sanjay Kumar, Dinesh Kant Kumar, Melaku Alemu, Mark Burry

PAGE 599-602

ABSTRACT:
This paper presents results of an investigative study to detect, measure and analyse human stress response under the presence of different intensities of external modifiers (white noises). Subjects' responses under the stressors have been detected and analysed using various bio-signals, such as Electrocardiography (ECG) and skin conductance. Applying different intensities of auditory stimuli to the participants while they are undertaking cognitive tasks, may induce certain levels of 'stress'. In order to analyse the level of stress efficiently, having an intelligent system is essential. The primary objective of this research is to develop such an intelligent system. Using bio-signals as an input, the system detects, recognises and classifies any psychophysiological change in human behaviour under different auditory conditions. The outcome of this research work has a wide range of benefits for the community and particularly in the area of clinical research.

# Representation of Head Related Transfer Functions with Principal Component Analysis

AUTHORS:
Jaka Sodnik, Anton Umek, Rudolf Susnik, Goran Bobojevic, Saso Tomazic

PAGE 603-608

ABSTRACT:
Head Related Transfer Functions (HRTFs) describe the changes in the sound wave as it propagates from a spatial sound source to the human eardrum. One possible representation of HRTF data is the use of Principal Component Analysis (PCA), which decomposes data to principal components and corresponding weights. We applied PCA to MIT Media Lab non-individualized HRTF library. The linear amplitudes of elevation 0° were decomposed to four principal components and four weights per amplitude. The aim of our experiment was to find some mathematical regularity in the weights for different azimuths. It has been established that the variation of each weight can be approximated with a suitable mathematical function (sinus functions or polynomial). Such representation of weight variation enables the reconstruction of HRTF amplitudes for non-measured positions and reduces the amount of necessary data. Our model was tested on 25 subjects and proved to be very efficient.

# Whole-Body Vibration — Review of Australian and International Standards and the Future

AUTHORS:
Scott J. Monaghan, Darren C. van Twest
PAGE 609-614

ABSTRACT:
A review of Whole-Body Vibration (WBV) assessment methodologies is presented showing that a definitive assessment methodology for health effects is not yet available. Issues confronting the assessor using International and Australian Standards are highlighted. A description of the recent International Standard for WBV containing shocks is included along with some results and advice regarding this standard compared with others. This standard is specific to spine related health effects and includes dynamic analysis to model mechanical stress on vertebral endplates. The shift in theory behind health effects resulting from exposure to WBV containing shocks is discussed. The paper concludes with comments about the future direction of WBV standards.

# Low Frequency Noise Assessment — An Update

AUTHOR:
Norm Broner

PAGE 615-618

ABSTRACT:
Due to the incidence of complaints about HVAC duct rumble noise, ASHRAE sponsored some research to firstly, document the extent and degree of low frequency noise problems and secondly, to determine by means of psycho-acoustic testing, a method of assessment of such noise. This paper describes some of the results obtained in the second phase. Subjects listened to four HVAC stimuli with prominent low frequency spectral peaks for an hour. Subjects rated the Loudness and Annoyance of these acoustic stimuli using the method of Magnitude Estimation. At lower frequencies, Loudness habituation was more rapid than Annoyance habituation at lower sensation levels, thus emphasizing and increasing the difference between Loudness and Annoyance. It appears that this effect increases with time so that longer noise exposures result in an increase in annoyance relative to loudness. The implications of this result with respect to assessment metrics are discussed.

# Ecoaccess Guideline for the Assessment of Low Frequency Noise

AUTHOR:
Cedric Roberts

PAGE 619-624

ABSTRACT:
As a result of the escalation in low frequency noise sources appearing in new industrial development and the incidence of low frequency noise complaints experienced by residents in Queensland, a low frequency noise guideline has been developed by the Environmental Protection Agency. The Guideline is applicable to low frequency noise emitted from industrial premises, commercial premises and mining operations (not blasting), and is intended for planning purposes as well as for the evaluation of existing problems. The intent of the established criteria is to accurately assess annoyance and discomfort to persons at noise sensitive premises caused by low frequency noise with a frequency range from 10 Hz to 200 Hz. The technical paper will describe the main elements of this guideline including: use of the G-weighting function to determine annoyance due to infrasound in the frequency range from 1 Hz to 20Hz and low frequency noise criterion adopted for initial screening inside home environments in terms of Linear, A-weighted and one-third octave band sound pressure levels in the range 20 to 200 Hz. Initially auditory perception is established by comparing one-third octave band frequency sound with the ISO median hearing threshold levels (HTLs) for the best 10% of the aged population (55–60 years old) followed by separate noise criteria applied to establish annoyance from tonal and non-tonal noise.

Two examples of the application of the guideline to infrasonic noise and non-tonal noise from industrial equipment are given in the paper.

# Managing Noise Impacts in Brisbane's Fortitude Valley Entertainment Precinct

AUTHORS:
Frank D. Henry, Ken C.S. Mackenzie

PAGE 625-630

ABSTRACT:
The construction of residential apartments within Brisbane's inner-city entertainment precinct of Fortitude Valley (known as The Valley) as part of a process of urban renewal, has led to dispute and concern regarding the future of the live music scene in the Valley. New residents expect to be able to sleep and enjoy their living areas without excessive intrusion from noise, and the established venues and musicians expect to be able to continue 'business as usual'. In early 2004 Brisbane City Council released its *Valley Music Harmony Plan*, which proposes a number of actions to manage the potential impacts of music noise while maintaining and enhancing the viability of the music industry and the vibrancy of the Valley. This innovative approach to noise impact management within entertainment precincts undergoing urban renewal, combines planning, regulatory and non-regulatory approaches and challenges the traditional way noise impacts are managed in such areas. This paper will discuss the background research conducted as part of developing the *Valley Music Harmony Plan*, including noise mapping and venue and apartment attenuation assessment. This paper will also discuss the major barriers to the project, including the management of low frequency noise, the lack of low frequency noise guidelines, current town planning (development) principles in Queensland and the traditional manner of music venue noise regulation.

# Heavy-Weight Floor Impact Sound in Reinforced Concrete Structures

AUTHORS:
J.Y. Jeon, J.H. Jeong, S.H. Seo
PAGE 631-636

ABSTRACT:
The purpose of this study was to evaluate the floor impact sound isolation systems in reinforced concrete constructions. The floor impact sounds were generated by the standard heavy-weight impact sources, a tyre drop tester[1] and an impact ball[2]. The noise and vibration from the impact sources were analyzed and the relationship between the sound levels and the subjective responses was investigated. From the different residential building structures, it was found that heavy-weight floor impact in a box frame-type concrete structure[3] readily transmits sound to the space below through the bearing walls, whereas the non-bearing walls of a rahmen structure[4] do not readily transmit sound. It was also observed that a linear relation exists between floor impact sound and vibration. In addition, when the noises were evaluated in in-situ conditions, the allowable sound levels were found to be 46dB for the tyre drop tester and 54dB for the impact ball.

# Architectural Acoustics Design of the Gold Coast City Council Chambers

AUTHOR:
James Heddle

PAGE 637-642

ABSTRACT:
This paper reviews the design challenges and development of solutions to the room acoustics design of the Council Chambers in the new Civic Focus building of the Gold Coast City Council. The proposed design incorporated a double concave light well and a concave main wall facing the Councillor seating positions with significant areas of glass behind them. Additionally, for a number of seating positions, the Councillors would be speaking with their backs to the Chambers Public Gallery.

Preliminary analysis of the space indicated the likelihood of significant sound focusing and flutter echo problems for the Chambers with the prospect of poor speech intelligibility for listeners. A 3D computer model of the Chambers was created and geometric ray tracing was used to investigate the behaviour of sound source propagation in the space, concentrating on the Councillor locations as the source positions with other Councillors and the Public Gallery as the receiver locations of interest. An analysis was undertaken of the sound reflection sequences in the Chambers considering the audibility of echoes and the provision of useful early reflected sound energy to enhance speech intelligibility at all the listener locations.

The development of surface features and treatments to solve the design issues within the imposed constraints and the outcomes of the design will be discussed.

# Development of Light Timber Frame Floor/Ceiling Systems with Good Low Frequency Performance

AUTHOR:
K. McGunnigle

PAGE 643-644

ABSTRACT:
In Australia and New Zealand the predominant form of construction for dwellings and low rise buildings is light timber frame, with plasterboard linings and particle board floors. A widely held perception is that light timber frame floors perform poorly for footfall noise at low frequencies below 100Hz and that concrete floor systems enjoy a unique technical and economic advantage, which is unassailable.

The Australian and New Zealand Building Codes are performance based but the subjectively troublesome frequencies below 100Hz are not included in the verification method. Consequently the subjectively poor footfall performance of light timber frame floors at low frequencies is not being addressed by regulation. Thus there are significant barriers to the expanded use of light timber frame floors in the construction market. To mitigate this problem the Forest & Wood Research & Development Corporation in Australia has initiated a one year programme with a consortium of industry partners and researchers. This paper introduces and sets out the framework of a multidisciplinary approach to develop practical light timber frame floors, which perform as well as 150mm concrete floors at frequencies below 100Hz. Firstly an overview of the mathematical modelling, which has been undertaken, secondly the selection of suitable floor systems, thirdly the construction of purpose built test rigs and lastly the measurement parameters to clarify the validity of the modelling. As the project progresses several practical floor systems will be constructed, which will be further assessed on site in respect of buildability, sound insulation performance and flanking at the wall/floor junctions.

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